MySQL 5.5 Reference Manual

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Abstract

This is the MySQL™ Reference Manual. It documents MySQL 5.5 through 5.5.16.

MySQL Cluster is currently not supported in MySQL 5.5. For information about MySQL Cluster, please see MySQL Cluster NDB 6.X/7.X.

MySQL 5.5 features. This manual describes features that are not included in every edition of MySQL 5.5; such features may not be included in the edition of MySQL 5.5 licensed to you. If you have any questions about the features included in your edition of MySQL 5.5, refer to your MySQL 5.5 license agreement or contact your Oracle sales representative.

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Getting Started	Platforms	Administrators	Developers	Functionality	Connectors	HA/Scalability
Tutorial	» Linux/Unix	Server Option/ Variable Reference	Server Option/ Variable Reference	SQL Syntax	Connector/J	» HA/ Scalability Guide
Installation	» Mac OS X	MySQL Change History	» MySQL Version Reference	Views	Connector/ ODBC	MySQL and DRBD
Upgrading	» Windows	» MySQL Version Reference	SQL Syntax	Stored Routines	Connector/Net	MySQL and Virtualization
Server Administration	» Solaris	» Security	Optimization	Replication	Connector/C++	Memcached
FAQs	» Building from Source	» Startup/ Shutdown	Connectors & APIs	Semisynchronous Replication	Connector/ OOo	MySQL Proxy
		» Backup and Recovery	Functions and Operators	Spatial Extensions	PHP	Replication
		Partitioning	Stored Programs and View	Precision Math	C API	Semisynchronous Replication
		Information Schema	SIGNAL/ RESIGNAL	Globalization		
				Partitioning		

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Preface and Notes

This is the Reference Manual for the MySQL Database System, version 5.5, through release 5.5.16. Differences between minor versions of MySQL 5.5 are noted in the present text with reference to release numbers (5.5.*x*). For license information, see the legal notice. This product may contain third-party code. For license information on third-party code, see Appendix A, *Licenses for Third-Party Components*.

This manual is not intended for use with older versions of the MySQL software due to the many functional and other differences between MySQL 5.5 and previous versions. If you are using an earlier release of the MySQL software, please refer to the appropriate manual. For example, *MySQL 5.1 Reference Manual*, covers the 5.1 series of MySQL software releases.

Chapter 1. General Information

The MySQL™ software delivers a very fast, multi-threaded, multi-user, and robust SQL (Structured Query Language) database server. MySQL Server is intended for mission-critical, heavy-load production systems as well as for embedding into mass-deployed software. Oracle is a registered trademark of Oracle Corporation and/or its affiliates. MySQL is a trademark of Oracle Corporation and/or its affiliates, and shall not be used by Customer without Oracle's express written authorization. Other names may be trademarks of their respective owners.

The MySQL software is Dual Licensed. Users can choose to use the MySQL software as an Open Source product under the terms of the GNU General Public License (http://www.fsf.org/licenses/) or can purchase a standard commercial license from Oracle. See http://www.mysql.com/company/legal/licensing/ for more information on our licensing policies.

The following list describes some sections of particular interest in this manual:

- For a discussion about the capabilities of the MySQL Database Server, see Section 1.3.3, “The Main Features of MySQL”.
- For development history, see Section 1.4, “MySQL Development History”.
- For installation instructions, see Chapter 2, *Installing and Upgrading MySQL*. For information about upgrading MySQL, see Section 2.11.1, “Upgrading MySQL”, and the change notes at Appendix D, *MySQL Change History*.
- For a tutorial introduction to the MySQL Database Server, see Chapter 3, *Tutorial*.
- For information about configuring and administering MySQL Server, see Chapter 5, *MySQL Server Administration*.
- For information about setting up replication servers, see Chapter 15, *Replication*.
- For answers to a number of questions that are often asked concerning the MySQL Database Server and its capabilities, see Appendix B, *MySQL 5.5 Frequently Asked Questions*.
- For a list of currently known bugs and misfeatures, see Section C.5.8, “Known Issues in MySQL”.
- For a list of all the contributors to this project, see Section 1.9, “Credits”.
- For a history of new features and bugfixes, see Appendix D, *MySQL Change History*.
- For tips on porting the MySQL Database Software to new architectures or operating systems, see MySQL Internals: Porting.
- For benchmarking information, see the `sql-bench` benchmarking directory in your MySQL distribution.

> **Important**
>
> To report errors (often called “bugs”), please use the instructions at Section 1.7, “How to Report Bugs or Problems”.
>
> If you have found a sensitive security bug in MySQL Server, please let us know immediately by sending an email message to `<security@mysql.com>`.

1.1. About This Manual

This is the Reference Manual for the MySQL Database System, version 5.5, through release 5.5.16. Differences between minor versions of MySQL 5.5 are noted in the present text with reference to release numbers (5.5.*x*).

This manual is not intended for use with older versions of the MySQL software due to the many functional and other differences between MySQL 5.5 and previous versions. If you are using an earlier release of the MySQL software, please refer to the appropriate manual. For example, *MySQL 5.1 Reference Manual*, covers the 5.1 series of MySQL software releases.

If you are using MySQL 5.6, please refer to the *MySQL 5.6 Reference Manual*.

Because this manual serves as a reference, it does not provide general instruction on SQL or relational database concepts. It also does not teach you how to use your operating system or command-line interpreter.

The MySQL Database Software is under constant development, and the Reference Manual is updated frequently as well. The most recent version of the manual is available online in searchable form at http://dev.mysql.com/doc/. Other formats also are available there, including HTML, PDF, and Windows CHM versions.

The Reference Manual source files are written in DocBook XML format. The HTML version and other formats are produced automatically, primarily using the DocBook XSL stylesheets. For information about DocBook, see http://docbook.org/

If you have questions about using MySQL, you can ask them using our mailing lists or forums. See Section 1.6.1, “MySQL Mailing Lists”, and Section 1.6.2, “MySQL Community Support at the MySQL Forums”. If you have suggestions concerning additions or corrections to the manual itself, please send them to the http://www.mysql.com/company/contact/.

This manual was originally written by David Axmark and Michael “Monty” Widenius. It is maintained by the MySQL Documentation Team, consisting of Paul DuBois, Stefan Hinz, Philip Olson, John Russell, and Jon Stephens.

1.2. Typographical and Syntax Conventions

This manual uses certain typographical conventions:

- `Text in this style` is used for SQL statements; database, table, and column names; program listings and source code; and environment variables. Example: “To reload the grant tables, use the `FLUSH PRIVILEGES` statement.”
- **`Text in this style`** indicates input that you type in examples.
- `Text in this style` indicates the names of executable programs and scripts, examples being `mysql` (the MySQL command line client program) and `mysqld` (the MySQL server executable).
- *`Text in this style`* is used for variable input for which you should substitute a value of your own choosing.
- *Text in this style* is used for emphasis.
- **Text in this style** is used in table headings and to convey especially strong emphasis.
- `Text in this style` is used to indicate a program option that affects how the program is executed, or that supplies information that is needed for the program to function in a certain way. *Example*: “The `--host` option (short form `-h`) tells the `mysql` client program the hostname or IP address of the MySQL server that it should connect to”.
- File names and directory names are written like this: “The global `my.cnf` file is located in the `/etc` directory.”
- Character sequences are written like this: “To specify a wildcard, use the ‘`%`’ character.”

When commands are shown that are meant to be executed from within a particular program, the prompt shown preceding the command indicates which command to use. For example, `shell>` indicates a command that you execute from your login shell, `root-shell>` is similar but should be executed as `root`, and `mysql>` indicates a statement that you execute from the `mysql` client program:

```
shell> type a shell command here
root-shell> type a shell command as root here
mysql> type a mysql statement here
```

In some areas different systems may be distinguished from each other to show that commands should be executed in two different environments. For example, while working with replication the commands might be prefixed with `master` and `slave`:

```
master> type a mysql command on the replication master here
slave> type a mysql command on the replication slave here
```

The “shell” is your command interpreter. On Unix, this is typically a program such as `sh`, `csh`, or `bash`. On Windows, the equivalent program is `command.com` or `cmd.exe`, typically run in a console window.

When you enter a command or statement shown in an example, do not type the prompt shown in the example.

Database, table, and column names must often be substituted into statements. To indicate that such substitution is necessary, this manual uses *`db_name`*, *`tbl_name`*, and *`col_name`*. For example, you might see a statement like this:

```
mysql> SELECT col_name FROM db_name.tbl_name;
```

This means that if you were to enter a similar statement, you would supply your own database, table, and column names, perhaps like this:

```
mysql> SELECT author_name FROM biblio_db.author_list;
```

SQL keywords are not case sensitive and may be written in any lettercase. This manual uses uppercase.

In syntax descriptions, square brackets (“`[`” and “`]`”) indicate optional words or clauses. For example, in the following statement, `IF EXISTS` is optional:

```
DROP TABLE [IF EXISTS] tbl_name
```

When a syntax element consists of a number of alternatives, the alternatives are separated by vertical bars ("`|`"). When one member from a set of choices *may* be chosen, the alternatives are listed within square brackets ("`[`" and "`]`"):

```
TRIM([[BOTH | LEADING | TRAILING] [remstr] FROM] str)
```

When one member from a set of choices *must* be chosen, the alternatives are listed within braces ("`{`" and "`}`"):

```
{DESCRIBE | DESC} tbl_name [col_name | wild]
```

An ellipsis (`...`) indicates the omission of a section of a statement, typically to provide a shorter version of more complex syntax. For example, `SELECT ... INTO OUTFILE` is shorthand for the form of `SELECT` statement that has an `INTO OUTFILE` clause following other parts of the statement.

An ellipsis can also indicate that the preceding syntax element of a statement may be repeated. In the following example, multiple *`reset_option`* values may be given, with each of those after the first preceded by commas:

```
RESET reset_option [,reset_option] ...
```

Commands for setting shell variables are shown using Bourne shell syntax. For example, the sequence to set the `CC` environment variable and run the `configure` command looks like this in Bourne shell syntax:

```
shell> CC=gcc ./configure
```

If you are using `csh` or `tcsh`, you must issue commands somewhat differently:

```
shell> setenv CC gcc
shell> ./configure
```

1.3. Overview of the MySQL Database Management System

1.3.1. What is MySQL?

MySQL, the most popular Open Source SQL database management system, is developed, distributed, and supported by Oracle Corporation.

The MySQL Web site (http://www.mysql.com/) provides the latest information about MySQL software.

- MySQL is a database management system.

  A database is a structured collection of data. It may be anything from a simple shopping list to a picture gallery or the vast amounts of information in a corporate network. To add, access, and process data stored in a computer database, you need a database management system such as MySQL Server. Since computers are very good at handling large amounts of data, database management systems play a central role in computing, as standalone utilities, or as parts of other applications.

- MySQL is a relational database management system.

  A relational database stores data in separate tables rather than putting all the data in one big storeroom. This adds speed and flexibility. The SQL part of "MySQL" stands for "Structured Query Language." SQL is the most common standardized language used to access databases and is defined by the ANSI/ISO SQL Standard. The SQL standard has been evolving since 1986 and several versions exist. In this manual, "SQL-92" refers to the standard released in 1992, "SQL:1999" refers to the standard released in 1999, and "SQL:2003" refers to the current version of the standard. We use the phrase "the SQL standard" to mean the current version of the SQL Standard at any time.

- MySQL software is Open Source.

  Open Source means that it is possible for anyone to use and modify the software. Anybody can download the MySQL software from the Internet and use it without paying anything. If you wish, you may study the source code and change it to suit your needs. The MySQL software uses the GPL (GNU General Public License), http://www.fsf.org/licenses/, to define what you may and may not do with the software in different situations. If you feel uncomfortable with the GPL or need to embed MySQL code into a commercial application, you can buy a commercially licensed version from us. See the MySQL Licensing Overview for more information (http://www.mysql.com/company/legal/licensing/).

- The MySQL Database Server is very fast, reliable, and easy to use.

If that is what you are looking for, you should give it a try. MySQL Server also has a practical set of features developed in close cooperation with our users. You can find a performance comparison of MySQL Server with other database managers on our benchmark page. See Section 7.12.2, “The MySQL Benchmark Suite”.

MySQL Server was originally developed to handle large databases much faster than existing solutions and has been successfully used in highly demanding production environments for several years. Although under constant development, MySQL Server today offers a rich and useful set of functions. Its connectivity, speed, and security make MySQL Server highly suited for accessing databases on the Internet.

- MySQL Server works in client/server or embedded systems.

  The MySQL Database Software is a client/server system that consists of a multi-threaded SQL server that supports different backends, several different client programs and libraries, administrative tools, and a wide range of application programming interfaces (APIs).

  We also provide MySQL Server as an embedded multi-threaded library that you can link into your application to get a smaller, faster, easier-to-manage standalone product.

- A large amount of contributed MySQL software is available.

  It is very likely that your favorite application or language supports the MySQL Database Server.

The official way to pronounce “MySQL” is “My Ess Que Ell” (not “my sequel”), but we do not mind if you pronounce it as “my sequel” or in some other localized way.

1.3.2. History of MySQL

We started out with the intention of using the `mSQL` database system to connect to our tables using our own fast low-level (ISAM) routines. However, after some testing, we came to the conclusion that `mSQL` was not fast enough or flexible enough for our needs. This resulted in a new SQL interface to our database but with almost the same API interface as `mSQL`. This API was designed to enable third-party code that was written for use with `mSQL` to be ported easily for use with MySQL.

MySQL is named after co-founder Monty Widenius's daughter, My.

The name of the MySQL Dolphin (our logo) is “Sakila,” which was chosen from a huge list of names suggested by users in our “Name the Dolphin” contest. The winning name was submitted by Ambrose Twebaze, an Open Source software developer from Swaziland, Africa. According to Ambrose, the feminine name Sakila has its roots in SiSwati, the local language of Swaziland. Sakila is also the name of a town in Arusha, Tanzania, near Ambrose's country of origin, Uganda.

1.3.3. The Main Features of MySQL

This section describes some of the important characteristics of the MySQL Database Software. See also Section 1.4, “MySQL Development History”. In most respects, the roadmap applies to all versions of MySQL. For information about features as they are introduced into MySQL on a series-specific basis, see the “In a Nutshell” section of the appropriate Manual:

- MySQL 5.0: MySQL 5.0 in a Nutshell
- MySQL 5.1: MySQL 5.1 in a Nutshell
- MySQL 5.5: MySQL 5.5 in a Nutshell

Internals and Portability:

- Written in C and C++.
- Tested with a broad range of different compilers.
- Works on many different platforms. See Section 2.1.1, “Operating Systems Supported by MySQL Community Server”.
- For portability, uses `CMake` in MySQL 5.5 and up. Previous series use GNU Automake, Autoconf, and Libtool.
- Tested with Purify (a commercial memory leakage detector) as well as with Valgrind, a GPL tool (http://developer.kde.org/~sewardj/).
- Uses multi-layered server design with independent modules.

- Designed to be fully multi-threaded using kernel threads, to easily use multiple CPUs if they are available.
- Provides transactional and nontransactional storage engines.
- Uses very fast B-tree disk tables (`MyISAM`) with index compression.
- Designed to make it relatively easy to add other storage engines. This is useful if you want to provide an SQL interface for an in-house database.
- Uses a very fast thread-based memory allocation system.
- Executes very fast joins using an optimized nested-loop join.
- Implements in-memory hash tables, which are used as temporary tables.
- Implements SQL functions using a highly optimized class library that should be as fast as possible. Usually there is no memory allocation at all after query initialization.
- Provides the server as a separate program for use in a client/server networked environment, and as a library that can be embedded (linked) into standalone applications. Such applications can be used in isolation or in environments where no network is available.

Data Types:

- Many data types: signed/unsigned integers 1, 2, 3, 4, and 8 bytes long, `FLOAT`, `DOUBLE`, `CHAR`, `VARCHAR`, `BINARY`, `VARBINARY`, `TEXT`, `BLOB`, `DATE`, `TIME`, `DATETIME`, `TIMESTAMP`, `YEAR`, `SET`, `ENUM`, and OpenGIS spatial types. See Chapter 10, *Data Types*.
- Fixed-length and variable-length string types.

Statements and Functions:

- Full operator and function support in the `SELECT` list and `WHERE` clause of queries. For example:

```
mysql> SELECT CONCAT(first_name, ' ', last_name)
    -> FROM citizen
    -> WHERE income/dependents > 10000 AND age > 30;
```

- Full support for SQL `GROUP BY` and `ORDER BY` clauses. Support for group functions (`COUNT()`, `AVG()`, `STD()`, `SUM()`, `MAX()`, `MIN()`, and `GROUP_CONCAT()`).
- Support for `LEFT OUTER JOIN` and `RIGHT OUTER JOIN` with both standard SQL and ODBC syntax.
- Support for aliases on tables and columns as required by standard SQL.
- Support for `DELETE`, `INSERT`, `REPLACE`, and `UPDATE` to return the number of rows that were changed (affected), or to return the number of rows matched instead by setting a flag when connecting to the server.
- Support for MySQL-specific `SHOW` statements that retrieve information about databases, storage engines, tables, and indexes. MySQL 5.0 adds support for the `INFORMATION_SCHEMA` database, implemented according to standard SQL.
- An `EXPLAIN` statement to show how the optimizer resolves a query.
- Independence of function names from table or column names. For example, `ABS` is a valid column name. The only restriction is that for a function call, no spaces are permitted between the function name and the “`(`” that follows it. See Section 8.3, “Reserved Words”.
- You can refer to tables from different databases in the same statement.

Security:

- A privilege and password system that is very flexible and secure, and that enables host-based verification.
- Password security by encryption of all password traffic when you connect to a server.

Scalability and Limits:

- Support for large databases. We use MySQL Server with databases that contain 50 million records. We also know of users who use MySQL Server with 200,000 tables and about 5,000,000,000 rows.
- Support for up to 64 indexes per table (32 before MySQL 4.1.2). Each index may consist of 1 to 16 columns or parts of columns. The maximum index width is 1000 bytes (767 for `InnoDB`); before MySQL 4.1.2, the limit is 500 bytes. An index may use a prefix of a column for `CHAR`, `VARCHAR`, `BLOB`, or `TEXT` column types.

Connectivity:

- Clients can connect to MySQL Server using several protocols:
  - Clients can connect using TCP/IP sockets on any platform.
  - On Windows systems in the NT family (NT, 2000, XP, 2003, or Vista), clients can connect using named pipes if the server is started with the `--enable-named-pipe` option. In MySQL 4.1 and higher, Windows servers also support shared-memory connections if started with the `--shared-memory` option. Clients can connect through shared memory by using the `--protocol=memory` option.
  - On Unix systems, clients can connect using Unix domain socket files.
- MySQL client programs can be written in many languages. A client library written in C is available for clients written in C or C++, or for any language that provides C bindings.
- APIs for C, C++, Eiffel, Java, Perl, PHP, Python, Ruby, and Tcl are available, enabling MySQL clients to be written in many languages. See Chapter 20, *Connectors and APIs*.
- The Connector/ODBC (MyODBC) interface provides MySQL support for client programs that use ODBC (Open Database Connectivity) connections. For example, you can use MS Access to connect to your MySQL server. Clients can be run on Windows or Unix. MyODBC source is available. All ODBC 2.5 functions are supported, as are many others. See Section 20.1, “MySQL Connector/ODBC”.
- The Connector/J interface provides MySQL support for Java client programs that use JDBC connections. Clients can be run on Windows or Unix. Connector/J source is available. See Section 20.3, “MySQL Connector/J”.
- MySQL Connector/Net enables developers to easily create .NET applications that require secure, high-performance data connectivity with MySQL. It implements the required ADO.NET interfaces and integrates into ADO.NET aware tools. Developers can build applications using their choice of .NET languages. MySQL Connector/Net is a fully managed ADO.NET driver written in 100% pure C#. See Section 20.2, “MySQL Connector/Net”.

Localization:

- The server can provide error messages to clients in many languages. See Section 9.2, “Setting the Error Message Language”.
- Full support for several different character sets, including `latin1` (cp1252), `german`, `big5`, `ujis`, and more. For example, the Scandinavian characters “`å`”, “`ä`” and “`ö`” are permitted in table and column names. Unicode support is available as of MySQL 4.1.
- All data is saved in the chosen character set.
- Sorting and comparisons are done according to the chosen character set and collation (using `latin1` and Swedish collation by default). It is possible to change this when the MySQL server is started. To see an example of very advanced sorting, look at the Czech sorting code. MySQL Server supports many different character sets that can be specified at compile time and runtime.
- As of MySQL 4.1, the server time zone can be changed dynamically, and individual clients can specify their own time zone. Section 9.6, “MySQL Server Time Zone Support”.

Clients and Tools:

- MySQL includes several client and utility programs. These include both command-line programs such as `mysqldump` and `mysqladmin`, and graphical programs such as MySQL Administrator and MySQL Query Browser.
- MySQL Server has built-in support for SQL statements to check, optimize, and repair tables. These statements are available from the command line through the `mysqlcheck` client. MySQL also includes `myisamchk`, a very fast command-line utility

for performing these operations on `MyISAM` tables. See Chapter 4, *MySQL Programs*.

- MySQL programs can be invoked with the `--help` or `-?` option to obtain online assistance.

1.4. MySQL Development History

This section describes the general MySQL development history, provides an overview about features that have been implemented in previous series and that are new in MySQL 5.5, the release series covered in this manual. The maturity level this release series is general availability. Information about maturity levels can be found in Section 2.1.2.1, "Choosing Which Version of MySQL to Install".

Before upgrading from one release series to the next, please see the notes in Section 2.11.1, "Upgrading MySQL".

The most requested features and the versions in which they were implemented are summarized in the following table.

Feature	**MySQL Series**
Unions	4.0
Subqueries	4.1
R-trees	4.1 (for the `MyISAM` storage engine)
Stored procedures and functions	5.0
Views	5.0
Cursors	5.0
XA transactions	5.0
Triggers	5.0 and 5.1
Event scheduler	5.1
Partitioning	5.1
Pluggable storage engine API	5.1
Plugin API	5.1
InnoDB Plugin	5.1
Row-based replication	5.1
Server log tables	5.1
Scalability and performance improvements	5.4
DTrace support	5.4
InnoDB as default storage engine	5.5
Semisynchronous replication	5.5
SIGNAL/RESIGNAL support in stored routines	5.5
Performance Schema	5.5
Supplementary Unicode characters	5.5

1.5. What Is New in MySQL 5.5

This section summarizes what has been added to and removed from MySQL 5.5.

Added Features

The following features have been added to MySQL 5.5:

- Scalability on multi-core CPUs is improved. The trend in hardware development now is toward more cores rather than continued increases in CPU clock speeds, which renders "wait until CPUs get faster" a nonviable means of improving database performance. Instead, it is necessary to make better use of multiple cores to maximally exploit the processing cycles they make available. MySQL 5.5 takes advantage of features of SMP systems and tries to eliminate bottlenecks in MySQL architecture that hinder full use of multiple cores. The focus has been on `InnoDB`, especially locking and memory management. See Section 1.5.1, "Scalability Improvements".

- `InnoDB` I/O subsystem changes enable more effective use of available I/O capacity. See Section 1.5.2, “`InnoDB` I/O Subsystem Changes”.
- There is better access to execution and performance information. Diagnostic improvements include Performance Schema (a feature for monitoring MySQL Server execution at a low level), DTrace probes, expanded `SHOW ENGINE INNODB STATUS` output, Debug Sync, and a new status variable. See Section 1.5.3, “Diagnostic and Monitoring Capabilities”.
- Several modifications improve operation of MySQL Server on Solaris. See Section 1.5.4, “Enhanced Solaris Support”.
- The default storage engine for new tables is `InnoDB` rather than `MyISAM`. See Section 13.3.1, “InnoDB as the Default MySQL Storage Engine”.
- Support for an interface for semisynchronous replication: A commit performed on the master side blocks before returning to the session that performed the transaction until at least one slave acknowledges that it has received and logged the events for the transaction. Semisynchronous replication is implemented through an optional plugin component. See Section 15.3.8, “Semisynchronous Replication”
- Support for supplementary Unicode characters; that is, characters outside the Basic Multilingual Plane (BMP). These new Unicode character sets include supplementary characters: `utf16`, `utf32`, and `utf8mb4`. See Section 9.1.10, “Unicode Support”.
- Enhancements to table partitioning:
  - Two new types of user-defined partitioning are supported: `RANGE COLUMNS` partitioning is an extension to `RANGE` partitioning; `LIST COLUMNS` partitioning is an extension to `LIST` partitioning. Each of these extensions provides two enhancements to MySQL partitioning capabilities:
    - It is possible to define partitioning ranges or lists based on `DATE`, `DATETIME`, or string values (such as `CHAR` or `VARCHAR`).

      You can also define ranges or lists based on multiple column values when partitioning tables by `RANGE COLUMNS` or `LIST COLUMNS`, respectively. Such a range or list may refer to up to 16 columns.
    - For tables defined using these partitioning types, partition pruning can now optimize queries with `WHERE` conditions that use multiple comparisons between (different) column values and constants, such as `a = 10 AND b > 5` or `a < "2005-11-25" AND b = 10 AND c = 50`.

    See Section 16.2.1, “`RANGE` Partitioning”, and Section 16.2.2, “`LIST` Partitioning”.
  - It is now possible to delete all rows from one or more partitions of a partitioned table using the `ALTER TABLE ... TRUNCATE PARTITION` statement. Executing the statement deletes rows without affecting the structure of the table. The partitions named in the `TRUNCATE PARTITION` clause do not have to be contiguous.
  - Key caches are now supported for indexes on partitioned `MyISAM` tables, using the `CACHE INDEX` and `LOAD INDEX INTO CACHE` statements. In addition, a key cache can be defined for and loaded with indexes from an entire partitioned table, or for one or more partitions. In the latter case, the partitions are not required to be contiguous.
  - The new `TO_SECONDS()` function converts a date or datetime expression to a number of seconds since the year 0. This is a general-purpose function, but is useful for partitioning. You may use it in partitioning expressions, and partition pruning is supported for tables defined using such expressions.
- Support for the SQL standard `SIGNAL` and `RESIGNAL` statements. See Section 12.7.8, “`SIGNAL` and `RESIGNAL`”.
- Enhancements to XML functionality, including a new `LOAD XML INFILE` statement. See Section 12.2.7, “`LOAD XML` Syntax”.
- MySQL authentication supports two new capabilities, pluggable authentication and proxy users. With pluggable authentication, the server can use plugins to authenticate incoming client connections, and clients can load an authentication plugin that interacts properly with the corresponding server plugin. This capability enables clients to connect to the MySQL server with credentials that are appropriate for authentication methods other than the built-in MySQL authentication based on native MySQL passwords stored in the `mysql.user` table. For example, plugins can be created to use external authentication methods such as LDAP, Kerberos, PAM, or Windows login IDs. Proxy user capability enables a client who connects and authenticates as one user to be treated, for purposes of access control while connected, as having the privileges of a different user. In effect, one user impersonates another. Proxy capability depends on pluggable authentication because it is based on having an authentication plugin return to the server the user name that the connecting user impersonates. See Section 5.5.6, “Pluggable Authentication”, and Section 5.5.7, “Proxy Users”.
- MySQL releases are now built using `CMake` rather than the GNU autotools. Accordingly, the instructions for installing MySQL from source have been updated to discuss how to build MySQL using `CMake`. See Section 2.9, “Installing MySQL from Source”.

  The build process is now similar enough on all platforms, including Windows, that there are no longer sections dedicated to notes for specific platforms.

Removed Features

The following constructs are obsolete and have been removed in MySQL 5.5. Where alternatives are shown, applications should be updated to use them.

- The `language` system variable (use `lc_messages_dir` and `lc_messages`).
- The `log_bin_trust_routine_creators` system variable (use `log_bin_trust_function_creators`).
- The `myisam_max_extra_sort_file_size` system variable.
- The `record_buffer` system variable (use `read_buffer_size`).
- The `sql_log_update` system variable.
- The `Innodb_buffer_pool_read_ahead_rnd` and `Innodb_buffer_pool_read_ahead_seq` status variables (use `Innodb_buffer_pool_read_ahead` and `Innodb_buffer_pool_read_ahead_evicted`).
- The `table_type` system variable (use `storage_engine`).
- The `FRAC_SECOND` modifier for the `TIMESTAMPADD()` function (use `MICROSECOND`).
- The `TYPE` table option to specify the storage engine for `CREATE TABLE` or `ALTER TABLE` (use `ENGINE`).
- The `SHOW TABLE TYPES` SQL statement (use `SHOW ENGINES`).
- The `SHOW INNODB STATUS` and `SHOW MUTEX STATUS` SQL statements (use `SHOW ENGINE INNODB STATUS` `SHOW ENGINE INNODB MUTEX`).
- The `SHOW PLUGIN` SQL statement (use `SHOW PLUGINS`).
- The `LOAD TABLE ... FROM MASTER` and `LOAD DATA FROM MASTER` SQL statements (use `mysqldump` or `mysqlhotcopy` to dump tables and `mysql` to reload dump files).
- The `BACKUP TABLE` and `RESTORE TABLE` SQL statements (use `mysqldump` or `mysqlhotcopy` to dump tables and `mysql` to reload dump files).
- `TIMESTAMP(N)` data type: The ability to specify a display width of *`N`* (use without *`N`*).
- The `--default-character-set` and `--default-collation` server options (use `--character-set-server` and `--collation-server`).
- The `--default-table-type` server option (use `--default-storage-engine`).
- The `--delay-key-write-for-all-tables` server option (use `--delay-key-write=ALL`).
- The `--enable-locking` and `--skip-locking` server options (use `--external-locking` and `--skip-external-locking`).
- The `--log-bin-trust-routine-creators` server option (use `--log-bin-trust-function-creators`).
- The `--log-long-format` server option.
- The `--log-update` server option.
- The `--master-xxx` server options to set replication parameters (use the `CHANGE MASTER TO` statement instead): `--master-host`, `--master-user`, `--master-password`, `--master-port`, `--master-connect-retry`, `--master-ssl`, `--master-ssl-ca`, `--master-ssl-capath`, `--master-ssl-cert`, `--master-ssl-cipher`, `--master-ssl-key`.
- The `--safe-show-database` server option.
- The `--skip-symlink` and `--use-symbolic-links` server options (use `--skip-symbolic-links` and `--symbolic-links`).
- The `--sql-bin-update-same` server option.

- The `--warnings` server option (use `--log-warnings`).
- The `--no-named-commands` option for `mysql` (use `--skip-named-commands`).
- The `--no-pager` option for `mysql` (use `--skip-pager`).
- The `--no-tee` option for `mysql` (use `--skip-tee`).
- The `--position` option for `mysqlbinlog` (use `--start-position`).
- The `--all` option for `mysqldump` (use `--create-options`).
- The `--first-slave` option for `mysqldump` (use `--lock-all-tables`).
- The `--config-file` option for `mysqld_multi` (use `--defaults-extra-file`).
- The `--set-variable=var_name=value` and `-O var_name=value` general-purpose options for setting program variables (use `--var_name=value`).
- The `--with-pstack` option for `configure` and the `--enable-pstack` option for `mysqld`.

1.5.1. Scalability Improvements

MySQL 5.5 modifications improve performance on SMP systems to increase scalability on multi-core systems. The changes affect `InnoDB` locking and memory management.

MySQL 5.5 incorporates changes in `InnoDB` that improve the performance of RW-locks by using atomic CPU instructions (on platforms where they are available), rather than less scalable mutexes. It is also possible for `InnoDB` memory allocation to be disabled and replaced by the normal `malloc` library, or by a different library that implements `malloc` such as `tcmalloc` on Linux or `mtalloc` on Solaris.

The reimplementation of RW-locks requires atomic instructions. A status variable, `Innodb_have_atomic_builtins`, shows whether the server was built with atomic instructions.

1.5.2. `InnoDB` I/O Subsystem Changes

MySQL 5.5 changes to the `InnoDB` I/O subsystem enable more effective use of available I/O capacity. The changes also provide more control over configuration of the I/O subsystem.

Background I/O Threads

`InnoDB` uses background threads to perform I/O for several kinds of activities, two of which are prefetching disk blocks and flushing dirty pages. Previously, `InnoDB` used only one thread each to perform these activities, but that can underutilize server capacity. MySQL 5.5 enables use of multiple background read and write threads, making it possible to read and write pages faster.

The patch makes the number of background I/O threads configurable using system variables: `innodb_read_io_threads` controls the number of threads to use for read prefetch requests. `innodb_write_io_threads` controls the number of threads to use for writing dirty pages from the buffer cache to disk. The default for both variables is 4.

The ability to increase the number of I/O threads can benefit systems that use multiple disks for `InnoDB`. However, the type of I/O being done should be considered. On systems that use buffered writes rather than direct writes, increasing the write thread count higher than 1 might yield little benefit because writes will be quick already.

Adjustable I/O Rate

Previously, the number of input/output operations per second (IOPS) that `InnoDB` will perform was a compile-time parameter. The rate was chosen to prevent background I/O from exhausting server capacity and the compiled-in value of 100 reflected an assumption that the server can perform 100 IOPS. However, many modern systems can exceed this, so the value is low and unnecessarily restricts I/O utilization.

MySQL 5.5 exposes this I/O rate parameter as a system variable, `innodb_io_capacity`. This variable can be set at server startup, which enables higher values to be selected for systems capable of higher I/O rates. Having a higher I/O rate can help the server handle a higher rate of row changes because it may be able to increase dirty-page flushing, deleted-row removal, and application of changes to the insert buffer. The default value of `innodb_io_capacity` is 200. In general, you can increase the value as a function of the number of drives used for `InnoDB` I/O.

The ability to raise the I/O limit should be especially beneficial on platforms that support many IOPS. For example, systems that use multiple disks or solid-state disks for `InnoDB` are likely to benefit from the ability to control this parameter.

1.5.3. Diagnostic and Monitoring Capabilities

MySQL 5.5 provides improved access to execution and performance information. Diagnostic improvements include Performance Schema, Dtrace probes, expanded `SHOW ENGINE INNODB STATUS` output, Debug Sync, and a new status variable.

Performance Schema

Performance Schema is a feature for monitoring MySQL Server execution at a low level. See Chapter 19, *MySQL Performance Schema*.

DTrace Support

The DTrace probes work on Solaris, Mac OS X, and FreeBSD. For information on using DTrace in MySQL, see Section 5.7, “Tracing `mysqld` Using DTrace”.

Enhanced `SHOW ENGINE INNODB STATUS` Output

The output from `SHOW ENGINE INNODB STATUS` includes more information due to changes made for `InnoDB Plugin`. A description of revisions to statement output follows.

A new `BACKGROUND THREAD` section has `srv_master_thread` lines that show work done by the main background thread.

```
----------
BACKGROUND THREAD
----------
srv_master_thread loops: 53 1_second, 44 sleeps, 5 10_second, 7 background,
  7 flush
srv_master_thread log flush and writes: 48
```

The `SEMAPHORES` section includes a line to show the number of spinlock rounds per OS wait for a mutex.

```
----------
SEMAPHORES
----------
...
Spin rounds per wait: 0.00 mutex, 20.00 RW-shared, 0.00 RW-excl
```

Debug Sync

The Debug Sync facility provides synchronization points for debugging, see MySQL Internals: Test Synchronization.

New Status Variable

The `Innodb_have_atomic_builtins` status variable provides information about availability of atomic instructions; see Section 1.5.1, “Scalability Improvements”.

1.5.4. Enhanced Solaris Support

MySQL 5.5 incorporates several modifications for improved operation of MySQL Server on Solaris:

- DTrace support for execution monitoring. See Section 1.5.3, “Diagnostic and Monitoring Capabilities”.
- Atomic instructions, which are needed for the improvements to RW-locking described in Section 1.5.1, “Scalability Improvements”. Atomic instructions now are supported for Sun Studio on SPARC and x86 platforms. This extends their previous availability (supported for `gcc` 4.1 and up on all platforms).
- The SMP improvements described in Section 1.5.1, “Scalability Improvements”, were originally intended for x86 platforms. In MySQL 5.5, these also work on SPARC platforms. Also, Solaris optimizations have been implemented.
- Large page support is enhanced for recent SPARC platforms. Standard use of large pages in MySQL attempts to use the largest size supported, up to 4MB. Under Solaris, a “super large pages” feature enables uses of pages up to 256MB. This feature can be enabled or disabled by using the `--super-large-pages` or `--skip-super-large-pages` option.
- Inline handling for `InnoDB` and processor instruction prefetching support, previously not enabled for builds created using Sun Studio, now are supported for that build environment.

1.6. MySQL Information Sources

This section lists sources of additional information that you may find helpful, such as the MySQL mailing lists and user forums, and Internet Relay Chat.

1.6.1. MySQL Mailing Lists

This section introduces the MySQL mailing lists and provides guidelines as to how the lists should be used. When you subscribe to a mailing list, you receive all postings to the list as email messages. You can also send your own questions and answers to the list.

To subscribe to or unsubscribe from any of the mailing lists described in this section, visit http://lists.mysql.com/. For most of them, you can select the regular version of the list where you get individual messages, or a digest version where you get one large message per day.

Please *do not* send messages about subscribing or unsubscribing to any of the mailing lists, because such messages are distributed automatically to thousands of other users.

Your local site may have many subscribers to a MySQL mailing list. If so, the site may have a local mailing list, so that messages sent from `lists.mysql.com` to your site are propagated to the local list. In such cases, please contact your system administrator to be added to or dropped from the local MySQL list.

If you wish to have traffic for a mailing list go to a separate mailbox in your mail program, set up a filter based on the message headers. You can use either the `List-ID:` or `Delivered-To:` headers to identify list messages.

The MySQL mailing lists are as follows:

- `announce`

  The list for announcements of new versions of MySQL and related programs. This is a low-volume list to which all MySQL users should subscribe.

- `mysql`

  The main list for general MySQL discussion. Please note that some topics are better discussed on the more-specialized lists. If you post to the wrong list, you may not get an answer.

- `bugs`

  The list for people who want to stay informed about issues reported since the last release of MySQL or who want to be actively involved in the process of bug hunting and fixing. See Section 1.7, “How to Report Bugs or Problems”.

- `internals`

  The list for people who work on the MySQL code. This is also the forum for discussions on MySQL development and for posting patches.

- `mysqldoc`

  The list for people who work on the MySQL documentation.

- `benchmarks`

  The list for anyone interested in performance issues. Discussions concentrate on database performance (not limited to MySQL), but also include broader categories such as performance of the kernel, file system, disk system, and so on.

- `packagers`

  The list for discussions on packaging and distributing MySQL. This is the forum used by distribution maintainers to exchange ideas on packaging MySQL and on ensuring that MySQL looks and feels as similar as possible on all supported platforms and operating systems.

- `java`

  The list for discussions about the MySQL server and Java. It is mostly used to discuss JDBC drivers such as MySQL Connector/J.

- `win32`

  The list for all topics concerning the MySQL software on Microsoft operating systems, such as Windows 9x, Me, NT, 2000, XP, and 2003.

- `myodbc`

  The list for all topics concerning connecting to the MySQL server with ODBC.

- `gui-tools`

The list for all topics concerning MySQL graphical user interface tools such as `MySQL Administrator` and `MySQL Query Browser`.

- `cluster`

  The list for discussion of MySQL Cluster.
- `dotnet`

  The list for discussion of the MySQL server and the .NET platform. It is mostly related to MySQL Connector/Net.
- `plusplus`

  The list for all topics concerning programming with the C++ API for MySQL.
- `perl`

  The list for all topics concerning Perl support for MySQL with `DBD::mysql`.

If you're unable to get an answer to your questions from a MySQL mailing list or forum, one option is to purchase support from Oracle. This puts you in direct contact with MySQL developers.

The following MySQL mailing lists are in languages other than English. These lists are not operated by Oracle.

- `<mysql-france-subscribe@yahoogroups.com>`

  A French mailing list.
- `<list@tinc.net>`

  A Korean mailing list. To subscribe, email `subscribe mysql your@email.address` to this list.
- `<mysql-de-request@lists.4t2.com>`

  A German mailing list. To subscribe, email `subscribe mysql-de your@email.address` to this list. You can find information about this mailing list at http://www.4t2.com/mysql/.
- `<mysql-br-request@listas.linkway.com.br>`

  A Portuguese mailing list. To subscribe, email `subscribe mysql-br your@email.address` to this list.
- `<mysql-alta@elistas.net>`

  A Spanish mailing list. To subscribe, email `subscribe mysql your@email.address` to this list.

1.6.1.1. Guidelines for Using the Mailing Lists

Please do not post mail messages from your browser with HTML mode turned on. Many users do not read mail with a browser.

When you answer a question sent to a mailing list, if you consider your answer to have broad interest, you may want to post it to the list instead of replying directly to the individual who asked. Try to make your answer general enough that people other than the original poster may benefit from it. When you post to the list, please make sure that your answer is not a duplication of a previous answer.

Try to summarize the essential part of the question in your reply. Do not feel obliged to quote the entire original message.

When answers are sent to you individually and not to the mailing list, it is considered good etiquette to summarize the answers and send the summary to the mailing list so that others may have the benefit of responses you received that helped you solve your problem.

1.6.2. MySQL Community Support at the MySQL Forums

The forums at http://forums.mysql.com are an important community resource. Many forums are available, grouped into these general categories:

- Migration

- MySQL Usage
- MySQL Connectors
- Programming Languages
- Tools
- 3rd-Party Applications
- Storage Engines
- MySQL Technology
- SQL Standards
- Business

1.6.3. MySQL Community Support on Internet Relay Chat (IRC)

In addition to the various MySQL mailing lists and forums, you can find experienced community people on Internet Relay Chat (IRC). These are the best networks/channels currently known to us:

freenode (see http://www.freenode.net/ for servers)

- `#mysql` is primarily for MySQL questions, but other database and general SQL questions are welcome. Questions about PHP, Perl, or C in combination with MySQL are also common.

If you are looking for IRC client software to connect to an IRC network, take a look at `xChat` (http://www.xchat.org/). X-Chat (GPL licensed) is available for Unix as well as for Windows platforms (a free Windows build of X-Chat is available at http://www.silverex.org/download/).

1.6.4. MySQL Enterprise

Oracle offers technical support in the form of MySQL Enterprise. For organizations that rely on the MySQL DBMS for business-critical production applications, MySQL Enterprise is a commercial subscription offering which includes:

- MySQL Enterprise Server
- MySQL Enterprise Monitor
- Monthly Rapid Updates and Quarterly Service Packs
- MySQL Knowledge Base
- 24x7 Technical and Consultative Support

MySQL Enterprise is available in multiple tiers, giving you the flexibility to choose the level of service that best matches your needs. For more information, see MySQL Enterprise.

1.7. How to Report Bugs or Problems

Before posting a bug report about a problem, please try to verify that it is a bug and that it has not been reported already:

- Start by searching the MySQL online manual at http://dev.mysql.com/doc/. We try to keep the manual up to date by updating it frequently with solutions to newly found problems. The change history (http://dev.mysql.com/doc/mysql/en/news.html) can be particularly useful since it is quite possible that a newer version contains a solution to your problem.
- If you get a parse error for an SQL statement, please check your syntax closely. If you cannot find something wrong with it, it is extremely likely that your current version of MySQL Server doesn't support the syntax you are using. If you are using the current version and the manual doesn't cover the syntax that you are using, MySQL Server doesn't support your statement. In this case, your options are to implement the syntax yourself or email `<licensing@mysql.com>` and ask for an offer to implement it.

  If the manual covers the syntax you are using, but you have an older version of MySQL Server, you should check the MySQL change history to see when the syntax was implemented. In this case, you have the option of upgrading to a newer version of MySQL Server.

- For solutions to some common problems, see Section C.5, “Problems and Common Errors”.
- Search the bugs database at http://bugs.mysql.com/ to see whether the bug has been reported and fixed.
- Search the MySQL mailing list archives at http://lists.mysql.com/. See Section 1.6.1, “MySQL Mailing Lists”.
- You can also use http://www.mysql.com/search/ to search all the Web pages (including the manual) that are located at the MySQL Web site.

If you cannot find an answer in the manual, the bugs database, or the mailing list archives, check with your local MySQL expert. If you still cannot find an answer to your question, please use the following guidelines for reporting the bug.

The normal way to report bugs is to visit http://bugs.mysql.com/, which is the address for our bugs database. This database is public and can be browsed and searched by anyone. If you log in to the system, you can enter new reports.

Bugs posted in the bugs database at http://bugs.mysql.com/ that are corrected for a given release are noted in the change history.

If you have found a sensitive security bug in MySQL, you can send email to `<security@mysql.com>`.

To discuss problems with other users, you can use one of the MySQL mailing lists. Section 1.6.1, “MySQL Mailing Lists”.

Writing a good bug report takes patience, but doing it right the first time saves time both for us and for yourself. A good bug report, containing a full test case for the bug, makes it very likely that we will fix the bug in the next release. This section helps you write your report correctly so that you do not waste your time doing things that may not help us much or at all. Please read this section carefully and make sure that all the information described here is included in your report.

Preferably, you should test the problem using the latest production or development version of MySQL Server before posting. Anyone should be able to repeat the bug by just using `mysql test < script_file` on your test case or by running the shell or Perl script that you include in the bug report. Any bug that we are able to repeat has a high chance of being fixed in the next MySQL release.

It is most helpful when a good description of the problem is included in the bug report. That is, give a good example of everything you did that led to the problem and describe, in exact detail, the problem itself. The best reports are those that include a full example showing how to reproduce the bug or problem. See MySQL Internals: Porting.

Remember that it is possible for us to respond to a report containing too much information, but not to one containing too little. People often omit facts because they think they know the cause of a problem and assume that some details do not matter. A good principle to follow is that if you are in doubt about stating something, state it. It is faster and less troublesome to write a couple more lines in your report than to wait longer for the answer if we must ask you to provide information that was missing from the initial report.

The most common errors made in bug reports are (a) not including the version number of the MySQL distribution that you use, and (b) not fully describing the platform on which the MySQL server is installed (including the platform type and version number). These are highly relevant pieces of information, and in 99 cases out of 100, the bug report is useless without them. Very often we get questions like, “Why doesn't this work for me?” Then we find that the feature requested wasn't implemented in that MySQL version, or that a bug described in a report has been fixed in newer MySQL versions. Errors often are platform-dependent. In such cases, it is next to impossible for us to fix anything without knowing the operating system and the version number of the platform.

If you compiled MySQL from source, remember also to provide information about your compiler if it is related to the problem. Often people find bugs in compilers and think the problem is MySQL-related. Most compilers are under development all the time and become better version by version. To determine whether your problem depends on your compiler, we need to know what compiler you used. Note that every compiling problem should be regarded as a bug and reported accordingly.

If a program produces an error message, it is very important to include the message in your report. If we try to search for something from the archives, it is better that the error message reported exactly matches the one that the program produces. (Even the lettercase should be observed.) It is best to copy and paste the entire error message into your report. You should never try to reproduce the message from memory.

If you have a problem with Connector/ODBC (MyODBC), please try to generate a trace file and send it with your report. See the MyODBC section of Chapter 20, *Connectors and APIs*.

If your report includes long query output lines from test cases that you run with the `mysql` command-line tool, you can make the output more readable by using the `--vertical` option or the `\G` statement terminator. The `EXPLAIN SELECT` example later in this section demonstrates the use of `\G`.

Please include the following information in your report:

- The version number of the MySQL distribution you are using (for example, MySQL 5.0.19). You can find out which version you are running by executing `mysqladmin version`. The `mysqladmin` program can be found in the `bin` directory under your MySQL installation directory.
- The manufacturer and model of the machine on which you experience the problem.
- The operating system name and version. If you work with Windows, you can usually get the name and version number by double-clicking your My Computer icon and pulling down the “Help/About Windows” menu. For most Unix-like operating systems, you can get this information by executing the command `uname -a`.
- Sometimes the amount of memory (real and virtual) is relevant. If in doubt, include these values.
- If you are using a source distribution of the MySQL software, include the name and version number of the compiler that you used. If you have a binary distribution, include the distribution name.
- If the problem occurs during compilation, include the exact error messages and also a few lines of context around the offending code in the file where the error occurs.
- If `mysqld` died, you should also report the statement that crashed `mysqld`. You can usually get this information by running `mysqld` with query logging enabled, and then looking in the log after `mysqld` crashes. See MySQL Internals: Porting.
- If a database table is related to the problem, include the output from the `SHOW CREATE TABLE db_name.tbl_name` statement in the bug report. This is a very easy way to get the definition of any table in a database. The information helps us create a situation matching the one that you have experienced.
- The SQL mode in effect when the problem occurred can be significant, so please report the value of the `sql_mode` system variable. For stored procedure, stored function, and trigger objects, the relevant `sql_mode` value is the one in effect when the object was created. For a stored procedure or function, the `SHOW CREATE PROCEDURE` or `SHOW CREATE FUNCTION` statement shows the relevant SQL mode, or you can query `INFORMATION_SCHEMA` for the information:

  ```
  SELECT ROUTINE_SCHEMA, ROUTINE_NAME, SQL_MODE
  FROM INFORMATION_SCHEMA.ROUTINES;
  ```

  For triggers, you can use this statement:

  ```
  SELECT EVENT_OBJECT_SCHEMA, EVENT_OBJECT_TABLE, TRIGGER_NAME, SQL_MODE
  FROM INFORMATION_SCHEMA.TRIGGERS;
  ```

- For performance-related bugs or problems with `SELECT` statements, you should always include the output of `EXPLAIN SELECT ...`, and at least the number of rows that the `SELECT` statement produces. You should also include the output from `SHOW CREATE TABLE tbl_name` for each table that is involved. The more information you provide about your situation, the more likely it is that someone can help you.

  The following is an example of a very good bug report. The statements are run using the `mysql` command-line tool. Note the use of the `\G` statement terminator for statements that would otherwise provide very long output lines that are difficult to read.

  ```
  mysql> SHOW VARIABLES;
  mysql> SHOW COLUMNS FROM ...\G
         <output from SHOW COLUMNS>
  mysql> EXPLAIN SELECT ...\G
         <output from EXPLAIN>
  mysql> FLUSH STATUS;
  mysql> SELECT ...;
         <A short version of the output from SELECT,
         including the time taken to run the query>
  mysql> SHOW STATUS;
         <output from SHOW STATUS>
  ```

- If a bug or problem occurs while running `mysqld`, try to provide an input script that reproduces the anomaly. This script should include any necessary source files. The more closely the script can reproduce your situation, the better. If you can make a reproducible test case, you should upload it to be attached to the bug report.

  If you cannot provide a script, you should at least include the output from `mysqladmin variables extended-status processlist` in your report to provide some information on how your system is performing.

- If you cannot produce a test case with only a few rows, or if the test table is too big to be included in the bug report (more than 10 rows), you should dump your tables using `mysqldump` and create a `README` file that describes your problem. Create a compressed archive of your files using `tar` and `gzip` or `zip`, and use FTP to transfer the archive to ftp://ftp.mysql.com/pub/mysql/upload/. Then enter the problem into our bugs database at http://bugs.mysql.com/.
- If you believe that the MySQL server produces a strange result from a statement, include not only the result, but also your opinion of what the result should be, and an explanation describing the basis for your opinion.

- When you provide an example of the problem, it is better to use the table names, variable names, and so forth that exist in your actual situation than to come up with new names. The problem could be related to the name of a table or variable. These cases are rare, perhaps, but it is better to be safe than sorry. After all, it should be easier for you to provide an example that uses your actual situation, and it is by all means better for us. If you have data that you do not want to be visible to others in the bug report, you can use FTP to transfer it to ftp://ftp.mysql.com/pub/mysql/upload/. If the information is really top secret and you do not want to show it even to us, go ahead and provide an example using other names, but please regard this as the last choice.

- Include all the options given to the relevant programs, if possible. For example, indicate the options that you use when you start the `mysqld` server, as well as the options that you use to run any MySQL client programs. The options to programs such as `mysqld` and `mysql`, and to the `configure` script, are often key to resolving problems and are very relevant. It is never a bad idea to include them. If your problem involves a program written in a language such as Perl or PHP, please include the language processor's version number, as well as the version for any modules that the program uses. For example, if you have a Perl script that uses the `DBI` and `DBD::mysql` modules, include the version numbers for Perl, `DBI`, and `DBD::mysql`.

- If your question is related to the privilege system, please include the output of `mysqlaccess`, the output of `mysqladmin reload`, and all the error messages you get when trying to connect. When you test your privileges, you should first run `mysqlaccess`. After this, execute `mysqladmin reload version` and try to connect with the program that gives you trouble. `mysqlaccess` can be found in the `bin` directory under your MySQL installation directory.

- If you have a patch for a bug, do include it. But do not assume that the patch is all we need, or that we can use it, if you do not provide some necessary information such as test cases showing the bug that your patch fixes. We might find problems with your patch or we might not understand it at all. If so, we cannot use it.

  If we cannot verify the exact purpose of the patch, we will not use it. Test cases help us here. Show that the patch handles all the situations that may occur. If we find a borderline case (even a rare one) where the patch will not work, it may be useless.

- Guesses about what the bug is, why it occurs, or what it depends on are usually wrong. Even the MySQL team cannot guess such things without first using a debugger to determine the real cause of a bug.

- Indicate in your bug report that you have checked the reference manual and mail archive so that others know you have tried to solve the problem yourself.

- If the problem is that your data appears corrupt or you get errors when you access a particular table, you should first check your tables and then try to repair them with `CHECK TABLE` and `REPAIR TABLE` or with `myisamchk`. See Chapter 5, *MySQL Server Administration*.

  If you are running Windows, please verify the value of `lower_case_table_names` using the `SHOW VARIABLES LIKE 'lower_case_table_names'` statement. This variable affects how the server handles lettercase of database and table names. Its effect for a given value should be as described in Section 8.2.2, “Identifier Case Sensitivity”.

- If you often get corrupted tables, you should try to find out when and why this happens. In this case, the error log in the MySQL data directory may contain some information about what happened. (This is the file with the `.err` suffix in the name.) See Section 5.2.2, “The Error Log”. Please include any relevant information from this file in your bug report. Normally `mysqld` should *never* crash a table if nothing killed it in the middle of an update. If you can find the cause of `mysqld` dying, it is much easier for us to provide you with a fix for the problem. See Section C.5.1, “How to Determine What Is Causing a Problem”.

- If possible, download and install the most recent version of MySQL Server and check whether it solves your problem. All versions of the MySQL software thoroughly tested and should work without problems. We believe in making everything as backward-compatible as possible, and you should be able to switch MySQL versions without difficulty. See Section 2.1.2, “Choosing Which MySQL Distribution to Install”.

1.8. MySQL Standards Compliance

This section describes how MySQL relates to the ANSI/ISO SQL standards. MySQL Server has many extensions to the SQL standard, and here you can find out what they are and how to use them. You can also find information about functionality missing from MySQL Server, and how to work around some of the differences.

The SQL standard has been evolving since 1986 and several versions exist. In this manual, “SQL-92” refers to the standard released in 1992, “SQL:1999” refers to the standard released in 1999, “SQL:2003” refers to the standard released in 2003, and “SQL:2008” refers to the most recent version of the standard, released in 2008. We use the phrase “the SQL standard” or “standard SQL” to mean the current version of the SQL Standard at any time.

One of our main goals with the product is to continue to work toward compliance with the SQL standard, but without sacrificing speed or reliability. We are not afraid to add extensions to SQL or support for non-SQL features if this greatly increases the usability of MySQL Server for a large segment of our user base. The `HANDLER` interface is an example of this strategy. See Section 12.2.4, “`HANDLER` Syntax”.

We continue to support transactional and nontransactional databases to satisfy both mission-critical 24/7 usage and heavy Web or logging usage.

MySQL Server was originally designed to work with medium-sized databases (10-100 million rows, or about 100MB per table) on small computer systems. Today MySQL Server handles terabyte-sized databases, but the code can also be compiled in a reduced version suitable for hand-held and embedded devices. The compact design of the MySQL server makes development in both directions possible without any conflicts in the source tree.

Currently, we are not targeting real-time support, although MySQL replication capabilities offer significant functionality.

MySQL supports high-availability database clustering using the `NDBCLUSTER` storage engine. See MySQL Cluster NDB 6.X/7.X.

We are implementing XML functionality beginning in MySQL 5.1, which supports most of the W3C XPath standard. We plan to increase support for XML as part of future MySQL development. See Section 11.11, “XML Functions”.

1.8.1. What Standards MySQL Follows

Our aim is to support the full ANSI/ISO SQL standard, but without making concessions to speed and quality of the code.

ODBC levels 0 to 3.51.

1.8.2. Selecting SQL Modes

The MySQL server can operate in different SQL modes, and can apply these modes differentially for different clients. This capability enables each application to tailor the server's operating mode to its own requirements.

SQL modes control aspects of server operation such as what SQL syntax MySQL should support and what kind of data validation checks it should perform. This makes it easier to use MySQL in different environments and to use MySQL together with other database servers.

You can set the default SQL mode by starting `mysqld` with the `--sql-mode="mode_value"` option. You can also change the mode at runtime by setting the `sql_mode` system variable with a `SET [GLOBAL|SESSION] sql_mode='mode_value'` statement.

For more information on setting the SQL mode, see Section 5.1.6, “Server SQL Modes”.

1.8.3. Running MySQL in ANSI Mode

You can tell `mysqld` to run in ANSI mode with the `--ansi` startup option. Running the server in ANSI mode is the same as starting it with the following options:

```
--transaction-isolation=SERIALIZABLE --sql-mode=ANSI
```

You can achieve the same effect at runtime by executing these two statements:

```
SET GLOBAL TRANSACTION ISOLATION LEVEL SERIALIZABLE;
SET GLOBAL sql_mode = 'ANSI';
```

You can see that setting the `sql_mode` system variable to `'ANSI'` enables all SQL mode options that are relevant for ANSI mode as follows:

```
mysql> SET GLOBAL sql_mode='ANSI';
mysql> SELECT @@global.sql_mode;
        -> 'REAL_AS_FLOAT,PIPES_AS_CONCAT,ANSI_QUOTES,IGNORE_SPACE,ANSI'
```

Running the server in ANSI mode with `--ansi` is not quite the same as setting the SQL mode to `'ANSI'`. The `--ansi` option affects the SQL mode and also sets the transaction isolation level. Setting the SQL mode to `'ANSI'` has no effect on the isolation level.

See Section 5.1.2, “Server Command Options”, and Section 1.8.2, “Selecting SQL Modes”.

1.8.4. MySQL Extensions to Standard SQL

MySQL Server supports some extensions that you probably won't find in other SQL DBMSs. Be warned that if you use them, your code won't be portable to other SQL servers. In some cases, you can write code that includes MySQL extensions, but is still portable, by using comments of the following form:

```
/*! MySQL-specific code */
```

In this case, MySQL Server parses and executes the code within the comment as it would any other SQL statement, but other SQL servers will ignore the extensions. For example, MySQL Server recognizes the `STRAIGHT_JOIN` keyword in the following statement, but other servers will not:

```
SELECT /*! STRAIGHT_JOIN */ col1 FROM table1,table2 WHERE ...
```

If you add a version number after the “`!`” character, the syntax within the comment is executed only if the MySQL version is greater than or equal to the specified version number. The `TEMPORARY` keyword in the following comment is executed only by servers from MySQL 3.23.02 or higher:

```
CREATE /*!32302 TEMPORARY */ TABLE t (a INT);
```

The following descriptions list MySQL extensions, organized by category.

- Organization of data on disk

  MySQL Server maps each database to a directory under the MySQL data directory, and maps tables within a database to file names in the database directory. This has a few implications:

  - Database and table names are case sensitive in MySQL Server on operating systems that have case-sensitive file names (such as most Unix systems). See Section 8.2.2, “Identifier Case Sensitivity”.
  - You can use standard system commands to back up, rename, move, delete, and copy tables that are managed by the `MyISAM` storage engine. For example, it is possible to rename a `MyISAM` table by renaming the `.MYD`, `.MYI`, and `.frm` files to which the table corresponds. (Nevertheless, it is preferable to use `RENAME TABLE` or `ALTER TABLE ... RENAME` and let the server rename the files.)
- General language syntax
  - By default, strings can be enclosed by either “`"`” or “`'`”, not just by “`'`”. (If the `ANSI_QUOTES` SQL mode is enabled, strings can be enclosed only by “`'`” and the server interprets strings enclosed by “`"`” as identifiers.)
  - “`\`” is the escape character in strings.
  - In SQL statements, you can access tables from different databases with the *`db_name.tbl_name`* syntax. Some SQL servers provide the same functionality but call this `User space`. MySQL Server doesn't support tablespaces such as used in statements like this: `CREATE TABLE ralph.my_table ... IN my_tablespace`.
- SQL statement syntax
  - The `ANALYZE TABLE`, `CHECK TABLE`, `OPTIMIZE TABLE`, and `REPAIR TABLE` statements.
  - The `CREATE DATABASE`, `DROP DATABASE`, and `ALTER DATABASE` statements. See Section 12.1.8, “`CREATE DATABASE` Syntax”, Section 12.1.17, “`DROP DATABASE` Syntax”, and Section 12.1.1, “`ALTER DATABASE` Syntax”.
  - The `DO` statement.
  - `EXPLAIN SELECT` to obtain a description of how tables are processed by the query optimizer.
  - The `FLUSH` and `RESET` statements.
  - The `SET` statement. See Section 12.4.4, “`SET` Syntax”.
  - The `SHOW` statement. See Section 12.4.5, “`SHOW` Syntax”. The information produced by many of the MySQL-specific `SHOW` statements can be obtained in more standard fashion by using `SELECT` to query `INFORMATION_SCHEMA`. See Chapter 18, *`INFORMATION_SCHEMA` Tables*.
  - Use of `LOAD DATA INFILE`. In many cases, this syntax is compatible with Oracle's `LOAD DATA INFILE`. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”.
  - Use of `RENAME TABLE`. See Section 12.1.26, “`RENAME TABLE` Syntax”.
  - Use of `REPLACE` instead of `DELETE` plus `INSERT`. See Section 12.2.8, “`REPLACE` Syntax”.
  - Use of `CHANGE` *`col_name`*, `DROP` *`col_name`*, or `DROP INDEX`, `IGNORE` or `RENAME` in `ALTER TABLE` statements. Use of multiple `ADD`, `ALTER`, `DROP`, or `CHANGE` clauses in an `ALTER TABLE` statement. See Section 12.1.6, “`ALTER TABLE` Syntax”.
  - Use of index names, indexes on a prefix of a column, and use of `INDEX` or `KEY` in `CREATE TABLE` statements. See Sec-

tion 12.1.14, “`CREATE TABLE` Syntax”.

  - Use of `TEMPORARY` or `IF NOT EXISTS` with `CREATE TABLE`.
  - Use of `IF EXISTS` with `DROP TABLE` and `DROP DATABASE`.
  - The capability of dropping multiple tables with a single `DROP TABLE` statement.
  - The `ORDER BY` and `LIMIT` clauses of the `UPDATE` and `DELETE` statements.
  - `INSERT INTO tbl_name SET col_name = ...` syntax.
  - The `DELAYED` clause of the `INSERT` and `REPLACE` statements.
  - The `LOW_PRIORITY` clause of the `INSERT`, `REPLACE`, `DELETE`, and `UPDATE` statements.
  - Use of `INTO OUTFILE` or `INTO DUMPFILE` in `SELECT` statements. See Section 12.2.9, “`SELECT` Syntax”.
  - Options such as `STRAIGHT_JOIN` or `SQL_SMALL_RESULT` in `SELECT` statements.
  - You don't need to name all selected columns in the `GROUP BY` clause. This gives better performance for some very specific, but quite normal queries. See Section 11.16, “Functions and Modifiers for Use with `GROUP BY` Clauses”.
  - You can specify `ASC` and `DESC` with `GROUP BY`, not just with `ORDER BY`.
  - The ability to set variables in a statement with the `:=` assignment operator. See Section 8.4, “User-Defined Variables”.

- Data types
  - The `MEDIUMINT`, `SET`, and `ENUM` data types, and the various `BLOB` and `TEXT` data types.
  - The `AUTO_INCREMENT`, `BINARY`, `NULL`, `UNSIGNED`, and `ZEROFILL` data type attributes.

- Functions and operators
  - To make it easier for users who migrate from other SQL environments, MySQL Server supports aliases for many functions. For example, all string functions support both standard SQL syntax and ODBC syntax.
  - MySQL Server understands the `||` and `&&` operators to mean logical OR and AND, as in the C programming language. In MySQL Server, `||` and `OR` are synonyms, as are `&&` and `AND`. Because of this nice syntax, MySQL Server doesn't support the standard SQL `||` operator for string concatenation; use `CONCAT()` instead. Because `CONCAT()` takes any number of arguments, it is easy to convert use of the `||` operator to MySQL Server.
  - Use of `COUNT(DISTINCT value_list)` where `value_list` has more than one element.
  - String comparisons are case-insensitive by default, with sort ordering determined by the collation of the current character set, which is `latin1` (cp1252 West European) by default. If you don't like this, you should declare your columns with the `BINARY` attribute or use the `BINARY` cast, which causes comparisons to be done using the underlying character code values rather then a lexical ordering.
  - The `%` operator is a synonym for `MOD()`. That is, `N % M` is equivalent to `MOD(N,M)`. `%` is supported for C programmers and for compatibility with PostgreSQL.
  - The `=`, `<>`, `<=`, `<`, `>=`, `>`, `<<`, `>>`, `<=>`, `AND`, `OR`, or `LIKE` operators may be used in expressions in the output column list (to the left of the `FROM`) in `SELECT` statements. For example:

    ```
    mysql> SELECT col1=1 AND col2=2 FROM my_table;
    ```

  - The `LAST_INSERT_ID()` function returns the most recent `AUTO_INCREMENT` value. See Section 11.14, “Information Functions”.
  - `LIKE` is permitted on numeric values.
  - The `REGEXP` and `NOT REGEXP` extended regular expression operators.
  - `CONCAT()` or `CHAR()` with one argument or more than two arguments. (In MySQL Server, these functions can take a variable number of arguments.)
  - The `BIT_COUNT()`, `CASE`, `ELT()`, `FROM_DAYS()`, `FORMAT()`, `IF()`, `PASSWORD()`, `ENCRYPT()`, `MD5()`, `ENCODE()`, `DECODE()`, `PERIOD_ADD()`, `PERIOD_DIFF()`, `TO_DAYS()`, and `WEEKDAY()` functions.

- Use of `TRIM()` to trim substrings. Standard SQL supports removal of single characters only.
- The `GROUP BY` functions `STD()`, `BIT_OR()`, `BIT_AND()`, `BIT_XOR()`, and `GROUP_CONCAT()`. See Section 11.16, “Functions and Modifiers for Use with `GROUP BY` Clauses”.

1.8.5. MySQL Differences from Standard SQL

We try to make MySQL Server follow the ANSI SQL standard and the ODBC SQL standard, but MySQL Server performs operations differently in some cases:

- There are several differences between the MySQL and standard SQL privilege systems. For example, in MySQL, privileges for a table are not automatically revoked when you delete a table. You must explicitly issue a `REVOKE` statement to revoke privileges for a table. For more information, see Section 12.4.1.5, “`REVOKE` Syntax”.
- The `CAST()` function does not support cast to `REAL` or `BIGINT`. See Section 11.10, “Cast Functions and Operators”.

1.8.5.1. `SELECT INTO TABLE` Differences

MySQL Server doesn't support the `SELECT ... INTO TABLE` Sybase SQL extension. Instead, MySQL Server supports the `INSERT INTO ... SELECT` standard SQL syntax, which is basically the same thing. See Section 12.2.5.1, “`INSERT ... SELECT` Syntax”. For example:

```
INSERT INTO tbl_temp2 (fld_id)
    SELECT tbl_temp1.fld_order_id
    FROM tbl_temp1 WHERE tbl_temp1.fld_order_id > 100;
```

Alternatively, you can use `SELECT ... INTO OUTFILE` or `CREATE TABLE ... SELECT`.

You can use `SELECT ... INTO` with user-defined variables. The same syntax can also be used inside stored routines using cursors and local variables. See Section 12.7.3.3, “`SELECT ... INTO` Statement”.

1.8.5.2. `UPDATE` Differences

If you access a column from the table to be updated in an expression, `UPDATE` uses the current value of the column. The second assignment in the following statement sets `col2` to the current (updated) `col1` value, not the original `col1` value. The result is that `col1` and `col2` have the same value. This behavior differs from standard SQL.

```
UPDATE t1 SET col1 = col1 + 1, col2 = col1;
```

1.8.5.3. Transaction and Atomic Operation Differences

MySQL Server (version 3.23-max and all versions 4.0 and above) supports transactions with the `InnoDB` transactional storage engine. `InnoDB` provides *full* ACID compliance. See Chapter 13, *Storage Engines*. For information about `InnoDB` differences from standard SQL with regard to treatment of transaction errors, see Section 13.3.13, “`InnoDB` Error Handling”.

The other nontransactional storage engines in MySQL Server (such as `MyISAM`) follow a different paradigm for data integrity called “atomic operations.” In transactional terms, `MyISAM` tables effectively always operate in `autocommit = 1` mode. Atomic operations often offer comparable integrity with higher performance.

Because MySQL Server supports both paradigms, you can decide whether your applications are best served by the speed of atomic operations or the use of transactional features. This choice can be made on a per-table basis.

As noted, the tradeoff for transactional versus nontransactional storage engines lies mostly in performance. Transactional tables have significantly higher memory and disk space requirements, and more CPU overhead. On the other hand, transactional storage engines such as `InnoDB` also offer many significant features. MySQL Server's modular design enables the concurrent use of different storage engines to suit different requirements and deliver optimum performance in all situations.

But how do you use the features of MySQL Server to maintain rigorous integrity even with the nontransactional `MyISAM` tables, and how do these features compare with the transactional storage engines?

- If your applications are written in a way that is dependent on being able to call `ROLLBACK` rather than `COMMIT` in critical situations, transactions are more convenient. Transactions also ensure that unfinished updates or corrupting activities are not committed to the database; the server is given the opportunity to do an automatic rollback and your database is saved.

If you use nontransactional tables, MySQL Server in almost all cases enables you to resolve potential problems by including simple checks before updates and by running simple scripts that check the databases for inconsistencies and automatically repair or warn if such an inconsistency occurs. You can normally fix tables perfectly with no data integrity loss just by using the MySQL log or even adding one extra log.

- More often than not, critical transactional updates can be rewritten to be atomic. Generally speaking, all integrity problems that transactions solve can be done with `LOCK TABLES` or atomic updates, ensuring that there are no automatic aborts from the server, which is a common problem with transactional database systems.
- To be safe with MySQL Server, regardless of whether you use transactional tables, you only need to have backups and have binary logging turned on. When that is true, you can recover from any situation that you could with any other transactional database system. It is always good to have backups, regardless of which database system you use.

The transactional paradigm has its advantages and disadvantages. Many users and application developers depend on the ease with which they can code around problems where an abort appears to be necessary, or is necessary. However, even if you are new to the atomic operations paradigm, or more familiar with transactions, do consider the speed benefit that nontransactional tables can offer on the order of three to five times the speed of the fastest and most optimally tuned transactional tables.

In situations where integrity is of highest importance, MySQL Server offers transaction-level reliability and integrity even for nontransactional tables. If you lock tables with `LOCK TABLES`, all updates stall until integrity checks are made. If you obtain a `READ LOCAL` lock (as opposed to a write lock) for a table that enables concurrent inserts at the end of the table, reads are permitted, as are inserts by other clients. The newly inserted records are not be seen by the client that has the read lock until it releases the lock. With `INSERT DELAYED`, you can write inserts that go into a local queue until the locks are released, without having the client wait for the insert to complete. See Section 7.10.3, “Concurrent Inserts”, and Section 12.2.5.2, “`INSERT DELAYED` Syntax”.

“Atomic,” in the sense that we mean it, is nothing magical. It only means that you can be sure that while each specific update is running, no other user can interfere with it, and there can never be an automatic rollback (which can happen with transactional tables if you are not very careful). MySQL Server also guarantees that there are no dirty reads.

Following are some techniques for working with nontransactional tables:

- Loops that need transactions normally can be coded with the help of `LOCK TABLES`, and you don't need cursors to update records on the fly.
- To avoid using `ROLLBACK`, you can employ the following strategy:
  1. Use `LOCK TABLES` to lock all the tables you want to access.
  2. Test the conditions that must be true before performing the update.
  3. Update if the conditions are satisfied.
  4. Use `UNLOCK TABLES` to release your locks.

  This is usually a much faster method than using transactions with possible rollbacks, although not always. The only situation this solution doesn't handle is when someone kills the threads in the middle of an update. In that case, all locks are released but some of the updates may not have been executed.
- You can also use functions to update records in a single operation. You can get a very efficient application by using the following techniques:
  - Modify columns relative to their current value.
  - Update only those columns that actually have changed.

  For example, when we are updating customer information, we update only the customer data that has changed and test only that none of the changed data, or data that depends on the changed data, has changed compared to the original row. The test for changed data is done with the `WHERE` clause in the `UPDATE` statement. If the record wasn't updated, we give the client a message: “Some of the data you have changed has been changed by another user.” Then we show the old row versus the new row in a window so that the user can decide which version of the customer record to use.

  This gives us something that is similar to column locking but is actually even better because we only update some of the columns, using values that are relative to their current values. This means that typical `UPDATE` statements look something like these:

```
UPDATE tablename SET pay_back=pay_back+125;

UPDATE customer
  SET
    customer_date='current_date',
    address='new address',
    phone='new phone',
    money_owed_to_us=money_owed_to_us-125
  WHERE
    customer_id=id AND address='old address' AND phone='old phone';
```

This is very efficient and works even if another client has changed the values in the `pay_back` or `money_owed_to_us` columns.

- In many cases, users have wanted `LOCK TABLES` or `ROLLBACK` for the purpose of managing unique identifiers. This can be handled much more efficiently without locking or rolling back by using an `AUTO_INCREMENT` column and either the `LAST_INSERT_ID()` SQL function or the `mysql_insert_id()` C API function. See Section 11.14, "Information Functions", and Section 20.9.3.37, "`mysql_insert_id()`".

  You can generally code around the need for row-level locking. Some situations really do need it, and `InnoDB` tables support row-level locking. Otherwise, with `MyISAM` tables, you can use a flag column in the table and do something like the following:

  ```
  UPDATE tbl_name SET row_flag=1 WHERE id=ID;
  ```

  MySQL returns `1` for the number of affected rows if the row was found and `row_flag` wasn't `1` in the original row. You can think of this as though MySQL Server changed the preceding statement to:

  ```
  UPDATE tbl_name SET row_flag=1 WHERE id=ID AND row_flag <> 1;
  ```

1.8.5.4. Foreign Key Differences

The `InnoDB` storage engine supports checking of foreign key constraints, including `CASCADE`, `ON DELETE`, and `ON UPDATE`. See Section 13.3.5.4, "`FOREIGN KEY` Constraints".

For storage engines other than `InnoDB`, MySQL Server parses the `FOREIGN KEY` syntax in `CREATE TABLE` statements, but does not use or store it. In the future, the implementation will be extended to store this information in the table specification file so that it may be retrieved by `mysqldump` and ODBC. At a later stage, foreign key constraints will be implemented for `MyISAM` tables as well.

Foreign key enforcement offers several benefits to database developers:

- Assuming proper design of the relationships, foreign key constraints make it more difficult for a programmer to introduce an inconsistency into the database.
- Centralized checking of constraints by the database server makes it unnecessary to perform these checks on the application side. This eliminates the possibility that different applications may not all check the constraints in the same way.
- Using cascading updates and deletes can simplify the application code.
- Properly designed foreign key rules aid in documenting relationships between tables.

Do keep in mind that these benefits come at the cost of additional overhead for the database server to perform the necessary checks. Additional checking by the server affects performance, which for some applications may be sufficiently undesirable as to be avoided if possible. (Some major commercial applications have coded the foreign key logic at the application level for this reason.)

MySQL gives database developers the choice of which approach to use. If you don't need foreign keys and want to avoid the overhead associated with enforcing referential integrity, you can choose another storage engine instead, such as `MyISAM`. (For example, the `MyISAM` storage engine offers very fast performance for applications that perform only `INSERT` and `SELECT` operations. In this case, the table has no holes in the middle and the inserts can be performed concurrently with retrievals. See Section 7.10.3, "Concurrent Inserts".)

If you choose not to take advantage of referential integrity checks, keep the following considerations in mind:

- In the absence of server-side foreign key relationship checking, the application itself must handle relationship issues. For example, it must take care to insert rows into tables in the proper order, and to avoid creating orphaned child records. It must also be able to recover from errors that occur in the middle of multiple-record insert operations.
- If `ON DELETE` is the only referential integrity capability an application needs, you can achieve a similar effect as of MySQL Server 4.0 by using multiple-table `DELETE` statements to delete rows from many tables with a single statement. See Section 12.2.2, "`DELETE` Syntax".

- A workaround for the lack of `ON DELETE` is to add the appropriate `DELETE` statements to your application when you delete records from a table that has a foreign key. In practice, this is often as quick as using foreign keys and is more portable.

Be aware that the use of foreign keys can sometimes lead to problems:

- Foreign key support addresses many referential integrity issues, but it is still necessary to design key relationships carefully to avoid circular rules or incorrect combinations of cascading deletes.
- It is not uncommon for a DBA to create a topology of relationships that makes it difficult to restore individual tables from a backup. (MySQL alleviates this difficulty by enabling you to temporarily disable foreign key checks when reloading a table that depends on other tables. See Section 13.3.5.4, “`FOREIGN KEY` Constraints”. As of MySQL 4.1.1, `mysqldump` generates dump files that take advantage of this capability automatically when they are reloaded.)

Foreign keys in SQL are used to check and enforce referential integrity, not to join tables. If you want to get results from multiple tables from a `SELECT` statement, you do this by performing a join between them:

```
SELECT * FROM t1 INNER JOIN t2 ON t1.id = t2.id;
```

See Section 12.2.9.1, “`JOIN` Syntax”, and Section 3.6.6, “Using Foreign Keys”.

The `FOREIGN KEY` syntax without `ON DELETE ...` is often used by ODBC applications to produce automatic `WHERE` clauses.

1.8.5.5. '`--`' as the Start of a Comment

Standard SQL uses the C syntax `/* this is a comment */` for comments, and MySQL Server supports this syntax as well. MySQL also support extensions to this syntax that enable MySQL-specific SQL to be embedded in the comment, as described in Section 8.6, “Comment Syntax”.

Standard SQL uses “`--`” as a start-comment sequence. MySQL Server uses “`#`” as the start comment character. MySQL Server 3.23.3 and up also supports a variant of the “`--`” comment style. That is, the “`--`” start-comment sequence must be followed by a space (or by a control character such as a newline). The space is required to prevent problems with automatically generated SQL queries that use constructs such as the following, where we automatically insert the value of the payment for `payment`:

```
UPDATE account SET credit=credit-payment
```

Consider about what happens if `payment` has a negative value such as `-1`:

```
UPDATE account SET credit=credit--1
```

`credit--1` is a legal expression in SQL, but “`--`” is interpreted as the start of a comment, part of the expression is discarded. The result is a statement that has a completely different meaning than intended:

```
UPDATE account SET credit=credit
```

The statement produces no change in value at all. This illustrates that permitting comments to start with “`--`” can have serious consequences.

Using our implementation requires a space following the “`--`” for it to be recognized as a start-comment sequence in MySQL Server 3.23.3 and newer. Therefore, `credit--1` is safe to use.

Another safe feature is that the `mysql` command-line client ignores lines that start with “`--`”.

The following information is relevant only if you are running a MySQL version earlier than 3.23.3:

If you have an SQL script in a text file that contains “`--`” comments, you should use the `replace` utility as follows to convert the comments to use “`#`” characters before executing the script:

```
shell> replace " --" " #" < text-file-with-funny-comments.sql \
         | mysql db_name
```

That is safer than executing the script in the usual way:

```
shell> mysql db_name < text-file-with-funny-comments.sql
```

You can also edit the script file “in place” to change the “`--`” comments to “`#`” comments:

```
shell> replace " --" " #" -- text-file-with-funny-comments.sql
```

Change them back with this command:

```
shell> replace " #" " --" -- text-file-with-funny-comments.sql
```

See Section 4.8.2, “`replace` — A String-Replacement Utility”.

1.8.6. How MySQL Deals with Constraints

MySQL enables you to work both with transactional tables that permit rollback and with nontransactional tables that do not. Because of this, constraint handling is a bit different in MySQL than in other DBMSs. We must handle the case when you have inserted or updated a lot of rows in a nontransactional table for which changes cannot be rolled back when an error occurs.

The basic philosophy is that MySQL Server tries to produce an error for anything that it can detect while parsing a statement to be executed, and tries to recover from any errors that occur while executing the statement. We do this in most cases, but not yet for all.

The options MySQL has when an error occurs are to stop the statement in the middle or to recover as well as possible from the problem and continue. By default, the server follows the latter course. This means, for example, that the server may coerce illegal values to the closest legal values.

Several SQL mode options are available to provide greater control over handling of bad data values and whether to continue statement execution or abort when errors occur. Using these options, you can configure MySQL Server to act in a more traditional fashion that is like other DBMSs that reject improper input. The SQL mode can be set globally at server startup to affect all clients. Individual clients can set the SQL mode at runtime, which enables each client to select the behavior most appropriate for its requirements. See Section 5.1.6, “Server SQL Modes”.

The following sections describe how MySQL Server handles different types of constraints.

1.8.6.1. `PRIMARY KEY` and `UNIQUE` Index Constraints

Normally, errors occurs for data-change statements (such as `INSERT` or `UPDATE`) that would violate primary-key, unique-key, or foreign-key constraints. If you are using a transactional storage engine such as `InnoDB`, MySQL automatically rolls back the statement. If you are using a nontransactional storage engine, MySQL stops processing the statement at the row for which the error occurred and leaves any remaining rows unprocessed.

MySQL supports an `IGNORE` keyword for `INSERT`, `UPDATE`, and so forth. If you use it, MySQL ignores primary-key or unique-key violations and continues processing with the next row. See the section for the statement that you are using (Section 12.2.5, “`INSERT` Syntax”, Section 12.2.11, “`UPDATE` Syntax”, and so forth).

You can get information about the number of rows actually inserted or updated with the `mysql_info()` C API function. You can also use the `SHOW WARNINGS` statement. See Section 20.9.3.35, “`mysql_info()`”, and Section 12.4.5.41, “`SHOW WARNINGS` Syntax”.

Currently, only `InnoDB` tables support foreign keys. See Section 13.3.5.4, “`FOREIGN KEY` Constraints”.

1.8.6.2. Constraints on Invalid Data

By default, MySQL is forgiving of illegal or improper data values and coerces them to legal values for data entry. However, you can change the server SQL mode to select more traditional treatment of bad values such that the server rejects them and aborts the statement in which they occur. See Section 5.1.6, “Server SQL Modes”.

This section describes the default (forgiving) behavior of MySQL, as well as the strict SQL mode and how it differs.

If you are not using strict mode, then whenever you insert an “incorrect” value into a column, such as a `NULL` into a `NOT NULL` column or a too-large numeric value into a numeric column, MySQL sets the column to the “best possible value” instead of producing an error: The following rules describe in more detail how this works:

- If you try to store an out of range value into a numeric column, MySQL Server instead stores zero, the smallest possible value, or the largest possible value, whichever is closest to the invalid value.
- For strings, MySQL stores either the empty string or as much of the string as can be stored in the column.
- If you try to store a string that doesn't start with a number into a numeric column, MySQL Server stores 0.
- Invalid values for `ENUM` and `SET` columns are handled as described in Section 1.8.6.3, “`ENUM` and `SET` Constraints”.
- MySQL enables you to store certain incorrect date values into `DATE` and `DATETIME` columns (such as `'2000-02-31'` or

`'2000-02-00'`). The idea is that it is not the job of the SQL server to validate dates. If MySQL can store a date value and retrieve exactly the same value, MySQL stores it as given. If the date is totally wrong (outside the server's ability to store it), the special "zero" date value `'0000-00-00'` is stored in the column instead.

- If you try to store `NULL` into a column that doesn't take `NULL` values, an error occurs for single-row `INSERT` statements. For multiple-row `INSERT` statements or for `INSERT INTO ... SELECT` statements, MySQL Server stores the implicit default value for the column data type. In general, this is `0` for numeric types, the empty string (`''`) for string types, and the "zero" value for date and time types. Implicit default values are discussed in Section 10.1.4, "Data Type Default Values".
- If an `INSERT` statement specifies no value for a column, MySQL inserts its default value if the column definition includes an explicit `DEFAULT` clause. If the definition has no such `DEFAULT` clause, MySQL inserts the implicit default value for the column data type.

The reason for using the preceding rules in nonstrict mode is that we can't check these conditions until the statement has begun executing. We can't just roll back if we encounter a problem after updating a few rows, because the storage engine may not support rollback. The option of terminating the statement is not that good; in this case, the update would be "half done," which is probably the worst possible scenario. In this case, it is better to "do the best you can" and then continue as if nothing happened.

In MySQL 5.0.2 and up, you can select stricter treatment of input values by using the `STRICT_TRANS_TABLES` or `STRICT_ALL_TABLES` SQL modes:

```
SET sql_mode = 'STRICT_TRANS_TABLES';
SET sql_mode = 'STRICT_ALL_TABLES';
```

`STRICT_TRANS_TABLES` enables strict mode for transactional storage engines, and also to some extent for nontransactional engines. It works like this:

- For transactional storage engines, bad data values occurring anywhere in a statement cause the statement to abort and roll back.
- For nontransactional storage engines, a statement aborts if the error occurs in the first row to be inserted or updated. (When the error occurs in the first row, the statement can be aborted to leave the table unchanged, just as for a transactional table.) Errors in rows after the first do not abort the statement, because the table has already been changed by the first row. Instead, bad data values are adjusted and result in warnings rather than errors. In other words, with `STRICT_TRANS_TABLES`, a wrong value causes MySQL to roll back all updates done so far, if that can be done without changing the table. But once the table has been changed, further errors result in adjustments and warnings.

For even stricter checking, enable `STRICT_ALL_TABLES`. This is the same as `STRICT_TRANS_TABLES` except that for nontransactional storage engines, errors abort the statement even for bad data in rows following the first row. This means that if an error occurs partway through a multiple-row insert or update for a nontransactional table, a partial update results. Earlier rows are inserted or updated, but those from the point of the error on are not. To avoid this for nontransactional tables, either use single-row statements or else use `STRICT_TRANS_TABLES` if conversion warnings rather than errors are acceptable. To avoid problems in the first place, do not use MySQL to check column content. It is safest (and often faster) to let the application ensure that it passes only legal values to the database.

With either of the strict mode options, you can cause errors to be treated as warnings by using `INSERT IGNORE` or `UPDATE IGNORE` rather than `INSERT` or `UPDATE` without `IGNORE`.

1.8.6.3. `ENUM` and `SET` Constraints

`ENUM` and `SET` columns provide an efficient way to define columns that can contain only a given set of values. See Section 10.4.4, "The `ENUM` Type", and Section 10.4.5, "The `SET` Type". However, before MySQL 5.0.2, `ENUM` and `SET` columns do not provide true constraints on entry of invalid data:

- `ENUM` columns always have a default value. If you specify no default value, then it is `NULL` for columns that can have `NULL`, otherwise it is the first enumeration value in the column definition.
- If you insert an incorrect value into an `ENUM` column or if you force a value into an `ENUM` column with `IGNORE`, it is set to the reserved enumeration value of `0`, which is displayed as an empty string in string context.
- If you insert an incorrect value into a `SET` column, the incorrect value is ignored. For example, if the column can contain the values `'a'`, `'b'`, and `'c'`, an attempt to assign `'a,x,b,y'` results in a value of `'a,b'`.

As of MySQL 5.0.2, you can configure the server to use strict SQL mode. See Section 5.1.6, "Server SQL Modes". With strict mode enabled, the definition of a `ENUM` or `SET` column does act as a constraint on values entered into the column. An error occurs for values that do not satisfy these conditions:

- An `ENUM` value must be one of those listed in the column definition, or the internal numeric equivalent thereof. The value cannot be the error value (that is, 0 or the empty string). For a column defined as `ENUM('a','b','c')`, values such as `''`, `'d'`, or `'ax'` are illegal and are rejected.
- A `SET` value must be the empty string or a value consisting only of the values listed in the column definition separated by commas. For a column defined as `SET('a','b','c')`, values such as `'d'` or `'a,b,c,d'` are illegal and are rejected.

Errors for invalid values can be suppressed in strict mode if you use `INSERT IGNORE` or `UPDATE IGNORE`. In this case, a warning is generated rather than an error. For `ENUM`, the value is inserted as the error member (`0`). For `SET`, the value is inserted as given except that any invalid substrings are deleted. For example, `'a,x,b,y'` results in a value of `'a,b'`.

1.9. Credits

The following sections list developers, contributors, and supporters that have helped to make MySQL what it is today.

1.9.1. Contributors to MySQL

Although Oracle Corporation and/or its affiliates own all copyrights in the `MySQL server` and the `MySQL manual`, we wish to recognize those who have made contributions of one kind or another to the `MySQL distribution`. Contributors are listed here, in somewhat random order:

- Gianmassimo Vigazzola `<qwerg@mbox.vol.it>` or `<qwerg@tin.it>`

  The initial port to Win32/NT.

- Per Eric Olsson

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- Irena Pancirov `<irena@mail.yacc.it>`

  Win32 port with Borland compiler. `mysqlshutdown.exe` and `mysqlwatch.exe`.

- David J. Hughes

  For the effort to make a shareware SQL database. At TcX, the predecessor of MySQL AB, we started with `mSQL`, but found that it couldn't satisfy our purposes so instead we wrote an SQL interface to our application builder Unireg. `mysqladmin` and `mysql` client are programs that were largely influenced by their `mSQL` counterparts. We have put a lot of effort into making the MySQL syntax a superset of `mSQL`. Many of the API's ideas are borrowed from `mSQL` to make it easy to port free `mSQL` programs to the MySQL API. The MySQL software doesn't contain any code from `mSQL`. Two files in the distribution (`client/insert_test.c` and `client/select_test.c`) are based on the corresponding (noncopyrighted) files in the `mSQL` distribution, but are modified as examples showing the changes necessary to convert code from `mSQL` to MySQL Server. (`mSQL` is copyrighted David J. Hughes.)

- Patrick Lynch

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  `mysqldump` (previously `msqldump`, but ported and enhanced by Monty).

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- Joshua Chamas `<joshua@chamas.com>`

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- Yves Carlier `<Yves.Carlier@rug.ac.be>`

  `mysqlaccess`, a program to show the access rights for a user.

- Rhys Jones `<rhys@wales.com>` (And GWE Technologies Limited)

  For one of the early JDBC drivers.

- Dr Xiaokun Kelvin ZHU `<X.Zhu@brad.ac.uk>`

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- James Cooper `<pixel@organic.com>`

  For setting up a searchable mailing list archive at his site.

- Rick Mehalick `<Rick_Mehalick@i-o.com>`

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- Doug Sisk `<sisk@wix.com>`

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- Diemand Alexander V. `<axeld@vial.ethz.ch>`

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- David Sacerdote `<davids@secnet.com>`

  Ideas for secure checking of DNS host names.

- Wei-Jou Chen `<jou@nematic.ieo.nctu.edu.tw>`

  Some support for Chinese(BIG5) characters.

- Wei He `<hewei@mail.ied.ac.cn>`

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- Jan Pazdziora `<adelton@fi.muni.cz>`

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  `FROM_UNIXTIME()` time formatting, `ENCRYPT()` functions, and `bison` advisor. Active mailing list member.

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- Alexis Mikhailov `<root@medinf.chuvashia.su>`

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- Andreas F. Bobak `<bobak@relog.ch>`

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  Examples in the MySQL Tutorial.

- Steve Harvey

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  http://www.pspl.co.in/konark/. Help with the Win64 port of the MySQL server.

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- Google Inc.

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  Irix setup.

- Luuk de Boer `<luuk@wxs.nl>`

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- Tim Sailer `<tps@users.buoy.com>`

  `DBD::mysql` questions.

- Boyd Lynn Gerber `<gerberb@zenez.com>`

  SCO-related questions.

- Richard Mehalick `<RM186061@shellus.com>`

  `xmysql`-related questions and basic installation questions.

- Zeev Suraski `<bourbon@netvision.net.il>`

  Apache module configuration questions (log & auth), PHP-related questions, SQL syntax-related questions and other general questions.

- Francesc Guasch `<frankie@citel.upc.es>`

  General questions.

- Jonathan J Smith `<jsmith@wtp.net>`

  Questions pertaining to OS-specifics with Linux, SQL syntax, and other things that might need some work.

- David Sklar `<sklar@student.net>`

  Using MySQL from PHP and Perl.

- Alistair MacDonald `<A.MacDonald@uel.ac.uk>`

  Is flexible and can handle Linux and perhaps HP-UX.

- John Lyon `<jlyon@imag.net>`

  Questions about installing MySQL on Linux systems, using either `.rpm` files or compiling from source.

- Lorvid Ltd. `<lorvid@WOLFENET.com>`

  Simple billing/license/support/copyright issues.

- Patrick Sherrill `<patrick@coconet.com>`

  ODBC and VisualC++ interface questions.

- Randy Harmon `<rjharmon@uptimecomputers.com>`

  `DBD`, Linux, some SQL syntax questions.

1.9.2. Documenters and translators

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- Paul DuBois

Ongoing help with making this manual correct and understandable. That includes rewriting Monty's and David's attempts at English into English as other people know it.

- Kim Aldale

  Helped to rewrite Monty's and David's early attempts at English into English.

- Michael J. Miller Jr. `<mke@terrapin.turbolift.com>`

  For the first MySQL manual. And a lot of spelling/language fixes for the FAQ (that turned into the MySQL manual a long time ago).

- Yan Cailin

  First translator of the MySQL Reference Manual into simplified Chinese in early 2000 on which the Big5 and HK coded (http://mysql.hitstar.com/) versions were based. Personal home page at linuxdb.yeah.net.

- Jay Flaherty `<fty@mediapulse.com>`

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  French error messages.

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  Hungarian error messages.

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Portuguese error messages.

- Carsten H. Pedersen

  Danish error messages.

- Arjen Lentz

  Dutch error messages, completing earlier partial translation (also work on consistency and spelling).

1.9.3. Packages that support MySQL

The following is a list of creators/maintainers of some of the most important API/packages/applications that a lot of people use with MySQL.

We cannot list every possible package here because the list would then be way to hard to maintain. For other packages, please refer to the software portal at http://solutions.mysql.com/software/.

- Tim Bunce, Alligator Descartes

  For the `DBD` (Perl) interface.

- Andreas Koenig `<a.koenig@mind.de>`

  For the Perl interface for MySQL Server.

- Jochen Wiedmann `<wiedmann@neckar-alb.de>`

  For maintaining the Perl `DBD::mysql` module.

- Eugene Chan `<eugene@acenet.com.sg>`

  For porting PHP for MySQL Server.

- Georg Richter

  MySQL 4.1 testing and bug hunting. New PHP 5.0 `mysqli` extension (API) for use with MySQL 4.1 and up.

- Giovanni Maruzzelli `<maruzz@matrice.it>`

  For porting iODBC (Unix ODBC).

- Xavier Leroy `<Xavier.Leroy@inria.fr>`

  The author of LinuxThreads (used by the MySQL Server on Linux).

1.9.4. Tools that were used to create MySQL

The following is a list of some of the tools we have used to create MySQL. We use this to express our thanks to those that has created them as without these we could not have made MySQL what it is today.

- Free Software Foundation

  From whom we got an excellent compiler (`gcc`), an excellent debugger (`gdb` and the `libc` library (from which we have borrowed `strto.c` to get some code working in Linux).

- Free Software Foundation & The XEmacs development team

  For a really great editor/environment.

- Julian Seward

  Author of `valgrind`, an excellent memory checker tool that has helped us find a lot of otherwise hard to find bugs in MySQL.

- Dorothea Lütkehaus and Andreas Zeller

For `DDD` (The Data Display Debugger) which is an excellent graphical front end to `gdb`).

1.9.5. Supporters of MySQL

Although Oracle Corporation and/or its affiliates own all copyrights in the `MySQL server` and the `MySQL manual`, we wish to recognize the following companies, which helped us finance the development of the `MySQL server`, such as by paying us for developing a new feature or giving us hardware for development of the `MySQL server`.

- VA Linux / Andover.net

  Funded replication.
- NuSphere

  Editing of the MySQL manual.
- Stork Design studio

  The MySQL Web site in use between 1998-2000.
- Intel

  Contributed to development on Windows and Linux platforms.
- Compaq

  Contributed to Development on Linux/Alpha.
- SWSoft

  Development on the embedded `mysqld` version.
- FutureQuest

  The `--skip-show-database` option.

Chapter 2. Installing and Upgrading MySQL

This chapter describes how to obtain and install MySQL. A summary of the procedure follows and later sections provide the details. If you plan to upgrade an existing version of MySQL to a newer version rather than install MySQL for the first time, see Section 2.11.1, “Upgrading MySQL”, for information about upgrade procedures and about issues that you should consider before upgrading.

If you are interested in migrating to MySQL from another database system, you may wish to read Section B.8, “MySQL 5.5 FAQ: Migration”, which contains answers to some common questions concerning migration issues.

1. **Determine whether MySQL runs and is supported on your platform.**

   Please note that not all platforms are equally suitable for running MySQL, and that not all platforms on which MySQL is known to run are officially supported by Oracle Corporation:

2. **Choose which distribution to install.**

   Several versions of MySQL are available, and most are available in several distribution formats. You can choose from prepackaged distributions containing binary (precompiled) programs or source code. When in doubt, use a binary distribution. We also provide public access to our current source tree for those who want to see our most recent developments and help us test new code. To determine which version and type of distribution you should use, see Section 2.1.2, “Choosing Which MySQL Distribution to Install”.

3. **Download the distribution that you want to install.**

   For instructions, see Section 2.1.3, “How to Get MySQL”. To verify the integrity of the distribution, use the instructions in Section 2.1.4, “Verifying Package Integrity Using MD5 Checksums or `GnuPG`”.

4. **Install the distribution.**

   To install MySQL from a binary distribution, use the instructions in Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.

   To install MySQL from a source distribution or from the current development source tree, use the instructions in Section 2.9, “Installing MySQL from Source”.

5. **Perform any necessary postinstallation setup.**

   After installing MySQL, read Section 2.10, “Postinstallation Setup and Testing”. This section contains important information about making sure the MySQL server is working properly. It also describes how to secure the initial MySQL user accounts, *which have no passwords* until you assign passwords. The section applies whether you install MySQL using a binary or source distribution.

6. If you want to run the MySQL benchmark scripts, Perl support for MySQL must be available. See Section 2.13, “Perl Installation Notes”.

Instructions for installing MySQL on different platforms and environments is available on a platform by platform basis:

- **Unix, Linux, FreeBSD**

  For instructions on installing MySQL on most Linux and Unix platforms using a generic binary (for example, a `.tar.gz` package), see Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.

  For information on building MySQL entirely from the source code distributions or the source code repositories, see Section 2.9, “Installing MySQL from Source”

  For specific platform help on installation, configuration, and building from source see the corresponding platform section:

  - Linux, including notes on distribution specific methods, see Section 2.5, “Installing MySQL on Linux”.
  - Solaris and OpenSolaris, including PKG and IPS formats, see Section 2.6, “Installing MySQL on Solaris and OpenSolaris”.
  - IBM AIX, see Section 2.6, “Installing MySQL on Solaris and OpenSolaris”.
  - Hewlett-Packard HP-UX, including the DEPOT package format, see Section 2.7, “Installing MySQL on HP-UX”.
  - FreeBSD, see Section 2.8, “Installing MySQL on FreeBSD”.

- **Microsoft Windows**

  For instructions on installing MySQL on Microsoft Windows, using either a Zipped binary or an MSI package, see Section 2.3, “Installing MySQL on Microsoft Windows”.

  For information on using the MySQL Server Instance Config Wizard, see Section 2.3.4, “MySQL Server Instance Configuration Wizard”.

  For details and instructions on building MySQL from source code using Microsoft Visual Studio, see Section 2.9, “Installing MySQL from Source”.

- **Mac OS X**

  For installation on Mac OS X, including using both the binary package and native PKG formats, see Section 2.4, “Installing MySQL on Mac OS X”.

  For information on making use of the MySQL Startup Item to automatically start and stop MySQL, see Section 2.4.3, “Installing the MySQL Startup Item”.

  For information on the MySQL Preference Pane, see Section 2.4.4, “Installing and Using the MySQL Preference Pane”.

- **IBM i5/OS**

2.1. General Installation Guidance

The immediately following sections contain the information necessary to choose, download, and verify your distribution. The instructions in later sections of the chapter describe how to install the distribution that you choose. For binary distributions, see the instructions at Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux” or the corresponding section for your platform if available. To build MySQL from source, use the instructions in Section 2.9, “Installing MySQL from Source”.

2.1.1. Operating Systems Supported by MySQL Community Server

This section lists the operating systems on which MySQL Community Server is known to run.

> **Important**
>
> Oracle Corporation does not necessarily provide official support for all the platforms listed in this section. For information about those platforms that are officially supported, see http://www.mysql.com/support/supportedplatforms.html on the MySQL Web site.

We use `CMake`, so it is possible to port MySQL to all modern systems that have a C++ compiler and a working implementation of POSIX threads. (Thread support is needed for the server. To compile only the client code, the only requirement is a C++ compiler.)

MySQL has been reported to compile successfully on the following combinations of operating system and thread package.

- FreeBSD 5.x and up with native threads. See Section 2.8, “Installing MySQL on FreeBSD”.
- HP-UX 11.x with the native threads. See Section 2.7, “Installing MySQL on HP-UX”.
- Linux. Builds on all recent Linux distributions based on the 2.6 kernel. See Section 2.5, “Installing MySQL on Linux”.
- Mac OS X. See Section 2.4, “Installing MySQL on Mac OS X”.
- Solaris 2.8 on SPARC and x86, including support for native threads. See Section 2.6, “Installing MySQL on Solaris and OpenSolaris”.
- Windows XP, Windows Vista, Windows Server 2003, and Windows Server 2008. See Section 2.3, “Installing MySQL on Microsoft Windows”.

MySQL has also been known to run on other systems in the past. See Section 2.1, “General Installation Guidance”. Some porting effort might be required for current versions of MySQL on these systems.

Not all platforms are equally well-suited for running MySQL. How well a certain platform is suited for a high-load mission-critical MySQL server is determined by the following factors:

- General stability of the thread library. A platform may have an excellent reputation otherwise, but MySQL is only as stable as the thread library it calls, even if everything else is perfect.

- The capability of the kernel and the thread library to take advantage of symmetric multi-processor (SMP) systems. In other words, when a process creates a thread, it should be possible for that thread to run on a CPU different from the original process.
- The capability of the kernel and the thread library to run many threads that acquire and release a mutex over a short critical region frequently without excessive context switches. If the implementation of `pthread_mutex_lock()` is too anxious to yield CPU time, this hurts MySQL tremendously. If this issue is not taken care of, adding extra CPUs actually makes MySQL slower.
- General file system stability and performance.
- Table size. If your tables are large, performance is affected by the ability of the file system to deal with large files and dealing with them efficiently.
- Our level of expertise here at Oracle Corporation with the platform. If we know a platform well, we enable platform-specific optimizations and fixes at compile time. We can also provide advice on configuring your system optimally for MySQL.
- The amount of testing we have done internally for similar configurations.
- The number of users that have run MySQL successfully on the platform in similar configurations. If this number is high, the likelihood of encountering platform-specific surprises is much smaller.

2.1.2. Choosing Which MySQL Distribution to Install

When preparing to install MySQL, you should decide which version to use. MySQL development occurs in several release series, and you can pick the one that best fits your needs. After deciding which version to install, you can choose a distribution format. Releases are available in binary or source format.

2.1.2.1. Choosing Which Version of MySQL to Install

The first decision to make is whether you want to use a production (stable) release or a development release. In the MySQL development process, multiple release series co-exist, each at a different stage of maturity.

Production Releases

- MySQL 5.5: Latest General Availability (Production) release
- MySQL 5.1: Previous stable (production-quality) release
- MySQL 5.0: Older stable release nearing the end of the product lifecycle

Development Release

- MySQL 5.6: Current release under development (pre-Production)

MySQL 4.1, 4.0, and 3.23 are old releases that are no longer supported.

See http://www.mysql.com/about/legal/lifecycle/ for information about support policies and schedules.

Normally, if you are beginning to use MySQL for the first time or trying to port it to some system for which there is no binary distribution, use the most recent General Availability series listed in the preceding descriptions. All MySQL releases, even those from development series, are checked with the MySQL benchmarks and an extensive test suite before being issued.

If you are running an older system and want to upgrade, but do not want to take the chance of having a nonseamless upgrade, you should upgrade to the latest version in the same release series you are using (where only the last part of the version number is newer than yours). We have tried to fix only fatal bugs and make only small, relatively “safe” changes to that version.

If you want to use new features not present in the production release series, you can use a version from a development series. Be aware that development releases are not as stable as production releases.

We do not use a complete code freeze because this prevents us from making bugfixes and other fixes that must be done. We may add small things that should not affect anything that currently works in a production release. Naturally, relevant bugfixes from an earlier series propagate to later series.

If you want to use the very latest sources containing all current patches and bugfixes, you can use one of our source code repositories (see Section 2.9.3, “Installing MySQL from a Development Source Tree”). These are not “releases” as such, but are available as previews of the code on which future releases are to be based.

The naming scheme in MySQL 5.5 uses release names that consist of three numbers and a suffix; for example, **mysql-5.5.6-m3**. The numbers within the release name are interpreted as follows:

- The first number (**5**) is the major version and describes the file format. All MySQL 5 releases have the same file format.
- The second number (**5**) is the release level. Taken together, the major version and release level constitute the release series number.
- The third number (**6**) is the version number within the release series. This is incremented for each new release. Usually you want the latest version for the series you have chosen.

For each minor update, the last number in the version string is incremented. When there are major new features or minor incompatibilities with previous versions, the second number in the version string is incremented. When the file format changes, the first number is increased.

Release names also include a suffix to indicates the stability level of the release. Releases within a series progress through a set of suffixes to indicate how the stability level improves. The possible suffixes are:

- **mN** (for example, **m1**, **m2**, **m3**, ...) indicate a milestone number. MySQL development uses a milestone model, in which each milestone proceeds through a small number of versions with a tight focus on a small subset of thoroughly tested features. Following the releases for one milestone, development proceeds with another small number of releases that focuses on the next small set of features, also thoroughly tested. Features within milestone releases may be considered to be of pre-production quality.
- **rc** indicates a Release Candidate. Release candidates are believed to be stable, having passed all of MySQL's internal testing, and with all known fatal runtime bugs fixed. However, the release has not been in widespread use long enough to know for sure that all bugs have been identified. Only minor fixes are added.
- If there is no suffix, it indicates that the release is a General Availability (GA) or Production release. GA releases are stable, having successfully passed through all earlier release stages and are believed to be reliable, free of serious bugs, and suitable for use in production systems. Only critical bugfixes are applied to the release.

All releases of MySQL are run through our standard tests and benchmarks to ensure that they are relatively safe to use. Because the standard tests are extended over time to check for all previously found bugs, the test suite keeps getting better.

All releases have been tested at least with these tools:

- **An internal test suite.** The `mysql-test` directory contains an extensive set of test cases. We run these tests for every server binary. See Section 21.1.2, “The MySQL Test Suite”, for more information about this test suite.
- **The MySQL benchmark suite.** This suite runs a range of common queries. It is also a test to determine whether the latest batch of optimizations actually made the code faster. See Section 7.12.2, “The MySQL Benchmark Suite”.

We also perform additional integration and nonfunctional testing of the latest MySQL version in our internal production environment. Integration testing is done with different connectors, storage engines, replication modes, backup, partitioning, stored programs, and so forth in various combinations. Additional nonfunctional testing is done in areas of performance, concurrency, stress, high volume, upgrade and downgrade.

2.1.2.2. Choosing a Distribution Format

After choosing which version of MySQL to install, you should decide whether to use a binary distribution or a source distribution. In most cases, you should probably use a binary distribution, if one exists for your platform. Binary distributions are available in native format for many platforms, such as RPM files for Linux or PKG package installers for Mac OS X or Solaris. Distributions also are available as Zip archives or compressed `tar` files.

Reasons to choose a binary distribution include the following:

- Binary distributions generally are easier to install than source distributions.
- To satisfy different user requirements, we provide several servers in binary distributions. `mysqld` is an optimized server that is

a smaller, faster binary. `mysqld-debug` is compiled with debugging support.

Each of these servers is compiled from the same source distribution, though with different configuration options. All native MySQL clients can connect to servers from either MySQL version.

Under some circumstances, you may be better off installing MySQL from a source distribution:

- You want to install MySQL at some explicit location. The standard binary distributions are ready to run at any installation location, but you might require even more flexibility to place MySQL components where you want.
- You want to configure `mysqld` to ensure that features are available that might not be included in the standard binary distributions. Here is a list of the most common extra options that you may want to use to ensure feature availability:
    - `-DWITH_LIBWRAP=1` for TCP wrappers support.
    - `-DWITH_ZLIB={system|bundled}` for features that depend on compression
    - `-DWITH_DEBUG=1` for debugging support
- You want to configure `mysqld` without some features that are included in the standard binary distributions. For example, distributions normally are compiled with support for all character sets. If you want a smaller MySQL server, you can recompile it with support for only the character sets you need.
- You want to use the latest sources from one of the Bazaar repositories to have access to all current bugfixes. For example, if you have found a bug and reported it to the MySQL development team, the bugfix is committed to the source repository and you can access it there. The bugfix does not appear in a release until a release actually is issued.
- You want to read (or modify) the C and C++ code that makes up MySQL. For this purpose, you should get a source distribution, because the source code is always the ultimate manual.
- Source distributions contain more tests and examples than binary distributions.

2.1.2.3. How and When Updates Are Released

MySQL is evolving quite rapidly and we want to share new developments with other MySQL users. We try to produce a new release whenever we have new and useful features that others also seem to have a need for.

We also try to help users who request features that are easy to implement. We take note of what our licensed users want, and we especially take note of what our support customers want and try to help them in this regard.

No one is *required* to download a new release. The News section helps you determine whether the new release has something you really want. See Appendix D, *MySQL Change History*.

We use the following policy when updating MySQL:

- Enterprise Server releases are meant to appear every 18 months, supplemented by quarterly service packs and monthly rapid updates. Community Server releases are meant to appear 2 to 3 times per year.
- Releases are issued within each series. For each release, the last number in the version is one more than the previous release within the same series.
- Binary distributions for some platforms are made by us for major releases. Other people may make binary distributions for other systems, but probably less frequently.
- We make fixes available as soon as we have identified and corrected small or noncritical but annoying bugs. The fixes are available in source form immediately from our public Bazaar repositories, and are included in the next release.
- If by any chance a security vulnerability or critical bug is found in a release, our policy is to fix it in a new release as soon as possible. (We would like other companies to do this, too!)

2.1.3. How to Get MySQL

Check our downloads page at http://dev.mysql.com/downloads/ for information about the current version of MySQL and for downloading instructions. For a complete up-to-date list of MySQL download mirror sites, see http://dev.mysql.com/downloads/mirrors.html. You can also find information there about becoming a MySQL mirror site and how to report a bad or out-of-date mirror.

To obtain the latest development source, see Section 2.9.3, “Installing MySQL from a Development Source Tree”.

2.1.4. Verifying Package Integrity Using MD5 Checksums or `GnuPG`

After you have downloaded the MySQL package that suits your needs and before you attempt to install it, you should make sure that it is intact and has not been tampered with. There are three means of integrity checking:

- MD5 checksums
- Cryptographic signatures using `GnuPG`, the GNU Privacy Guard
- For RPM packages, the built-in RPM integrity verification mechanism

The following sections describe how to use these methods.

If you notice that the MD5 checksum or GPG signatures do not match, first try to download the respective package one more time, perhaps from another mirror site. If you repeatedly cannot successfully verify the integrity of the package, please notify us about such incidents, including the full package name and the download site you have been using, at `<webmaster@mysql.com>` or `<build@mysql.com>`. Do not report downloading problems using the bug-reporting system.

2.1.4.1. Verifying the MD5 Checksum

After you have downloaded a MySQL package, you should make sure that its MD5 checksum matches the one provided on the MySQL download pages. Each package has an individual checksum that you can verify with the following command, where *`package_name`* is the name of the package you downloaded:

```
shell> md5sum package_name
```

Example:

```
shell> md5sum mysql-standard-5.5.16-linux-i686.tar.gz
aaab65abbec64d5e907dcd41b8699945  mysql-standard-5.5.16-linux-i686.tar.gz
```

You should verify that the resulting checksum (the string of hexadecimal digits) matches the one displayed on the download page immediately below the respective package.

> **Note**
>
> Make sure to verify the checksum of the *archive file* (for example, the `.zip` or `.tar.gz` file) and not of the files that are contained inside of the archive.

Note that not all operating systems support the `md5sum` command. On some, it is simply called `md5`, and others do not ship it at all. On Linux, it is part of the **GNU Text Utilities** package, which is available for a wide range of platforms. You can download the source code from http://www.gnu.org/software/textutils/ as well. If you have OpenSSL installed, you can use the command `openssl md5 package_name` instead. A Windows implementation of the `md5` command line utility is available from http://www.fourmilab.ch/md5/. `winMd5Sum` is a graphical MD5 checking tool that can be obtained from http://www.nullriver.com/index/products/winmd5sum.

2.1.4.2. Signature Checking Using `GnuPG`

Another method of verifying the integrity and authenticity of a package is to use cryptographic signatures. This is more reliable than using MD5 checksums, but requires more work.

We sign MySQL downloadable packages with `GnuPG` (GNU Privacy Guard). `GnuPG` is an Open Source alternative to the well-known Pretty Good Privacy (`PGP`) by Phil Zimmermann. See http://www.gnupg.org/ for more information about `GnuPG` and how to obtain and install it on your system. Most Linux distributions ship with `GnuPG` installed by default. For more information about `GnuPG`, see http://www.openpgp.org/.

To verify the signature for a specific package, you first need to obtain a copy of our public GPG build key, which you can download from http://keyserver.pgp.com/. The key that you want to obtain is named `build@mysql.com`. Alternatively, you can cut and paste the key directly from the following text:

```
-----BEGIN PGP PUBLIC KEY BLOCK-----
Version: GnuPG v1.4.5 (GNU/Linux)

mQGiBD4+owwRBAC14GIfUfCyEDSIePvEW3SAFUdJBtoQHH/nJKZyQT7h9bPlUWC3
RODjQReyCITRrdwyrKUGku2FmeVGwn2u2WmDMNABLnpprWPkBdCk96+OmSLN9brZ
fw2vOUgCmYv2hW0hyDHuvYlQA/BThQoADgj8AW6/0Lo7V1W9/8VuHP0gQwCgvzV3
```

```
BqOxRznNCRCRxAuAuVztHRcEAJooQK1+iSiunZMYD1WufeXfshc57S/+yeJkegNW
hxwR9pRWVArNYJdDRT+rf2RUe3vpquKNQU/hnEIUHJRQqYHo8gTxvxXNQc7fJYLV
K2HtkrPbP72vwsEKMYhhr0eKCbtLGfls9krjJ6sBgACyP/Vb7hiPwxh6rDZ7ITnE
kYpXBACmWpP8NJTkamEnPCia2ZoOHODANwpUkP43I7jsDmgtobZX9qnrAXw+uNDI
QJEXM6FSbi0LLtZciNlYsafwAPEOMDKpMqAK6IyisNtPvaLd8lH0bPAnWqcyefep
rv0sxxqUEMcM3o7wwgfN83POkDasDbs3pjwPhxvhz6//62zQJ7Q7TXlTUUwgUGFj
a2FnZSBzaWduaW5nIGtleSAod3d3Lm15c3FsLmNvbSkgPGJ1aWxkQG15c3FsLmNv
bT6IXQQTEQIAHQULBwoDBAMVAwIDFgIBAheABQJLcC5lBQkQ8/JZAAoJEIxxjTtQ
cuH1oD4AoIcOQ4EoGsZvy06D0Ei5vcsWEy8dAJ4g46i3WEcdSWxMhcBSsPz65sh5
lohMBBMRAgAMBQI+PqPRBYMJZgC7AAoJEElQ4SqycpHyJOEAn1mxHijft00bKXvu
cSo/pECUmppiAJ41M9MRVj5VcdH/KN/KjRtW6tHFPYhMBBMRAgAMBQI+QoIDBYMJ
YiKJAAoJELb1zU3GuiQ/lpEAoIhpp6BozKI8p6eaabzF5MlJH58pAKCu/ROofK8J
Eg2aLos+5zEYrB/LsrkCDQQ+PqMdEAgA7+GJfxbMdY4wslPnjH9rF4N2qfWsEN/l
xaZoJYc3a6M02WCnHl6ahT2/tBK2w1QI4YFteR47gCvtgb6O1JHffOo2HfLmRDRi
Rjd1DTCHqeyX7CHhcghj/dNRlW2Z0l5QFEcmV9U0Vhp3aFfWC4Ujfs3LU+hkAWzE
7zaD5cH9J7yv/6xuZVw411x0h4UqsTcWMu0iM1BzELqX1DY7LwoPEb/O9Rkbf4fm
Le11EzIaCa4PqARXQZc4dhSinMt6K3X4BrRsKTfozBu74F47D8Ilbf5vSYHbuE5p
/1oIDznkg/p8kW+3FxuWrycciqFTcNz215yyX39LXFnlLzKUb/F5GwADBQf+Lwqq
a8CGrRfsOAJxim63CHfty5mUc5rUSnTslGYEIOCR1BeQauyPZbPDsDD9MZ1ZaSaf
anFvwFG6Llx9xkU7tzq+vKLoWkm4u5xf3vn55VjnSd1aQ9eQnUcXiL4cnBGoTbOW
I39EcyzgslzBdC++MPjcQTcA7p6JUVsP6oAB3FQWg54tuUo0Ec8bsM8b3Ev42Lmu
QT5NdKHGwHsXTPtl0klk4bQk4OajHsiy1BMahpT27jWjJlMiJc+IWJ0mghkKHt92
6s/ymfdf5HkdQ1cyvsz5tryVI3Fx78XeSYfQvuuwqp2H139pXGEkg0n6KdUOetdZ
Whe70YGNPw1yjWJT1IhMBBgRAgAMBQI+PqMdBQkJZgGAAAoJEIxxjTtQcuH17p4A
n3r1QpVC9yhnW2cSAjq+kr72GX0eAJ4295kl6NxYEuFApmr1+0uUq/SlsQ==
=Mski

-----END PGP PUBLIC KEY BLOCK-----
```

To import the build key into your personal public GPG keyring, use `gpg --import`. For example, if you have saved the key in a file named `mysql_pubkey.asc`, the import command looks like this:

```
shell> gpg --import mysql_pubkey.asc
gpg: key 5072E1F5: public key "MySQL Package signing key (www.mysql.com) <build@mysql.com>" imported
gpg: Total number processed: 1
gpg:               imported: 1
gpg: no ultimately trusted keys found
```

You can also download the key from the public keyserver using the public key id, `5072E1F5`:

```
shell> gpg --recv-keys 5072E1F5
gpg: requesting key 5072E1F5 from hkp server subkeys.pgp.net
gpg: key 5072E1F5: "MySQL Package signing key (www.mysql.com) <build@mysql.com>" 2 new signatures
gpg: no ultimately trusted keys found
gpg: Total number processed: 1
gpg:         new signatures: 2
```

If you want to import the key into your RPM configuration to validate RPM install packages, you should be able to import the key directly:

```
shell> rpm --import mysql_pubkey.asc
```

If you experience problems, try exporting the key from `gpg` and importing:

```
shell> gpg --export -a 5072e1f5 > 5072e1f5.asc
shell> rpm --import 5072e1f5.asc
```

Alternatively, `rpm` also supports loading the key directly from a URL, and you cas use this manual page:

```
shell> rpm --import http://dev.mysql.com/doc/refman/5.5/en/checking-gpg-signature.html
```

After you have downloaded and imported the public build key, download your desired MySQL package and the corresponding signature, which also is available from the download page. The signature file has the same name as the distribution file with an `.asc` extension, as shown by the examples in the following table.

Table 2.1. MySQL Package and Signature Files

File Type	File Name
Distribution file	`mysql-standard-5.5.16-linux-i686.tar.gz`
Signature file	`mysql-standard-5.5.16-linux-i686.tar.gz.asc`

Make sure that both files are stored in the same directory and then run the following command to verify the signature for the distribution file:

```
shell> gpg --verify package_name.asc
```

Example:

```
shell> gpg --verify mysql-standard-5.5.16-linux-i686.tar.gz.asc
gpg: Signature made Tue 12 Jul 2005 23:35:41 EST using DSA key ID 5072E1F5
gpg: Good signature from "MySQL Package signing key (www.mysql.com) <build@mysql.com>"
```

The `Good signature` message indicates that everything is all right. You can ignore any `insecure memory` warning you might obtain.

See the GPG documentation for more information on how to work with public keys.

2.1.4.3. Signature Checking Using `RPM`

For RPM packages, there is no separate signature. RPM packages have a built-in GPG signature and MD5 checksum. You can verify a package by running the following command:

```
shell> rpm --checksig package_name.rpm
```

Example:

```
shell> rpm --checksig MySQL-server-5.5.16-0.glibc23.i386.rpm
MySQL-server-5.5.16-0.glibc23.i386.rpm: md5 gpg OK
```

> **Note**
>
> If you are using RPM 4.1 and it complains about `(GPG) NOT OK (MISSING KEYS: GPG#5072e1f5)`, even though you have imported the MySQL public build key into your own GPG keyring, you need to import the key into the RPM keyring first. RPM 4.1 no longer uses your personal GPG keyring (or GPG itself). Rather, RPM maintains a separate keyring because it is a system-wide application and a user's GPG public keyring is a user-specific file. To import the MySQL public key into the RPM keyring, first obtain the key as described in Section 2.1.4.2, "Signature Checking Using `GnuPG`". Then use `rpm --import` to import the key. For example, if you have saved the public key in a file named `mysql_pubkey.asc`, import it using this command:

```
shell> rpm --import mysql_pubkey.asc
```

If you need to obtain the MySQL public key, see Section 2.1.4.2, "Signature Checking Using `GnuPG`".

2.1.5. Installation Layouts

The installation layout differs for different installation types (for example, native packages, binary tarballs, and source tarballs), which can lead to confusion when managing different systems or using different installation sources. The individual layouts are given in the corresponding installation type or platform chapter, as described following. Note that the layout of installations from vendors other than Oracle may differ from these layouts.

- Section 2.3.1, "MySQL Installation Layout on Microsoft Windows"
- Section 2.9.1, "MySQL Layout for Source Installation"
- Table 2.2, "MySQL Installation Layout for Generic Unix/Linux Binary Package"
- Table 2.11, "MySQL Installation Layout for Linux RPM"
- Table 2.8, "MySQL Installation Layout on Mac OS X"

2.1.6. Compiler-Specific Build Characteristics

In some cases, the compiler used to build MySQL affects the features available for use. The notes in this section apply for binary distributions provided by Oracle Corporation or that you compile yourself from source.

`icc` (Intel C++ Compiler) Builds

A server built with `icc` has these characteristics:

- SSL support is not included.

2.2. Installing MySQL from Generic Binaries on Unix/Linux

Oracle provides a set of binary distributions of MySQL. These include binary distributions in the form of compressed `tar` files (files with a `.tar.gz` extension) for a number of platforms, as well as binaries in platform-specific package formats for selected platforms.

This section covers the installation of MySQL from a compressed `tar` file binary distribution. For other platform-specific package formats, see the other platform-specific sections. For example, for Windows distributions, see Section 2.3, “Installing MySQL on Microsoft Windows”.

To obtain MySQL, see Section 2.1.3, “How to Get MySQL”.

MySQL compressed `tar` file binary distributions have names of the form `mysql-`*`VERSION`*`-`*`OS`*`.tar.gz`, where *`VERSION`* is a number (for example, `5.5.16`), and *`OS`* indicates the type of operating system for which the distribution is intended (for example, `pc-linux-i686` or `winx64`).

To install MySQL from a compressed `tar` file binary distribution, your system must have GNU `gunzip` to uncompress the distribution and a reasonable `tar` to unpack it. If your `tar` program supports the `z` option, it can both uncompress and unpack the file.

GNU `tar` is known to work. The standard `tar` provided with some operating systems is not able to unpack the long file names in the MySQL distribution. You should download and install GNU `tar`, or if available, use a preinstalled version of GNU tar. Usually this is available as `gnutar`, `gtar`, or as `tar` within a GNU or Free Software directory, such as `/usr/sfw/bin` or `/usr/local/bin`. GNU `tar` is available from http://www.gnu.org/software/tar/.

> **Warning**
>
> If you have previously installed MySQL using your operating system native package management system, such as `yum` or `apt-get`, you may experience problems installing using a native binary. Make sure your previous MySQL previous installation has been removed entirely (using your package management system), and that any additional files, such as old versions of your data files, have also been removed. You should also check the existence of configuration files such as `/etc/my.cnf` or the `/etc/mysql` directory have been deleted.

If you run into problems and need to file a bug report, please use the instructions in Section 1.7, “How to Report Bugs or Problems”.

On Unix, to install a compressed `tar` file binary distribution, unpack it at the installation location you choose (typically `/usr/local/mysql`). This creates the directories shown in the following table.

Table 2.2. MySQL Installation Layout for Generic Unix/Linux Binary Package

Directory	Contents of Directory
`bin`	Client programs and the `mysqld` server
`data`	Log files, databases
`docs`	Manual in Info format
`man`	Unix manual pages
`include`	Include (header) files
`lib`	Libraries
`scripts`	`mysql_install_db`
`share`	Miscellaneous support files, including error messages, sample configuration files, SQL for database installation
`sql-bench`	Benchmarks

Debug versions of the `mysqld` binary are available as `mysqld-debug`. To compile your own debug version of MySQL from a source distribution, use the appropriate configuration options to enable debugging support. For more information on compiling from source, see Section 2.9, “Installing MySQL from Source”.

To install and use a MySQL binary distribution, the basic command sequence looks like this:

```
shell> groupadd mysql
shell> useradd -r -g mysql mysql
shell> cd /usr/local
shell> tar zxvf /path/to/mysql-VERSION-OS.tar.gz
shell> ln -s full-path-to-mysql-VERSION-OS mysql
shell> cd mysql
shell> chown -R mysql .
shell> chgrp -R mysql .
shell> scripts/mysql_install_db --user=mysql
shell> chown -R root .
shell> chown -R mysql data
# Next command is optional
shell> cp support-files/my-medium.cnf /etc/my.cnf
shell> bin/mysqld_safe --user=mysql &
# Next command is optional
shell> cp support-files/mysql.server /etc/init.d/mysql.server
```

A more detailed version of the preceding description for installing a binary distribution follows.

> **Note**
>
> This procedure assumes that you have `root` (administrator) access to your system. Alternatively, you can prefix each command using the `sudo` (Linux) or `pfexec` (OpenSolaris) command.
>
> The procedure does not set up any passwords for MySQL accounts. After following the procedure, proceed to Section 2.10, “Postinstallation Setup and Testing”.

Create a `mysql` User and Group

If your system does not already have a user and group for `mysqld` to run as, you may need to create one. The following commands add the `mysql` group and the `mysql` user. You might want to call the user and group something else instead of `mysql`. If so, substitute the appropriate name in the following instructions. The syntax for `useradd` and `groupadd` may differ slightly on different versions of Unix, or they may have different names such as `adduser` and `addgroup`.

```
shell> groupadd mysql
shell> useradd -r -g mysql mysql
```

> **Note**
>
> Because the user is required only for ownership purposes, not login purposes, the `useradd` command uses the `-r` option to create a user that does not have login permissions to your server host. Omit this option to permit logins for the user (or if your `useradd` does not support the option).

Obtain and Unpack the Distribution

Pick the directory under which you want to unpack the distribution and change location into it. The example here unpacks the distribution under `/usr/local`. The instructions, therefore, assume that you have permission to create files and directories in `/usr/local`. If that directory is protected, you must perform the installation as `root`.

```
shell> cd /usr/local
```

Obtain a distribution file using the instructions in Section 2.1.3, “How to Get MySQL”. For a given release, binary distributions for all platforms are built from the same MySQL source distribution.

Unpack the distribution, which creates the installation directory. Then create a symbolic link to that directory. `tar` can uncompress and unpack the distribution if it has `z` option support:

```
shell> tar zxvf /path/to/mysql-VERSION-OS.tar.gz
shell> ln -s full-path-to-mysql-VERSION-OS mysql
```

The `tar` command creates a directory named `mysql-VERSION-OS`. The `ln` command makes a symbolic link to that directory. This enables you to refer more easily to the installation directory as `/usr/local/mysql`.

If your `tar` does not have `z` option support, use `gunzip` to unpack the distribution and `tar` to unpack it. Replace the preceding `tar` command with the following alternative command to uncompress and extract the distribution:

```
shell> gunzip < /path/to/mysql-VERSION-OS.tar.gz | tar xvf -
```

Perform Postinstallation Setup

The remainder of the installation process involves setting up the configuration file, creating the core databases, and starting the MySQL server. For instructions, see Section 2.10, “Postinstallation Setup and Testing”.

> **Note**
>
> The accounts that are listed in the MySQL grant tables initially have no passwords. After starting the server, you should set up passwords for them using the instructions in Section 2.10, “Postinstallation Setup and Testing”.

2.3. Installing MySQL on Microsoft Windows

A native Windows distribution of MySQL has been available since version 3.21 and represents a sizable percentage of the daily downloads of MySQL. This section describes the process for installing MySQL on Windows.

> **Note**
>
> If you are upgrading MySQL from an existing installation older than MySQL 4.1.5, you must first perform the procedure described in Section 2.3.7, “Upgrading MySQL on Windows”.

To run MySQL on Windows, you need the following:

- A Windows operating system such as Windows 2000, Windows XP, Windows Vista, Windows Server 2003, or Windows Server 2008. Both 32-bit and 64-bit versions are supported.

  A Windows operating system permits you to run the MySQL server as a service. See Section 2.3.5.7, “Starting MySQL as a Windows Service”.

  Generally, you should install MySQL on Windows using an account that has administrator rights. Otherwise, you may encounter problems with certain operations such as editing the `PATH` environment variable or accessing the `Service Control Manager`. Once installed, MySQL does not need to be executed using a user with Administrator privileges.

- TCP/IP protocol support.

- Enough space on the hard drive to unpack, install, and create the databases in accordance with your requirements (generally a minimum of 200 megabytes is recommended.)

For a list of limitations within the Windows version of MySQL, see Section E.9.5, “Windows Platform Limitations”.

There may also be other requirements, depending on how you plan to use MySQL:

- If you plan to connect to the MySQL server using ODBC, you need a Connector/ODBC driver. See Section 20.1, “MySQL Connector/ODBC”.

- If you plan to use MySQL server with ADO.NET applications, you need the Connector/Net driver. See Section 20.2, “MySQL Connector/Net”.

- If you need tables with a size larger than 4GB, install MySQL on an NTFS or newer file system. Do not forget to use `MAX_ROWS` and `AVG_ROW_LENGTH` when you create tables. See Section 12.1.14, “`CREATE TABLE` Syntax”.

MySQL for Windows is available in several distribution formats:

- Binary distributions are available that contain a setup program that installs everything you need so that you can start the server immediately. Another binary distribution format contains an archive that you simply unpack in the installation location and then configure yourself. For details, see Section 2.3.2, “Choosing An Installation Package”.

- The source distribution contains all the code and support files for building the executables using the Visual Studio compiler system.

Generally speaking, you should use a binary distribution that includes an installer. It is simpler to use than the others, and you need no additional tools to get MySQL up and running. The installer for the Windows version of MySQL, combined with a GUI Configuration Wizard, automatically installs MySQL, creates an option file, starts the server, and secures the default user accounts.

> **Caution**
>
> Using virus scanning software such as Norton/Symantec Anti-Virus on directories containing MySQL data and temporary tables can cause issues, both in terms of the performance of MySQL and the virus-scanning software misidentifying the contents of the files as containing spam. This is because of the fingerprinting mechanism used by the virus scanning software, and the way in which MySQL rapidly updates different files, which may be identified as a potential security risk.
>
> After installing MySQL Server, it is recommended that you disable virus scanning on the main directory (`datadir`) being used to store your MySQL table data. There is usually a system built into the virus scanning software to enable certain directories to be specifically ignored during virus scanning.

> In addition, by default, MySQL creates temporary files in the standard Windows temporary directory. To prevent the temporary files also being scanned, you should configure a separate temporary directory for MySQL temporary files and add this to the virus scanning exclusion list. To do this, add a configuration option for the `tmpdir` parameter to your `my.ini` configuration file. For more information, see Section 2.3.5.2, “Creating an Option File”.

The following section describes how to install MySQL on Windows using a binary distribution. To use an installation package that does not include an installer, follow the procedure described in Section 2.3.5, “Installing MySQL on Microsoft Windows Using a `noinstall` Zip Archive”. To install using a source distribution, see Section 2.9, “Installing MySQL from Source”.

MySQL distributions for Windows can be downloaded from http://dev.mysql.com/downloads/. See Section 2.1.3, “How to Get MySQL”.

2.3.1. MySQL Installation Layout on Microsoft Windows

For MySQL 5.5 on Windows, the default installation directory is `C:\Program Files\MySQL\MySQL Server 5.5`. Some Windows users prefer to install in `C:\mysql`, the directory that formerly was used as the default. However, the layout of the subdirectories remains the same.

All of the files are located within this parent directory, using the structure shown in the following table.

Table 2.3. MySQL Installation Layout for Windows

Directory	Contents of Directory
`bin`	Client programs and the `mysqld` server
`C:\Documents and Settings\All Users\Application Data\MySQL`	Log files, databases (Windows XP, Windows Server 2003)
`C:\ProgramData\MySQL`	Log files, databases (Windows 7, Windows Server 2008)
`examples`	Example programs and scripts
`include`	Include (header) files
`lib`	Libraries
`scripts`	Utility scripts
`share`	Miscellaneous support files, including error messages, character set files, sample configuration files, SQL for database installation

If you install MySQL using a Windows MSI package, this package creates and sets up the data directory that the installed server will use, but as of MySQL 5.5.5, it also creates a pristine “template” data directory named `data` under the installation directory. This directory can be useful when the machine will be used to run multiple instances of MySQL: After an installation has been performed using an MSI package, the template data directory can be copied to set up additional MySQL instances. See Section 5.6, “Running Multiple MySQL Instances on One Machine”.

2.3.2. Choosing An Installation Package

For MySQL 5.5, there are installation package formats to choose from when installing MySQL on Windows:

- **The Complete Package**: This package has a file name similar to `mysql-5.5.16-win32.msi` and contains all files needed for a complete Windows installation, including the Configuration Wizard. This package includes optional components such as the embedded server and benchmark suite.
- **The Noinstall Archive**: This package has a file name similar to `mysql-5.5.16-win32.zip` and contains all the files found in the Complete install package, with the exception of the Configuration Wizard. This package does not include an automated installer, and must be manually installed and configured.

The Complete package is recommended for most users. The Complete distribution is available as an `.msi` file for use with the Windows Installer. The Noinstall distribution is packaged as a Zip archive. To use a Zip archive, you must have a tool that can unpack `.zip` files.

Your choice of install package affects the installation process you must follow. If you choose to install a Complete install package, see Section 2.3.3, “Installing MySQL on Microsoft Windows Using an MSI Package”. If you choose to install a Noinstall archive, see Section 2.3.5, “Installing MySQL on Microsoft Windows Using a `noinstall` Zip Archive”.

2.3.3. Installing MySQL on Microsoft Windows Using an MSI Package

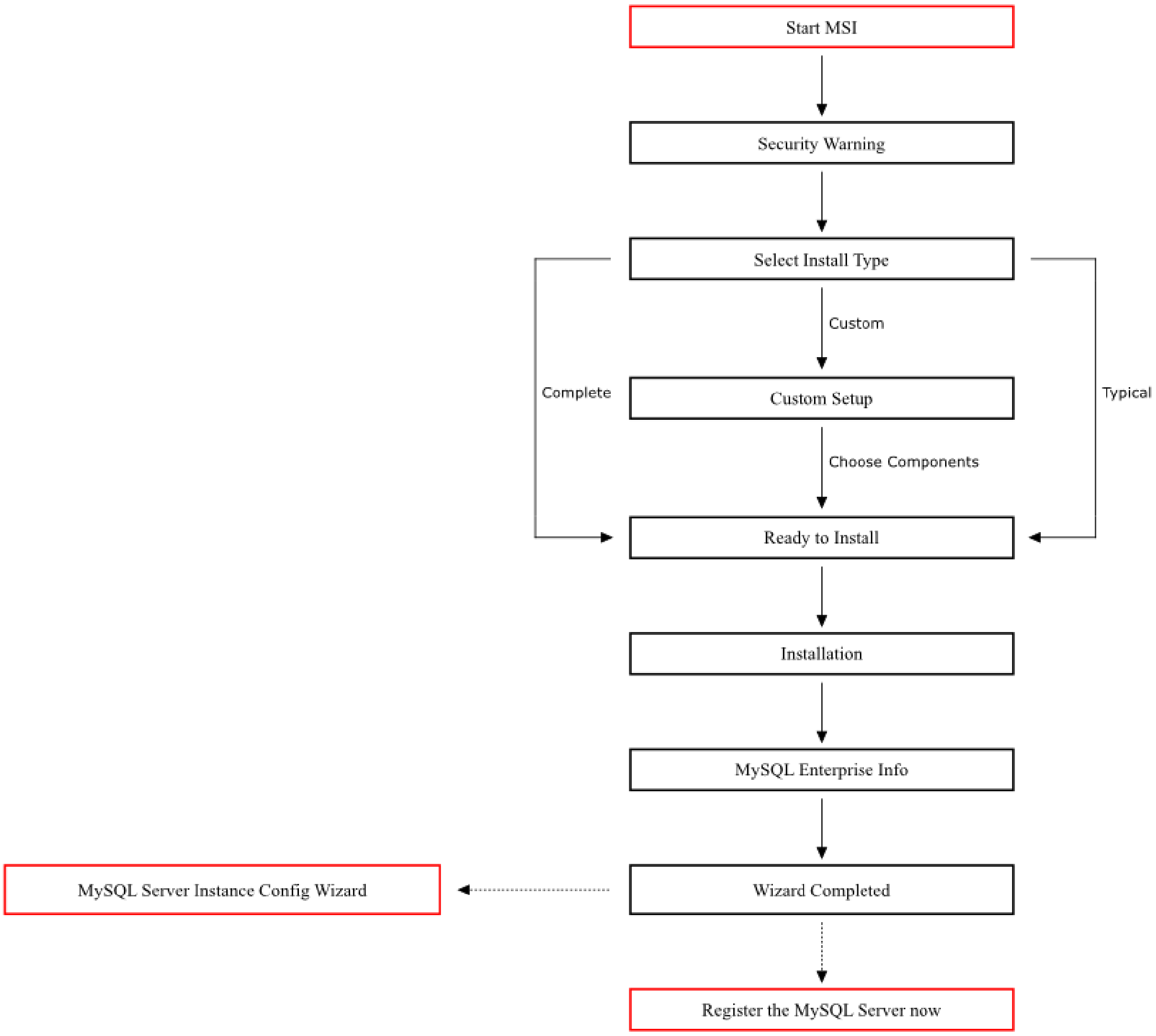
The MSI package is designed to install and configure MySQL in such a way that you can immediately get started using MySQL.

The MySQL Installation Wizard and MySQL Configuration Wizard are available in the Complete install package, which is recommended for most standard MySQL installations. Exceptions include users who need to install multiple instances of MySQL on a single server host and advanced users who want complete control of server configuration.

- For information on installing using the GUI MSI installer process, see Section 2.3.3.1, “Using the MySQL Installation Wizard”.
- For information on installing using the command line using the MSI package, see Section 2.3.3.2, “Automating MySQL Installation on Microsoft Windows using the MSI Package”.
- If you have previously installed MySQL using the MSI package and want to remove MySQL, see Section 2.3.3.3, “Removing MySQL When Installed from the MSI Package”.

The workflow sequence for using the installer is shown in the figure below:

Figure 2.1. Installation Workflow for Windows using MSI Installer


Start MSI
Security Warning
Select Install Type
Custom
Complete
Custom Setup
Typical
Choose Components
Ready to Install
Installation
MySQL Enterprise Info
MySQL Server Instance Config Wizard
Wizard Completed
Register the MySQL Server now

Note

Microsoft Windows XP and later include a firewall which specifically blocks ports. If you plan on using MySQL through a network port then you should open and create an exception for this port before performing the installation. To check and if necessary add an exception to the firewall settings:

1. First ensure that you are logged in as an Administrator or a user with Administrator privileges.
2. Go to the **Control Panel**, and double click the **Windows Firewall** icon.
3. Choose the **Allow a program through Windows Firewall** option and click the Add port button.
4. Enter `MySQL` into the **Name** text box and `3306` (or the port of your choice) into the **Port number** text box.
5. Also ensure that the **TCP** protocol radio button is selected.
6. If you wish, you can also limit access to the MySQL server by choosing the **Change scope** button.
7. Confirm your choices by clicking the OK button.

Additionally, when running the MySQL Installation Wizard on Windows Vista or newer, ensure that you are logged in as a user with administrative rights.

Note

When using Windows Vista or newer, you may want to disable User Account Control (UAC) before performing the installation. If you do not do so, then MySQL may be identified as a security risk, which will mean that you need to enable MySQL. You can disable the security checking by following these instructions:

1. Open **Control Panel**.
2. Under the **User Accounts and Family Safety**, select **Add or remove user accounts.**
3. Click the **Got to the main User Accounts page** link.
4. Click on **Turn User Account Control on or off**. You may be prompted to provide permission to change this setting. Click Continue.
5. Deselect or uncheck the check box next to **Use User Account Control (UAC) to help protect your computer**. Click OK to save the setting.

You will need to restart to complete the process. Click Restart Now to reboot the machine and apply the changes. You can then follow the instructions below for installing Windows.

2.3.3.1. Using the MySQL Installation Wizard

MySQL Installation Wizard is an installer for the MySQL server that uses the latest installer technologies for Microsoft Windows. The MySQL Installation Wizard, in combination with the MySQL Configuration Wizard, enables a user to install and configure a MySQL server that is ready for use immediately after installation.

The MySQL Installation Wizard is the standard installer for all MySQL server distributions, version 4.1.5 and higher. Users of previous versions of MySQL need to shut down and remove their existing MySQL installations manually before installing MySQL with the MySQL Installation Wizard. See Section 2.3.3.1.6, “Upgrading MySQL with the Installation Wizard”, for more information on upgrading from a previous version.

Microsoft has included an improved version of their Microsoft Windows Installer (MSI) in the recent versions of Windows. MSI has become the de-facto standard for application installations on Windows 2000, Windows XP, and Windows Server 2003. The MySQL Installation Wizard makes use of this technology to provide a smoother and more flexible installation process.

The Microsoft Windows Installer Engine was updated with the release of Windows XP; those using a previous version of Windows can reference this Microsoft Knowledge Base article for information on upgrading to the latest version of the Windows Installer Engine.

In addition, Microsoft has introduced the WiX (Windows Installer XML) toolkit recently. This is the first highly acknowledged Open Source project from Microsoft. We have switched to WiX because it is an Open Source project and it enables us to handle the complete Windows installation process in a flexible manner using scripts.

Improving the MySQL Installation Wizard depends on the support and feedback of users like you. If you find that the MySQL Installation Wizard is lacking some feature important to you, or if you discover a bug, please report it in our bugs database using the instructions given in Section 1.7, “How to Report Bugs or Problems”.

2.3.3.1.1. Downloading and Starting the MySQL Installation Wizard

The MySQL installation packages can be downloaded from http://dev.mysql.com/downloads/. If the package you download is contained within a Zip archive, you need to extract the archive first.

> **Note**
>
> If you are installing on Windows Vista or newer, it is best to open a network port before beginning the installation. To do this, first ensure that you are logged in as an Administrator, go to the `Control Panel`, and double-click the `Windows Firewall` icon. Choose the `Allow a program through Windows Firewall` option and click the ADD PORT button. Enter `MySQL` into the **NAME** text box and `3306` (or the port of your choice) into the **PORT NUMBER** text box. Also ensure that the **TCP** protocol radio button is selected. If you wish, you can also limit access to the MySQL server by choosing the **CHANGE SCOPE** button. Confirm your choices by clicking the OK button. If you do not open a port prior to installation, you cannot configure the MySQL server immediately after installation. Additionally, when running the MySQL Installation Wizard on Windows Vista or newer, ensure that you are logged in as a user with administrative rights.

The process for starting the wizard depends on the contents of the installation package you download. If there is a `setup.exe` file present, double-click it to start the installation process. If there is an `.msi` file present, double-click it to start the installation process.

2.3.3.1.2. Choosing an Install Type

There are three installation types available: **Typical**, **Complete**, and **Custom**.

The **Typical** installation type installs the MySQL server, the `mysql` command-line client, and the command-line utilities. The command-line clients and utilities include `mysqldump`, `myisamchk`, and several other tools to help you manage the MySQL server.

The **Complete** installation type installs all components included in the installation package. The full installation package includes components such as the embedded server library, the benchmark suite, support scripts, and documentation.

The **Custom** installation type gives you complete control over which packages you wish to install and the installation path that is used. See Section 2.3.3.1.3, “The Custom Install Dialog”, for more information on performing a custom install.

If you choose the **Typical** or **Complete** installation types and click the NEXT button, you advance to the confirmation screen to verify your choices and begin the installation. If you choose the **Custom** installation type and click the NEXT button, you advance to the custom installation dialog, described in Section 2.3.3.1.3, “The Custom Install Dialog”.

2.3.3.1.3. The Custom Install Dialog

If you wish to change the installation path or the specific components that are installed by the MySQL Installation Wizard, choose the **Custom** installation type.

A tree view on the left side of the custom install dialog lists all available components. Components that are not installed have a red X icon; components that are installed have a gray icon. To change whether a component is installed, click that component's icon and choose a new option from the drop-down list that appears.

You can change the default installation path by clicking the CHANGE... button to the right of the displayed installation path.

After choosing your installation components and installation path, click the NEXT button to advance to the confirmation dialog.

2.3.3.1.4. The Confirmation Dialog

Once you choose an installation type and optionally choose your installation components, you advance to the confirmation dialog. Your installation type and installation path are displayed for you to review.

To install MySQL if you are satisfied with your settings, click the INSTALL button. To change your settings, click the BACK button. To exit the MySQL Installation Wizard without installing MySQL, click the CANCEL button.

The final screen of the installer provides a summary of the installation and gives you the option to launch the MySQL Configuration Wizard, which you can use to create a configuration file, install the MySQL service, and configure security settings.

2.3.3.1.5. Changes Made by MySQL Installation Wizard

Once you click the INSTALL button, the MySQL Installation Wizard begins the installation process and makes certain changes to your system which are described in the sections that follow.

Changes to the Registry

The MySQL Installation Wizard creates one Windows registry key in a typical install situation, located in `HKEY_LOCAL_MACHINE\SOFTWARE\MySQL AB`.

The MySQL Installation Wizard creates a key named after the major version of the server that is being installed, such as `MySQL`

`Server 5.5`. It contains two string values, `Location` and `Version`. The `Location` string contains the path to the installation directory. In a default installation it contains `C:\Program Files\MySQL\MySQL Server 5.5\`. The `Version` string contains the release number. For example, for an installation of MySQL Server 5.5.16, the key contains a value of `5.5.16`.

These registry keys are used to help external tools identify the installed location of the MySQL server, preventing a complete scan of the hard-disk to determine the installation path of the MySQL server. The registry keys are not required to run the server, and if you install MySQL using the `noinstall` Zip archive, the registry keys are not created.

Changes to the Start Menu

The MySQL Installation Wizard creates a new entry in the Windows START menu under a common MySQL menu heading named after the major version of MySQL that you have installed. For example, if you install MySQL 5.5, the MySQL Installation Wizard creates a MySQL Server 5.5 section in the START menu.

The following entries are created within the new START menu section:

- MySQL Command Line Client: This is a shortcut to the `mysql` command-line client and is configured to connect as the `root` user. The shortcut prompts for a `root` user password when you connect.
- MySQL Server Instance Config Wizard: This is a shortcut to the MySQL Configuration Wizard. Use this shortcut to configure a newly installed server, or to reconfigure an existing server.
- MySQL Documentation: This is a link to the MySQL server documentation that is stored locally in the MySQL server installation directory.

Changes to the File System

The MySQL Installation Wizard by default installs the MySQL 5.5 server to `C:\Program Files\MySQL\MySQL Server 5.5`, where *`Program Files`* is the default location for applications in your system, and *`5.5`* is the major version of your MySQL server. This is the recommended location for the MySQL server, replacing the former default location `C:\mysql`.

By default, all MySQL applications are stored in a common directory at `C:\Program Files\MySQL`, where *`Program Files`* is the default location for applications in your Windows installation. A typical MySQL installation on a developer machine might look like this:

```
C:\Program Files\MySQL\MySQL Server 5.5
C:\Program Files\MySQL\MySQL Workbench 5.1 OSS
```

This approach makes it easier to manage and maintain all MySQL applications installed on a particular system.

The default location of the data directory is the `AppData` directory configured for the user that installed the MySQL application.

2.3.3.1.6. Upgrading MySQL with the Installation Wizard

The MySQL Installation Wizard can perform server upgrades automatically using the upgrade capabilities of MSI. That means you do not need to remove a previous installation manually before installing a new release. The installer automatically shuts down and removes the previous MySQL service before installing the new version.

Automatic upgrades are available only when upgrading between installations that have the same major and minor version numbers. For example, you can upgrade automatically from MySQL 5.5.5 to MySQL 5.5.6, but not from MySQL 5.1 to MySQL 5.5.

See Section 2.3.7, “Upgrading MySQL on Windows”.

2.3.3.2. Automating MySQL Installation on Microsoft Windows using the MSI Package

The Microsoft Installer (MSI) supports a both a *quiet* and a *passive* mode that can be used to install MySQL automatically without requiring intervention. You can use this either in scripts to automatically install MySQL or through a terminal connection such as Telnet where you do not have access to the standard Windows user interface. The MSI packages can also be used in combination with Microsoft's Group Policy system (part of Windows Server 2003 and Windows Server 2008) to install MySQL across multiple machines.

To install MySQL from one of the MSI packages automatically from the command line (or within a script), you need to use the `msiexec.exe` tool. For example, to perform a quiet installation (which shows no dialog boxes or progress):

```
shell> msiexec /i /quiet mysql-5.5.16.msi
```

The `/i` indicates that you want to perform an installation. The `/quiet` option indicates that you want no interactive elements.

To provide a dialog box showing the progress during installation, and the dialog boxes providing information on the installation and registration of MySQL, use `/passive` mode instead of `/quiet`:

```
shell> msiexec /i /passive mysql-5.5.16.msi
```

Regardless of the mode of the installation, installing the package in this manner performs a 'Typical' installation, and installs the default components into the standard location.

You can also use this method to uninstall MySQL by using the `/uninstall` or `/x` options:

```
shell> msiexec /x /quiet mysql-5.5.16.msi
```

To install MySQL and configure a MySQL instance from the command line, see Section 2.3.4.13, “MySQL Server Instance Config Wizard: Creating an Instance from the Command Line”.

For information on using MSI packages to install software automatically using Group Policy, see How to use Group Policy to remotely install software in Windows Server 2003.

2.3.3.3. Removing MySQL When Installed from the MSI Package

To uninstall a MySQL where you have used the MSI packages, you must use the **Add/Remove Programs** tool within **Control Panel**. To do this:

1. Right-click the **start** menu and choose **Control Panel**.
2. If the Control Panel is set to category mode (you will see **Pick a category** at the top of the **Control Panel** window), double-click **Add or Remove Programs**. If the Control is set to classic mode, double-click the **Add or Remove Programs** icon.
3. Find MySQL in the list of installed software. MySQL Server is installed against major version numbers (MySQL 5.1, MySQL 5.5, etc.). Select the version that you want to remove and click Remove.
4. You will be prompted to confirm the removal. Click Yes to remove MySQL.

When MySQL is removed using this method, only the installed components are removed. Any database information (including the tables and data), import or export files, log files, and binary logs produced during execution are kept in their configured location.

If you try to install MySQL again the information will be retained and you will be prompted to enter the password configured with the original installation.

If you want to delete MySQL completely:

- Delete the associated data directory. On Windows XP and Windows Server 2003, the default data directory is the configured AppData directory, which is `C:\Documents and Settings\All Users\Application Data\MySQL` by default.
- On Windows 7 and Windows Server 2008, the default data directory location is `C:\ProgramData\Mysql`.

> **Note**
>
> The `C:\ProgramData` directory is hidden by default. You must change your folder options to view the hidden file. Choose Organize, Folder and search options, **Show hidden folders**.

2.3.4. MySQL Server Instance Configuration Wizard

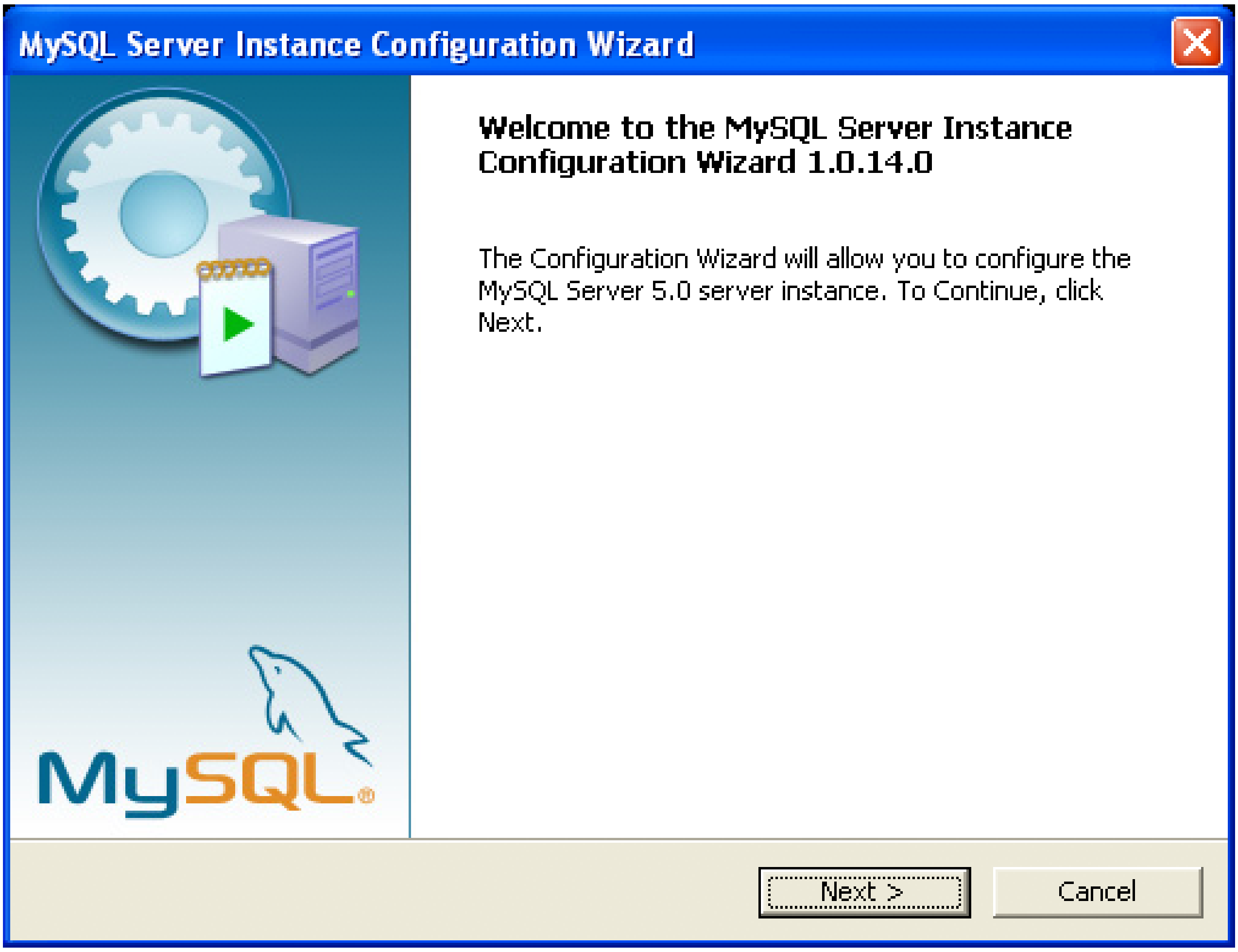
The MySQL Server Instance Configuration Wizard helps automate the process of configuring your server. It creates a custom MySQL configuration file (`my.ini` or `my.cnf`) by asking you a series of questions and then applying your responses to a template to generate the configuration file that is tuned to your installation.

The MySQL Server Instance Configuration Wizard is included with the MySQL 5.5 server. The MySQL Server Instance Configuration Wizard is only available for Windows.

2.3.4.1. Starting the MySQL Server Instance Configuration Wizard

The MySQL Server Instance Configuration Wizard is normally started as part of the installation process. You should only need to run the MySQL Server Instance Configuration Wizard again when you need to change the configuration parameters of your server.

If you chose not to open a port prior to installing MySQL on Windows Vista or newer, you can choose to use the MySQL Server Configuration Wizard after installation. However, you must open a port in the Windows Firewall. To do this see the instructions given in Section 2.3.3.1.1, "Downloading and Starting the MySQL Installation Wizard". Rather than opening a port, you also have the option of adding MySQL as a program that bypasses the Windows Firewall. One or the other option is sufficient—you need not do both. Additionally, when running the MySQL Server Configuration Wizard on Windows Vista or newer, ensure that you are logged in as a user with administrative rights.



MySQL Server Instance Configuration Wizard

Welcome to the MySQL Server Instance Configuration Wizard 1.0.14.0

The Configuration Wizard will allow you to configure the MySQL Server 5.0 server instance. To Continue, click Next.

You can launch the MySQL Configuration Wizard by clicking the MySQL Server Instance Config Wizard entry in the MySQL section of the Windows START menu.

Alternatively, you can navigate to the `bin` directory of your MySQL installation and launch the `MySQLInstanceConfig.exe` file directly.

The MySQL Server Instance Configuration Wizard places the `my.ini` file in the installation directory for the MySQL server. This helps associate configuration files with particular server instances.

To ensure that the MySQL server knows where to look for the `my.ini` file, an argument similar to this is passed to the MySQL server as part of the service installation:

```
--defaults-file="C:\Program Files\MySQL\MySQL Server 5.5\my.ini"
```

Here, *`C:\Program Files\MySQL\MySQL Server 5.5`* is replaced with the installation path to the MySQL Server. The `--defaults-file` option instructs the MySQL server to read the specified file for configuration options when it starts.

Apart from making changes to the `my.ini` file by running the MySQL Server Instance Configuration Wizard again, you can modify it by opening it with a text editor and making any necessary changes. You can also modify the server configuration with the http://www.mysql.com/products/administrator/ utility. For more information about server configuration, see Section 5.1.2, "Server Command Options".

MySQL clients and utilities such as the `mysql` and `mysqldump` command-line clients are not able to locate the `my.ini` file located in the server installation directory. To configure the client and utility applications, create a new `my.ini` file in the Windows installation directory (for example, `C:\WINDOWS`).

Under Windows Server 2003, Windows Server 2000, Windows XP, and Windows Vista, MySQL Server Instance Configuration Wizard will configure MySQL to work as a Windows service. To start and stop MySQL you use the `Services` application that is supplied as part of the Windows Administrator Tools.

2.3.4.2. Choosing a Maintenance Option

If the MySQL Server Instance Configuration Wizard detects an existing configuration file, you have the option of either reconfiguring your existing server, or removing the server instance by deleting the configuration file and stopping and removing the MySQL service.

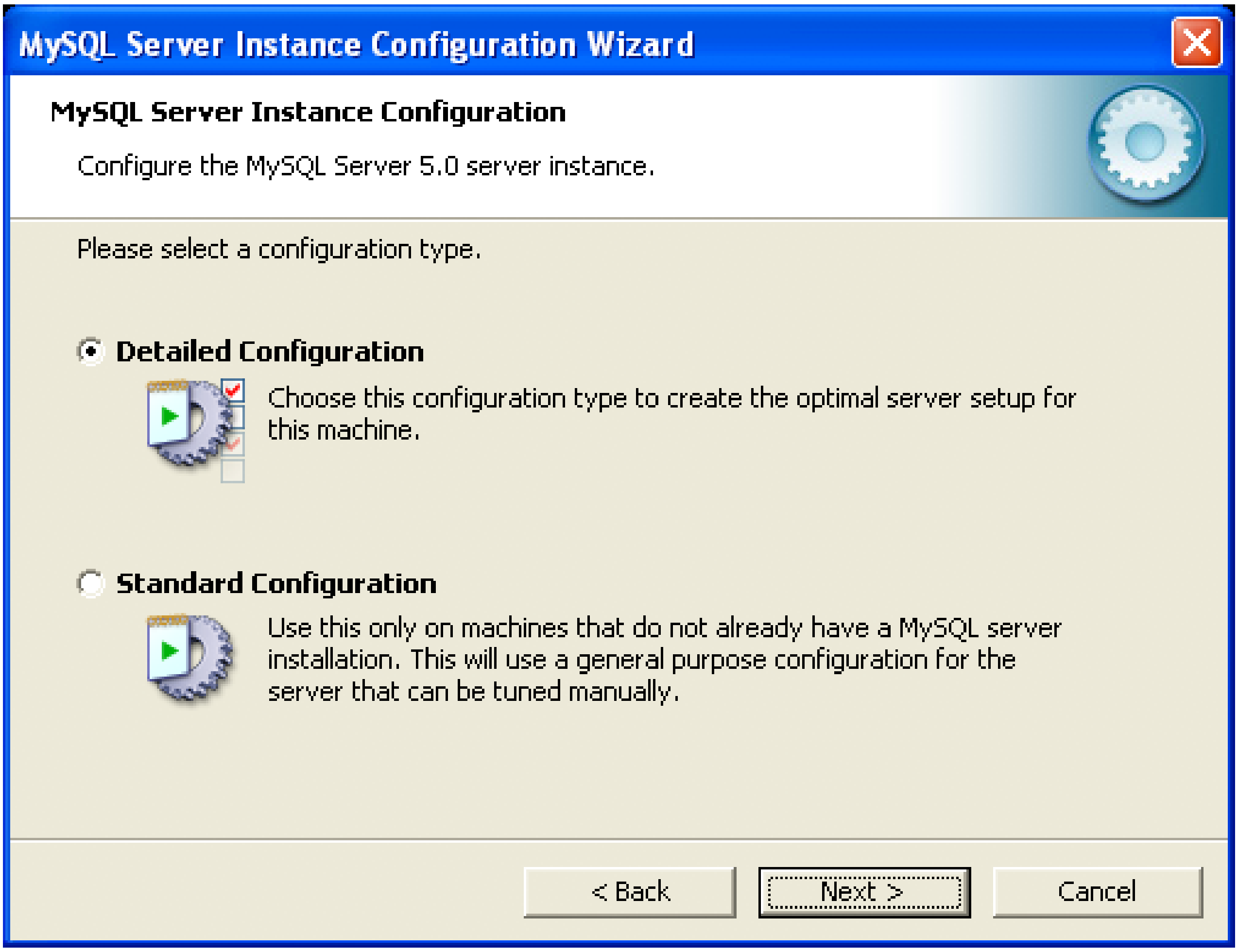
To reconfigure an existing server, choose the Re-configure Instance option and click the Next button. Any existing configuration file is not overwritten, but renamed (within the same directory) using a timestamp (Windows) or sequential number (Linux). To remove the existing server instance, choose the Remove Instance option and click the Next button.

If you choose the Remove Instance option, you advance to a confirmation window. Click the Execute button. The MySQL Server Configuration Wizard stops and removes the MySQL service, and then deletes the configuration file. The server installation and its `data` folder are not removed.

If you choose the Re-configure Instance option, you advance to the Configuration Type dialog where you can choose the type of installation that you wish to configure.

2.3.4.3. Choosing a Configuration Type

When you start the MySQL Server Instance Configuration Wizard for a new MySQL installation, or choose the Re-configure Instance option for an existing installation, you advance to the Configuration Type dialog.



MySQL Server Instance Configuration Wizard

MySQL Server Instance Configuration

Configure the MySQL Server 5.0 server instance.

Please select a configuration type.

● **Detailed Configuration**

Choose this configuration type to create the optimal server setup for this machine.

○ **Standard Configuration**

Use this only on machines that do not already have a MySQL server installation. This will use a general purpose configuration for the server that can be tuned manually.

There are two configuration types available: Detailed Configuration and Standard Configuration. The Standard Configuration option is intended for new users who want to get started with MySQL quickly without having to make many decisions about server configuration. The Detailed Configuration option is intended for advanced users who want more fine-grained control over server configuration.

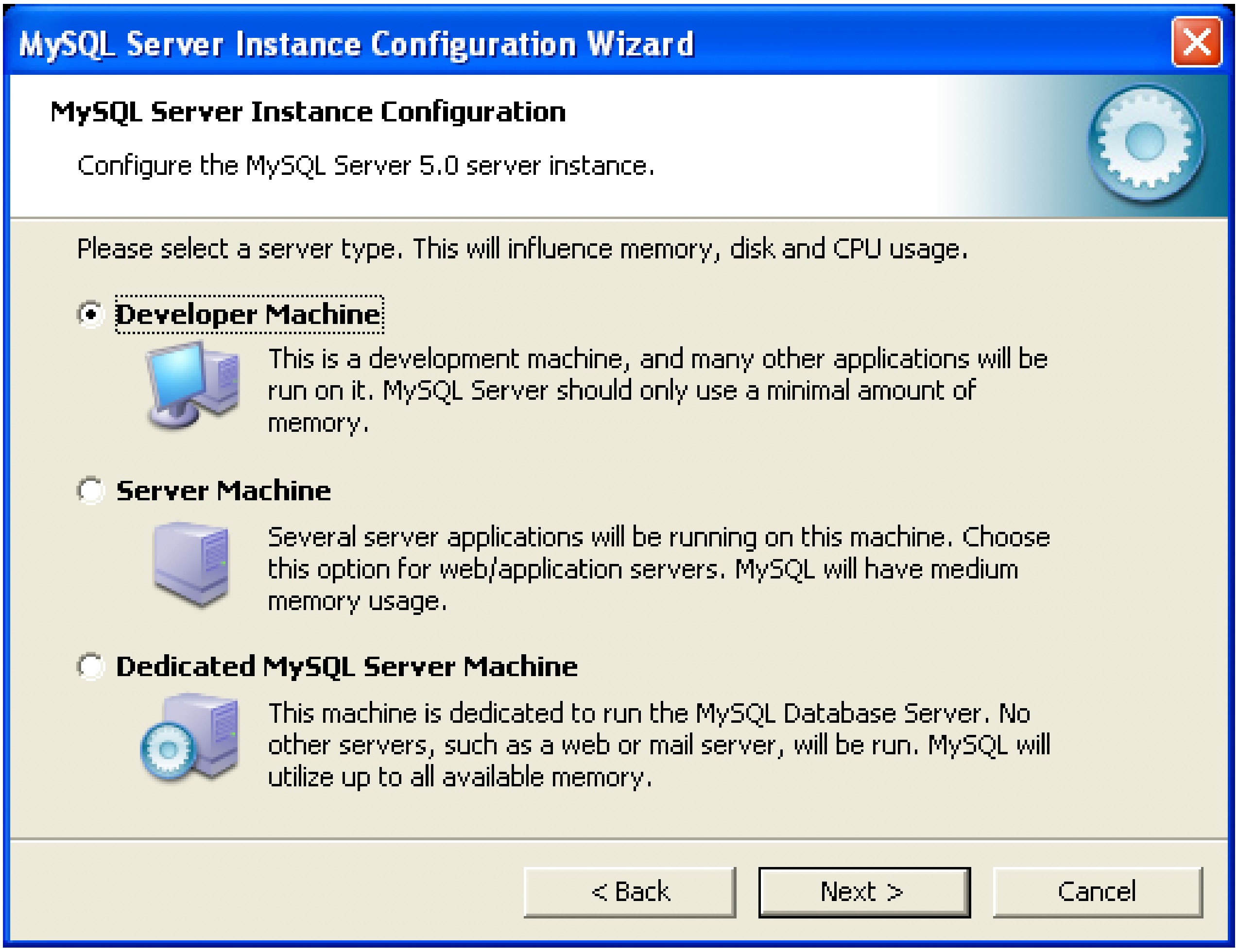
If you are new to MySQL and need a server configured as a single-user developer machine, the Standard Configuration should suit your needs. Choosing the Standard Configuration option causes the MySQL Configuration Wizard to set all configuration options automatically with the exception of Service Options and Security Options.

The Standard Configuration sets options that may be incompatible with systems where there are existing MySQL installations. If you have an existing MySQL installation on your system in addition to the installation you wish to configure, the Detailed Configuration option is recommended.

To complete the Standard Configuration, please refer to the sections on Service Options and Security Options in Section 2.3.4.10, “The Service Options Dialog”, and Section 2.3.4.11, “The Security Options Dialog”, respectively.

2.3.4.4. The Server Type Dialog

There are three different server types available to choose from. The server type that you choose affects the decisions that the MySQL Server Instance Configuration Wizard makes with regard to memory, disk, and processor usage.



MySQL Server Instance Configuration Wizard

MySQL Server Instance Configuration

Configure the MySQL Server 5.0 server instance.

Please select a server type. This will influence memory, disk and CPU usage.

● Developer Machine

This is a development machine, and many other applications will be run on it. MySQL Server should only use a minimal amount of memory.

○ Server Machine

Several server applications will be running on this machine. Choose this option for web/application servers. MySQL will have medium memory usage.

○ Dedicated MySQL Server Machine

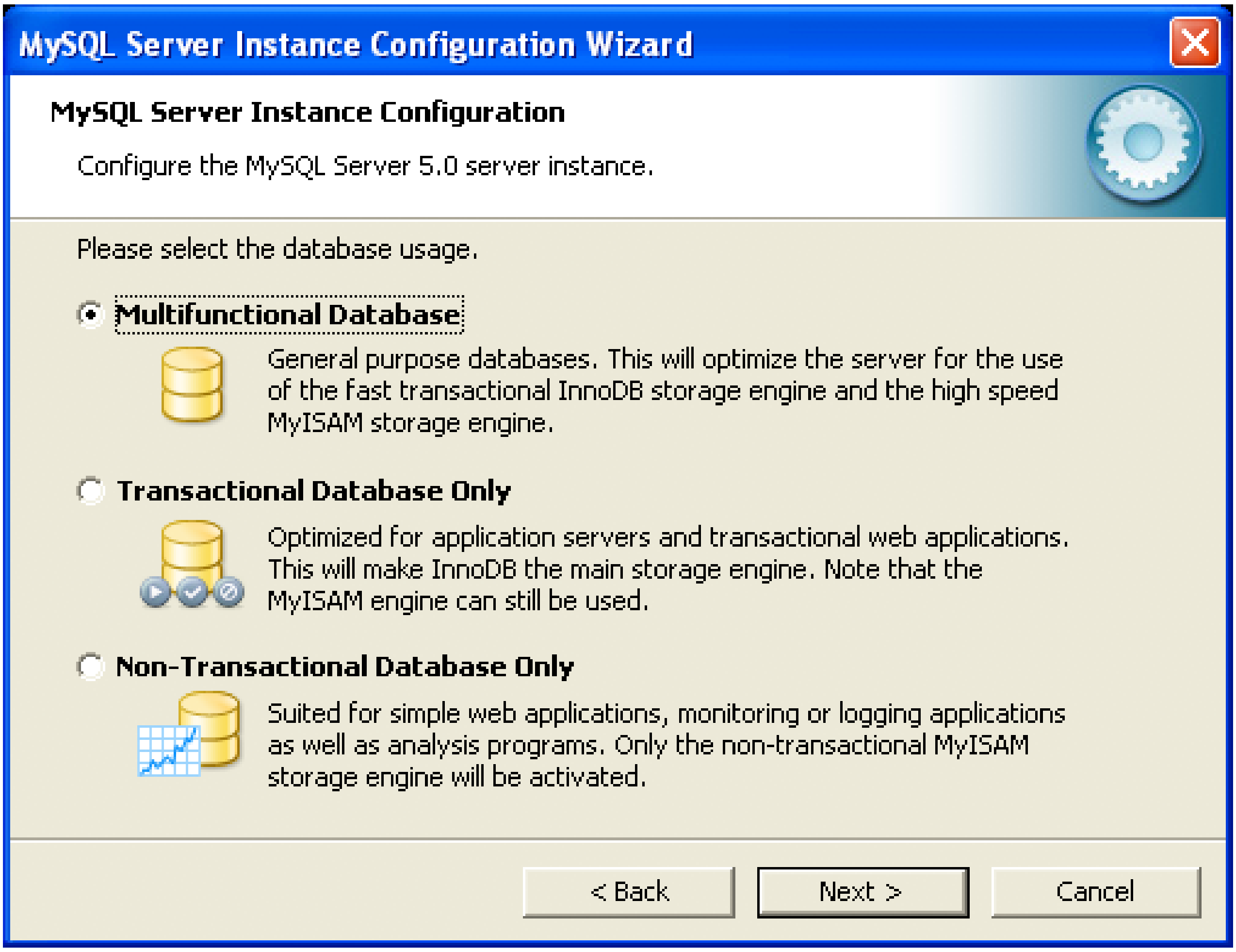
This machine is dedicated to run the MySQL Database Server. No other servers, such as a web or mail server, will be run. MySQL will utilize up to all available memory.

- Developer Machine: Choose this option for a typical desktop workstation where MySQL is intended only for personal use. It is assumed that many other desktop applications are running. The MySQL server is configured to use minimal system resources.
- Server Machine: Choose this option for a server machine where the MySQL server is running alongside other server applications such as FTP, email, and Web servers. The MySQL server is configured to use a moderate portion of the system resources.
- Dedicated MySQL Server Machine: Choose this option for a server machine that is intended to run only the MySQL server. It is assumed that no other applications are running. The MySQL server is configured to use all available system resources.

> **Note**
>
> By selecting one of the preconfigured configurations, the values and settings of various options in your `my.cnf` or `my.ini` will be altered accordingly. The default values and options as described in the reference manual may therefore be different to the options and values that were created during the execution of the configuration wizard.

2.3.4.5. The Database Usage Dialog

The DATABASE USAGE dialog enables you to indicate the storage engines that you expect to use when creating MySQL tables. The option you choose determines whether the `InnoDB` storage engine is available and what percentage of the server resources are available to `InnoDB`.



MySQL Server Instance Configuration Wizard

MySQL Server Instance Configuration

Configure the MySQL Server 5.0 server instance.

Please select the database usage.

● **Multifunctional Database**

General purpose databases. This will optimize the server for the use of the fast transactional InnoDB storage engine and the high speed MyISAM storage engine.

○ **Transactional Database Only**

Optimized for application servers and transactional web applications. This will make InnoDB the main storage engine. Note that the MyISAM engine can still be used.

○ **Non-Transactional Database Only**

Suited for simple web applications, monitoring or logging applications as well as analysis programs. Only the non-transactional MyISAM storage engine will be activated.

- Multifunctional Database: This option enables both the `InnoDB` and `MyISAM` storage engines and divides resources evenly between the two. This option is recommended for users who use both storage engines on a regular basis.
- Transactional Database Only: This option enables both the `InnoDB` and `MyISAM` storage engines, but dedicates most server resources to the `InnoDB` storage engine. This option is recommended for users who use `InnoDB` almost exclusively and make only minimal use of `MyISAM`.
- Non-Transactional Database Only: This option disables the `InnoDB` storage engine completely and dedicates all server resources to the `MyISAM` storage engine. This option is recommended for users who do not use `InnoDB`.

The Configuration Wizard uses a template to generate the server configuration file. The DATABASE USAGE dialog sets one of the following option strings:

```
Multifunctional Database:        MIXED
Transactional Database Only:     INNODB
Non-Transactional Database Only: MYISAM
```

When these options are processed through the default template (my-template.ini) the result is:

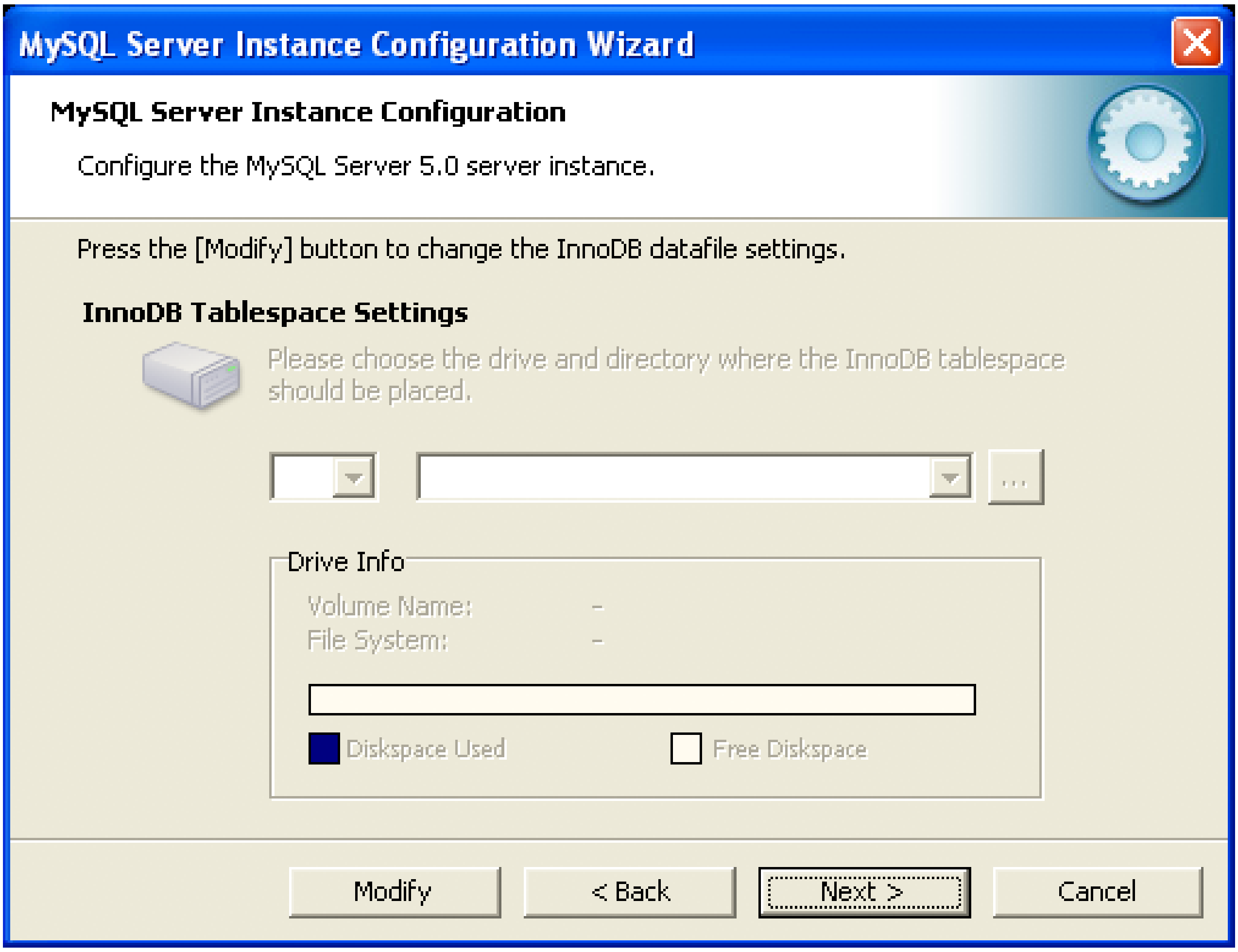
```
Multifunctional Database:
default-storage-engine=InnoDB
_myisam_pct=50

Transactional Database Only:
default-storage-engine=InnoDB
_myisam_pct=5
```

```
Non-Transactional Database Only:
default-storage-engine=MyISAM
_myisam_pct=100
skip-innodb
```

The `_myisam_pct` value is used to calculate the percentage of resources dedicated to `MyISAM`. The remaining resources are allocated to `InnoDB`.

2.3.4.6. The InnoDB Tablespace Dialog

Some users may want to locate the `InnoDB` tablespace files in a different location than the MySQL server data directory. Placing the tablespace files in a separate location can be desirable if your system has a higher capacity or higher performance storage device available, such as a RAID storage system.



MySQL Server Instance Configuration Wizard

MySQL Server Instance Configuration

Configure the MySQL Server 5.0 server instance.

Press the [Modify] button to change the InnoDB datafile settings.

InnoDB Tablespace Settings

Please choose the drive and directory where the InnoDB tablespace should be placed.

Drive Info

Volume Name: -

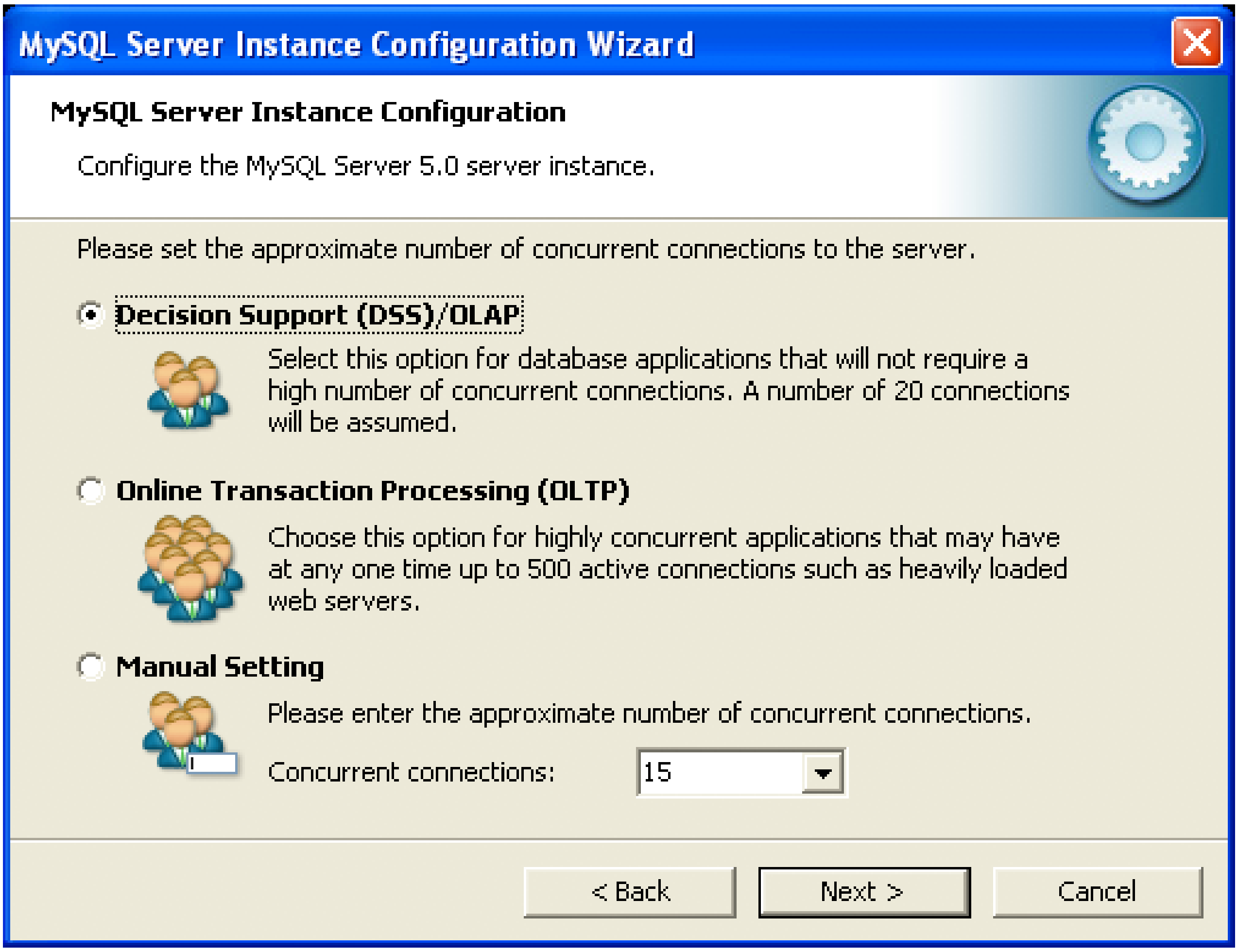
File System: -

To change the default location for the `InnoDB` tablespace files, choose a new drive from the drop-down list of drive letters and choose a new path from the drop-down list of paths. To create a custom path, click the ... button.

If you are modifying the configuration of an existing server, you must click the MODIFY button before you change the path. In this situation you must move the existing tablespace files to the new location manually before starting the server.

2.3.4.7. The Concurrent Connections Dialog

To prevent the server from running out of resources, it is important to limit the number of concurrent connections to the MySQL server that can be established. The CONCURRENT CONNECTIONS dialog enables you to choose the expected usage of your server, and sets the limit for concurrent connections accordingly. It is also possible to set the concurrent connection limit manually.



MySQL Server Instance Configuration

Configure the MySQL Server 5.0 server instance.

Please set the approximate number of concurrent connections to the server.

● **Decision Support (DSS)/OLAP**

Select this option for database applications that will not require a high number of concurrent connections. A number of 20 connections will be assumed.

○ **Online Transaction Processing (OLTP)**

Choose this option for highly concurrent applications that may have at any one time up to 500 active connections such as heavily loaded web servers.

○ **Manual Setting**

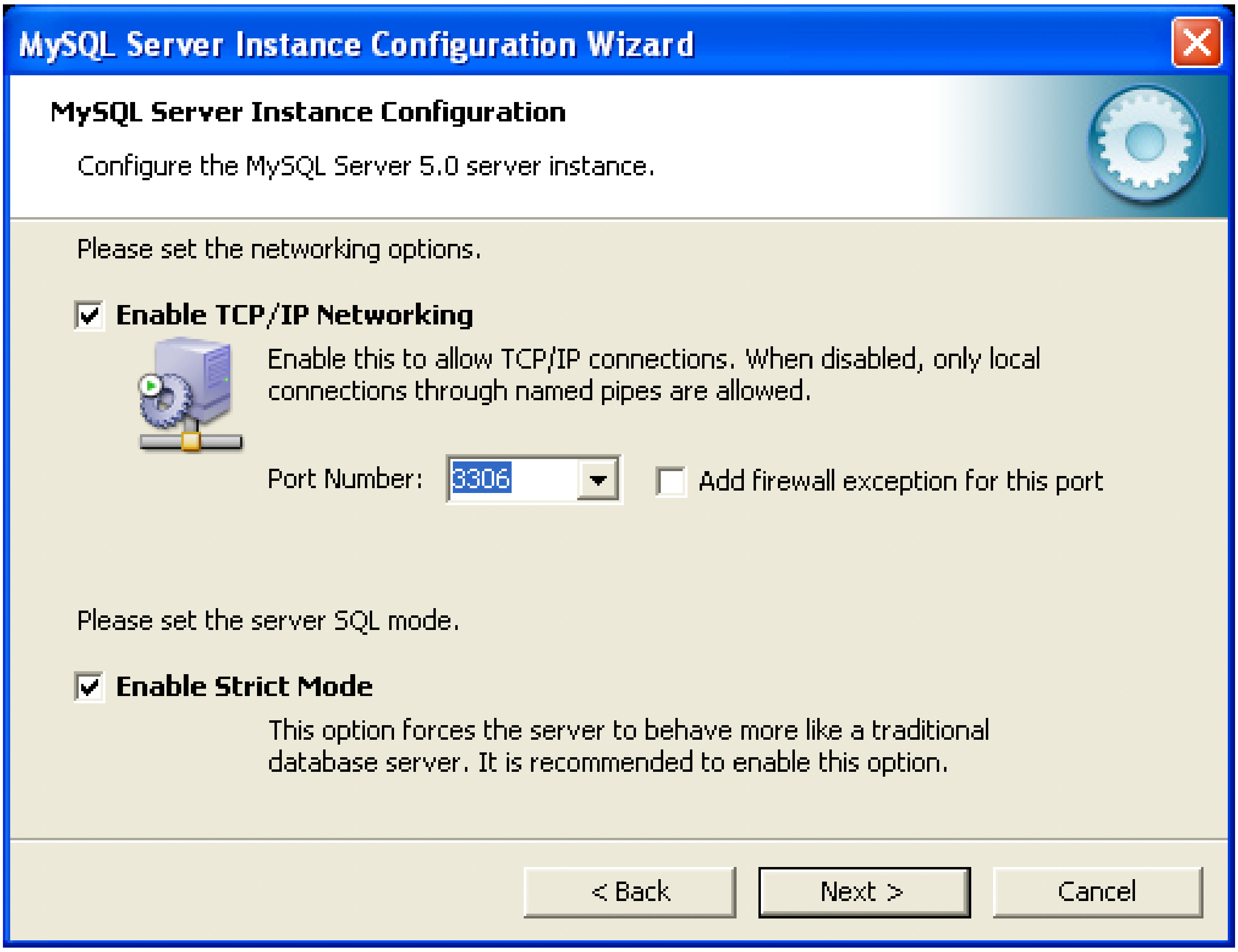
Please enter the approximate number of concurrent connections.

Concurrent connections: 15

- Decision Support (DSS)/OLAP: Choose this option if your server does not require a large number of concurrent connections. The maximum number of connections is set at 100, with an average of 20 concurrent connections assumed.
- Online Transaction Processing (OLTP): Choose this option if your server requires a large number of concurrent connections. The maximum number of connections is set at 500.
- Manual Setting: Choose this option to set the maximum number of concurrent connections to the server manually. Choose the number of concurrent connections from the drop-down box provided, or enter the maximum number of connections into the drop-down box if the number you desire is not listed.

2.3.4.8. The Networking and Strict Mode Options Dialog

Use the NETWORKING OPTIONS dialog to enable or disable TCP/IP networking and to configure the port number that is used to connect to the MySQL server.



MySQL Server Instance Configuration Wizard
MySQL Server Instance Configuration
Configure the MySQL Server 5.0 server instance.

Please set the networking options.

☑ Enable TCP/IP Networking

Enable this to allow TCP/IP connections. When disabled, only local connections through named pipes are allowed.

Port Number: 3306

☐ Add firewall exception for this port

Please set the server SQL mode.

☑ Enable Strict Mode

This option forces the server to behave more like a traditional database server. It is recommended to enable this option.

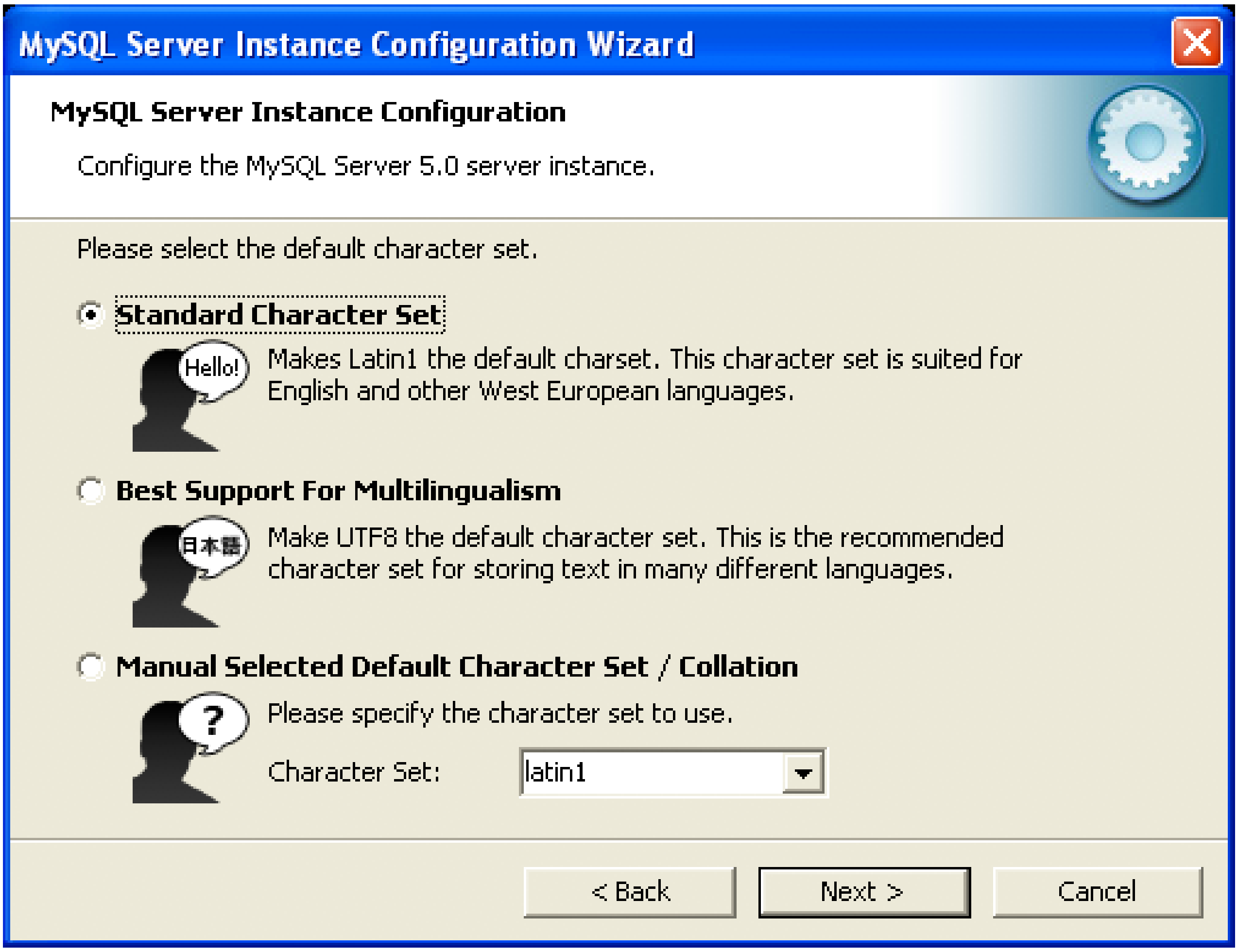
TCP/IP networking is enabled by default. To disable TCP/IP networking, uncheck the box next to the Enable TCP/IP Networking option.

Port 3306 is used by default. To change the port used to access MySQL, choose a new port number from the drop-down box or type a new port number directly into the drop-down box. If the port number you choose is in use, you are prompted to confirm your choice of port number.

Set the SERVER SQL MODE to either enable or disable strict mode. Enabling strict mode (default) makes MySQL behave more like other database management systems. *If you run applications that rely on MySQL's old "forgiving" behavior, make sure to either adapt those applications or to disable strict mode.* For more information about strict mode, see Section 5.1.6, "Server SQL Modes".

2.3.4.9. The Character Set Dialog

The MySQL server supports multiple character sets and it is possible to set a default server character set that is applied to all tables, columns, and databases unless overridden. Use the CHARACTER SET dialog to change the default character set of the MySQL server.



MySQL Server Instance Configuration

Configure the MySQL Server 5.0 server instance.

Please select the default character set.

● Standard Character Set

Makes Latin1 the default charset. This character set is suited for English and other West European languages.

○ Best Support For Multilingualism

Make UTF8 the default character set. This is the recommended character set for storing text in many different languages.

○ Manual Selected Default Character Set / Collation

Please specify the character set to use.

Character Set: latin1

- Standard Character Set: Choose this option if you want to use `latin1` as the default server character set. `latin1` is used for English and many Western European languages.
- Best Support For Multilingualism: Choose this option if you want to use `utf8` as the default server character set. This is a Unicode character set that can store characters from many different languages.
- Manual Selected Default Character Set / Collation: Choose this option if you want to pick the server's default character set manually. Choose the desired character set from the provided drop-down list.

2.3.4.10. The Service Options Dialog

On Windows platforms, the MySQL server can be installed as a Windows service. When installed this way, the MySQL server can be started automatically during system startup, and even restarted automatically by Windows in the event of a service failure.

The MySQL Server Instance Configuration Wizard installs the MySQL server as a service by default, using the service name `MySQL`. If you do not wish to install the service, uncheck the box next to the Install As Windows Service option. You can change the service name by picking a new service name from the drop-down box provided or by entering a new service name into the drop-down box.

> **Note**
>
> Service names can include any legal character except forward (`/`) or backward (`\`) slashes, and must be less than 256 characters long.

> **Warning**
>
> If you are installing multiple versions of MySQL onto the same machine, you *must* choose a different service name for each version that you install. If you do not choose a different service for each installed version then the service manager information will be inconsistent and this will cause problems when you try to uninstall a previous version.

> If you have already installed multiple versions using the same service name, you must manually edit the contents of the `HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services` parameters within the Windows registry to update the association of the service name with the correct server version.
>
> Typically, when installing multiple versions you create a service name based on the version information. For example, you might install MySQL 5.x as `mysql5`, or specific versions such as MySQL 5.5.0 as `mysql50500`.

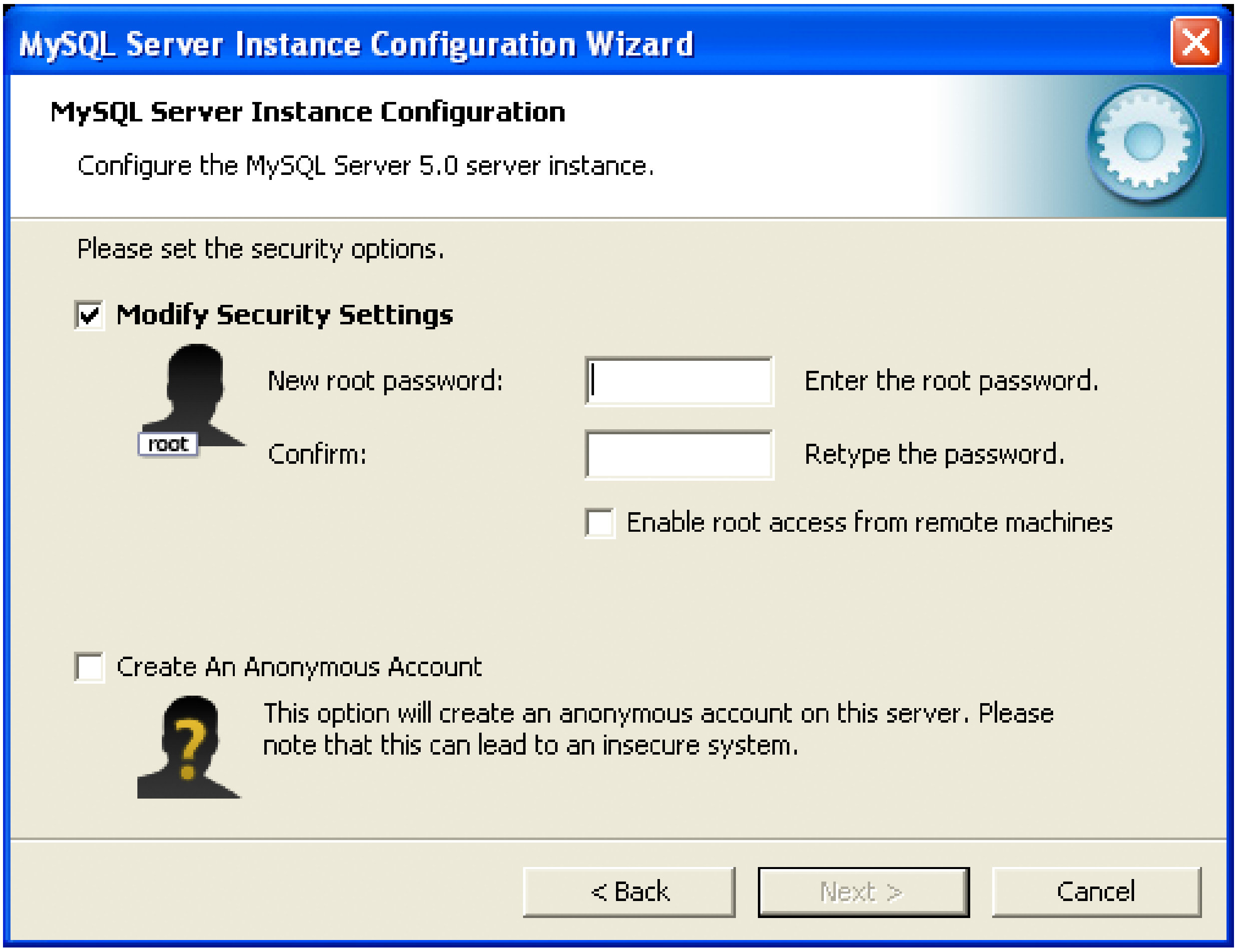
To install the MySQL server as a service but not have it started automatically at startup, uncheck the box next to the Launch the MySQL Server Automatically option.

2.3.4.11. The Security Options Dialog

The content of the security options portion of the MySQL Server Instance Configuration Wizard will depend on whether this is a new installation, or modifying an existing installation.

- **Setting the root password for a new installation**

  It is strongly recommended that you set a `root` password for your MySQL server, and the MySQL Server Instance Config Wizard requires by default that you do so. If you do not wish to set a `root` password, uncheck the box next to the Modify Security Settings option.

  MySQL Server Instance Configuration Wizard

  MySQL Server Instance Configuration

  Configure the MySQL Server 5.0 server instance.

  Please set the security options.

  ☑ Modify Security Settings

  New root password: Enter the root password.

  Confirm: Retype the password.

  ☐ Enable root access from remote machines

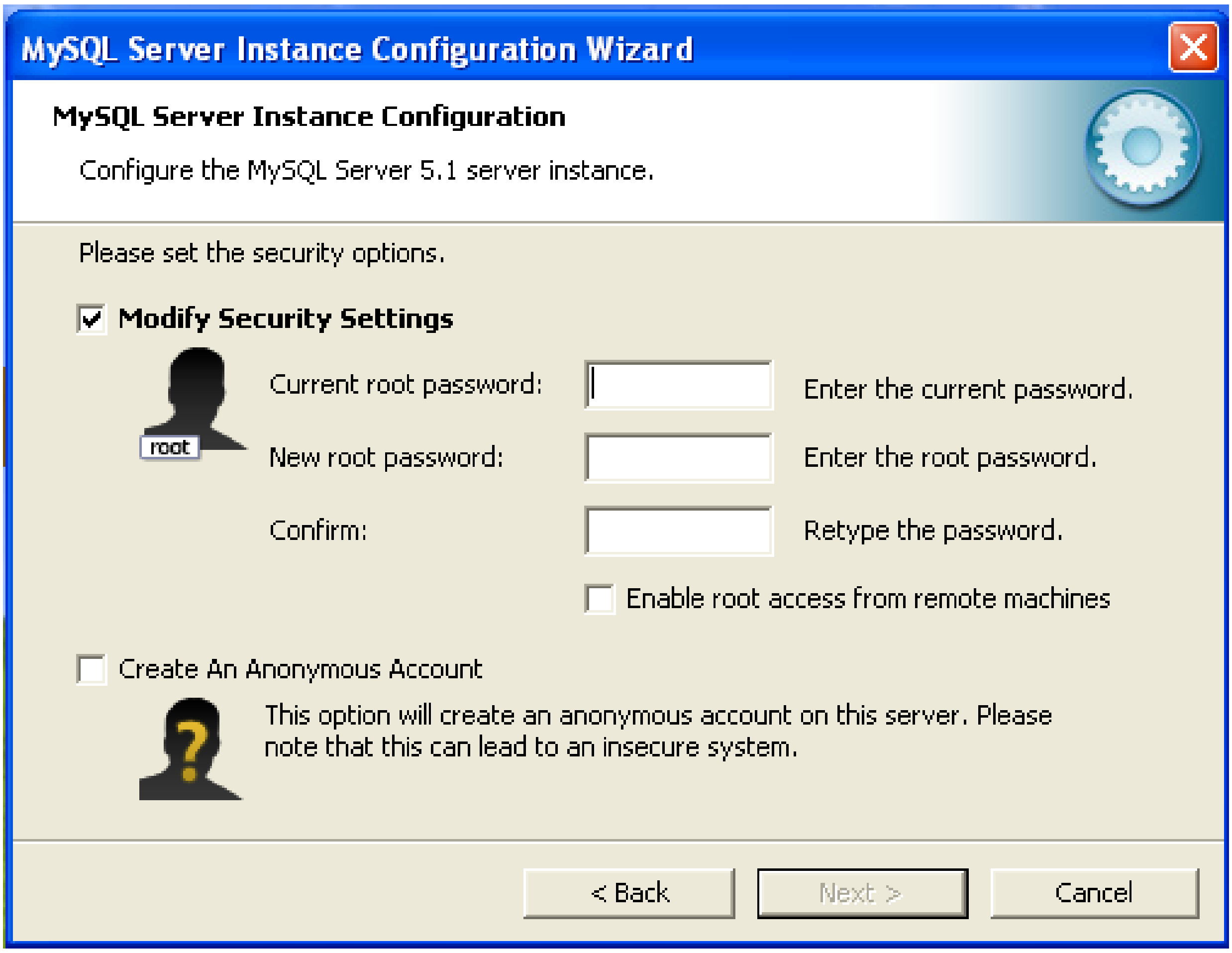
  ☐ Create An Anonymous Account

  This option will create an anonymous account on this server. Please note that this can lead to an insecure system.

- To set the `root` password, enter the desired password into both the New root password and Confirm boxes.

  Setting the root password for an existing installation

  If you are modifying the configuration of an existing configuration, or you are installing an upgrade and the MySQL Server Instance Configuration Wizard has detected an existing MySQL system, then you must enter the existing password for `root` before changing the configuration information.


MySQL Server Instance Configuration Wizard
MySQL Server Instance Configuration
Configure the MySQL Server 5.1 server instance.
Please set the security options.
☑ Modify Security Settings
root
Current root password:
Enter the current password.
New root password:
Enter the root password.
Confirm:
Retype the password.
☐ Enable root access from remote machines
☐ Create An Anonymous Account
This option will create an anonymous account on this server. Please note that this can lead to an insecure system.
< Back
Next >
Cancel

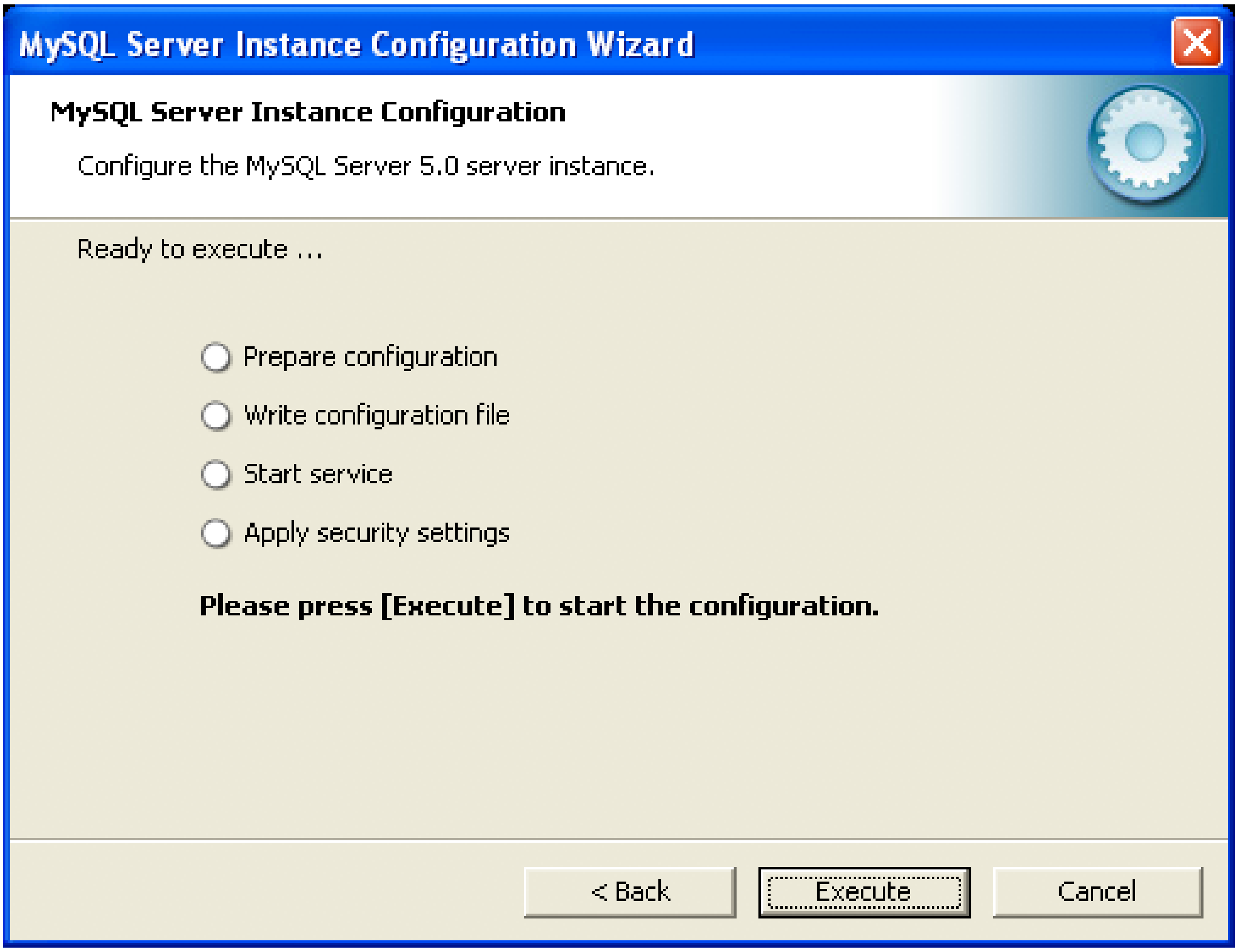
If you want to change the current `root` password, enter the desired new password into both the New root password and Confirm boxes.

To permit `root` logins from across the network, check the box next to the Enable root access from remote machines option. This decreases the security of your `root` account.

To create an anonymous user account, check the box next to the Create An Anonymous Account option. Creating an anonymous account can decrease server security and cause login and permission difficulties. For this reason, it is not recommended.

2.3.4.12. The Confirmation Dialog

The final dialog in the MySQL Server Instance Configuration Wizard is the CONFIRMATION DIALOG. To start the configuration process, click the EXECUTE button. To return to a previous dialog, click the BACK button. To exit the MySQL Server Instance Configuration Wizard without configuring the server, click the CANCEL button.



MySQL Server Instance Configuration Wizard

MySQL Server Instance Configuration

Configure the MySQL Server 5.0 server instance.

Ready to execute ...

○ Prepare configuration

○ Write configuration file

○ Start service

○ Apply security settings

Please press [Execute] to start the configuration.

After you click the EXECUTE button, the MySQL Server Instance Configuration Wizard performs a series of tasks and displays the progress onscreen as the tasks are performed.

The MySQL Server Instance Configuration Wizard first determines configuration file options based on your choices using a template prepared by MySQL developers and engineers. This template is named `my-template.ini` and is located in your server installation directory.

The MySQL Configuration Wizard then writes these options to the corresponding configuration file.

If you chose to create a service for the MySQL server, the MySQL Server Instance Configuration Wizard creates and starts the service. If you are reconfiguring an existing service, the MySQL Server Instance Configuration Wizard restarts the service to apply your configuration changes.

If you chose to set a `root` password, the MySQL Configuration Wizard connects to the server, sets your new `root` password, and applies any other security settings you may have selected.

After the MySQL Server Instance Configuration Wizard has completed its tasks, it displays a summary. Click the FINISH button to exit the MySQL Server Configuration Wizard.

2.3.4.13. MySQL Server Instance Config Wizard: Creating an Instance from the Command Line

In addition to using the GUI interface to the MySQL Server Instance Config Wizard, you can also create instances automatically from the command line.

To use the MySQL Server Instance Config Wizard on the command line, you need to use the `MySQLInstanceConfig.exe` command that is installed with MySQL in the `bin` directory within the installation directory. `MySQLInstanceConfig.exe` takes a number of command-line arguments the set the properties that would normally be selected through the GUI interface, and then creates a new configuration file (`my.ini`) by combining these selections with a template configuration file to produce the working configuration file.

The main command line options are provided in the table below. Some of the options are required, while some options are optional.

Table 2.4. MySQL Server Instance Config Wizard Command Line Options

Option	Description
Required Parameters	
`-nPRODUCTNAME`	The name of the instance when installed
`-pPATH`	Path of the base directory for installation. This is equivalent to the directory when using the `basedir` configuration parameter
`-vVERSION`	The version tag to use for this installation
Action to Perform	
`-i`	Install an instance
`-r`	Remove an instance
`-s`	Stop an existing instance
`-q`	Perform the operation quietly
`-lFILENAME`	Sae the installation progress in a logfile
Config File to Use	
`-tFILENAME`	Path to the template config file that will be used to generate the installed configuration file
`-cFILENAME`	Path to a config file to be generated

The `-t` and `-c` options work together to set the configuration parameters for a new instance. The `-t` option specifies the template configuration file to use as the basic configuration, which are then merged with the configuration parameters generated by the MySQL Server Instance Config Wizard into the configuration file specified by the `-c` option.

A sample template file, `my-template.ini` is provided in the toplevel MySQL installation directory. The file contains elements are replaced automatically by the MySQL Server Instance Config Wizard during configuration.

If you specify a configuration file that already exists, the existing configuration file will be saved in the file with the original, with the date and time added. For example, the `mysql.ini` will be copied to `mysql 2009-10-27 1646.ini.bak`.

The parameters that you can specify on the command line are listed in the table below.

Table 2.5. MySQL Server Instance Config Wizard Parameters

Parameter	Description
`ServiceName=$`	Specify the name of the service to be created
`AddBinToPath={yes | no}`	Specifies whether to add the binary directory of MySQL to the standard `PATH` environment variable
`Server-Type={DEVELOPMENT | SERVER | DEDICATED}`	Specify the server type. For more information, see Section 2.3.4.4, "The Server Type Dialog"
`DatabaseType={MIXED | INNODB | MYISAM}`	Specify the default database type. For more information, see Section 2.3.4.5, "The Database Usage Dialog"
`ConnectionUsage={DSS | OLTP}`	Specify the type of connection support, this automates the setting for the number of concurrent connections (see the `ConnectionCount` parameter). For more information, see Section 2.3.4.7, "The Concurrent Connections Dialog"
`ConnectionCount=#`	Specify the number of concurrent connections to support. For more information, see Section 2.3.4.4, "The Server Type Dialog"
`SkipNetworking={yes | no}`	Specify whether network support should be supported. Specifying `yes` disables network access altogether
`Port=#`	Specify the network port number to use for network connections. For more information, see Section 2.3.4.8, "The Networking and Strict Mode Options Dialog"
`StrictMode={yes | no}`	Specify whether to use the `strict` SQL mode. For more information, see Section 2.3.4.8, "The Networking and Strict Mode Options Dialog"
`Charset=$`	Specify the default character set. For more information, see Section 2.3.4.9, "The Character Set Dialog"
`RootPassword=$`	Specify the root password
`RootCurrentPassword=$`	Specify the current root password then stopping or reconfiguring an existing service

> **Note**
>
> When specifying options on the command line, you can enclose the entire command-line option and the value you are specifying using double quotation marks. This enables you to use spaces in the options. For example, `"-cC:\mysql.ini"`.

The following command installs a MySQL Server 5.5 instance from the directory `C:\Program Files\MySQL\MySQL Server 5.5` using the service name `MySQL55` and setting the root password to 1234.

```
shell> MySQLInstanceConfig.exe -i -q "-lC:\mysql_install_log.txt" »
   "-nMySQL Server 5.5" "-pC:\Program Files\MySQL\MySQL Server 5.5" -v5.5.16 »
   "-tmy-template.ini" "-cC:\mytest.ini" ServerType=DEVELOPMENT DatabaseType=MIXED »
   ConnectionUsage=DSS Port=3311 ServiceName=MySQL55 RootPassword=1234
```

In the above example, a log file will be generated in `mysql_install_log.txt` containing the information about the instance creation process. The log file generated by the above example is shown below:

```
Welcome to the MySQL Server Instance Configuration Wizard 1.0.16.0
Date: 2009-10-27 17:07:21

Installing service ...

Product Name:         MySQL Server 5.5
Version:              5.5.16
Installation Path:    C:\Program Files\MySQL\MySQL Server 5.5\

Creating configuration file C:\mytest.ini using template my-template.ini.
Options:
DEVELOPMENT
MIXED
DSS
STRICTMODE

Variables:
port: 3311
default-character-set: latin1
basedir: "C:/Program Files/MySQL/MySQL Server 5.5/"
datadir: "C:/Program Files/MySQL/MySQL Server 5.5/Data/"


Creating Windows service entry.
Service name: "MySQL55"
Parameters:   "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld" --defaults-file="C:\mytest.ini" MySQL55.
Windows service MySQL55 installed.
```

When using the command line, the return values in the following table indicate an error performing the specified option.

Table 2.6. Return Value from MySQL Server Instance Config Wizard

Value	Description
2	Configuration template file cannot be found
3	The Windows service entry cannot be created
4	Could not connect to the Service Control Manager
5	The MySQL service cannot be started
6	The MySQL service cannot be stopped
7	The security settings cannot be applied
8	The configuration file cannot be written
9	The Windows service entry cannot be removed

You can perform an installation of MySQL automatically using the MSI package. For more information, see Section 2.3.3.2, “Automating MySQL Installation on Microsoft Windows using the MSI Package”.

2.3.5. Installing MySQL on Microsoft Windows Using a `noinstall` Zip Archive

Users who are installing from the Noinstall package can use the instructions in this section to manually install MySQL. The process for installing MySQL from a Zip archive is as follows:

1. Extract the archive to the desired install directory
2. Create an option file

3. Choose a MySQL server type
4. Start the MySQL server
5. Secure the default user accounts

This process is described in the sections that follow.

2.3.5.1. Extracting the Install Archive

To install MySQL manually, do the following:

1. If you are upgrading from a previous version please refer to Section 2.3.7, “Upgrading MySQL on Windows”, before beginning the upgrade process.
2. Make sure that you are logged in as a user with administrator privileges.
3. Choose an installation location. Traditionally, the MySQL server is installed in `C:\mysql`. The MySQL Installation Wizard installs MySQL under `C:\Program Files\MySQL`. If you do not install MySQL at `C:\mysql`, you must specify the path to the install directory during startup or in an option file. See Section 2.3.5.2, “Creating an Option File”.
4. Extract the install archive to the chosen installation location using your preferred Zip archive tool. Some tools may extract the archive to a folder within your chosen installation location. If this occurs, you can move the contents of the subfolder into the chosen installation location.

2.3.5.2. Creating an Option File

If you need to specify startup options when you run the server, you can indicate them on the command line or place them in an option file. For options that are used every time the server starts, you may find it most convenient to use an option file to specify your MySQL configuration. This is particularly true under the following circumstances:

- The installation or data directory locations are different from the default locations (`C:\Program Files\MySQL\MySQL Server 5.5` and `C:\Program Files\MySQL\MySQL Server 5.5\data`).
- You need to tune the server settings, such as memory, cache, or InnoDB configuration information.

When the MySQL server starts on Windows, it looks for option files in several locations, such as the Windows directory, `C:\`, and the MySQL installation directory (for the full list of locations, see Section 4.2.3.3, “Using Option Files”). The Windows directory typically is named something like `C:\WINDOWS`. You can determine its exact location from the value of the `WINDIR` environment variable using the following command:

```
C:\> echo %WINDIR%
```

MySQL looks for options in each location first in the `my.ini` file, and then in the `my.cnf` file. However, to avoid confusion, it is best if you use only one file. If your PC uses a boot loader where `C:` is not the boot drive, your only option is to use the `my.ini` file. Whichever option file you use, it must be a plain text file.

You can also make use of the example option files included with your MySQL distribution; see Section 4.2.3.3.2, “Preconfigured Option Files”.

An option file can be created and modified with any text editor, such as Notepad. For example, if MySQL is installed in `E:\mysql` and the data directory is in `E:\mydata\data`, you can create an option file containing a `[mysqld]` section to specify values for the `basedir` and `datadir` options:

```
[mysqld]
# set basedir to your installation path
basedir=E:/mysql
# set datadir to the location of your data directory
datadir=E:/mydata/data
```

Note that Windows path names are specified in option files using (forward) slashes rather than backslashes. If you do use backslashes, double them:

```
[mysqld]
# set basedir to your installation path
basedir=E:\\mysql
# set datadir to the location of your data directory
```

```
datadir=E:\\mydata\\data
```

The rules for use of backslash in option file values are given in Section 4.2.3.3, “Using Option Files”.

The data directory is located within the `AppData` directory for the user running MySQL.

If you would like to use a data directory in a different location, you should copy the entire contents of the `data` directory to the new location. For example, if you want to use `E:\mydata` as the data directory instead, you must do two things:

1. Move the entire `data` directory and all of its contents from the default location (for example `C:\Program Files\MySQL\MySQL Server 5.5\data`) to `E:\mydata`.
2. Use a `--datadir` option to specify the new data directory location each time you start the server.

2.3.5.3. Selecting a MySQL Server Type

The following table shows the available servers for Windows in MySQL 5.5.

Binary	Description
`mysqld`	Optimized binary with named-pipe support
`mysqld-debug`	Like `mysqld`, but compiled with full debugging and automatic memory allocation checking

All of the preceding binaries are optimized for modern Intel processors, but should work on any Intel i386-class or higher processor.

Each of the servers in a distribution support the same set of storage engines. The `SHOW ENGINES` statement displays which engines a given server supports.

All Windows MySQL 5.5 servers have support for symbolic linking of database directories.

MySQL supports TCP/IP on all Windows platforms. MySQL servers on Windows support named pipes as indicated in the following list. However, the default is to use TCP/IP regardless of platform. (Named pipes are slower than TCP/IP in many Windows configurations.)

Named pipes are enabled only if you start the server with the `--enable-named-pipe` option. It is necessary to use this option explicitly because some users have experienced problems with shutting down the MySQL server when named pipes were used.

2.3.5.4. Starting the Server for the First Time

This section gives a general overview of starting the MySQL server. The following sections provide more specific information for starting the MySQL server from the command line or as a Windows service.

The information here applies primarily if you installed MySQL using the `Noinstall` version, or if you wish to configure and test MySQL manually rather than with the GUI tools.

The examples in these sections assume that MySQL is installed under the default location of `C:\Program Files\MySQL\MySQL Server 5.5`. Adjust the path names shown in the examples if you have MySQL installed in a different location.

Clients have two options. They can use TCP/IP, or they can use a named pipe if the server supports named-pipe connections.

MySQL for Windows also supports shared-memory connections if the server is started with the `--shared-memory` option. Clients can connect through shared memory by using the `--protocol=MEMORY` option.

For information about which server binary to run, see Section 2.3.5.3, “Selecting a MySQL Server Type”.

Testing is best done from a command prompt in a console window (or “DOS window”). In this way you can have the server display status messages in the window where they are easy to see. If something is wrong with your configuration, these messages make it easier for you to identify and fix any problems.

To start the server, enter this command:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld" --console
```

For a server that includes `InnoDB` support, you should see the messages similar to those following as it starts (the path names and sizes may differ):

```
InnoDB: The first specified datafile c:\ibdata\ibdata1 did not exist:
InnoDB: a new database to be created!
InnoDB: Setting file c:\ibdata\ibdata1 size to 209715200
InnoDB: Database physically writes the file full: wait...
InnoDB: Log file c:\iblogs\ib_logfile0 did not exist: new to be created
InnoDB: Setting log file c:\iblogs\ib_logfile0 size to 31457280
InnoDB: Log file c:\iblogs\ib_logfile1 did not exist: new to be created
InnoDB: Setting log file c:\iblogs\ib_logfile1 size to 31457280
InnoDB: Log file c:\iblogs\ib_logfile2 did not exist: new to be created
InnoDB: Setting log file c:\iblogs\ib_logfile2 size to 31457280
InnoDB: Doublewrite buffer not found: creating new
InnoDB: Doublewrite buffer created
InnoDB: creating foreign key constraint system tables
InnoDB: foreign key constraint system tables created
011024 10:58:25  InnoDB: Started
```

When the server finishes its startup sequence, you should see something like this, which indicates that the server is ready to service client connections:

```
mysqld: ready for connections
Version: '5.5.16'  socket: ''  port: 3306
```

The server continues to write to the console any further diagnostic output it produces. You can open a new console window in which to run client programs.

If you omit the `--console` option, the server writes diagnostic output to the error log in the data directory (`C:\Program Files\MySQL\MySQL Server 5.5\data` by default). The error log is the file with the `.err` extension.

> **Note**
>
> The accounts that are listed in the MySQL grant tables initially have no passwords. After starting the server, you should set up passwords for them using the instructions in Section 2.10, “Postinstallation Setup and Testing”.

2.3.5.5. Starting MySQL from the Windows Command Line

The MySQL server can be started manually from the command line. This can be done on any version of Windows.

To start the `mysqld` server from the command line, you should start a console window (or “DOS window”) and enter this command:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld"
```

The path to `mysqld` may vary depending on the install location of MySQL on your system.

You can stop the MySQL server by executing this command:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqladmin" -u root shutdown
```

> **Note**
>
> If the MySQL `root` user account has a password, you need to invoke `mysqladmin` with the `-p` option and supply the password when prompted.

This command invokes the MySQL administrative utility `mysqladmin` to connect to the server and tell it to shut down. The command connects as the MySQL `root` user, which is the default administrative account in the MySQL grant system. Note that users in the MySQL grant system are wholly independent from any login users under Windows.

If `mysqld` doesn't start, check the error log to see whether the server wrote any messages there to indicate the cause of the problem. The error log is located in the `C:\Program Files\MySQL\MySQL Server 5.5\data` directory. It is the file with a suffix of `.err`. You can also try to start the server as `mysqld --console`; in this case, you may get some useful information on the screen that may help solve the problem.

The last option is to start `mysqld` with the `--standalone` and `--debug` options. In this case, `mysqld` writes a log file `C:\mysqld.trace` that should contain the reason why `mysqld` doesn't start. See MySQL Internals: Porting.

Use `mysqld --verbose --help` to display all the options that `mysqld` supports.

2.3.5.6. Customizing the PATH for MySQL Tools

To make it easier to invoke MySQL programs, you can add the path name of the MySQL `bin` directory to your Windows system `PATH` environment variable:

- On the Windows desktop, right-click the My Computer icon, and select Properties.
- Next select the Advanced tab from the SYSTEM PROPERTIES menu that appears, and click the ENVIRONMENT VARIABLES button.
- Under **SYSTEM VARIABLES**, select Path, and then click the EDIT button. The EDIT SYSTEM VARIABLE dialogue should appear.
- Place your cursor at the end of the text appearing in the space marked **VARIABLE VALUE**. (Use the **End** key to ensure that your cursor is positioned at the very end of the text in this space.) Then enter the complete path name of your MySQL `bin` directory (for example, `C:\Program Files\MySQL\MySQL Server 5.5\bin`)

  Note

  There must be a semicolon separating this path from any values present in this field.

  Dismiss this dialogue, and each dialogue in turn, by clicking OK until all of the dialogues that were opened have been dismissed. You should now be able to invoke any MySQL executable program by typing its name at the DOS prompt from any directory on the system, without having to supply the path. This includes the servers, the `mysql` client, and all MySQL command-line utilities such as `mysqladmin` and `mysqldump`.

  You should not add the MySQL `bin` directory to your Windows `PATH` if you are running multiple MySQL servers on the same machine.

  Warning

  You must exercise great care when editing your system `PATH` by hand; accidental deletion or modification of any portion of the existing `PATH` value can leave you with a malfunctioning or even unusable system.

2.3.5.7. Starting MySQL as a Windows Service

On Windows, the recommended way to run MySQL is to install it as a Windows service, whereby MySQL starts and stops automatically when Windows starts and stops. A MySQL server installed as a service can also be controlled from the command line using `NET` commands, or with the graphical `Services` utility. Generally, to install MySQL as a Windows service you should be logged in using an account that has administrator rights.

The `Services` utility (the Windows `Service Control Manager`) can be found in the Windows Control Panel (under Administrative Tools on Windows 2000, XP, Vista, and Server 2003). To avoid conflicts, it is advisable to close the `Services` utility while performing server installation or removal operations from the command line.

Before installing MySQL as a Windows service, you should first stop the current server if it is running by using the following command:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqladmin"
         -u root shutdown
```

Note

If the MySQL `root` user account has a password, you need to invoke `mysqladmin` with the `-p` option and supply the password when prompted.

This command invokes the MySQL administrative utility `mysqladmin` to connect to the server and tell it to shut down. The command connects as the MySQL `root` user, which is the default administrative account in the MySQL grant system. Note that users in the MySQL grant system are wholly independent from any login users under Windows.

Install the server as a service using this command:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld" --install
```

The service-installation command does not start the server. Instructions for that are given later in this section.

To make it easier to invoke MySQL programs, you can add the path name of the MySQL `bin` directory to your Windows system `PATH` environment variable:

- On the Windows desktop, right-click the My Computer icon, and select Properties.
- Next select the Advanced tab from the SYSTEM PROPERTIES menu that appears, and click the ENVIRONMENT VARIABLES button.
- Under **SYSTEM VARIABLES**, select Path, and then click the EDIT button. The EDIT SYSTEM VARIABLE dialogue should appear.

- Place your cursor at the end of the text appearing in the space marked **VARIABLE VALUE**. (Use the **End** key to ensure that your cursor is positioned at the very end of the text in this space.) Then enter the complete path name of your MySQL `bin` directory (for example, `C:\Program Files\MySQL\MySQL Server 5.5\bin`), Note that there should be a semicolon separating this path from any values present in this field. Dismiss this dialogue, and each dialogue in turn, by clicking OK until all of the dialogues that were opened have been dismissed. You should now be able to invoke any MySQL executable program by typing its name at the DOS prompt from any directory on the system, without having to supply the path. This includes the servers, the `mysql` client, and all MySQL command-line utilities such as `mysqladmin` and `mysqldump`.

  You should not add the MySQL `bin` directory to your Windows `PATH` if you are running multiple MySQL servers on the same machine.

> **Warning**
>
> You must exercise great care when editing your system `PATH` by hand; accidental deletion or modification of any portion of the existing `PATH` value can leave you with a malfunctioning or even unusable system.

The following additional arguments can be used when installing the service:

- You can specify a service name immediately following the `--install` option. The default service name is `MySQL`.
- If a service name is given, it can be followed by a single option. By convention, this should be `--defaults-file=file_name` to specify the name of an option file from which the server should read options when it starts.

  The use of a single option other than `--defaults-file` is possible but discouraged. `--defaults-file` is more flexible because it enables you to specify multiple startup options for the server by placing them in the named option file.
- You can also specify a `--local-service` option following the service name. This causes the server to run using the `LocalService` Windows account that has limited system privileges. This account is available only for Windows XP or newer. If both `--defaults-file` and `--local-service` are given following the service name, they can be in any order.

For a MySQL server that is installed as a Windows service, the following rules determine the service name and option files that the server uses:

- If the service-installation command specifies no service name or the default service name (`MySQL`) following the `--install` option, the server uses the a service name of `MySQL` and reads options from the `[mysqld]` group in the standard option files.
- If the service-installation command specifies a service name other than `MySQL` following the `--install` option, the server uses that service name. It reads options from the `[mysqld]` group and the group that has the same name as the service in the standard option files. This enables you to use the `[mysqld]` group for options that should be used by all MySQL services, and an option group with the service name for use by the server installed with that service name.
- If the service-installation command specifies a `--defaults-file` option after the service name, the server reads options only from the `[mysqld]` group of the named file and ignores the standard option files.

As a more complex example, consider the following command:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld"
          --install MySQL --defaults-file=C:\my-opts.cnf
```

Here, the default service name (`MySQL`) is given after the `--install` option. If no `--defaults-file` option had been given, this command would have the effect of causing the server to read the `[mysqld]` group from the standard option files. However, because the `--defaults-file` option is present, the server reads options from the `[mysqld]` option group, and only from the named file.

You can also specify options as Start parameters in the Windows `Services` utility before you start the MySQL service.

Once a MySQL server has been installed as a service, Windows starts the service automatically whenever Windows starts. The service also can be started immediately from the `Services` utility, or by using a `NET START MySQL` command. The `NET` command is not case sensitive.

When run as a service, `mysqld` has no access to a console window, so no messages can be seen there. If `mysqld` does not start, check the error log to see whether the server wrote any messages there to indicate the cause of the problem. The error log is located in the MySQL data directory (for example, `C:\Program Files\MySQL\MySQL Server 5.5\data`). It is the file with a suffix of `.err`.

When a MySQL server has been installed as a service, and the service is running, Windows stops the service automatically when Windows shuts down. The server also can be stopped manually by using the `Services` utility, the `NET STOP MySQL` command, or the `mysqladmin shutdown` command.

You also have the choice of installing the server as a manual service if you do not wish for the service to be started automatically during the boot process. To do this, use the `--install-manual` option rather than the `--install` option:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld" --install-manual
```

To remove a server that is installed as a service, first stop it if it is running by executing `NET STOP MySQL`. Then use the `--remove` option to remove it:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld" --remove
```

If `mysqld` is not running as a service, you can start it from the command line. For instructions, see Section 2.3.5.5, "Starting MySQL from the Windows Command Line".

Please see Section 2.3.6, "Troubleshooting a MySQL Installation Under Windows", if you encounter difficulties during installation.

2.3.5.8. Testing The MySQL Installation

You can test whether the MySQL server is working by executing any of the following commands:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqlshow"
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqlshow" -u root mysql
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqladmin" version status proc
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysql" test
```

If `mysqld` is slow to respond to TCP/IP connections from client programs, there is probably a problem with your DNS. In this case, start `mysqld` with the `--skip-name-resolve` option and use only `localhost` and IP addresses in the `Host` column of the MySQL grant tables.

You can force a MySQL client to use a named-pipe connection rather than TCP/IP by specifying the `--pipe` or `--protocol=PIPE` option, or by specifying `.` (period) as the host name. Use the `--socket` option to specify the name of the pipe if you do not want to use the default pipe name.

Note that if you have set a password for the `root` account, deleted the anonymous account, or created a new user account, then you must use the appropriate `-u` and `-p` options with the commands shown above to connect with the MySQL Server. See Section 4.2.2, "Connecting to the MySQL Server".

For more information about `mysqlshow`, see Section 4.5.6, "`mysqlshow` — Display Database, Table, and Column Information".

2.3.6. Troubleshooting a MySQL Installation Under Windows

When installing and running MySQL for the first time, you may encounter certain errors that prevent the MySQL server from starting. The purpose of this section is to help you diagnose and correct some of these errors.

Your first resource when troubleshooting server issues is the error log. The MySQL server uses the error log to record information relevant to the error that prevents the server from starting. The error log is located in the data directory specified in your `my.ini` file. The default data directory location is `C:\Program Files\MySQL\MySQL Server 5.5\data`. See Section 5.2.2, "The Error Log".

Another source of information regarding possible errors is the console messages displayed when the MySQL service is starting. Use the `NET START MySQL` command from the command line after installing `mysqld` as a service to see any error messages regarding the starting of the MySQL server as a service. See Section 2.3.5.7, "Starting MySQL as a Windows Service".

The following examples show other common error messages you may encounter when installing MySQL and starting the server for the first time:

- If the MySQL server cannot find the `mysql` privileges database or other critical files, you may see these messages:

  ```
  System error 1067 has occurred.
  Fatal error: Can't open privilege tables: Table 'mysql.host' doesn't exist
  ```

  These messages often occur when the MySQL base or data directories are installed in different locations than the default locations (`C:\Program Files\MySQL\MySQL Server 5.5` and `C:\Program Files\MySQL\MySQL Server`

`5.5\data`, respectively).

This situation may occur when MySQL is upgraded and installed to a new location, but the configuration file is not updated to reflect the new location. In addition, there may be old and new configuration files that conflict. Be sure to delete or rename any old configuration files when upgrading MySQL.

If you have installed MySQL to a directory other than `C:\Program Files\MySQL\MySQL Server 5.5`, you need to ensure that the MySQL server is aware of this through the use of a configuration (`my.ini`) file. The `my.ini` file needs to be located in your Windows directory, typically `C:\WINDOWS`. You can determine its exact location from the value of the `WINDIR` environment variable by issuing the following command from the command prompt:

```
C:\> echo %WINDIR%
```

An option file can be created and modified with any text editor, such as Notepad. For example, if MySQL is installed in `E:\mysql` and the data directory is `D:\MySQLdata`, you can create the option file and set up a `[mysqld]` section to specify values for the `basedir` and `datadir` options:

```
[mysqld]
# set basedir to your installation path
basedir=E:/mysql
# set datadir to the location of your data directory
datadir=D:/MySQLdata
```

Note that Windows path names are specified in option files using (forward) slashes rather than backslashes. If you do use backslashes, double them:

```
[mysqld]
# set basedir to your installation path
basedir=C:\\Program Files\\MySQL\\MySQL Server 5.5
# set datadir to the location of your data directory
datadir=D:\\MySQLdata
```

The rules for use of backslash in option file values are given in Section 4.2.3.3, “Using Option Files”.

If you change the `datadir` value in your MySQL configuration file, you must move the contents of the existing MySQL data directory before restarting the MySQL server.

See Section 2.3.5.2, “Creating an Option File”.

- If you reinstall or upgrade MySQL without first stopping and removing the existing MySQL service and install MySQL using the MySQL Configuration Wizard, you may see this error:

  ```
  Error: Cannot create Windows service for MySql. Error: 0
  ```

  This occurs when the Configuration Wizard tries to install the service and finds an existing service with the same name.

  One solution to this problem is to choose a service name other than `mysql` when using the configuration wizard. This enables the new service to be installed correctly, but leaves the outdated service in place. Although this is harmless, it is best to remove old services that are no longer in use.

  To permanently remove the old `mysql` service, execute the following command as a user with administrative privileges, on the command-line:

  ```
  C:\> sc delete mysql
  [SC] DeleteService SUCCESS
  ```

  If the `sc` utility is not available for your version of Windows, download the `delsrv` utility from http://www.microsoft.com/windows2000/techinfo/reskit/tools/existing/delsrv-o.asp and use the `delsrv mysql` syntax.

2.3.7. Upgrading MySQL on Windows

This section lists some of the steps you should take when upgrading MySQL on Windows.

1. Review Section 2.11.1, “Upgrading MySQL”, for additional information on upgrading MySQL that is not specific to Windows.

2. You should always back up your current MySQL installation before performing an upgrade. See Section 6.2, “Database Backup Methods”.

3. Download the latest Windows distribution of MySQL from http://dev.mysql.com/downloads/.

4. Before upgrading MySQL, you must stop the server. If the server is installed as a service, stop the service with the following command from the command prompt:

   ```
   C:\> NET STOP MySQL
   ```

   If you are not running the MySQL server as a service, use `mysqladmin` to stop it. For example, before upgrading from MySQL 5.1 to 5.5, use `mysqladmin` from MySQL 5.1 as follows:

   ```
   C:\> "C:\Program Files\MySQL\MySQL Server 5.1\bin\mysqladmin" -u root shutdown
   ```

   > **Note**
   >
   > If the MySQL `root` user account has a password, you need to invoke `mysqladmin` with the `-p` option and supply the password when prompted.

5. Before upgrading a MySQL service from MySQL 5.1 to 5.5, you should stop the 5.1 server and remove the instance. Run the MySQL Instance Configuration Wizard, choose the Remove Instance option and in the next screen, confirm removal. After that it is safe to uninstall MySQL Server 5.1.

6. Before upgrading to MySQL 5.5 from a version previous to 4.1.5, or from a version of MySQL installed from a Zip archive to a version of MySQL installed with the MySQL Installation Wizard, you must first manually remove the previous installation and MySQL service (if the server is installed as a service).

   To remove the MySQL service, use the following command:

   ```
   C:\> C:\mysql\bin\mysqld --remove
   ```

   If you do not remove the existing service, the MySQL Installation Wizard may fail to properly install the new MySQL service.

7. If you are using the MySQL Installation Wizard, start the wizard as described in Section 2.3.3.1, “Using the MySQL Installation Wizard”.

8. If you are installing MySQL from a Zip archive, extract the archive. You may either overwrite your existing MySQL installation (usually located at `C:\mysql`), or install it into a different directory, such as `C:\mysql5`. Overwriting the existing installation is recommended.

9. If you were running MySQL as a Windows service and you had to remove the service earlier in this procedure, reinstall the service. (See Section 2.3.5.7, “Starting MySQL as a Windows Service”.)

10. Restart the server. For example, use `NET START MySQL` if you run MySQL as a service, or invoke `mysqld` directly otherwise.

11. As Administrator, run `mysql_upgrade` to check your tables, attempt to repair them if necessary, and update your grant tables if they have changed so that you can take advantage of any new capabilities. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

12. If you encounter errors, see Section 2.3.6, “Troubleshooting a MySQL Installation Under Windows”.

2.3.8. Windows Postinstallation Procedures

On Windows, you need not create the data directory and the grant tables. MySQL Windows distributions include the grant tables with a set of preinitialized accounts in the `mysql` database under the data directory. Regarding passwords, if you installed MySQL using the Windows Installation Wizard, you may have already assigned passwords to the accounts. (See Section 2.3.3.1, “Using the MySQL Installation Wizard”.) Otherwise, use the password-assignment procedure given in Section 2.10.2, “Securing the Initial MySQL Accounts”.

Before setting up passwords, you might want to try running some client programs to make sure that you can connect to the server and that it is operating properly. Make sure that the server is running (see Section 2.3.5.4, “Starting the Server for the First Time”), and then issue the following commands to verify that you can retrieve information from the server. You may need to specify directory different from `C:\mysql\bin` on the command line. If you used the Windows Installation Wizard, the default directory is `C:\Program Files\MySQL\MySQL Server 5.5`, and the `mysql` and `mysqlshow` client programs are in `C:\Program Files\MySQL\MySQL Server 5.5\bin`. See Section 2.3.3.1, “Using the MySQL Installation Wizard”, for more information.

Use `mysqlshow` to see what databases exist:

```
C:\> C:\mysql\bin\mysqlshow
+--------------------+
|     Databases      |
+--------------------+
| information_schema |
| mysql              |
| test               |
+--------------------+
```

The list of installed databases may vary, but will always include the minimum of `mysql` and `information_schema`. In most cases, the `test` database will also be installed automatically.

The preceding command (and commands for other MySQL programs such as `mysql`) may not work if the correct MySQL account does not exist. For example, the program may fail with an error, or you may not be able to view all databases. If you installed using the MSI packages and used the MySQL Server Instance Config Wizard, then the `root` user will have been created automatically with the password you supplied. In this case, you should use the `-u root` and `-p` options. (You will also need to use the `-u root` and `-p` options if you have already secured the initial MySQL accounts.) With `-p`, you will be prompted for the `root` password. For example:

```
C:\> C:\mysql\bin\mysqlshow -u root -p
Enter password: (enter root password here)
+--------------------+
|     Databases      |
+--------------------+
| information_schema |
| mysql              |
| test               |
+--------------------+
```

If you specify a database name, `mysqlshow` displays a list of the tables within the database:

```
C:\> C:\mysql\bin\mysqlshow mysql
Database: mysql
+---------------------------+
|          Tables           |
+---------------------------+
| columns_priv              |
| db                        |
| event                     |
| func                      |
| help_category             |
| help_keyword              |
| help_relation             |
| help_topic                |
| host                      |
| plugin                    |
| proc                      |
| procs_priv                |
| servers                   |
| tables_priv               |
| time_zone                 |
| time_zone_leap_second     |
| time_zone_name            |
| time_zone_transition      |
| time_zone_transition_type |
| user                      |
+---------------------------+
```

Use the `mysql` program to select information from a table in the `mysql` database:

```
C:\> C:\mysql\bin\mysql -e "SELECT Host,Db,User FROM mysql.db"
+------+--------+------+
| host | db     | user |
+------+--------+------+
| %    | test   |      |
| %    | test_% |      |
+------+--------+------+
```

For more information about `mysqlshow` and `mysql`, see Section 4.5.6, “`mysqlshow` — Display Database, Table, and Column Information”, and Section 4.5.1, “`mysql` — The MySQL Command-Line Tool”.

If you are running a version of Windows that supports services, you can set up the MySQL server to run automatically when Windows starts. See Section 2.3.5.7, “Starting MySQL as a Windows Service”.

2.4. Installing MySQL on Mac OS X

MySQL for Mac OS X is available in a number of different forms:

- Native Package Installer format, which uses the native Mac OS X installer to walk you through the installation of MySQL. For more information, see Section 2.4.2, “Installing MySQL on Mac OS X Using Native Packages”. You can use the package installer with Mac OS X 10.3 and later, and the package is available for both PowerPC and Intel architectures, and 32-bit and 64-bit architectures. There is no Universal Binary available using the package installation method. The user you use to perform the installation must have administrator privileges.

- Tar package format, which uses a file packaged using the Unix `tar` and `gzip` commands. To use this method, you will need to open a `Terminal` window. You do not need administrator privileges using this method, as you can install the MySQL server anywhere using this method. For more information on using this method, you can use the generic instructions for using a tarball, Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.You can use the package installer with Mac OS X 10.3 and later, and available for both PowerPC and Intel architectures, and both 32-bit and 64-bit architectures. A Universal Binary, incorporating both Power PC and Intel architectures and 32-bit and 64-bit binaries is available.

  In addition to the core installation, the Package Installer also includes Section 2.4.3, “Installing the MySQL Startup Item” and Section 2.4.4, “Installing and Using the MySQL Preference Pane”, both of which simplify the management of your installation.

- Mac OS X server includes a version of MySQL as standard. If you want to use a more recent version than that supplied with the Mac OS X server release, you can make use of the package or tar formats. For more information on using the MySQL bundled with Mac OS X, see Section 2.4.5, “Using the Bundled MySQL on Mac OS X Server”.

For additional information on using MySQL on Mac OS X, see Section 2.4.1, “General Notes on Installing MySQL on Mac OS X”.

2.4.1. General Notes on Installing MySQL on Mac OS X

You should keep the following issues and notes in mind:

- The default location for the MySQL Unix socket is different on Mac OS X and Mac OS X Server depending on the installation type you chose. The following table shows the default locations by installation type.

  ### Table 2.7. MySQL Unix Socket Locations on Mac OS X by Installation Type

Installation Type	Socket Location
Package Installer from MySQL	`/tmp/mysql.sock`
Tarball from MySQL	`/tmp/mysql.sock`
MySQL Bundled with Mac OS X Server	`/var/mysql/mysql.sock`

  To prevent issues, you should either change the configuration of the socket used within your application (for example, changing `php.ini`), or you should configure the socket location using a MySQL configuration file and the `socket` option. For more information, see Section 5.1.2, “Server Command Options”.

- You may need (or want) to create a specific `mysql` user to own the MySQL directory and data. On Mac OS X 10.4 and lower you can do this by using the `Netinfo Manager` application, located within the `Utilities` folder within the `Applications` folder. On Mac OS X 10.5 and later you can do this through the `Directory Utility`. From Mac OS X 10.5 and later (including Mac OS X Server 10.5) the `mysql` should already exist. For use in single user mode, an entry for `_mysql` (note the underscore prefix) should already exist within the system `/etc/passwd` file.

- Due to a bug in the Mac OS X package installer, you may see this error message in the destination disk selection dialog:

  ```
  You cannot install this software on this disk. (null)
  ```

  If this error occurs, click the `Go Back` button once to return to the previous screen. Then click `Continue` to advance to the destination disk selection again, and you should be able to choose the destination disk correctly. We have reported this bug to Apple and it is investigating this problem.

- Because the MySQL package installer installs the MySQL contents into a version and platform specific directory, you can use this to upgrade and migrate your database between versions. You will need to either copy the `data` directory from the old version to the new version, or alternatively specify an alternative `datadir` value to set location of the data directory.

- You might want to add aliases to your shell's resource file to make it easier to access commonly used programs such as `mysql` and `mysqladmin` from the command line. The syntax for `bash` is:

  ```
  alias mysql=/usr/local/mysql/bin/mysql
  alias mysqladmin=/usr/local/mysql/bin/mysqladmin
  ```

  For `tcsh`, use:

```
alias mysql /usr/local/mysql/bin/mysql
alias mysqladmin /usr/local/mysql/bin/mysqladmin
```

Even better, add `/usr/local/mysql/bin` to your `PATH` environment variable. You can do this by modifying the appropriate startup file for your shell. For more information, see Section 4.2.1, "Invoking MySQL Programs".

- After you have copied over the MySQL database files from the previous installation and have successfully started the new server, you should consider removing the old installation files to save disk space. Additionally, you should also remove older versions of the Package Receipt directories located in `/Library/Receipts/mysql-VERSION.pkg`.

2.4.2. Installing MySQL on Mac OS X Using Native Packages

You can install MySQL on Mac OS X 10.3.x ("Panther") or newer using a Mac OS X binary package in PKG format instead of the binary tarball distribution. Please note that older versions of Mac OS X (for example, 10.1.x or 10.2.x) are *not* supported by this package.

The package is located inside a disk image (`.dmg`) file that you first need to mount by double-clicking its icon in the Finder. It should then mount the image and display its contents.

> **Note**
>
> Before proceeding with the installation, be sure to stop all running MySQL server instances by using either the MySQL Manager Application (on Mac OS X Server) or `mysqladmin shutdown` on the command line.

When installing from the package version, you should also install the MySQL Preference Pane, which will enable you to control the startup and execution of your MySQL server from System Preferences. For more information, see Section 2.4.4, "Installing and Using the MySQL Preference Pane".

When installing using the package installer, the files are installed into a directory within `/usr/local` matching the name of the installation version and platform. For example, the installer file `mysql-5.1.39-osx10.5-x86_64.pkg` installs MySQL into `/usr/local/mysql-5.1.39-osx10.5-x86_64` . The following table shows the layout of the installation directory.

Table 2.8. MySQL Installation Layout on Mac OS X

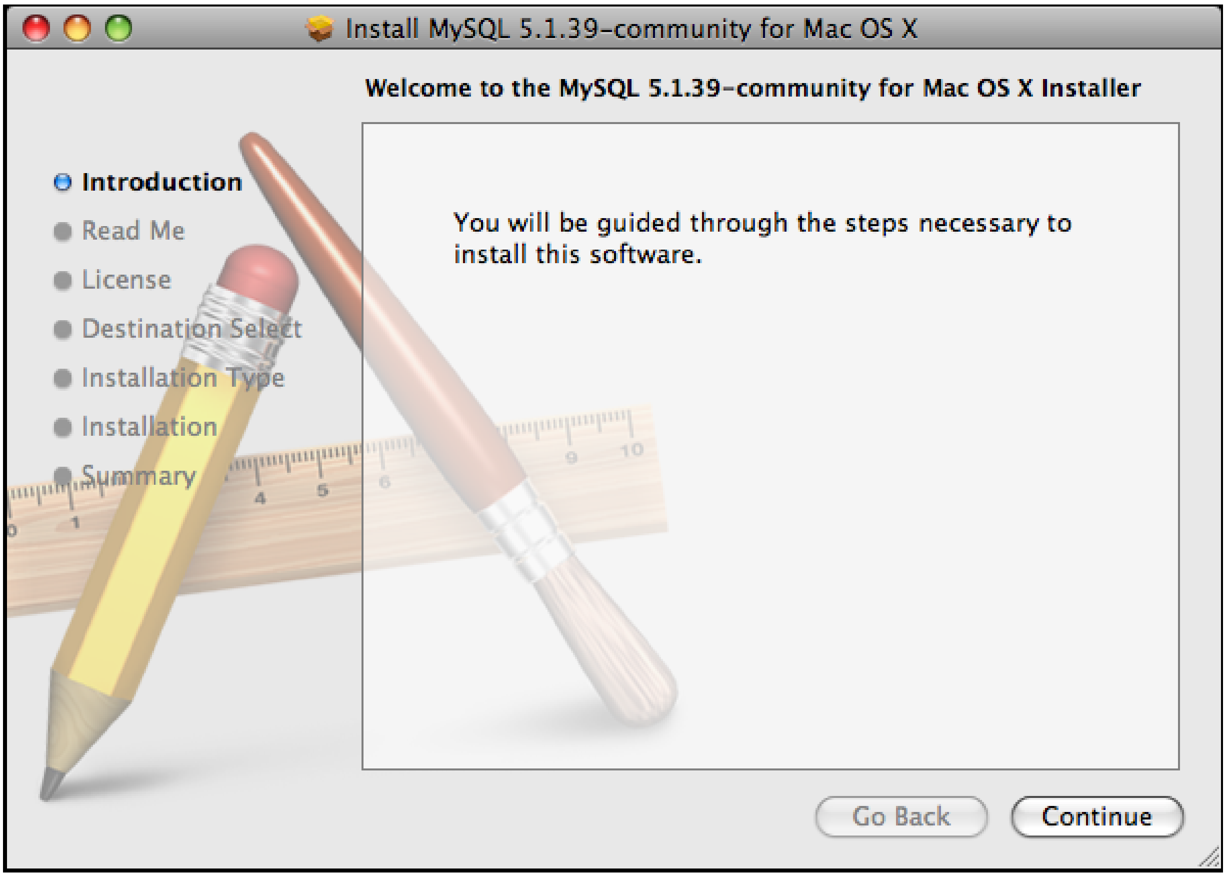
Directory	Contents of Directory
`bin`	Client programs and the `mysqld` server
`data`	Log files, databases
`docs`	Manual in Info format
`include`	Include (header) files
`lib`	Libraries
`man`	Unix manual pages
`mysql-test`	MySQL test suite
`scripts`	`mysql_install_db`
`share`	Miscellaneous support files, including error messages, sample configuration files, SQL for database installation
`sql-bench`	Benchmarks
`support-files`	Scripts and sample configuration files
`/tmp/mysql.sock`	Location of the MySQL Unix socket

During the package installer process, a symbolic link from `/usr/local/mysql` to the version/platform specific directory created during installation will be created automatically.

1. Download and open the MySQL package installer, which is provided on a disk image (`.dmg`) that includes the main MySQL installation package, the `MySQLStartupItem.pkg` installation package, and the `MySQL.prefPane`. Double-click the disk image to open it.

2. Double-click the MySQL installer package. It will be named according to the version of MySQL you have downloaded. For example, if you have downloaded MySQL 5.1.39, double-click `mysql-5.1.39-osx10.5-x86.pkg`.

3. You will be presented with the opening installer dialog. Click CONTINUE to begin installation.


Install MySQL 5.1.39-community for Mac OS X
Introduction
Read Me
License
Destination Select
Installation Type
Installation
Summary
Go Back
Continue

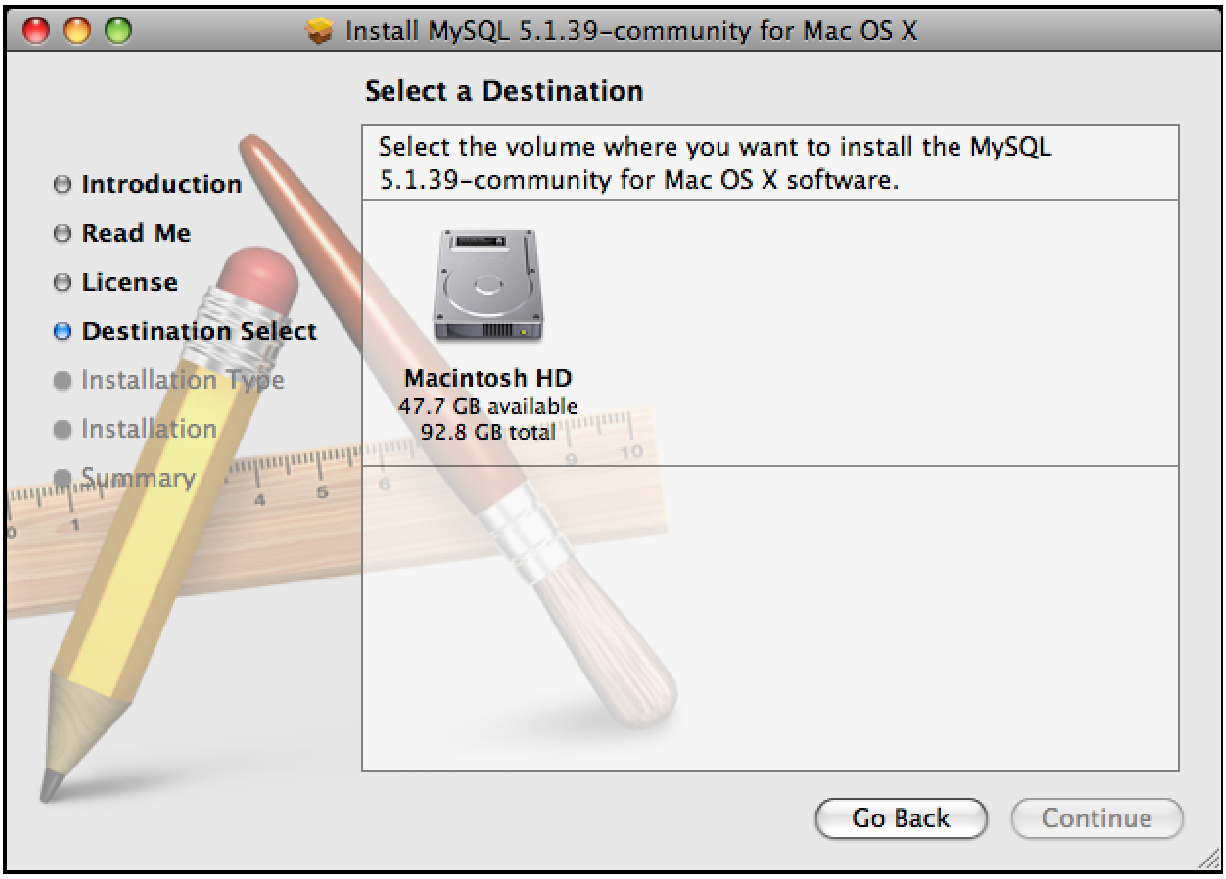
Welcome to the MySQL 5.1.39-community for Mac OS X Installer

You will be guided through the steps necessary to install this software.

4. A copy of the installation instructions and other important information relevant to this installation are displayed. Click CONTINUE .

5. If you have downloaded the community version of MySQL, you will be shown a copy of the relevant GNU General Public License. Click CONTINUE .

6. Select the drive you want to use to install the MySQL Startup Item. The drive must have a valid, bootable, Mac OS X operating system installed. Click CONTINUE.


Install MySQL 5.1.39-community for Mac OS X
Select a Destination
Introduction
Read Me
License
Destination Select
Installation Type
Installation
Summary
Macintosh HD
47.7 GB available
92.8 GB total
Go Back
Continue

Select the volume where you want to install the MySQL 5.1.39-community for Mac OS X software.

7. You will be asked to confirm the details of the installation, including the space required for the installation. To change the drive on which the startup item is installed, click either GO BACK or CHANGE INSTALL LOCATION.... To install the startup item, click INSTALL.
8. Once the installation has been completed successfully, you will be shown an **INSTALL SUCCEEDED** message.

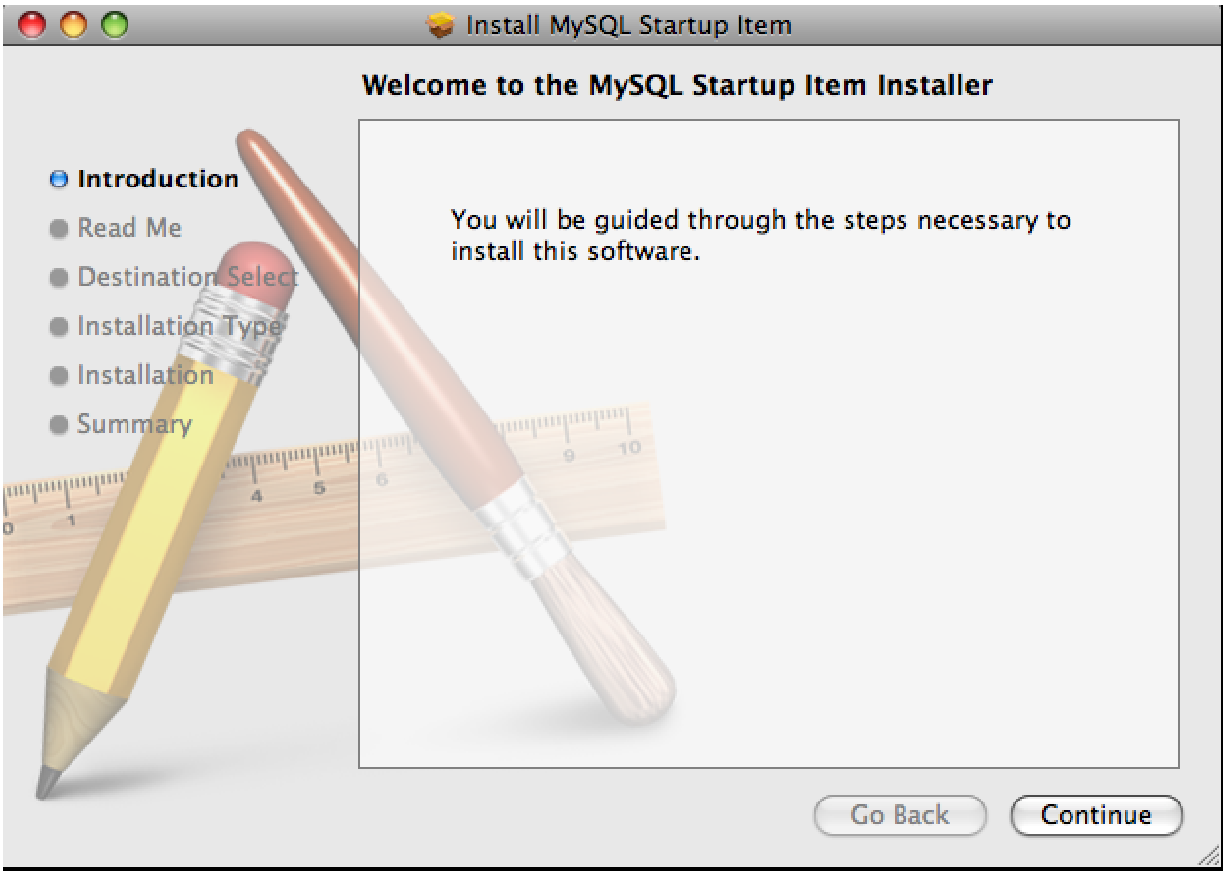
For convenience, you may also want to install the startup item and preference pane. See Section 2.4.3, “Installing the MySQL Startup Item”, and Section 2.4.4, “Installing and Using the MySQL Preference Pane”.

2.4.3. Installing the MySQL Startup Item

The MySQL Installation Package includes a startup item that can be used to automatically start and stop MySQL.

To install the MySQL Startup Item:

1. Download and open the MySQL package installer, which is provided on a disk image (`.dmg`) that includes the main MySQL installation package, the `MySQLStartupItem.pkg` installation package, and the `MySQL.prefPane`. Double-click the disk image to open it.
2. Double-click the `MySQLStartItem.pkg` file to start the installation process.
3. You will be presented with the **INSTALL MYSQL STARTUP ITEM** dialog.


Install MySQL Startup Item
Introduction
Read Me
Destination Select
Installation Type
Installation
Summary
Go Back
Continue

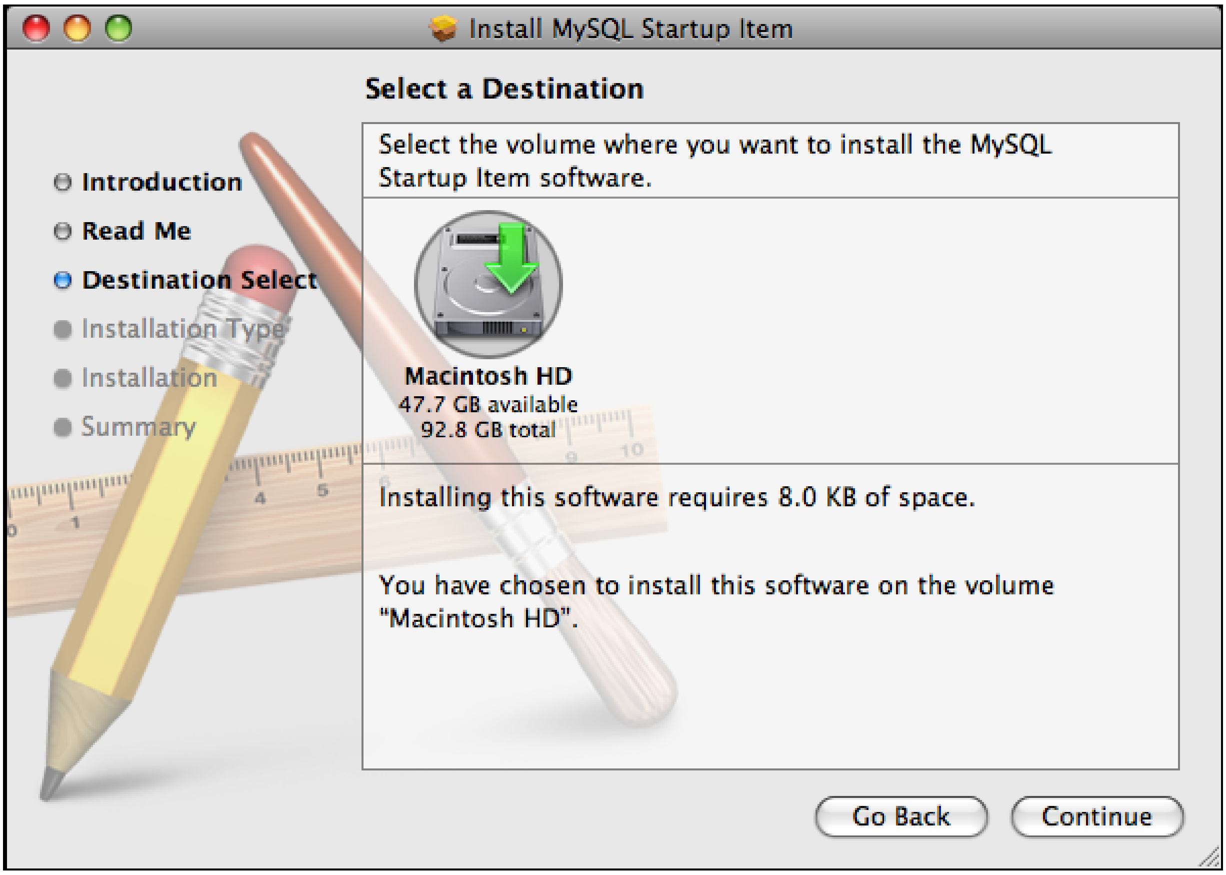
Welcome to the MySQL Startup Item Installer

You will be guided through the steps necessary to install this software.

Click CONTINUE to continue the installation process.

4. A copy of the installation instructions and other important information relevant to this installation are displayed. Click CONTINUE .

5. Select the drive you want to use to install the MySQL Startup Item. The drive must have a valid, bootable, Mac OS X operating system installed. Click CONTINUE.


Install MySQL Startup Item
Introduction
Read Me
Destination Select
Installation Type
Installation
Summary
Go Back
Continue

Select a Destination

Select the volume where you want to install the MySQL Startup Item software.

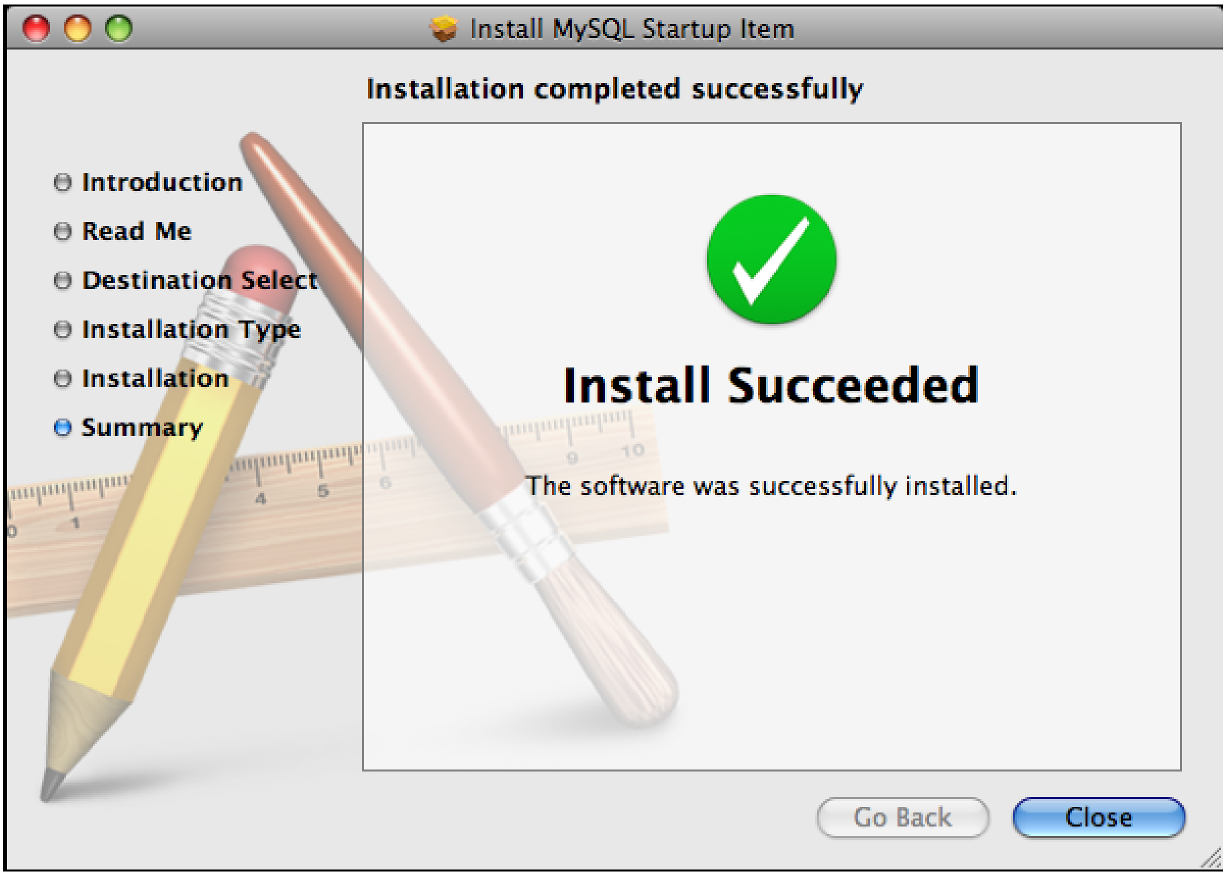
Macintosh HD
47.7 GB available
92.8 GB total

Installing this software requires 8.0 KB of space.

You have chosen to install this software on the volume "Macintosh HD".

6. You will be asked to confirm the details of the installation. To change the drive on which the startup item is installed, click either GO BACK or CHANGE INSTALL LOCATION.... To install the startup item, click INSTALL.

7. Once the installation has been completed successfully, you will be shown an **INSTALL SUCCEEDED** message.



Installation completed successfully

Install Succeeded

The software was successfully installed.

The Startup Item for MySQL is installed into `/Library/StartupItems/MySQLCOM`. The Startup Item installation adds a variable `MYSQLCOM=-YES-` to the system configuration file `/etc/hostconfig`. If you want to disable the automatic startup of MySQL, change this variable to `MYSQLCOM=-NO-`.

After the installation, you can start and stop MySQL by running the following commands in a terminal window. You must have administrator privileges to perform these tasks, and you may be prompted for your password.

If you have installed the Startup Item, use this command to start the server:

```
shell> sudo /Library/StartupItems/MySQLCOM/MySQLCOM start
```

If you have installed the Startup Item, use this command to stop the server:

```
shell> sudo /Library/StartupItems/MySQLCOM/MySQLCOM stop
```

2.4.4. Installing and Using the MySQL Preference Pane

The MySQL Package installer disk image also includes a custom MySQL Preference Pane that enables you to start, stop, and control automated startup during boot of your MySQL installation.

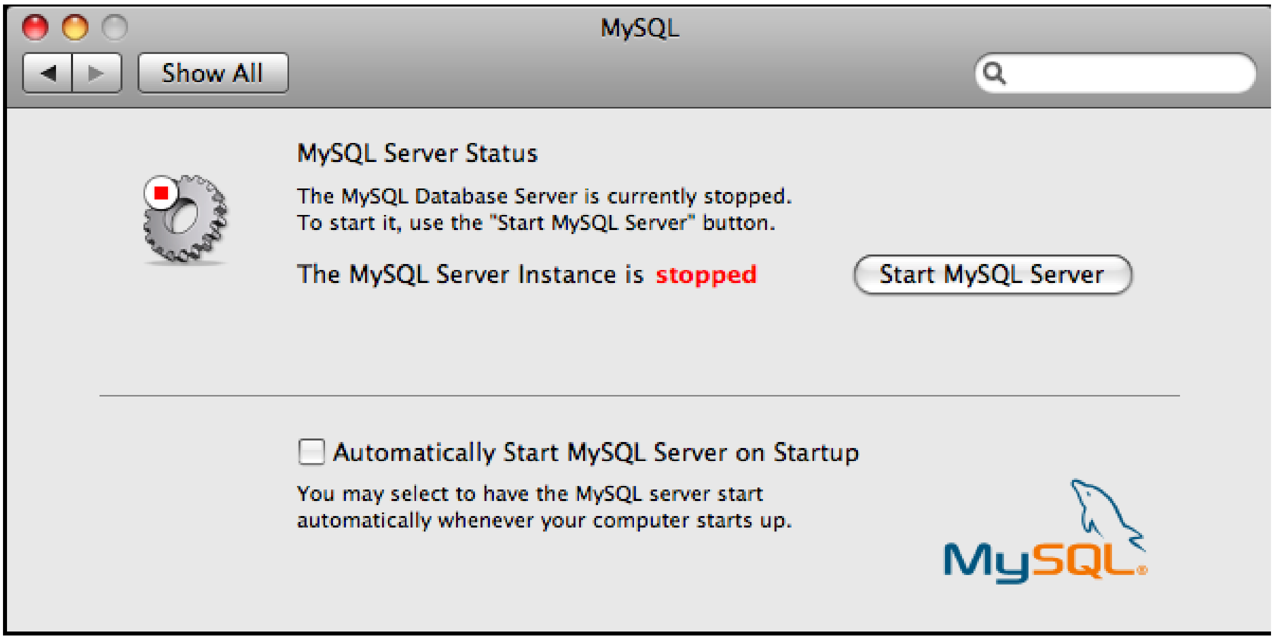
To install the MySQL Preference Pane:

1. Download and open the MySQL package installer package, which is provided on a disk image (`.dmg`) that includes the main MySQL installation package, the `MySQLStartupItem.pkg` installation package, and the `MySQL.prefPane`. Double-click the disk image to open it.
2. Double-click the `MySQL.prefPane`. The MySQL System Preferences will open.
3. If this is the first time you have installed the preference pane, you will be asked to confirm installation and whether you want to install the preference pane for all users, or only the current user. To install the preference pane for all users you will need administrator privileges. If necessary, you will be prompted for the username and password for a user with administrator privileges.

4. If you already have the MySQL Preference Pane installed, you will be asked to confirm whether you want to overwrite the existing MySQL Preference Pane.

> **Note**
>
> The MySQL Preference Pane only starts and stops MySQL installation installed from the MySQL package installation that have been installed in the default location.

Once the MySQL Preference Pane has been installed, you can control your MySQL server instance using the preference pane. To use the preference pane, open the **System Preferences...** from the Apple menu. Select the MySQL preference pane by clicking the MySQL logo within the **Other** section of the preference panes list.



MySQL Server Status

The MySQL Database Server is currently stopped.
To start it, use the "Start MySQL Server" button.

The MySQL Server Instance is stopped

☐ Automatically Start MySQL Server on Startup

You may select to have the MySQL server start automatically whenever your computer starts up.

The MySQL Preference Pane shows the current status of the MySQL server, showing **STOPPED** (in red) if the server is not running and **RUNNING** (in green) if the server has already been started. The preference pane also shows the current setting for whether the MySQL server has been set to start automatically.

- **To start MySQL using the preference pane:**

  Click Start MySQL Server. You may be prompted for the username and password of a user with administrator privileges to start the MySQL server.

- **To stop MySQL using the preference pane:**

  Click Stop MySQL Server. You may be prompted for the username and password of a user with administrator privileges to stop the MySQL server.

- **To automatically start the MySQL server when the system boots:**

  Check the check box next to **Automatically Start MySQL Server on Startup**.

- **To disable automatic MySQL server startup when the system boots:**

  Uncheck the check box next to **Automatically Start MySQL Server on Startup**.

You can close the `System Preferences...` window once you have completed your settings.

2.4.5. Using the Bundled MySQL on Mac OS X Server

If you are running Mac OS X Server, a version of MySQL should already be installed. The following table shows the versions of MySQL that ship with Mac OS X Server versions.

Table 2.9. MySQL Versions Preinstalled with Mac OS X Server

Mac OS X Server Version	MySQL Version
10.2-10.2.2	3.23.51
10.2.3-10.2.6	3.23.53
10.3	4.0.14
10.3.2	4.0.16
10.4.0	4.1.10a
10.5.0	5.0.45
10.6.0	5.0.82

The following table shows the installation layout of MySQL on Mac OS X Server.

Table 2.10. MySQL Directory Layout for Preinstalled MySQL Installations on Mac OS X Server

Directory	Contents of Directory
`/usr/bin`	Client programs
`/var/mysql`	Log files, databases
`/usr/libexec`	The `mysqld` server
`/usr/share/man`	Unix manual pages
`/usr/share/mysql/mysql-test`	MySQL test suite
`/usr/share/mysql`	Miscellaneous support files, including error messages, character set files, sample configuration files, SQL for database installation
`/var/mysql/mysql.sock`	Location of the MySQL Unix socket

Additional Resources

- For more information on managing the bundled MySQL instance in Mac OS X Server 10.5, see Mac OS X Server: Web Technologies Administration For Version 10.5 Leopard.
- For more information on managing the bundled MySQL instance in Mac OS X Server 10.6, see Mac OS X Server: Web Technologies Administration Version 10.6 Snow Leopard.
- The MySQL server bundled with Mac OS X Server does not include the MySQL client libraries and header files required to access and use MySQL from a third-party driver, such as Perl DBI or PHP. For more information on obtaining and installing MySQL libraries, see Mac OS X Server version 10.5: MySQL libraries available for download. Alternatively, you can ignore the bundled MySQL server and install MySQL from the package or tarball installation.

2.5. Installing MySQL on Linux

Linux supports a number of different solutions for installing MySQL. The recommended method is to use one of the distributions from Oracle. If you choose this method, there are three options available:

- Installing from a generic binary package in `.tar.gz` format. See Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux” for more information.
- Extracting and compiling MySQL from a source distribution. For detailed instructions, see Section 2.9, “Installing MySQL from Source”.
- Installing using a pre-compiled RPM package. For more information on using the RPM solution, see Section 2.5.1, “Installing MySQL from RPM Packages on Linux”.

As an alternative, you can use the native package manager within your Linux distribution to automatically download and install MySQL for you. Native package installations can take of the download and dependencies required to run MySQL, but the MySQL version will often be some way behind the currently available release. You will also normally be unable to install developmental releases, as these are not usually made available in the native repository. For more information on using the native package installers, see Section 2.5.2, “Installing MySQL on Linux using Native Package Manager”.

Note

> For many Linux installations, you will want to set up MySQL to be started automatically when your machine starts. Many of the native package installations perform this operation for you, but for source, binary and RPM solutions you may need to set this up separately. The required script, `mysql.server`, can be found in the `support-files` directory under the MySQL installation directory or in a MySQL source tree. You can install it as `/etc/init.d/mysql` for automatic MySQL startup and shutdown. See Section 2.10.1.2, “Starting and Stopping MySQL Automatically”.

2.5.1. Installing MySQL from RPM Packages on Linux

The recommended way to install MySQL on RPM-based Linux distributions is by using the RPM packages. The RPMs that we provide to the community should work on all versions of Linux that support RPM packages and use `glibc` 2.3. To obtain RPM packages, see Section 2.1.3, “How to Get MySQL”.

For non-RPM Linux distributions, you can install MySQL using a `.tar.gz` package. See Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.

Installations created from our Linux RPM distributions result in files under the following system directories.

Table 2.11. MySQL Installation Layout for Linux RPM

Directory	Contents of Directory
`/usr/bin`	Client programs and scripts
`/usr/sbin`	The `mysqld` server
`/var/lib/mysql`	Log files, databases
`/usr/share/info`	Manual in Info format
`/usr/share/man`	Unix manual pages
`/usr/include/mysql`	Include (header) files
`/usr/lib/mysql`	Libraries
`/usr/share/mysql`	Miscellaneous support files, including error messages, character set files, sample configuration files, SQL for database installation
`/usr/share/sql-bench`	Benchmarks

> **Note**
>
> RPM distributions of MySQL often are provided by other vendors. Be aware that they may differ in features and capabilities from those built by us, and that the instructions in this manual do not necessarily apply to installing them. The vendor's instructions should be consulted instead.

In most cases, you need to install only the `MySQL-server` and `MySQL-client` packages to get a functional MySQL installation. The other packages are not required for a standard installation.

RPMs for MySQL Cluster. Standard MySQL server RPMs built by MySQL do not provide support for the `NDBCLUSTER` storage engine.

> **Important**
>
> When upgrading a MySQL Cluster RPM installation, you must upgrade *all* installed RPMs, including the `Server` and `Client` RPMs.

For more information about installing MySQL Cluster from RPMs, see MySQL Cluster Installation.

For upgrades, if your installation was originally produced by installing multiple RPM packages, it is best to upgrade all the packages, not just some. For example, if you previously installed the server and client RPMs, do not upgrade just the server RPM.

If you get a dependency failure when trying to install MySQL packages (for example, `error: removing these packages would break dependencies: libmysqlclient.so.10 is needed by ...`), you should also install the `MySQL-shared-compat` package, which includes both the shared libraries for backward compatibility (`libmysqlclient.so.12` for MySQL 4.0 and `libmysqlclient.so.10` for MySQL 3.23).

The RPM packages shown in the following list are available. The names shown here use a suffix of `.glibc23.i386.rpm`, but particular packages can have different suffixes, described later.

- `MySQL-server-`*`VERSION`*`.glibc23.i386.rpm`

The MySQL server. You need this unless you only want to connect to a MySQL server running on another machine.

- `MySQL-client-VERSION.glibc23.i386.rpm`

  The standard MySQL client programs. You probably always want to install this package.

- `MySQL-devel-VERSION.glibc23.i386.rpm`

  The libraries and include files that are needed if you want to compile other MySQL clients, such as the Perl modules.

- `MySQL-debuginfo-VERSION.glibc23.i386.rpm`

  This package contains debugging information. `debuginfo` RPMs are never needed to use MySQL software; this is true both for the server and for client programs. However, they contain additional information that might be needed by a debugger to analyze a crash.

- `MySQL-shared-VERSION.glibc23.i386.rpm`

  This package contains the shared libraries (`libmysqlclient.so*`) that certain languages and applications need to dynamically load and use MySQL. It contains single-threaded and thread-safe libraries. Prior to MySQL 5.5.6, if you install this package, do not install the `MySQL-shared-compat` package.

- `MySQL-shared-compat-VERSION.glibc23.i386.rpm`

  This package includes the shared libraries for MySQL 3.23, 4.0, and so on. It contains single-threaded and thread-safe libraries. Install this package if you have applications installed that are dynamically linked against older versions of MySQL but you want to upgrade to the current version without breaking the library dependencies. Before MySQL 5.5.6, `MySQL-shared-compat` also includes the libraries for the current release, so if you install it, you should not also install `MySQL-shared`. As of 5.5.6, `MySQL-shared-compat` does not include the current library version, so there is no conflict.

- `MySQL-embedded-VERSION.glibc23.i386.rpm`

  The embedded MySQL server library.

- `MySQL-test-VERSION.glibc23.i386.rpm`

  This package includes the MySQL test suite.

- `MySQL-VERSION.src.rpm`

  This contains the source code for all of the previous packages. It can also be used to rebuild the RPMs on other architectures (for example, Alpha or SPARC).

The suffix of RPM package names (following the *`VERSION`* value) has the following syntax:

```
.PLATFORM.CPU.rpm
```

The *`PLATFORM`* and *`CPU`* values indicate the type of system for which the package is built. *`PLATFORM`* indicates the platform and *`CPU`* indicates the processor type or family.

All packages are dynamically linked against `glibc` 2.3. The *`PLATFORM`* value indicates whether the package is platform independent or intended for a specific platform, as shown in the following table.

Table 2.12. MySQL Linux Installation Packages

***`PLATFORM`* Value**	**Intended Use**
`glibc23`	Platform independent, should run on any Linux distribution that supports `glibc` 2.3
`rhel3`, `rhel4`	Red Hat Enterprise Linux 3 or 4
`sles9`, `sles10`	SuSE Linux Enterprise Server 9 or 10

In MySQL 5.5, only `glibc23` packages are available currently.

The *`CPU`* value indicates the processor type or family for which the package is built.

Table 2.13. MySQL Installation Packages for Linux CPU Identifier

`CPU` **Value**	**Intended Processor Type or Family**
`i386`	x86 processor, 386 and up
`i586`	x86 processor, Pentium and up
`x86_64`	64-bit x86 processor
`ia64`	Itanium (IA-64) processor

To see all files in an RPM package (for example, a `MySQL-server` RPM), run a command like this:

```
shell> rpm -qpl MySQL-server-VERSION.glibc23.i386.rpm
```

To perform a standard minimal installation, install the server and client RPMs:

```
shell> rpm -i MySQL-server-VERSION.glibc23.i386.rpm
shell> rpm -i MySQL-client-VERSION.glibc23.i386.rpm
```

To install only the client programs, install just the client RPM:

```
shell> rpm -i MySQL-client-VERSION.glibc23.i386.rpm
```

RPM provides a feature to verify the integrity and authenticity of packages before installing them. If you would like to learn more about this feature, see Section 2.1.4, “Verifying Package Integrity Using MD5 Checksums or `GnuPG`”.

The server RPM places data under the `/var/lib/mysql` directory. The RPM also creates a login account for a user named `mysql` (if one does not exist) to use for running the MySQL server, and creates the appropriate entries in `/etc/init.d/` to start the server automatically at boot time. (This means that if you have performed a previous installation and have made changes to its startup script, you may want to make a copy of the script so that you do not lose it when you install a newer RPM.) See Section 2.10.1.2, “Starting and Stopping MySQL Automatically”, for more information on how MySQL can be started automatically on system startup.

If you want to install the MySQL RPM on older Linux distributions that do not support initialization scripts in `/etc/init.d` (directly or through a symlink), you should create a symbolic link that points to the location where your initialization scripts actually are installed. For example, if that location is `/etc/rc.d/init.d`, use these commands before installing the RPM to create `/etc/init.d` as a symbolic link that points there:

```
shell> cd /etc
shell> ln -s rc.d/init.d .
```

However, all current major Linux distributions should support the new directory layout that uses `/etc/init.d`, because it is required for LSB (Linux Standard Base) compliance.

In MySQL 5.5.5 and later, during a new installation, the server boot scripts are installed, but the MySQL server is not started at the end of the installation, since the status of the server during an unattended installation is not known.

In MySQL 5.5.5 and later, during an upgrade installation using the RPM packages, if the MySQL server is running when the upgrade occurs, the MySQL server is stopped, the upgrade occurs, and the MySQL server is restarted. If the MySQL server is not already running when the RPM upgrade occurs, the MySQL server is not started at the end of the installation.

If something goes wrong, you can find more information in the binary installation section. See Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.

> **Note**
>
> The accounts that are listed in the MySQL grant tables initially have no passwords. After starting the server, you should set up passwords for them using the instructions in Section 2.10, “Postinstallation Setup and Testing”.

During RPM installation, a user named `mysql` and a group named `mysql` are created on the system. This is done using the `useradd`, `groupadd`, and `usermod` commands. Those commands require appropriate administrative privileges, which is required for locally managed users and groups (as listed in the `/etc/passwd` and `/etc/group` files) by the RPM installation process being run by `root`.

If you log in as the `mysql` user, you may find that MySQL displays “Invalid (old?) table or database name” errors that mention `.mysqlgui`, `lost+found`, `.mysqlgui`, `.bash_history`, `.fonts.cache-1`, `.lesshst`, `.mysql_history`, `.profile`, `.viminfo`, and similar files created by MySQL or operating system utilities. You can safely ignore these error messages or remove the files or directories that cause them if you do not need them.

For nonlocal user management (LDAP, NIS, and so forth), the administrative tools may require additional authentication (such as a password), and will fail if the installing user does not provide this authentication. Even if they fail, the RPM installation will not abort but succeed, and this is intentional. If they failed, some of the intended transfer of ownership may be missing, and it is recommended that the system administrator then manually ensures some appropriate user and group exists and manually transfers ownership following the actions in the RPM spec file.

2.5.2. Installing MySQL on Linux using Native Package Manager

Many Linux distributions include a version of the MySQL server, client tools, and development components into the standard package management system built into distributions such as Fedora, Debian, Ubuntu, and Gentoo. This section provides basic instructions for installing MySQL using these systems.

> **Important**
>
> Native package installations can take care of the download and dependencies required to run MySQL, but the MySQL version will often be some way behind the currently available release. You will also normally be unable to install developmental releases, as these are not usually made available in the native repository.

Distribution specific instructions are shown below:

- **Red Hat Linux, Fedora, CentOS**

  For Red Hat and similar distributions, the MySQL distribution is divided into a number of separate packages, `mysql` for the client tools, `mysql-server` for the server and associated tools, and `mysql-libs` for the libraries. The libraries are required if you want to provide connectivity from different languages and environments such as Perl, Python and others.

  To install, use the `yum` command to specify the packages that you want to install. For example:

```
root-shell> yum install mysql mysql-server mysql-libs mysql-server
Loaded plugins: presto, refresh-packagekit
Setting up Install Process
Resolving Dependencies
--> Running transaction check
---> Package mysql.x86_64 0:5.1.48-2.fc13 set to be updated
---> Package mysql-libs.x86_64 0:5.1.48-2.fc13 set to be updated
---> Package mysql-server.x86_64 0:5.1.48-2.fc13 set to be updated
--> Processing Dependency: perl-DBD-MySQL for package: mysql-server-5.1.48-2.fc13.x86_64
--> Running transaction check
---> Package perl-DBD-MySQL.x86_64 0:4.017-1.fc13 set to be updated
--> Finished Dependency Resolution

Dependencies Resolved

================================================================================
 Package               Arch          Version               Repository      Size
================================================================================
Installing:
 mysql                 x86_64        5.1.48-2.fc13         updates        889 k
 mysql-libs            x86_64        5.1.48-2.fc13         updates        1.2 M
 mysql-server          x86_64        5.1.48-2.fc13         updates        8.1 M
Installing for dependencies:
 perl-DBD-MySQL        x86_64        4.017-1.fc13          updates        136 k

Transaction Summary
================================================================================
Install       4 Package(s)
Upgrade       0 Package(s)

Total download size: 10 M
Installed size: 30 M
Is this ok [y/N]: y
Downloading Packages:
Setting up and reading Presto delta metadata
Processing delta metadata
Package(s) data still to download: 10 M
(1/4): mysql-5.1.48-2.fc13.x86_64.rpm                  | 889 kB     00:04
(2/4): mysql-libs-5.1.48-2.fc13.x86_64.rpm             | 1.2 MB     00:06
(3/4): mysql-server-5.1.48-2.fc13.x86_64.rpm           | 8.1 MB     00:40
(4/4): perl-DBD-MySQL-4.017-1.fc13.x86_64.rpm          | 136 kB     00:00
--------------------------------------------------------------------------------
Total                                          201 kB/s |  10 MB     00:52
Running rpm_check_debug
Running Transaction Test
Transaction Test Succeeded
Running Transaction
  Installing     : mysql-libs-5.1.48-2.fc13.x86_64                          1/4
  Installing     : mysql-5.1.48-2.fc13.x86_64                               2/4
  Installing     : perl-DBD-MySQL-4.017-1.fc13.x86_64                       3/4
  Installing     : mysql-server-5.1.48-2.fc13.x86_64                        4/4

Installed:
  mysql.x86_64 0:5.1.48-2.fc13            mysql-libs.x86_64 0:5.1.48-2.fc13
  mysql-server.x86_64 0:5.1.48-2.fc13

Dependency Installed:
  perl-DBD-MySQL.x86_64 0:4.017-1.fc13
```

```
Complete!
```

MySQL and the MySQL server should now be installed. A sample configuration file is installed into `/etc/my.cnf`. An init script, to start and stop the server, will have been installed into `/etc/init.d/mysqld`. To start the MySQL server use `service`:

```
root-shell> service mysqld start
```

To enable the server to be started and stopped automatically during boot, use `chkconfig`:

```
root-shell> chkconfig --levels 235 mysqld on
```

Which enables the MySQL server to be started (and stopped) automatically at the specified the run levels.

The database tables will have been automatically created for you, if they do not already exist. You should, however, run `mysql_secure_installation` to set the root passwords on your server.

- **Debian, Ubuntu, Kubuntu**

  On Debian and related distributions, there are two packages, `mysql-client` and `mysql-server`, for the client and server components respectively. You should specify an explicit version, for example `mysql-client-5.1`, to ensure that you install the version of MySQL that you want.

  To download and install, including any dependencies, use the `apt-get` command, specifying the packages that you want to install.

  > **Note**
  >
  > Before installing, make sure that you update your `apt-get` index files to ensure you are downloading the latest available version.

  A sample installation of the MySQL packages might look like this (some sections trimmed for clarity):

```
root-shell> apt-get install mysql-client-5.1 mysql-server-5.1
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  linux-headers-2.6.28-11 linux-headers-2.6.28-11-generic
Use 'apt-get autoremove' to remove them.
The following extra packages will be installed:
  bsd-mailx libdbd-mysql-perl libdbi-perl libhtml-template-perl
  libmysqlclient15off libmysqlclient16 libnet-daemon-perl libplrpc-perl mailx
  mysql-common postfix
Suggested packages:
  dbishell libipc-sharedcache-perl tinyca procmail postfix-mysql postfix-pgsql
  postfix-ldap postfix-pcre sasl2-bin resolvconf postfix-cdb
The following NEW packages will be installed
  bsd-mailx libdbd-mysql-perl libdbi-perl libhtml-template-perl
  libmysqlclient15off libmysqlclient16 libnet-daemon-perl libplrpc-perl mailx
  mysql-client-5.1 mysql-common mysql-server-5.1 postfix
0 upgraded, 13 newly installed, 0 to remove and 182 not upgraded.
Need to get 1907kB/25.3MB of archives.
After this operation, 59.5MB of additional disk space will be used.
Do you want to continue [Y/n]? Y
Get: 1 http://gb.archive.ubuntu.com jaunty-updates/main mysql-common 5.1.30really5.0.75-0ubuntu10.5 [63.6kB]
Get: 2 http://gb.archive.ubuntu.com jaunty-updates/main libmysqlclient15off 5.1.30really5.0.75-0ubuntu10.5 [1843kB]
Fetched 1907kB in 9s (205kB/s)
Preconfiguring packages ...
Selecting previously deselected package mysql-common.
(Reading database ... 121260 files and directories currently installed.)
...
Processing 1 added doc-base file(s)...
Registering documents with scrollkeeper...
Setting up libnet-daemon-perl (0.43-1) ...
Setting up libplrpc-perl (0.2020-1) ...
Setting up libdbi-perl (1.607-1) ...
Setting up libmysqlclient15off (5.1.30really5.0.75-0ubuntu10.5) ...

Setting up libdbd-mysql-perl (4.008-1) ...
Setting up libmysqlclient16 (5.1.31-1ubuntu2) ...

Setting up mysql-client-5.1 (5.1.31-1ubuntu2) ...

Setting up mysql-server-5.1 (5.1.31-1ubuntu2) ...
 * Stopping MySQL database server mysqld
   ...done.
100825 11:46:15  InnoDB: Started; log sequence number 0 46409
100825 11:46:15  InnoDB: Starting shutdown...
100825 11:46:17  InnoDB: Shutdown completed; log sequence number 0 46409
100825 11:46:17 [Warning] Forcing shutdown of 1 plugins
 * Starting MySQL database server mysqld
```

```
    ...done.
 * Checking for corrupt, not cleanly closed and upgrade needing tables.
...
Processing triggers for libc6 ...
ldconfig deferred processing now taking place
```

> **Note**
>
> The `apt-get` command will install a number of packages, including the MySQL server, in order to provide the typical tools and application environment. This can mean that you install a large number of packages in addition to the main MySQL package.

During installation, the initial database will be created, and you will be prompted for the MySQL root password (and confirmation). A configuration file will have been created in `/etc/mysql/my.cnf`. An init script will have been created in `/etc/init.d/mysql`.

The server will already be started. You can manually start and stop the server using:

```
root-shell> service mysql [start|stop]
```

The service will automatically be added to the 2, 3 and 4 run levels, with stop scripts in the single, shutdown and restart levels.

- **Gentoo Linux**

  As a source-based distribution, installing MySQL on Gentoo involves downloading the source, patching the Gentoo specifics, and then compiling the MySQL server and installing it. This process is handled automatically by the `emerge` command. Depending on the version of MySQL that you want to install, you may need to unmask the specific version that you want for your chosen platform.

  The MySQL server and client tools are provided within a single package, `dev-db/mysql`. You can obtain a list of the versions available to install by looking at the portage directory for the package:

  ```
  root-shell> ls /usr/portage/dev-db/mysql/mysql-5.1*
  mysql-5.1.39-r1.ebuild
  mysql-5.1.44-r1.ebuild
  mysql-5.1.44-r2.ebuild
  mysql-5.1.44-r3.ebuild
  mysql-5.1.44.ebuild
  mysql-5.1.45-r1.ebuild
  mysql-5.1.45.ebuild
  mysql-5.1.46.ebuild
  ```

  To install a specific MySQL version, you must specify the entire atom. For example:

  ```
  root-shell> emerge =dev-db/mysql-5.1.46
  ```

  A simpler alternative is to use the `virtual/mysql-5.1` package, which will install the latest version:

  ```
  root-shell> emerge =virtual/mysql-5.1
  ```

  If the package is masked (because it is not tested or certified for the current platform), use the `ACCEPT_KEYWORDS` environment variable. For example:

  ```
  root-shell> ACCEPT_KEYWORDS="~x86" emerge =virtual/mysql-5.1
  ```

  After installation, you should create a new database using `mysql_install_db`, and set the password for the root user on MySQL. You can use the configuration interface to set the password and create the initial database:

  ```
  root-shell> emerge --config =dev-db/mysql-5.1.46
  ```

  A sample configuration file will have been created for you in `/etc/mysql/my.cnf`, and an init script will have been created in `/etc/init.d/mysql`.

  To enable MySQL to start automatically at the normal (default) run levels, you can use:

  ```
  root-shell> rc-update add default mysql
  ```

2.6. Installing MySQL on Solaris and OpenSolaris

MySQL on Solaris and OpenSolaris is available in a number of different formats.

- For information on installing using the native Solaris `PKG` format, see Section 2.6.1, "Installing MySQL on Solaris using a Solaris `PKG`".
- On OpenSolaris, the standard package repositories include MySQL packages specially built for OpenSolaris that include entries for the Service Management Framework (SMF) to enable control of the installation using the SMF administration commands. For more information, see Section 2.6.2, "Installing MySQL on OpenSolaris using IPS".
- To use a standard `tar` binary installation, use the notes provided in Section 2.2, "Installing MySQL from Generic Binaries on Unix/Linux". Check the notes and hints at the end of this section for Solaris specific notes that you may need before or after installation.

To obtain a binary MySQL distribution for Solaris in tarball or PKG format, http://dev.mysql.com/downloads/mysql/5.5.html.

Additional notes to be aware of when installing and using MySQL on Solaris:

- If you want to use MySQL with the `mysql` user and group, use the `groupadd` and `useradd` commands:

  ```
  groupadd mysql
  useradd -g mysql mysql
  ```

- If you install MySQL using a binary tarball distribution on Solaris, you may run into trouble even before you get the MySQL distribution unpacked, as the Solaris `tar` cannot handle long file names. This means that you may see errors when you try to unpack MySQL.

  If this occurs, you must use GNU `tar` (`gtar`) to unpack the distribution. In Solaris 10 and OpenSolaris `gtar` is normally located in `/usr/sfw/bin/gtar`, but may not be included in the default path definition.
- When using Solaris 10 for x86_64, you should mount any file systems on which you intend to store `InnoDB` files with the `forcedirectio` option. (By default mounting is done without this option.) Failing to do so will cause a significant drop in performance when using the `InnoDB` storage engine on this platform.
- If you would like MySQL to start automatically, you can copy `support-files/mysql.server` to `/etc/init.d` and create a symbolic link to it named `/etc/rc3.d/S99mysql.server`.
- If too many processes try to connect very rapidly to `mysqld`, you should see this error in the MySQL log:

  ```
  Error in accept: Protocol error
  ```

  You might try starting the server with the `--back_log=50` option as a workaround for this.
- To configure the generation of core files on Solaris you should use the `coreadm` command. Because of the security implications of generating a core on a `setuid()` application, by default, Solaris does not support core files on `setuid()` programs. However, you can modify this behavior using `coreadm`. If you enable `setuid()` core files for the current user, they will be generated using the mode 600 and owned by the superuser.

2.6.1. Installing MySQL on Solaris using a Solaris `PKG`

You can install MySQL on Solaris and OpenSolaris using a binary package using the native Solaris PKG format instead of the binary tarball distribution.

To use this package, download the corresponding `mysql-VERSION-solaris10-PLATFORM.pkg.gz` file, then decompress it. For example:

```
shell> gunzip mysql-5.5.16-solaris10-x86_64.pkg.gz
```

To install a new package, use `pkgadd` and follow the onscreen prompts. You must have root privileges to perform this operation:

```
shell> pkgadd -d mysql-5.5.16-solaris10-x86_64.pkg

The following packages are available:
  1  mysql     MySQL Community Server (GPL)
               (i86pc) 5.5.16

Select package(s) you wish to process (or 'all' to process
all packages). (default: all) [?,??,q]:
```

The `PKG` installer installs all of the files and tools needed, and then initializes your database if one does not exist. To complete the installation, you should set the root password for MySQL as provided in the instructions at the end of the installation. Alternatively, you can run the `mysql_secure_installation` script that comes with the installation.

The default installation directory is `/opt/mysql`. You can only change the root path of the installation when using `pkgadd`, which can be used to install MySQL in a different Solaris zone. If you need to install in a specific directory, use the binary `tar` file.

The `pkg` installer copies a suitable startup script for MySQL into `/etc/init.d/mysql`. To enable MySQL to startup and shutdown automatically, you should create a link between this file and the init script directories. For example, to ensure safe startup and shutdown of MySQL you could use the following commands to add the right links:

```
shell> ln /etc/init.d/mysql /etc/rc3.d/S91mysql
shell> ln /etc/init.d/mysql /etc/rc0.d/K02mysql
```

To remove MySQL, the installed package name is `mysql`. You can use this in combination with the `pkgrm` command to remove the installation.

To upgrade when using the Solaris package file format, you must remove the existing installation before installing the updated package. Removal of the package does not delete the existing database information, only the server, binaries and support files. The typical upgrade sequence is therefore:

```
shell> mysqladmin shutdown
shell> pkgrm mysql
shell> pkgadd -d mysql-5.5.16-solaris10-x86_64.pkg
shell> mysql_upgrade
shell> mysqld_safe &
```

You should check the notes in Section 2.11, “Upgrading or Downgrading MySQL” before performing any upgrade.

2.6.2. Installing MySQL on OpenSolaris using IPS

OpenSolaris includes standard packages for MySQL in the core repository. The MySQL packages are based on a specific release of MySQL and updated periodically. For the latest release you must use either the native Solaris `PKG`, `tar`, or source installations. The native OpenSolaris packages include SMF files so that you can easily control your MySQL installation, including automatic startup and recovery, using the native service management tools.

To install MySQL on OpenSolaris, use the `pkg` command. You will need to be logged in as root, or use the `pfexec` tool, as shown in the example below:

```
shell> pfexec pkg install SUNWmysql55
```

The package set installs three individual packages, `SUNWmysql55lib`, which contains the MySQL client libraries; `SUNWmysql55r` which contains the root components, including SMF and configuration files; and `SUNWmysql55u` which contains the scripts, binary tools and other files. You can install these packages individually if you only need the corresponding components.

The MySQL files are installed into `/usr/mysql` which symbolic links for the sub directories (`bin`, `lib`, etc.) to a version specific directory. For MySQL 5.5, the full installation is located in `/usr/mysql/5.5`. The default data directory is `/var/mysql/5.5/data`. The configuration file is installed in `/etc/mysql/5.5/my.cnf`. This layout permits multiple versions of MySQL to be installed, without overwriting the data and binaries from other versions.

Once installed, you must run `mysql_install_db` to initialize the database, and use the `mysql_secure_installation` to secure your installation.

Using SMF to manage your MySQL installation

Once installed, you can start and stop your MySQL server using the installed SMF configuration. The service name is `mysql`, or if you have multiple versions installed, you should use the full version name, for example `mysql:version_55`. To start and enable MySQL to be started at boot time:

```
shell> svcadm enable mysql
```

To disable MySQL from starting during boot time, and shut the MySQL server down if it is running, use:

```
shell> svcadm disable mysql
```

To restart MySQL, for example after a configuration file changes, use the `restart` option:

```
shell> svcadm restart mysql
```

You can also use SMF to configure the data directory and enable full 64-bit mode. For example, to set the data directory used by MySQL:

```
shell> svccfg
svc:> select mysql:version_55
svc:/application/database/mysql:version_55> setprop mysql/data=/data0/mysql
```

By default, the 32-bit binaries are used. To enable the 64-bit server on 64-bit platforms, set the `enable_64bit` parameter. For example:

```
svc:/application/database/mysql:version_55> setprop mysql/enable_64bit=1
```

You need to refresh the SMF after settings these options:

```
shell> svcadm refresh mysql
```

2.7. Installing MySQL on HP-UX

MySQL for HP-UX is available in a number of different forms:

- Using a DEPOT distribution provided at http://dev.mysql.com/downloads/. Please read the general notes on HP-UX installation before continuing. For more information on DEPOT installations, see Section 2.7.2, “Installing MySQL on HP-UX using DEPOT”.
- Using a binary tarball distribution provided at http://dev.mysql.com/downloads/. Please read the general notes on HP-UX installation before continuing. For more information on binary installations, see Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.

2.7.1. General Notes on Installing MySQL on HP-UX

Some additional notes on installing and using MySQL on HP-UX:

- If you install MySQL using a binary tarball distribution on HP-UX, you may run into trouble even before you get the MySQL distribution unpacked, as the HP-UX `tar` cannot handle long file names. This means that you may see errors when you try to unpack MySQL.

  If this occurs, you must use GNU `tar` (`gtar`) to unpack the distribution.
- Because of some critical bugs in the standard HP-UX libraries, you should install the following patches before trying to run MySQL on HP-UX 11.0:

  ```
  PHKL_22840 Streams cumulative
  PHNE_22397 ARPA cumulative
  ```

  This solves the problem of getting `EWOULDBLOCK` from `recv()` and `EBADF` from `accept()` in threaded applications.

2.7.2. Installing MySQL on HP-UX using DEPOT

The HP-UX DEPOT format packages can be installed using the `swinstall` command. You should install the `ncurses` and `zlib` libraries before installing the MySQL DEPOT package. You can use the free software `depothelper` tool to install these packages and any dependencies for you automatically.

To install using the MySQL DEPOT packages, follow this guide:

1. Download the MySQL DEPOT package from http://dev.mysql.com/downloads/. You must decompress the package before installation:

   ```
   root-shell> gunzip mysql-5.1.48-hpux11.31-ia64-64bit.depot.gz
   ```

2. Install the DEPOT package using `swinstall`:

   ```
   root-shell> swinstall -s mysql-5.1.49-hpux11.31-ia64-64bit.depot
   ```

MySQL will be installed into a directory matching the depot package name, within `/usr/local`. For convenience, you may want to create a symbolic link to the installed directory, for example:

```
root-shell> ln -s mysql-5.1.49-hpux11.31-ia64-64bit mysql
```

3. Your package is now installed. You should complete the configuration of MySQL by creating a user and group:

```
root-shell> /usr/sbin/groupadd mysql
root-shell> /usr/sbin/useradd -g mysql -d /var/lib/mysql/ -s /bin/false mysql
```

4. Create the standard database using the new user/group you have created, and set the permissions:

```
root-shell> cd /usr/local/
root-shell> scripts/mysql_install_db --user=mysql
root-shell> chown -R root .
root-shell> chown -R mysql data
```

5. Finally, secure your new installation by setting the root passwords, and then start your MySQL server using the `mysql` user:

```
root-shell> mysql_secure_installation
root-shell> mysqld_safe --user=mysql &
```

2.8. Installing MySQL on FreeBSD

This section provides information about installing MySQL on variants of FreeBSD Unix.

You can install MySQL on FreeBSD by using the binary distribution provided by Oracle. For more information, see Section 2.2, "Installing MySQL from Generic Binaries on Unix/Linux".

The easiest (and preferred) way to install MySQL is to use the `mysql-server` and `mysql-client` ports available at http://www.freebsd.org/. Using these ports gives you the following benefits:

- A working MySQL with all optimizations enabled that are known to work on your version of FreeBSD.
- Automatic configuration and build.
- Startup scripts installed in `/usr/local/etc/rc.d`.
- The ability to use `pkg_info -L` to see which files are installed.
- The ability to use `pkg_delete` to remove MySQL if you no longer want it on your machine.

The MySQL build process requires GNU make (`gmake`) to work. If GNU `make` is not available, you must install it first before compiling MySQL.

To install using the ports system:

```
# cd /usr/ports/databases/mysql51-server
# make
...
# cd /usr/ports/databases/mysql51-client
# make
...
```

The standard port installation places the server into `/usr/local/libexec/mysqld`, with the startup script for the MySQL server placed in `/usr/local/etc/rc.d/mysql-server`.

Some additional notes on the BSD implementation:

- To remove MySQL after installation using the ports system:

```
# cd /usr/ports/databases/mysql51-server
# make deinstall
...
# cd /usr/ports/databases/mysql51-client
# make deinstall
...
```

- If you get problems with the current date in MySQL, setting the `TZ` variable should help. See Section 2.12, “Environment Variables”.

2.9. Installing MySQL from Source

Building MySQL from the source code enables you to customize build parameters, compiler optimizations, and installation location. For a list of systems on which MySQL is known to run, see Section 2.1.1, “Operating Systems Supported by MySQL Community Server”.

Before you proceed with an installation from source, check whether Oracle produces a precompiled binary distribution for your platform and whether it works for you. We put a great deal of effort into ensuring that our binaries are built with the best possible options for optimal performance. Instructions for installing binary distributions are available in Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.

> **Note**
>
> This section describes how to build MySQL from source using `CMake`. Before MySQL 5.5, source builds used the GNU autotools on Unix-like systems. Source builds on Windows used `CMake`, but the process was different from that described here. For source-building instructions for older versions of MySQL, see Installing MySQL from Source, in the MySQL 5.1 Reference Manual. If you are familiar with autotools but not `CMake`, you might find this transition document helpful: http://forge.mysql.com/wiki/Autotools_to_CMake_Transition_Guide

Source Installation Methods

There are two methods for installing MySQL from source:

- Use a standard MySQL source distribution. To obtain a standard distribution, see Section 2.1.3, “How to Get MySQL”. For instructions on building from a standard distribution, see Section 2.9.2, “Installing MySQL from a Standard Source Distribution”.

  Standard distributions are available as compressed `tar` files, Zip archives, or RPM packages. Distribution files have names of the form `mysql-`*`VERSION`*`.tar.gz`, `mysql-`*`VERSION`*`.zip`, or `mysql-`*`VERSION`*`.rpm`, where *`VERSION`* is a number like `5.5.16`. File names for source distributions can be distinguished from those for precompiled binary distributions in that source distribution names are generic and include no platform name, whereas binary distribution names include a platform name indicating the type of system for which the distribution is intended (for example, `pc-linux-i686` or `winx64`).

- Use a MySQL development tree. Development trees have not necessarily received the same level of testing as standard release distributions, so this installation method is usually required only if you need the most recent code changes. For information on building from one of the development trees, see Section 2.9.3, “Installing MySQL from a Development Source Tree”.

Source Installation System Requirements

Installation of MySQL from source requires several development tools. Some of these tools are needed no matter whether you use a standard source distribution or a development source tree. Other tool requirements depend on which installation method you use.

To install MySQL from source, your system must have the following tools, regardless of installation method:

- `CMake`, which is used as the build framework on all platforms. `CMake` can be downloaded from http://www.cmake.org.
- A good `make` program. Although some platforms come with their own `make` implementations, it is highly recommended that you use GNU `make` 3.75 or newer. It may already be available on your system as `gmake`. GNU `make` is available from http://www.gnu.org/software/make/.
- A working ANSI C++ compiler. GCC 4.2.1 or later, Sun Studio 10 or later, Visual Studio 2008 or later, and many current vendor-supplied compilers are known to work.
- Perl is needed if you intend to run test scripts. Most Unix-like systems include Perl. On Windows, you can use a version such as ActiveState Perl.

To install MySQL from a standard source distribution, one of the following tools is required to unpack the distribution file:

- For a `.tar.gz` compressed `tar` file: GNU `gunzip` to uncompress the distribution and a reasonable `tar` to unpack it. If your `tar` program supports the `z` option, it can both uncompress and unpack the file.

GNU `tar` is known to work. The standard `tar` provided with some operating systems is not able to unpack the long file names in the MySQL distribution. You should download and install GNU `tar`, or if available, use a preinstalled version of GNU tar. Usually this is available as `gnutar`, `gtar`, or as `tar` within a GNU or Free Software directory, such as `/usr/sfw/bin` or `/usr/local/bin`. GNU `tar` is available from http://www.gnu.org/software/tar/.

- For a `.zip` Zip archive: `WinZip` or another tool that can read `.zip` files.
- For an `.rpm` RPM package: The `rpmbuild` program used to build the distribution unpacks it.

To install MySQL from a development source tree, the following additional tools are required:

- To obtain the source tree, you must have Bazaar installed. The Bazaar VCS Web site has instructions for downloading and installing Bazaar on different platforms. Bazaar is supported on any platform that supports Python, and is therefore compatible with any Linux, Unix, Windows, or Mac OS X host.
- `bison` is needed to generate `sql_yacc.cc` from `sql_yacc.yy` You should use the latest version of `bison` where possible. Versions 1.75 and 2.1 are known to work. There have been reported problems with `bison` 1.875. If you experience problems, upgrade to a later, rather than earlier, version.

  `bison` is available from http://www.gnu.org/software/bison/. `bison` for Windows can be downloaded from http://gnuwin32.sourceforge.net/packages/bison.htm. Download the package labeled “Complete package, excluding sources”. On Windows, the default location for `bison` is the `C:\Program Files\GnuWin32` directory. Some utilities may fail to find `bison` because of the space in the directory name. Also, Visual Studio may simply hang if there are spaces in the path. You can resolve these problems by installing into a directory that does not contain a space; for example `C:\GnuWin32`.
- On OpenSolaris and Solaris Express, `m4` must be installed in addition to `bison`. `m4` is available from http://www.gnu.org/software/m4/.

> **Note**
>
> If you have to install any programs, modify your `PATH` environment variable to include any directories in which the programs are located. See Section 4.2.4, “Setting Environment Variables”.

If you run into problems and need to file a bug report, please use the instructions in Section 1.7, “How to Report Bugs or Problems”.

2.9.1. MySQL Layout for Source Installation

By default, when you install MySQL after compiling it from source, the installation step installs files under `/usr/local/mysql`. The component locations under the installation directory are the same as for binary distributions. See Table 2.2, “MySQL Installation Layout for Generic Unix/Linux Binary Package”, and Section 2.3.1, “MySQL Installation Layout on Microsoft Windows”. To configure installation locations different from the defaults, use the options described at Section 2.9.4, “MySQL Source-Configuration Options”.

2.9.2. Installing MySQL from a Standard Source Distribution

To install MySQL from a standard source distribution:

1. Verify that your system satisfies the tool requirements listed at Section 2.9, “Installing MySQL from Source”.
2. Obtain a distribution file using the instructions in Section 2.1.3, “How to Get MySQL”.
3. Configure, build, and install the distribution using the instructions in this section.
4. Perform postinstallation procedures using the instructions in Section 2.10, “Postinstallation Setup and Testing”.

In MySQL 5.5, `CMake` is used as the build framework on all platforms. The instructions given here should enable you to produce a working installation. For additional information on using `CMake` to build MySQL, see http://forge.mysql.com/wiki/CMake.

If you start from a source RPM, use the following command to make a binary RPM that you can install. If you do not have `rpmbuild`, use `rpm` instead.

```
shell> rpmbuild --rebuild --clean MySQL-VERSION.src.rpm
```

The result is one or more binary RPM packages that you install as indicated in Section 2.5.1, “Installing MySQL from RPM Packages on Linux”.

The sequence for installation from a compressed `tar` file or Zip archive source distribution is similar to the process for installing from a generic binary distribution (see Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”), except that it is used on all platforms and includes steps to configure and compile the distribution. For example, with a compressed `tar` file source distribution on Unix, the basic installation command sequence looks like this:

```
# Preconfiguration setup
shell> groupadd mysql
shell> useradd -r -g mysql mysql
# Beginning of source-build specific instructions
shell> tar zxvf mysql-VERSION.tar.gz
shell> cd mysql-VERSION
shell> cmake .
shell> make
shell> make install
# End of source-build specific instructions
# Postinstallation setup
shell> cd /usr/local/mysql
shell> chown -R mysql .
shell> chgrp -R mysql .
shell> scripts/mysql_install_db --user=mysql
shell> chown -R root .
shell> chown -R mysql data
# Next command is optional
shell> cp support-files/my-medium.cnf /etc/my.cnf
shell> bin/mysqld_safe --user=mysql &
# Next command is optional
shell> cp support-files/mysql.server /etc/init.d/mysql.server
```

A more detailed version of the source-build specific instructions is shown following.

> **Note**
>
> The procedure shown here does not set up any passwords for MySQL accounts. After following the procedure, proceed to Section 2.10, “Postinstallation Setup and Testing”, for postinstallation setup and testing.

Perform Preconfiguration Setup

On Unix, set up the `mysql` user and group that will be used to run and execute the MySQL server and own the database directory. For details, see Creating a `mysql` System User and Group, in Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”. Then perform the following steps as the `mysql` user, except as noted.

Obtain and Unpack the Distribution

Pick the directory under which you want to unpack the distribution and change location into it.

Obtain a distribution file using the instructions in Section 2.1.3, “How to Get MySQL”.

Unpack the distribution into the current directory:

- To unpack a compressed `tar` file, `tar` can uncompress and unpack the distribution if it has `z` option support:

  ```
  shell> tar zxvf mysql-VERSION.tar.gz
  ```

  If your `tar` does not have `z` option support, use `gunzip` to unpack the distribution and `tar` to unpack it:

  ```
  shell> gunzip < mysql-VERSION.tar.gz | tar xvf -
  ```

  Alternatively, `CMake` can uncompress and unpack the distribution:

  ```
  shell> cmake -E tar zxvf mysql-VERSION.tar.gz
  ```

- To unpack a Zip archive, use `WinZip` or another tool that can read `.zip` files.

Unpacking the distribution file creates a directory named `mysql-VERSION`.

Configure the Distribution

Change location into the top-level directory of the unpacked distribution:

```
shell> cd mysql-VERSION
```

Configure the source directory. The minimum configuration command includes no options to override configuration defaults:

```
shell> cmake .
```

On Windows, specify the development environment. For example, the following commands configure MySQL for 32-bit or 64-bit builds, respectively:

```
shell> cmake . -G "Visual Studio 9 2008"
shell> cmake . -G "Visual Studio 9 2008 Win64"
```

On Mac OS X, to use the Xcode IDE:

```
shell> cmake . -G Xcode
```

When you run `cmake`, you might want to add options to the command line. Here are some examples:

- `-DBUILD_CONFIG=mysql_release`: Configure the source with the same build options used by Oracle to produce binary distributions for official MySQL releases.
- `-DCMAKE_INSTALL_PREFIX=dir_name`: Configure the distribution for installation under a particular location.
- `-DCPACK_MONOLITHIC_INSTALL=1`: Cause `make package` to generate a single installation file rather than multiple files.
- `-DWITH_DEBUG=1`: Build the distribution with debugging support.

For a more extensive list of options, see Section 2.9.4, “MySQL Source-Configuration Options”.

To list the configuration options, use one of the following commands:

```
shell> cmake . -L   # overview
shell> cmake . -LH  # overview with help text
shell> cmake . -LAH # all params with help text
shell> ccmake .     # interactive display
```

If `CMake` fails, you might need to reconfigure by running it again with different options. If you do reconfigure, take note of the following:

- If `CMake` is run after it has previously been run, it may use information that was gathered during its previous invocation. This information is stored in `CMakeCache.txt`. When `CMake` starts up, it looks for that file and reads its contents if it exists, on the assumption that the information is still correct. That assumption is invalid when you reconfigure.
- Each time you run `CMake`, you must run `make` again to recompile. However, you may want to remove old object files from previous builds first because they were compiled using different configuration options.

To prevent old object files or configuration information from being used, run these commands on Unix before re-running `CMake`:

```
shell> make clean
shell> rm CMakeCache.txt
```

Or, on Windows:

```
shell> devenv MySQL.sln /clean
shell> del CMakeCache.txt
```

If you build out of the source tree (as described later), the `CMakeCache.txt` file and all built files are in the build directory, so you can remove that directory to object files and cached configuration information.

If you are going to send mail to a MySQL mailing list to ask for configuration assistance, first check the files in the `CMakeFiles` directory for useful information about the failure. To file a bug report, please use the instructions in Section 1.7, “How to Report Bugs or Problems”.

Build the Distribution

On Unix:

```
shell> make
shell> make VERBOSE=1
```

The second command sets `VERBOSE` to show the commands for each compiled source.

Use `gmake` instead on systems where you are using GNU `make` and it has been installed as `gmake`.

On Windows:

```
shell> devenv MySQL.sln /build RelWithDebInfo
```

It is possible to build out of the source tree to keep the tree clean. If the top-level source directory is named `mysql-src` under your current working directory, you can build in a directory named `build` at the same level like this:

```
shell> mkdir build
shell> cd build
shell> cmake ../mysql-src
```

If you have gotten to the compilation stage, but the distribution does not build, see Section 2.9.5, "Dealing with Problems Compiling MySQL", for help. If that does not solve the problem, please enter it into our bugs database using the instructions given in Section 1.7, "How to Report Bugs or Problems". If you have installed the latest versions of the required tools, and they crash trying to process our configuration files, please report that also. However, if you get a `command not found` error or a similar problem for required tools, do not report it. Instead, make sure that all the required tools are installed and that your `PATH` variable is set correctly so that your shell can find them.

Install the Distribution

On Unix:

```
shell> make install
```

This installs the files under the configured installation directory (by default, `/usr/local/mysql`). You might need to run the command as `root`.

To install in a specific directory, add a `DESTDIR` parameter to the command line:

```
shell> make install DESTDIR="/opt/mysql"
```

Alternatively, generate installation package files that you can install where you like:

```
shell> make package
```

This operation produces one or more `.tar.gz` files that can be installed like generic binary distribution packages. See Section 2.2, "Installing MySQL from Generic Binaries on Unix/Linux". If you run `CMake` with `-DCPACK_MONOLITHIC_INSTALL=1`, the operation produces a single file. Otherwise, it produces multiple files.

On Windows, generate the data directory, then create a `.zip` archive installation package:

```
shell> devenv MySQL.sln /build RelWithDebInfo /project initial_database
shell> devenv MySQL.sln /build RelWithDebInfo /project package
```

You can install the resulting `.zip` archive where you like. See Section 2.3.5, "Installing MySQL on Microsoft Windows Using a `noinstall` Zip Archive".

Perform Postinstallation Setup

The remainder of the installation process involves setting up the configuration file, creating the core databases, and starting the MySQL server. For instructions, see Section 2.10, "Postinstallation Setup and Testing".

> **Note**
>
> The accounts that are listed in the MySQL grant tables initially have no passwords. After starting the server, you should set up passwords for them using the instructions in Section 2.10, "Postinstallation Setup and Testing".

2.9.3. Installing MySQL from a Development Source Tree

This section discusses how to install MySQL from the latest development source code. Development trees have not necessarily received the same level of testing as standard release distributions, so this installation method is usually required only if you need the most recent code changes. Do not use a development tree for production systems. If your goal is simply to get MySQL up and running on your system, you should use a standard release distribution (either a binary or source distribution). See Section 2.1.3, “How to Get MySQL”.

MySQL development projects are hosted on Launchpad. MySQL projects, including MySQL Server, MySQL Workbench, and others are available from the Oracle/MySQL Engineering page. For the repositories related only to MySQL Server, see the MySQL Server page.

To install MySQL from a development source tree, your system must satisfy the tool requirements listed at Section 2.9, “Installing MySQL from Source”, including the requirements for Bazaar and `bison`. For information about using Bazaar with MySQL, see http://forge.mysql.com/wiki/MySQL_Bazaar_Howto.

To create a local branch of the MySQL development tree on your machine, use this procedure:

1. To obtain a copy of the MySQL source code, you must create a new Bazaar branch. If you do not already have a Bazaar repository directory set up, you must initialize a new directory:

   ```
   shell> mkdir mysql-server
   shell> bzr init-repo --trees mysql-server
   ```

   This is a one-time operation.

2. Assuming that you have an initialized repository directory, you can branch from the public MySQL server repositories to create a local source tree. To create a branch of a specific version:

   ```
   shell> cd mysql-server
   shell> bzr branch lp:mysql-server/5.5 mysql-5.5
   ```

   This is a one-time operation per source tree. You can branch the source trees for several versions of MySQL under the `mysql-server` directory.

3. The initial download will take some time to complete, depending on the speed of your connection. Please be patient. Once you have downloaded the first tree, additional trees should take significantly less time to download.

4. When building from the Bazaar branch, you may want to create a copy of your active branch so that you can make configuration and other changes without affecting the original branch contents. You can achieve this by branching from the original branch:

   ```
   shell> bzr branch mysql-5.5 mysql-5.5-build
   ```

5. To obtain changes made after you have set up the branch initially, update it using the `pull` option periodically. Use this command in the top-level directory of the local copy:

   ```
   shell> bzr pull
   ```

   To examine the changeset comments for the tree, use the `log` option to `bzr`:

   ```
   shell> bzr log
   ```

   You can also browse changesets, comments, and source code online at the Launchpad MySQL Server page.

   If you see diffs (changes) or code that you have a question about, do not hesitate to send email to the MySQL `internals` mailing list. See Section 1.6.1, “MySQL Mailing Lists”. If you think you have a better idea on how to do something, send an email message to the list with a patch.

After you have the local branch, you can build MySQL server from the source code. For information, see Section 2.9.2, “Installing MySQL from a Standard Source Distribution”, except that you skip the part about obtaining and unpacking the distribution.

Be careful about installing a build from a distribution source tree on a production machine. The installation command may overwrite your live release installation. If you already have MySQL installed and do not want to overwrite it, run `CMake` with values for the `CMAKE_INSTALL_PREFIX`, `MYSQL_TCP_PORT`, and `MYSQL_UNIX_ADDR` options different from those used by your production server. For additional information about preventing multiple servers from interfering with each other, see Section 5.6, “Running Multiple MySQL Instances on One Machine”.

Play hard with your new installation. For example, try to make new features crash. Start by running `make test`. See Section 21.1.2, “The MySQL Test Suite”.

2.9.4. MySQL Source-Configuration Options

The `CMake` program provides a great deal of control over how you configure a MySQL source distribution. Typically, you do this using options on the `CMake` command line. For information about options supported by `CMake`, run either of these commands in the top-level source directory:

```
shell> cmake . -LH
shell> ccmake .
```

You can also affect `CMake` using certain environment variables. See Section 2.12, “Environment Variables”.

The following table shows the available `CMake` options. In the `Default` column, `PREFIX` stands for the value of the `CMAKE_INSTALL_PREFIX` option, which specifies the installation base directory. This value is used as the parent location for several of the installation subdirectories.

Table 2.14. MySQL Source-Configuration Option Reference (`CMake`)

Formats	**Description**	**Default**	**Introduced**	**Removed**
`BUILD_CONFIG`	Use same build options as official releases		5.5.7	
`CMAKE_BUILD_TYPE`	Type of build to produce	`RelWithDebInfo`	5.5.7	
`CMAKE_INSTALL_PREFIX`	Installation base directory	`/usr/local/mysql`	5.5.8	
`CPACK_MONOLITHIC_INSTALL`	Whether package build produces single file	`OFF`	5.5.7	
`DEFAULT_CHARSET`	The default server character set	`latin1`	5.5.7	
`DEFAULT_COLLATION`	The default server collation	`latin1_swedish_ci`	5.5.7	
`ENABLE_DEBUG_SYNC`	Whether to enable Debug Sync support	`ON`	5.5.7	
`ENABLE_DOWNLOADS`	Whether to download optional files	`OFF`	5.5.7	
`ENABLE_DTRACE`	Whether to include DTrace support		5.5.7	
`ENABLE_GCOV`	Whether to include gcov support		5.5.14	
`ENABLED_LOCAL_INFILE`	Whether to enable LOCAL for LOAD DATA INFILE	`OFF`	5.5.7	
`ENABLED_PROFILING`	Whether to enable query profiling code	`ON`	5.5.7	
`INSTALL_BINDIR`	User executables directory	`PREFIX/bin`	5.5.7	
`INSTALL_DOCDIR`	Documentation directory	`PREFIX/docs`	5.5.7	
`INSTALL_DOCREADMEDIR`	README file directory	`PREFIX`	5.5.7	
`INSTALL_INCLUDEDIR`	Header file directory	`PREFIX/include`	5.5.7	
`INSTALL_INFODIR`	Info file directory	`PREFIX/docs`	5.5.7	
`INSTALL_LAYOUT`	Select predefined installation layout	`STANDALONE`	5.5.7	
`INSTALL_LIBDIR`	Library file directory	`PREFIX/lib`	5.5.7	
`INSTALL_MANDIR`	Manual page directory	`PREFIX/man`	5.5.7	
`INSTALL_MYSQLSHAREDIR`	Shared data directory	`PREFIX/share`	5.5.7	
`INSTALL_MYSQLTESTDIR`	mysql-test directory	`PREFIX/mysql-test`	5.5.7	
`INSTALL_PLUGINDIR`	Plugin directory	`PREFIX/lib/plugin`	5.5.7	
`INSTALL_SBINDIR`	Server executable directory	`PREFIX/bin`	5.5.7	
`INSTALL_SCRIPTDIR`	Scripts directory	`PREFIX/scripts`	5.5.7	
`INSTALL_SHAREDIR`	aclocal/mysql.m4 installation directory	`PREFIX/share`	5.5.7	
`INSTALL_SQLBENCHDIR`	sql-bench directory	`PREFIX`	5.5.7	
`INSTALL_SUPPORTFILESDIR`	Extra support files directory	`PREFIX/sup-`	5.5.7	

Formats	Description	Default	Introduced	Removed
		`port-files`		
`MYSQL_DATADIR`	Data directory		5.5.7	
`MYSQL_MAINTAINER_MODE`	Whether to enable MySQL maintainer-specific development environment	`OFF`	5.5.7	
`MYSQL_TCP_PORT`	TCP/IP port number	`3306`	5.5.7	
`MYSQL_UNIX_ADDR`	Unix socket file	`/tmp/mysql.sock`	5.5.7	
`SYSCONFDIR`	Option file directory		5.5.7	
`WITH_COMMENT`	Comment about compilation environment		5.5.7	
`WITH_DEBUG`	Whether to include debugging support	`OFF`	5.5.7	
`WITH_EMBEDDED_SERVER`	Whether to build embedded server	`OFF`	5.5.7	
`WITH_xxx_STORAGE_ENGINE`	Compile storage engine xxx statically into server		5.5.7	
`WITH_EXTRA_CHARSETS`	Which extra character sets to include	`all`	5.5.7	
`WITH_LIBWRAP`	Whether to include libwrap (TCP wrappers) support	`OFF`	5.5.7	
`WITH_READLINE`	Use bundled readline	`OFF`	5.5.7	
`WITH_SSL`	Type of SSL support	`no`	5.5.7	
`WITH_ZLIB`	Type of zlib support	`system`	5.5.7	
`WITHOUT_xxx_STORAGE_ENGINE`	Exclude storage engine xxx from build		5.5.7	

The following sections provide more information about `CMake` options.

- General Options
- Installation Layout Options
- Feature Options
- Compiler Flags

For boolean options, the value may be specified as 1 or `ON` to enable the option, or as 0 or `OFF` to disable the option.

Many options configure compile-time defaults that can be overridden at server startup. For example, the `CMAKE_INSTALL_PREFIX`, `MYSQL_TCP_PORT`, and `MYSQL_UNIX_ADDR` options that configure the default installation base directory location, TCP/IP port number, and Unix socket file can be changed at server startup with the `--basedir`, `--port`, and `--socket` options for `mysqld`. Where applicable, configuration option descriptions indicate the corresponding `mysqld` startup option.

General Options

- `-DBUILD_CONFIG=mysql_release`

  This option configures a source distribution with the same build options used by Oracle to produce binary distributions for official MySQL releases.

- `-DCMAKE_BUILD_TYPE=`*`type`*

  The type of build to produce:

  - `RelWithDebInfo`: Enable optimizations and generate debugging information. This is the default MySQL build type.
  - `Debug`: Disable optimizations and generate debugging information. This build type is also used if the `WITH_DEBUG` option is enabled. That is, `-DWITH_DEBUG=1` has the same effect as `-DCMAKE_BUILD_TYPE=Debug`.

- `-DCPACK_MONOLITHIC_INSTALL=`*`bool`*

This option affects whether the `make package` operation produces multiple installation package files or a single file. If disabled, the operation produces multiple installation package files, which may be useful if you want to install only a subset of a full MySQL installation. If enabled, it produces a single file for installing everything.

Installation Layout Options

The `CMAKE_INSTALL_PREFIX` option indicates the base installation directory. Other options with names of the form `INSTALL_xxx` that indicate component locations are interpreted relative to the prefix and their values are relative pathnames. Their values should not include the prefix.

- `-DCMAKE_INSTALL_PREFIX=dir_name`

  The installation base directory.

  This value can be set at server startup with the `--basedir` option.

- `-DINSTALL_BINDIR=dir_name`

  Where to install user programs.

- `-DINSTALL_DOCDIR=dir_name`

  Where to install documentation.

- `-DINSTALL_DOCREADMEDIR=dir_name`

  Where to install `README` files.

- `-DINSTALL_INCLUDEDIR=dir_name`

  Where to install header files.

- `-DINSTALL_INFODIR=dir_name`

  Where to install Info files.

- `-DINSTALL_LAYOUT=name`

  Select a predefined installation layout:

  - `STANDALONE`: Same layout as used for `.tar.gz` and `.zip` packages. This is the default.
  - `RPM`: Layout similar to RPM packages.
  - `SVR4`: Solaris package layout.
  - `DEB`: DEB package layout (experimental).

  You can select a predefined layout but modify individual component installation locations by specifying other options. For example:

  ```
  shell> cmake . -DINSTALL_LAYOUT=SVR4 -DMYSQL_DATADIR=/var/mysql/data
  ```

- `-DINSTALL_LIBDIR=dir_name`

  Where to install library files.

- `-DINSTALL_MANDIR=dir_name`

  Where to install manual pages.

- `-DINSTALL_MYSQLSHAREDIR=dir_name`

  Where to install shared data files.

- `-DINSTALL_MYSQLTESTDIR=dir_name`

  Where to install the `mysql-test` directory.

- `-DINSTALL_PLUGINDIR=dir_name`

  The location of the plugin directory.

  This value can be set at server startup with the `--plugin_dir` option.

- `-DINSTALL_SBINDIR=dir_name`

  Where to install the `mysqld` server.

- `-DINSTALL_SCRIPTDIR=dir_name`

  Where to install `mysql_install_db`.

- `-DINSTALL_SHAREDIR=dir_name`

  Where to install `aclocal/mysql.m4`.

- `-DINSTALL_SQLBENCHDIR=dir_name`

  Where to install the `sql-bench` directory. To not install this directory, use an empty value (`-DINSTALL_SQLBENCHDIR=`).

- `-DINSTALL_SUPPORTFILESDIR=dir_name`

  Where to install extra support files.

- `-DMYSQL_DATADIR=dir_name`

  The location of the MySQL data directory.

  This value can be set at server startup with the `--datadir` option.

- `-DSYSCONFDIR=dir_name`

  The default `my.cnf` option file directory.

  This location cannot be set at server startup, but you can start the server with a given option file using the `--defaults-file=file_name` option, where `file_name` is the full path name to the file.

Storage Engine Options

Storage engines are built as plugins. You can build a plugin as a static module (compiled into the server) or a dynamic module (built as a dynamic library that must be installed into the server using the `INSTALL PLUGIN` statement or the `--plugin-load` option before it can be used). Some plugins might not support static or dynamic building.

The `MyISAM`, `MERGE`, `MEMORY`, and `CSV` engines are mandatory (always compiled into the server) and need not be installed explicitly.

To compile a storage engine statically into the server, use `-DWITH_engine_STORAGE_ENGINE=1`. Some permissible `engine` values are `ARCHIVE`, `BLACKHOLE`, `EXAMPLE`, `FEDERATED`, `INNOBASE` (`InnoDB`), `PARTITION` (partitioning support), and `PERFSCHEMA` (Performance Schema). Examples:

```
-DWITH_INNOBASE_STORAGE_ENGINE=1
-DWITH_ARCHIVE_STORAGE_ENGINE=1
-DWITH_BLACKHOLE_STORAGE_ENGINE=1
-DWITH_PERFSCHEMA_STORAGE_ENGINE=1
```

To exclude a storage engine from the build, use `-DWITHOUT_engine_STORAGE_ENGINE=1`. Examples:

```
-DWITHOUT_EXAMPLE_STORAGE_ENGINE=1
-DWITHOUT_FEDERATED_STORAGE_ENGINE=1
-DWITHOUT_PARTITION_STORAGE_ENGINE=1
```

If neither `-DWITH_engine_STORAGE_ENGINE` nor `-DWITHOUT_engine_STORAGE_ENGINE` are specified for a given storage engine, the engine is built as a shared module, or excluded if it cannot be built as a shared module.

Feature Options

- `-DDEFAULT_CHARSET=charset_name`

  The server character set. By default, MySQL uses the `latin1` (cp1252 West European) character set.

  `charset_name` may be one of `binary`, `armscii8`, `ascii`, `big5`, `cp1250`, `cp1251`, `cp1256`, `cp1257`, `cp850`, `cp852`, `cp866`, `cp932`, `dec8`, `eucjpms`, `euckr`, `gb2312`, `gbk`, `geostd8`, `greek`, `hebrew`, `hp8`, `keybcs2`, `koi8r`, `koi8u`, `latin1`, `latin2`, `latin5`, `latin7`, `macce`, `macroman`, `sjis`, `swe7`, `tis620`, `ucs2`, `ujis`, `utf8`, `utf8mb4`, `utf16`, `utf32`. The permissible character sets are listed in the `cmake/character_sets.cmake` file as the value of `CHARSETS_AVAILABLE`.

  This value can be set at server startup with the `--character_set_server` option.

- `-DDEFAULT_COLLATION=collation_name`

  The server collation. By default, MySQL uses `latin1_swedish_ci`. Use the `SHOW COLLATION` statement to determine which collations are available for each character set.

  This value can be set at server startup with the `--collation_server` option.

- `-DENABLE_DEBUG_SYNC=bool`

  Whether to compile the Debug Sync facility into the server. This facility is used for testing and debugging. This option is enabled by default, but has no effect unless MySQL is configured with debugging enabled. If debugging is enabled and you want to disable Debug Sync, use `-DENABLE_DEBUG_SYNC=0`.

  When compiled in, Debug Sync is disabled by default at runtime. To enable it, start `mysqld` with the `--debug-sync-timeout=N` option, where `N` is a timeout value greater than 0. (The default value is 0, which disables Debug Sync.) `N` becomes the default timeout for individual synchronization points.

  For a description of the Debug Sync facility and how to use synchronization points, see MySQL Internals: Test Synchronization.

- `-DENABLE_DOWNLOADS=bool`

  Whether to download optional files. For example, with this option enabled, `CMake` downloads the Google Test distribution that is used by the test suite to run unit tests.

- `-DENABLE_DTRACE=bool`

  Whether to include support for DTrace probes. For information about DTrace, wee Section 5.7, “Tracing `mysqld` Using DTrace”

- `-DENABLE_DTRACE=bool`

  Whether to include gcov support (Linux only).

- `-DENABLED_LOCAL_INFILE=bool`

  Whether to enable `LOCAL` capability in the client library for `LOAD DATA INFILE`.

  This option controls client-side `LOCAL` capability, but the capability can be set on the server side at server startup with the `--local-infile` option. See Section 5.3.5, “Security Issues with `LOAD DATA LOCAL`”.

- `-DENABLED_PROFILING=bool`

  Whether to enable query profiling code (for the `SHOW PROFILE` and `SHOW PROFILES` statements).

- `-DMYSQL_MAINTAINER_MODE=bool`

  Whether to enable a MySQL maintainer-specific development environment. If enabled, this option causes compiler warnings to become errors.

- `-DMYSQL_TCP_PORT=port_num`

  The port number on on which the server listens for TCP/IP connections. The default is 3306.

  This value can be set at server startup with the `--port` option.

- `-DMYSQL_UNIX_ADDR=file_name`

  The Unix socket file path on which the server listens for socket connections. This must be an absolute path name. The default is `/tmp/mysql.sock`.

This value can be set at server startup with the `--socket` option.

- `-DWITH_COMMENT=string`

  A descriptive comment about the compilation environment.

- `-DWITH_DEBUG=bool`

  Whether to include debugging support.

  Configuring MySQL with debugging support enables you to use the `--debug="d,parser_debug"` option when you start the server. This causes the Bison parser that is used to process SQL statements to dump a parser trace to the server's standard error output. Typically, this output is written to the error log.

- `-DWITH_EMBEDDED_SERVER=bool`

  Whether to build the `libmysqld` embedded server library.

- `-DWITH_EXTRA_CHARSETS=name`

  Which extra character sets to include:

  - `all`: All character sets. This is the default.
  - `complex`: Complex character sets.
  - `none`: No extra character sets.

- `-DWITH_LIBWRAP=bool`

  Whether to include `libwrap` (TCP wrappers) support.

- `-DWITH_READLINE=bool`

  Whether to use the `readline` library bundled with the distribution.

- `-DWITH_SSL=ssl_type`

  The type of SSL support to include, if any:

  - `no`: No SSL support. This is the default.
  - `yes`: Use the system SSL library if present, else the library bundled with the distribution.
  - `bundled`: Use the SSL library bundled with the distribution.
  - `system`: Use the system SSL library.

  For information about using SSL support, see Section 5.5.8, “Using SSL for Secure Connections”.

- `-DWITH_ZLIB=zlib_type`

  Some features require that the server be built with compression library support, such as the `COMPRESS()` and `UNCOMPRESS()` functions, and compression of the client/server protocol. The `WITH_ZLIB` indicates the source of `zlib` support:

  - `bundled`: Use the `zlib` library bundled with the distribution.
  - `system`: Use the system `zlib` library. This is the default.

Compiler Flags

To specify compiler flags, set the `CFLAGS` and `CXXFLAGS` environment variables before running `CMake`. Example:

```
shell> CFLAGS=-DDISABLE_GRANT_OPTIONS
shell> CXXFLAGS=-DDISABLE_GRANT_OPTIONS
shell> export CFLAGS CXXFLAGS
shell> cmake [options]
```

The following flags control configuration features:

- `DISABLE_GRANT_OPTIONS`

  If this flag is defined, it causes the `--bootstrap`, `--skip-grant-tables`, and `--init-file` options for `mysqld` to be disabled.

- `HAVE_EMBEDDED_PRIVILEGE_CONTROL`

  By default, authentication for connections to the embedded server is disabled. To enable connection authentication, define this flag.

2.9.5. Dealing with Problems Compiling MySQL

The solution to many problems involves reconfiguring. If you do reconfigure, take note of the following:

- If `CMake` is run after it has previously been run, it may use information that was gathered during its previous invocation. This information is stored in `CMakeCache.txt`. When `CMake` starts up, it looks for that file and reads its contents if it exists, on the assumption that the information is still correct. That assumption is invalid when you reconfigure.
- Each time you run `CMake`, you must run `make` again to recompile. However, you may want to remove old object files from previous builds first because they were compiled using different configuration options.

To prevent old object files or configuration information from being used, run these commands on Unix before re-running `CMake`:

```
shell> make clean
shell> rm CMakeCache.txt
```

Or, on Windows:

```
shell> devenv MySQL.sln /clean
shell> del CMakeCache.txt
```

On some systems, warnings may occur due to differences in system include files. The following list describes other problems that have been found to occur most often when compiling MySQL:

- To define flags to be used by your C or C++ compilers, specify them using the `CFLAGS` and `CXXFLAGS` environment variables. You can also specify the compiler names this way using `CC` and `CXX`. For example:

  ```
  shell> CC=gcc
  shell> CFLAGS=-O3
  shell> CXX=gcc
  shell> CXXFLAGS=-O3
  shell> export CC CFLAGS CXX CXXFLAGS
  ```

- If compilation fails, check whether the `MYSQL_MAINTAINER_MODE` option is enabled. This mode causes compiler warnings to become errors, so disabling it may enable compilation to proceed.
- If your compile fails with errors such as any of the following, you must upgrade your version of `make` to GNU `make`:

  ```
  make: Fatal error in reader: Makefile, line 18:
  Badly formed macro assignment
  ```

  Or:

  ```
  make: file `Makefile' line 18: Must be a separator (:
  ```

  Or:

  ```
  pthread.h: No such file or directory
  ```

  Solaris and FreeBSD are known to have troublesome `make` programs.

  GNU `make` 3.75 is known to work.

- The `sql_yacc.cc` file is generated from `sql_yacc.yy`. Normally, the build process does not need to create `sql_yacc.cc` because MySQL comes with a pregenerated copy. However, if you do need to re-create it, you might encounter this error:

```
"sql_yacc.yy", line xxx fatal: default action causes potential...
```

  This is a sign that your version of `yacc` is deficient. You probably need to install `bison` (the GNU version of `yacc`) and use that instead.

  Versions of `bison` older than 1.75 may report this error:

```
sql_yacc.yy:#####: fatal error: maximum table size (32767) exceeded
```

  The maximum table size is not actually exceeded; the error is caused by bugs in older versions of `bison`.

- On Debian Linux 3.0, you need to install `gawk` instead of the default `mawk`.

For information about acquiring or updating tools, see the system requirements in Section 2.9, “Installing MySQL from Source”.

2.9.6. MySQL Configuration and Third-Party Tools

Third-party tools that need to determine the MySQL version from the MySQL source can read the `VERSION` file in the top-level source directory. The file lists the pieces of the version separately. For example, if the version is 5.5.8, the file looks like this:

```
MYSQL_VERSION_MAJOR=5
MYSQL_VERSION_MINOR=5
MYSQL_VERSION_PATCH=8
MYSQL_VERSION_EXTRA=
```

If the source is not for a General Availability (GA) release, the `MYSQL_VERSION_EXTRA` value will be nonempty. For example, the value for a Release Candidate release would look like this:

```
MYSQL_VERSION_EXTRA=rc
```

To construct a five-digit number from the version components, use this formula:

```
MYSQL_VERSION_MAJOR*10000 + MYSQL_VERSION_MINOR*100 + MYSQL_VERSION_PATCH
```

2.10. Postinstallation Setup and Testing

After installing MySQL, there are some issues that you should address. For example, on Unix, you should initialize the data directory and create the MySQL grant tables. On all platforms, an important security concern is that the initial accounts in the grant tables have no passwords. You should assign passwords to prevent unauthorized access to the MySQL server. Optionally, you can create time zone tables to enable recognition of named time zones.

The following sections include postinstallation procedures that are specific to Windows systems and to Unix systems. Another section, Section 2.10.1.3, “Starting and Troubleshooting the MySQL Server”, applies to all platforms; it describes what to do if you have trouble getting the server to start. Section 2.10.2, “Securing the Initial MySQL Accounts”, also applies to all platforms. You should follow its instructions to make sure that you have properly protected your MySQL accounts by assigning passwords to them.

When you are ready to create additional user accounts, you can find information on the MySQL access control system and account management in Section 5.4, “The MySQL Access Privilege System”, and Section 5.5, “MySQL User Account Management”.

2.10.1. Unix Postinstallation Procedures

After installing MySQL on Unix, you must initialize the grant tables, start the server, and make sure that the server works satisfactorily. You may also wish to arrange for the server to be started and stopped automatically when your system starts and stops. You should also assign passwords to the accounts in the grant tables.

On Unix, the grant tables are set up by the `mysql_install_db` program. For some installation methods, this program is run for you automatically if an existing database cannot be found.

- If you install MySQL on Linux using RPM distributions, the server RPM runs `mysql_install_db`.
- Using the native packaging system on many platforms, including Debian Linux, Ubuntu Linux, Gentoo Linux and others, the `mysql_install_db` command is run for you.
- If you install MySQL on Mac OS X using a PKG distribution, the installer runs `mysql_install_db`.

For other platforms and installation types, including generic binary and source installs, you will need to run `mysql_install_db` yourself.

The following procedure describes how to initialize the grant tables (if that has not previously been done) and start the server. It also suggests some commands that you can use to test whether the server is accessible and working properly. For information about starting and stopping the server automatically, see Section 2.10.1.2, “Starting and Stopping MySQL Automatically”.

After you complete the procedure and have the server running, you should assign passwords to the accounts created by `mysql_install_db` and perhaps restrict access to test databases. For instructions, see Section 2.10.2, “Securing the Initial MySQL Accounts”.

In the examples shown here, the server runs under the user ID of the `mysql` login account. This assumes that such an account exists. Either create the account if it does not exist, or substitute the name of a different existing login account that you plan to use for running the server. For information about creating the account, see Creating a `mysql` System User and Group, in Section 2.2, “Installing MySQL from Generic Binaries on Unix/Linux”.

1. Change location into the top-level directory of your MySQL installation, represented here by *`BASEDIR`*:

   ```
   shell> cd BASEDIR
   ```

   `BASEDIR` is the installation directory for your MySQL instance. It is likely to be something like `/usr/local/mysql` or `/usr/local`. The following steps assume that you have changed location to this directory.

   You will find several files and subdirectories in the *`BASEDIR`* directory. The most important for installation purposes are the `bin` and `scripts` subdirectories:

   - The `bin` directory contains client programs and the server. You should add the full path name of this directory to your `PATH` environment variable so that your shell finds the MySQL programs properly. See Section 2.12, “Environment Variables”.

   - The `scripts` directory contains the `mysql_install_db` script used to initialize the `mysql` database containing the grant tables that store the server access permissions.

2. If necessary, ensure that the distribution contents are accessible to `mysql`. If you installed the distribution as `mysql`, no further action is required. If you installed the distribution as `root`, its contents will be owned by `root`. Change its ownership to `mysql` by executing the following commands as `root` in the installation directory. The first command changes the owner attribute of the files to the `mysql` user. The second changes the group attribute to the `mysql` group.

   ```
   shell> chown -R mysql .
   shell> chgrp -R mysql .
   ```

3. If necessary, run the `mysql_install_db` program to set up the initial MySQL grant tables containing the privileges that determine how users are permitted to connect to the server. You will need to do this if you used a distribution type for which the installation procedure does not run the program for you.

   ```
   shell> scripts/mysql_install_db --user=mysql
   ```

   Typically, `mysql_install_db` needs to be run only the first time you install MySQL, so you can skip this step if you are upgrading an existing installation, However, `mysql_install_db` does not overwrite any existing privilege tables, so it should be safe to run in any circumstances.

   It might be necessary to specify other options such as `--basedir` or `--datadir` if `mysql_install_db` does not identify the correct locations for the installation directory or data directory. For example:

   ```
   shell> scripts/mysql_install_db --user=mysql \
            --basedir=/opt/mysql/mysql \
            --datadir=/opt/mysql/mysql/data
   ```

   The `mysql_install_db` script creates the server's data directory with `mysql` as the owner. Under the data directory, it creates directories for the `mysql` database that holds the grant tables and the `test` database that you can use to test MySQL. The script also creates privilege table entries for `root` and anonymous-user accounts. The accounts have no passwords initially. Section 2.10.2, “Securing the Initial MySQL Accounts”, describes the initial privileges. Briefly, these privileges permit the MySQL `root` user to do anything, and permit anybody to create or use databases with a name of `test` or starting with `test_`. See Section 5.4, “The MySQL Access Privilege System”, for a complete listing and description of the grant tables.

   It is important to make sure that the database directories and files are owned by the `mysql` login account so that the server has read and write access to them when you run it later. To ensure this if you run `mysql_install_db` as `root`, include the `--user` option as shown. Otherwise, you should execute the script while logged in as `mysql`, in which case you can omit the `--user` option from the command.

If you do not want to have the `test` database, you can remove it after starting the server, using the instructions in Section 2.10.2, “Securing the Initial MySQL Accounts”.

If you have trouble with `mysql_install_db` at this point, see Section 2.10.1.1, “Problems Running `mysql_install_db`”.

4. Most of the MySQL installation can be owned by `root` if you like. The exception is that the data directory must be owned by `mysql`. To accomplish this, run the following commands as `root` in the installation directory:

```
shell> chown -R root .
shell> chown -R mysql data
```

5. If the plugin directory (the directory named by the `plugin_dir` system variable) is writable by the server, it may be possible for a user to write executable code to a file in the directory using `SELECT ... INTO DUMPFILE`. This can be prevented by making `plugin_dir` read only to the server or by setting `--secure-file-priv` to a directory where `SELECT` writes can be made safely.

6. If you installed MySQL using a source distribution, you may want to optionally copy one of the provided configuration files from the `support-files` directory into your `/etc` directory. There are different sample configuration files for different use cases, server types, and CPU and RAM configurations. If you want to use one of these standard files, you should copy it to `/etc/my.cnf`, or `/etc/mysql/my.cnf` and edit and check the configuration before starting your MySQL server for the first time.

   If you do not copy one of the standard configuration files, the MySQL server will be started with the default settings.

   If you want MySQL to start automatically when you boot your machine, you can copy `support-files/mysql.server` to the location where your system has its startup files. More information can be found in the `mysql.server` script itself, and in Section 2.10.1.2, “Starting and Stopping MySQL Automatically”.

7. Start the MySQL server:

```
shell> bin/mysqld_safe --user=mysql &
```

   It is important that the MySQL server be run using an unprivileged (non-`root`) login account. To ensure this if you run `mysqld_safe` as `root`, include the `--user` option as shown. Otherwise, you should execute the script while logged in as `mysql`, in which case you can omit the `--user` option from the command.

   For further instructions for running MySQL as an unprivileged user, see Section 5.3.6, “How to Run MySQL as a Normal User”.

   If the command fails immediately and prints `mysqld ended`, look for information in the error log (which by default is the *`host_name`*`.err` file in the data directory).

   If you neglected to create the grant tables by running `mysql_install_db` before proceeding to this step, the following message appears in the error log file when you start the server:

```
mysqld: Can't find file: 'host.frm'
```

   This error also occurs if you run `mysql_install_db` as `root` without the `--user` option. Remove the `data` directory and run `mysql_install_db` with the `--user` option as described previously.

   If you have other problems starting the server, see Section 2.10.1.3, “Starting and Troubleshooting the MySQL Server”. For more information about `mysqld_safe`, see Section 4.3.2, “`mysqld_safe` — MySQL Server Startup Script”.

8. Use `mysqladmin` to verify that the server is running. The following commands provide simple tests to check whether the server is up and responding to connections:

```
shell> bin/mysqladmin version
shell> bin/mysqladmin variables
```

   The output from `mysqladmin version` varies slightly depending on your platform and version of MySQL, but should be similar to that shown here:

```
shell> bin/mysqladmin version
mysqladmin  Ver 14.12 Distrib 5.5.16, for pc-linux-gnu on i686
...

Server version          5.5.16
Protocol version        10
Connection              Localhost via UNIX socket
UNIX socket             /var/lib/mysql/mysql.sock
```

```
Uptime:                  14 days 5 hours 5 min 21 sec

Threads: 1  Questions: 366  Slow queries: 0
Opens: 0  Flush tables: 1  Open tables: 19
Queries per second avg: 0.000
```

To see what else you can do with `mysqladmin`, invoke it with the `--help` option.

9. Verify that you can shut down the server:

   ```
   shell> bin/mysqladmin -u root shutdown
   ```

10. Verify that you can start the server again. Do this by using `mysqld_safe` or by invoking `mysqld` directly. For example:

    ```
    shell> bin/mysqld_safe --user=mysql &
    ```

    If `mysqld_safe` fails, see Section 2.10.1.3, “Starting and Troubleshooting the MySQL Server”.

11. Run some simple tests to verify that you can retrieve information from the server. The output should be similar to what is shown here:

    ```
    shell> bin/mysqlshow
    +--------------------+
    |     Databases      |
    +--------------------+
    | information_schema |
    | mysql              |
    | test               |
    +--------------------+

    shell> bin/mysqlshow mysql
    Database: mysql
    +---------------------------+
    |          Tables           |
    +---------------------------+
    | columns_priv              |
    | db                        |
    | event                     |
    | func                      |
    | help_category             |
    | help_keyword              |
    | help_relation             |
    | help_topic                |
    | host                      |
    | plugin                    |
    | proc                      |
    | procs_priv                |
    | servers                   |
    | tables_priv               |
    | time_zone                 |
    | time_zone_leap_second     |
    | time_zone_name            |
    | time_zone_transition      |
    | time_zone_transition_type |
    | user                      |
    +---------------------------+

    shell> bin/mysql -e "SELECT Host,Db,User FROM db" mysql
    +------+--------+------+
    | host | db     | user |
    +------+--------+------+
    | %    | test   |      |
    | %    | test_% |      |
    +------+--------+------+
    ```

12. There is a benchmark suite in the `sql-bench` directory (under the MySQL installation directory) that you can use to compare how MySQL performs on different platforms. The benchmark suite is written in Perl. It requires the Perl DBI module that provides a database-independent interface to the various databases, and some other additional Perl modules:

    ```
    DBI
    DBD::mysql
    Data::Dumper
    Data::ShowTable
    ```

    These modules can be obtained from CPAN (http://www.cpan.org/). See also Section 2.13.1, “Installing Perl on Unix”.

    The `sql-bench/Results` directory contains the results from many runs against different databases and platforms. To run all tests, execute these commands:

    ```
    shell> cd sql-bench
    shell> perl run-all-tests
    ```

If you do not have the `sql-bench` directory, you probably installed MySQL using RPM files other than the source RPM. (The source RPM includes the `sql-bench` benchmark directory.) In this case, you must first install the benchmark suite before you can use it. There are separate benchmark RPM files named `mysql-bench-VERSION.i386.rpm` that contain benchmark code and data.

If you have a source distribution, there are also tests in its `tests` subdirectory that you can run. For example, to run `auto_increment.tst`, execute this command from the top-level directory of your source distribution:

```
shell> mysql -vvf test < ./tests/auto_increment.tst
```

The expected result of the test can be found in the `./tests/auto_increment.res` file.

13. At this point, you should have the server running. However, none of the initial MySQL accounts have a password, and the server permits permissive access to test databases. To tighten security, follow the instructions in Section 2.10.2, “Securing the Initial MySQL Accounts”.

The MySQL 5.5 installation procedure creates time zone tables in the `mysql` database but does not populate them. To do so, use the instructions in Section 9.6, “MySQL Server Time Zone Support”.

To make it more convenient to invoke programs installed in the `bin` directory under the installation directory, you can add that directory to your `PATH` environment variable setting. That enables you to run a program by typing only its name, not its entire path name. See Section 4.2.4, “Setting Environment Variables”.

You can set up new accounts using the `bin/mysql_setpermission` script if you install the `DBI` and `DBD::mysql` Perl modules. See Section 4.6.13, “`mysql_setpermission` — Interactively Set Permissions in Grant Tables”. For Perl module installation instructions, see Section 2.13, “Perl Installation Notes”.

If you would like to use `mysqlaccess` and have the MySQL distribution in some nonstandard location, you must change the location where `mysqlaccess` expects to find the `mysql` client. Edit the `bin/mysqlaccess` script at approximately line 18. Search for a line that looks like this:

```
$MYSQL     = '/usr/local/bin/mysql';    # path to mysql executable
```

Change the path to reflect the location where `mysql` actually is stored on your system. If you do not do this, a `Broken pipe` error will occur when you run `mysqlaccess`.

2.10.1.1. Problems Running `mysql_install_db`

The purpose of the `mysql_install_db` script is to generate new MySQL privilege tables. It does not overwrite existing MySQL privilege tables, and it does not affect any other data.

If you want to re-create your privilege tables, first stop the `mysqld` server if it is running. Then rename the `mysql` directory under the data directory to save it, and then run `mysql_install_db`. Suppose that your current directory is the MySQL installation directory and that `mysql_install_db` is located in the `bin` directory and the data directory is named `data`. To rename the `mysql` database and re-run `mysql_install_db`, use these commands.

```
shell> mv data/mysql data/mysql.old
shell> scripts/mysql_install_db --user=mysql
```

When you run `mysql_install_db`, you might encounter the following problems:

- **`mysql_install_db` fails to install the grant tables**

  You may find that `mysql_install_db` fails to install the grant tables and terminates after displaying the following messages:

  ```
  Starting mysqld daemon with databases from XXXXXX
  mysqld ended
  ```

  In this case, you should examine the error log file very carefully. The log should be located in the directory `XXXXXX` named by the error message and should indicate why `mysqld` did not start. If you do not understand what happened, include the log when you post a bug report. See Section 1.7, “How to Report Bugs or Problems”.

- **There is a `mysqld` process running**

  This indicates that the server is running, in which case the grant tables have probably been created already. If so, there is no need to run `mysql_install_db` at all because it needs to be run only once (when you install MySQL the first time).

- **Installing a second `mysqld` server does not work when one server is running**

  This can happen when you have an existing MySQL installation, but want to put a new installation in a different location. For example, you might have a production installation, but you want to create a second installation for testing purposes. Generally the problem that occurs when you try to run a second server is that it tries to use a network interface that is in use by the first server. In this case, you should see one of the following error messages:

  ```
  Can't start server: Bind on TCP/IP port:
  Address already in use
  Can't start server: Bind on unix socket...
  ```

  For instructions on setting up multiple servers, see Section 5.6, "Running Multiple MySQL Instances on One Machine".

- **You do not have write access to the `/tmp` directory**

  If you do not have write access to create temporary files or a Unix socket file in the default location (the `/tmp` directory) or the `TMP_DIR` environment variable, if it has been set, an error occurs when you run `mysql_install_db` or the `mysqld` server.

  You can specify different locations for the temporary directory and Unix socket file by executing these commands prior to starting `mysql_install_db` or `mysqld`, where *`some_tmp_dir`* is the full path name to some directory for which you have write permission:

  ```
  shell> TMPDIR=/some_tmp_dir/
  shell> MYSQL_UNIX_PORT=/some_tmp_dir/mysql.sock
  shell> export TMPDIR MYSQL_UNIX_PORT
  ```

  Then you should be able to run `mysql_install_db` and start the server with these commands:

  ```
  shell> scripts/mysql_install_db --user=mysql
  shell> bin/mysqld_safe --user=mysql &
  ```

  If `mysql_install_db` is located in the `scripts` directory, modify the first command to `scripts/mysql_install_db`.

  See Section C.5.4.5, "How to Protect or Change the MySQL Unix Socket File", and Section 2.12, "Environment Variables".

There are some alternatives to running the `mysql_install_db` script provided in the MySQL distribution:

- If you want the initial privileges to be different from the standard defaults, you can modify `mysql_install_db` before you run it. However, it is preferable to use `GRANT` and `REVOKE` to change the privileges *after* the grant tables have been set up. In other words, you can run `mysql_install_db`, and then use `mysql -u root mysql` to connect to the server as the MySQL `root` user so that you can issue the necessary `GRANT` and `REVOKE` statements.

  If you want to install MySQL on several machines with the same privileges, you can put the `GRANT` and `REVOKE` statements in a file and execute the file as a script using `mysql` after running `mysql_install_db`. For example:

  ```
  shell> scripts/mysql_install_db --user=mysql
  shell> bin/mysql -u root < your_script_file
  ```

  By doing this, you can avoid having to issue the statements manually on each machine.

- It is possible to re-create the grant tables completely after they have previously been created. You might want to do this if you are just learning how to use `GRANT` and `REVOKE` and have made so many modifications after running `mysql_install_db` that you want to wipe out the tables and start over.

  To re-create the grant tables, remove all the `.frm`, `.MYI`, and `.MYD` files in the `mysql` database directory. Then run the `mysql_install_db` script again.

- You can start `mysqld` manually using the `--skip-grant-tables` option and add the privilege information yourself using `mysql`:

  ```
  shell> bin/mysqld_safe --user=mysql --skip-grant-tables &
  shell> bin/mysql mysql
  ```

  From `mysql`, manually execute the SQL commands contained in `mysql_install_db`. Make sure that you run `mysqladmin flush-privileges` or `mysqladmin reload` afterward to tell the server to reload the grant tables.

  Note that by not using `mysql_install_db`, you not only have to populate the grant tables manually, you also have to create them first.

2.10.1.2. Starting and Stopping MySQL Automatically

Generally, you start the `mysqld` server in one of these ways:

- Invoke `mysqld` directly. This works on any platform.
- Run the MySQL server as a Windows service. The service can be set to start the server automatically when Windows starts, or as a manual service that you start on request. For instructions, see Section 2.3.5.7, “Starting MySQL as a Windows Service”.
- Invoke `mysqld_safe`, which tries to determine the proper options for `mysqld` and then runs it with those options. This script is used on Unix and Unix-like systems. See Section 4.3.2, “`mysqld_safe` — MySQL Server Startup Script”.
- Invoke `mysql.server`. This script is used primarily at system startup and shutdown on systems that use System V-style run directories (that is, `/etc/init.d` and run-level specific directories), where it usually is installed under the name `mysql`. The `mysql.server` script starts the server by invoking `mysqld_safe`. See Section 4.3.3, “`mysql.server` — MySQL Server Startup Script”.
- On Mac OS X, install a separate MySQL Startup Item package to enable the automatic startup of MySQL on system startup. The Startup Item starts the server by invoking `mysql.server`. See Section 2.4.3, “Installing the MySQL Startup Item”, for details. A MySQL Preference Pane also provides control for starting and stopping MySQL through the System Preferences, see Section 2.4.4, “Installing and Using the MySQL Preference Pane”.
- Use the Solaris/OpenSolaris service management framework (SMF) system to initiate and control MySQL startup. For more information, see Section 2.6.2, “Installing MySQL on OpenSolaris using IPS”.

The `mysqld_safe` and `mysql.server` scripts, Windows server, Solaris/OpenSolaris SMF, and the Mac OS X Startup Item (or MySQL Preference Pane) can be used to start the server manually, or automatically at system startup time. `mysql.server` and the Startup Item also can be used to stop the server.

To start or stop the server manually using the `mysql.server` script, invoke it with `start` or `stop` arguments:

```
shell> mysql.server start
shell> mysql.server stop
```

Before `mysql.server` starts the server, it changes location to the MySQL installation directory, and then invokes `mysqld_safe`. If you want the server to run as some specific user, add an appropriate `user` option to the `[mysqld]` group of the `/etc/my.cnf` option file, as shown later in this section. (It is possible that you will need to edit `mysql.server` if you've installed a binary distribution of MySQL in a nonstandard location. Modify it to change location into the proper directory before it runs `mysqld_safe`. If you do this, your modified version of `mysql.server` may be overwritten if you upgrade MySQL in the future, so you should make a copy of your edited version that you can reinstall.)

`mysql.server stop` stops the server by sending a signal to it. You can also stop the server manually by executing `mysqladmin shutdown`.

To start and stop MySQL automatically on your server, you need to add start and stop commands to the appropriate places in your `/etc/rc*` files.

If you use the Linux server RPM package (`MySQL-server-`*`VERSION`*`.rpm`), or a native Linux package installation, the `mysql.server` script may be installed in the `/etc/init.d` directory with the name `mysql`. See Section 2.5.1, “Installing MySQL from RPM Packages on Linux”, for more information on the Linux RPM packages.

Some vendors provide RPM packages that install a startup script under a different name such as `mysqld`.

If you install MySQL from a source distribution or using a binary distribution format that does not install `mysql.server` automatically, you can install it manually. The script can be found in the `support-files` directory under the MySQL installation directory or in a MySQL source tree.

To install `mysql.server` manually, copy it to the `/etc/init.d` directory with the name `mysql`, and then make it executable. Do this by changing location into the appropriate directory where `mysql.server` is located and executing these commands:

```
shell> cp mysql.server /etc/init.d/mysql
shell> chmod +x /etc/init.d/mysql
```

Note

> Older Red Hat systems use the `/etc/rc.d/init.d` directory rather than `/etc/init.d`. Adjust the preceding commands accordingly. Alternatively, first create `/etc/init.d` as a symbolic link that points to `/etc/rc.d/init.d`:

```
shell> cd /etc
shell> ln -s rc.d/init.d .
```

After installing the script, the commands needed to activate it to run at system startup depend on your operating system. On Linux, you can use `chkconfig`:

```
shell> chkconfig --add mysql
```

On some Linux systems, the following command also seems to be necessary to fully enable the `mysql` script:

```
shell> chkconfig --level 345 mysql on
```

On FreeBSD, startup scripts generally should go in `/usr/local/etc/rc.d/`. The `rc(8)` manual page states that scripts in this directory are executed only if their basename matches the `*.sh` shell file name pattern. Any other files or directories present within the directory are silently ignored. In other words, on FreeBSD, you should install the `mysql.server` script as `/usr/local/etc/rc.d/mysql.server.sh` to enable automatic startup.

As an alternative to the preceding setup, some operating systems also use `/etc/rc.local` or `/etc/init.d/boot.local` to start additional services on startup. To start up MySQL using this method, you could append a command like the one following to the appropriate startup file:

```
/bin/sh -c 'cd /usr/local/mysql; ./bin/mysqld_safe --user=mysql &'
```

For other systems, consult your operating system documentation to see how to install startup scripts.

You can add options for `mysql.server` in a global `/etc/my.cnf` file. A typical `/etc/my.cnf` file might look like this:

```
[mysqld]
datadir=/usr/local/mysql/var
socket=/var/tmp/mysql.sock
port=3306
user=mysql

[mysql.server]
basedir=/usr/local/mysql
```

The `mysql.server` script supports the following options: `basedir`, `datadir`, and `pid-file`. If specified, they *must* be placed in an option file, not on the command line. `mysql.server` supports only `start` and `stop` as command-line arguments.

The following table shows which option groups the server and each startup script read from option files.

Table 2.15. MySQL Startup scripts and supported server option groups

Script	Option Groups
`mysqld`	`[mysqld]`, `[server]`, `[mysqld-`*`major_version`*`]`
`mysqld_safe`	`[mysqld]`, `[server]`, `[mysqld_safe]`
`mysql.server`	`[mysqld]`, `[mysql.server]`, `[server]`

`[mysqld-`*`major_version`*`]` means that groups with names like `[mysqld-5.1]` and `[mysqld-5.5]` are read by servers having versions 5.1.x, 5.5.x, and so forth. This feature can be used to specify options that can be read only by servers within a given release series.

For backward compatibility, `mysql.server` also reads the `[mysql_server]` group and `mysqld_safe` also reads the `[safe_mysqld]` group. However, you should update your option files to use the `[mysql.server]` and `[mysqld_safe]` groups instead when using MySQL 5.5.

For more information on MySQL configuration files and their structure and contents, see Section 4.2.3.3, “Using Option Files”.

2.10.1.3. Starting and Troubleshooting the MySQL Server

This section provides troubleshooting suggestions for problems starting the server on Unix. If you are using Windows, see Section 2.3.6, “Troubleshooting a MySQL Installation Under Windows”.

If you have problems starting the server, here are some things to try:

- Check the error log to see why the server does not start.
- Specify any special options needed by the storage engines you are using.
- Make sure that the server knows where to find the data directory.
- Make sure that the server can access the data directory. The ownership and permissions of the data directory and its contents must be set such that the server can read and modify them.
- Verify that the network interfaces the server wants to use are available.

Some storage engines have options that control their behavior. You can create a `my.cnf` file and specify startup options for the engines that you plan to use. If you are going to use storage engines that support transactional tables (`InnoDB`, `NDB`), be sure that you have them configured the way you want before starting the server:

If you are using `InnoDB` tables, see Section 13.3.2, “Configuring `InnoDB`”.

Storage engines will use default option values if you specify none, but it is recommended that you review the available options and specify explicit values for those for which the defaults are not appropriate for your installation.

When the `mysqld` server starts, it changes location to the data directory. This is where it expects to find databases and where it expects to write log files. The server also writes the pid (process ID) file in the data directory.

The data directory location is hardwired in when the server is compiled. This is where the server looks for the data directory by default. If the data directory is located somewhere else on your system, the server will not work properly. You can determine what the default path settings are by invoking `mysqld` with the `--verbose` and `--help` options.

If the default locations do not match the MySQL installation layout on your system, you can override them by specifying options to `mysqld` or `mysqld_safe` on the command line or in an option file.

To specify the location of the data directory explicitly, use the `--datadir` option. However, normally you can tell `mysqld` the location of the base directory under which MySQL is installed and it looks for the data directory there. You can do this with the `--basedir` option.

To check the effect of specifying path options, invoke `mysqld` with those options followed by the `--verbose` and `--help` options. For example, if you change location into the directory where `mysqld` is installed and then run the following command, it shows the effect of starting the server with a base directory of `/usr/local`:

```
shell> ./mysqld --basedir=/usr/local --verbose --help
```

You can specify other options such as `--datadir` as well, but `--verbose` and `--help` must be the last options.

Once you determine the path settings you want, start the server without `--verbose` and `--help`.

If `mysqld` is currently running, you can find out what path settings it is using by executing this command:

```
shell> mysqladmin variables
```

Or:

```
shell> mysqladmin -h host_name variables
```

`host_name` is the name of the MySQL server host.

If you get `Errcode 13` (which means `Permission denied`) when starting `mysqld`, this means that the privileges of the data directory or its contents do not permit server access. In this case, you change the permissions for the involved files and directories so that the server has the right to use them. You can also start the server as `root`, but this raises security issues and should be avoided.

On Unix, change location into the data directory and check the ownership of the data directory and its contents to make sure the server has access. For example, if the data directory is `/usr/local/mysql/var`, use this command:

```
shell> ls -la /usr/local/mysql/var
```

If the data directory or its files or subdirectories are not owned by the login account that you use for running the server, change their ownership to that account. If the account is named `mysql`, use these commands:

```
shell> chown -R mysql /usr/local/mysql/var
shell> chgrp -R mysql /usr/local/mysql/var
```

If it possible that even with correct ownership, MySQL may fail to start up if there is other security software running on your system that manages application access to various parts of the file system. In this case, you may need to reconfigure that software to enable `mysqld` to access the directories it uses during normal operation.

If the server fails to start up correctly, check the error log. Log files are located in the data directory (typically `C:\Program Files\MySQL\MySQL Server 5.5\data` on Windows, `/usr/local/mysql/data` for a Unix binary distribution, and `/usr/local/var` for a Unix source distribution). Look in the data directory for files with names of the form `host_name.err` and `host_name.log`, where `host_name` is the name of your server host. Then examine the last few lines of these files. On Unix, you can use `tail` to display them:

```
shell> tail host_name.err
shell> tail host_name.log
```

The error log should contain information that indicates why the server could not start.

If either of the following errors occur, it means that some other program (perhaps another `mysqld` server) is using the TCP/IP port or Unix socket file that `mysqld` is trying to use:

```
Can't start server: Bind on TCP/IP port: Address already in use
Can't start server: Bind on unix socket...
```

Use `ps` to determine whether you have another `mysqld` server running. If so, shut down the server before starting `mysqld` again. (If another server is running, and you really want to run multiple servers, you can find information about how to do so in Section 5.6, “Running Multiple MySQL Instances on One Machine”.)

If no other server is running, try to execute the command `telnet your_host_name tcp_ip_port_number`. (The default MySQL port number is 3306.) Then press Enter a couple of times. If you do not get an error message like `telnet: Unable to connect to remote host: Connection refused`, some other program is using the TCP/IP port that `mysqld` is trying to use. You will need to track down what program this is and disable it, or else tell `mysqld` to listen to a different port with the `--port` option. In this case, you will also need to specify the port number for client programs when connecting to the server using TCP/IP.

Another reason the port might be inaccessible is that you have a firewall running that blocks connections to it. If so, modify the firewall settings to permit access to the port.

If the server starts but you cannot connect to it, you should make sure that you have an entry in `/etc/hosts` that looks like this:

```
127.0.0.1       localhost
```

If you cannot get `mysqld` to start, you can try to make a trace file to find the problem by using the `--debug` option. See MySQL Internals: Porting.

2.10.2. Securing the Initial MySQL Accounts

Part of the MySQL installation process is to set up the `mysql` database that contains the grant tables:

- Windows distributions contain preinitialized grant tables.
- On Unix, the `mysql_install_db` program populates the grant tables. Some installation methods run this program for you. Others require that you execute it manually. For details, see Section 2.10.1, “Unix Postinstallation Procedures”.

The `mysql.user` grant table defines the initial MySQL user accounts and their access privileges:

- Some accounts have the user name `root`. These are superuser accounts that have all privileges and can do anything. The initial `root` account passwords are empty, so anyone can connect to the MySQL server as `root` *without a password* and be granted all privileges.
    - On Windows, `root` accounts are created that permit connections from the local host only. Connections can be made by specifying the host name `localhost`, the IP address `127.0.0.1`, or the IPv6 address `::1`. If the user selects the **ENABLE ROOT ACCESS FROM REMOTE MACHINES** option during installation, the Windows installer creates another `root` account that permits connections from any host.
    - On Unix, each `root` account permits connections from the local host. Connections can be made by specifying the host

name `localhost`, the IP address `127.0.0.1`, the IPv6 address `::1`, or the actual host name or IP address.

An attempt to connect to the host `127.0.0.1` normally resolves to the `localhost` account. However, this fails if the server is run with the `--skip-name-resolve` option, so the `127.0.0.1` account is useful in that case. The `::1` account is used for IPv6 connections.

- Some accounts are for anonymous users. These have an empty user name. The anonymous accounts have no password, so anyone can use them to connect to the MySQL server.
  - On Windows, there is one anonymous account that permits connections from the local host. Connections can be made by specifying a host name of `localhost`.
  - On Unix, each anonymous account permits connections from the local host. Connections can be made by specifying a host name of `localhost` for one of the accounts, or the actual host name or IP address for the other.

To display which accounts exist in the `mysql.user` table and check whether their passwords are empty, use the following statement:

```
mysql> SELECT User, Host, Password FROM mysql.user;
+------+--------------------+----------+
| User | Host               | Password |
+------+--------------------+----------+
| root | localhost          |          |
| root | myhost.example.com |          |
| root | 127.0.0.1          |          |
| root | ::1                |          |
|      | localhost          |          |
|      | myhost.example.com |          |
+------+--------------------+----------+
```

This output indicates that there are several `root` and anonymous-user accounts, none of which have passwords. The output might differ on your system, but the presence of accounts with empty passwords means that your MySQL installation is unprotected until you do something about it:

- You should assign a password to each MySQL `root` account.
- If you want to prevent clients from connecting as anonymous users without a password, you should either assign a password to each anonymous account or else remove the accounts.

In addition, the `mysql.db` table contains rows that permit all accounts to access the `test` database and other databases with names that start with `test_`. This is true even for accounts that otherwise have no special privileges such as the default anonymous accounts. This is convenient for testing but inadvisable on production servers. Administrators who want database access restricted only to accounts that have permissions granted explicitly for that purpose should remove these `mysql.db` table rows.

The following instructions describe how to set up passwords for the initial MySQL accounts, first for the `root` accounts, then for the anonymous accounts. The instructions also cover how to remove the anonymous accounts, should you prefer not to permit anonymous access at all, and describe how to remove permissive access to test databases. Replace *`newpwd`* in the examples with the password that you want to use. Replace *`host_name`* with the name of the server host. You can determine this name from the output of the preceding `SELECT` statement. For the output shown, *`host_name`* is `myhost.example.com`.

> **Note**
>
> For additional information about setting passwords, see Section 5.5.5, “Assigning Account Passwords”. If you forget your `root` password after setting it, see Section C.5.4.1, “How to Reset the Root Password”.

You might want to defer setting the passwords until later, to avoid the need to specify them while you perform additional setup or testing. However, be sure to set them before using your installation for production purposes.

To set up additional accounts, see Section 5.5.2, “Adding User Accounts”.

Assigning `root` Account Passwords

The `root` account passwords can be set several ways. The following discussion demonstrates three methods:

- Use the `SET PASSWORD` statement
- Use the `UPDATE` statement

- Use the `mysqladmin` command-line client program

To assign passwords using `SET PASSWORD`, connect to the server as `root` and issue a `SET PASSWORD` statement for each `root` account listed in the `mysql.user` table. Be sure to encrypt the password using the `PASSWORD()` function.

For Windows, do this:

```
shell> mysql -u root
mysql> SET PASSWORD FOR 'root'@'localhost' = PASSWORD('newpwd');
mysql> SET PASSWORD FOR 'root'@'127.0.0.1' = PASSWORD('newpwd');
mysql> SET PASSWORD FOR 'root'@'::1' = PASSWORD('newpwd');
mysql> SET PASSWORD FOR 'root'@'%' = PASSWORD('newpwd');
```

The last statement is unnecessary if the `mysql.user` table has no `root` account with a host value of `%`.

For Unix, do this:

```
shell> mysql -u root
mysql> SET PASSWORD FOR 'root'@'localhost' = PASSWORD('newpwd');
mysql> SET PASSWORD FOR 'root'@'127.0.0.1' = PASSWORD('newpwd');
mysql> SET PASSWORD FOR 'root'@'::1' = PASSWORD('newpwd');
mysql> SET PASSWORD FOR 'root'@'host_name' = PASSWORD('newpwd');
```

You can also use a single statement that assigns a password to all `root` accounts by using `UPDATE` to modify the `mysql.user` table directly. This method works on any platform:

```
shell> mysql -u root
mysql> UPDATE mysql.user SET Password = PASSWORD('newpwd')
    ->     WHERE User = 'root';
mysql> FLUSH PRIVILEGES;
```

The `FLUSH` statement causes the server to reread the grant tables. Without it, the password change remains unnoticed by the server until you restart it.

To assign passwords to the `root` accounts using `mysqladmin`, execute the following commands:

```
shell> mysqladmin -u root password "newpwd"
shell> mysqladmin -u root -h host_name password "newpwd"
```

Those commands apply both to Windows and to Unix. The double quotation marks around the password are not always necessary, but you should use them if the password contains spaces or other characters that are special to your command interpreter.

The `mysqladmin` method of setting the `root` account passwords does not work for the `'root'@'127.0.0.1'` or `'root'@'::1'` account. Use the `SET PASSWORD` method shown earlier.

After the `root` passwords have been set, you must supply the appropriate password whenever you connect as `root` to the server. For example, to shut down the server with `mysqladmin`, use this command:

```
shell> mysqladmin -u root -p shutdown
Enter password: (enter root password here)
```

Assigning Anonymous Account Passwords

The `mysql` commands in the following instructions include a `-p` option based on the assumption that you have set the `root` account passwords using the preceding instructions and must specify that password when connecting to the server.

To assign passwords to the anonymous accounts, connect to the server as `root`, then use either `SET PASSWORD` or `UPDATE`. Be sure to encrypt the password using the `PASSWORD()` function.

To use `SET PASSWORD` on Windows, do this:

```
shell> mysql -u root -p
Enter password: (enter root password here)
mysql> SET PASSWORD FOR ''@'localhost' = PASSWORD('newpwd');
```

To use `SET PASSWORD` on Unix, do this:

```
shell> mysql -u root -p
Enter password: (enter root password here)
mysql> SET PASSWORD FOR ''@'localhost' = PASSWORD('newpwd');
mysql> SET PASSWORD FOR ''@'host_name' = PASSWORD('newpwd');
```

To set the anonymous-user account passwords with a single `UPDATE` statement, do this (on any platform):

```
shell> mysql -u root -p
Enter password: (enter root password here)
mysql> UPDATE mysql.user SET Password = PASSWORD('newpwd')
    ->     WHERE User = '';
mysql> FLUSH PRIVILEGES;
```

The `FLUSH` statement causes the server to reread the grant tables. Without it, the password change remains unnoticed by the server until you restart it.

Removing Anonymous Accounts

If you prefer to remove any anonymous accounts rather than assigning them passwords, do so as follows on Windows:

```
shell> mysql -u root -p
Enter password: (enter root password here)
mysql> DROP USER ''@'localhost';
```

On Unix, remove the anonymous accounts like this:

```
shell> mysql -u root -p
Enter password: (enter root password here)
mysql> DROP USER ''@'localhost';
mysql> DROP USER ''@'host_name';
```

Securing Test Databases

By default, the `mysql.db` table contains rows that permit access by any user to the `test` database and other databases with names that start with `test_`. (These rows have an empty `User` column value, which for access-checking purposes matches any user name.) This means that such databases can be used even by accounts that otherwise possess no privileges. If you want to remove any-user access to test databases, do so as follows:

```
shell> mysql -u root -p
Enter password: (enter root password here)
mysql> DELETE FROM mysql.db WHERE Db LIKE 'test%';
mysql> FLUSH PRIVILEGES;
```

The `FLUSH` statement causes the server to reread the grant tables. Without it, the privilege change remains unnoticed by the server until you restart it.

With the preceding change, only users who have global database privileges or privileges granted explicitly for the `test` database can use it. However, if you do not want the database to exist at all, drop it:

```
mysql> DROP DATABASE test;
```

> **Note**
>
> On Windows, you can also perform the process described in this section using the Configuration Wizard (see Section 2.3.4.11, “The Security Options Dialog”). On other platforms, the MySQL distribution includes `mysql_secure_installation`, a command-line utility that automates much of the process of securing a MySQL installation.

2.11. Upgrading or Downgrading MySQL

2.11.1. Upgrading MySQL

As a general rule, to upgrade from one release series to another, you should go to the next series rather than skipping a series. To upgrade from a release series previous to MySQL 5.1, upgrade to each successive release series in turn until you have reached MySQL 5.1, and then proceed with the upgrade to MySQL 5.5. For example, if you currently are running MySQL 5.0 and wish to upgrade to a newer series, upgrade to MySQL 5.1 first before upgrading to 5.5, and so forth. For information on upgrading to MySQL 5.1, see the *MySQL 5.1 Reference Manual*.

There is a special case for upgrading to MySQL 5.5, which is that there was a short-lived MySQL 5.4 development series. This series is no longer being worked on, but to accommodate users of both series, this section includes one subsection for users upgrading from MySQL 5.1 to 5.5 and another for users upgrading from MySQL 5.4 to 5.5.

To upgrade to MySQL 5.5, use the items in the following checklist as a guide:

- Before any upgrade, back up your databases, including the `mysql` database that contains the grant tables. See Section 6.2, “Database Backup Methods”.
- Read *all* the notes in Section 2.11.1.1, “Upgrading from MySQL 5.1 to 5.5”, or Section 2.11.1.2, “Upgrading from MySQL 5.4 to 5.5”, depending on whether you currently use MySQL 5.1 or 5.4. These notes enable you to identify upgrade issues that apply to your current MySQL installation. Some incompatibilities discussed in that section require your attention *before* upgrading. Others should be dealt with *after* upgrading.
- Read Appendix D, *MySQL Change History* as well, which provides information about features that are new in MySQL 5.5 or differ from those found in earlier MySQL releases.
- After upgrading to a new version of MySQL, run `mysql_upgrade` (see Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”). This program checks your tables, and attempts to repair them if necessary. It also updates your grant tables to make sure that they have the current structure so that you can take advantage of any new capabilities. (Some releases of MySQL introduce changes to the structure of the grant tables to add new privileges or features.)

  `mysql_upgrade` does not upgrade the contents of the help tables. For upgrade instructions, see Section 5.1.8, “Server-Side Help”.
- If you run MySQL Server on Windows, see Section 2.3.7, “Upgrading MySQL on Windows”.
- If you use replication, see Section 15.4.3, “Upgrading a Replication Setup”, for information on upgrading your replication setup.
- If you upgrade an installation originally produced by installing multiple RPM packages, it is best to upgrade all the packages, not just some. For example, if you previously installed the server and client RPMs, do not upgrade just the server RPM.
- If you have created a user-defined function (UDF) with a given name and upgrade MySQL to a version that implements a new built-in function with the same name, the UDF becomes inaccessible. To correct this, use `DROP FUNCTION` to drop the UDF, and then use `CREATE FUNCTION` to re-create the UDF with a different nonconflicting name. The same is true if the new version of MySQL implements a built-in function with the same name as an existing stored function. See Section 8.2.4, “Function Name Parsing and Resolution”, for the rules describing how the server interprets references to different kinds of functions.

You can always move the MySQL format files and data files between different versions on systems with the same architecture as long as you stay within versions for the same release series of MySQL.

If you are cautious about using new versions, you can always rename your old `mysqld` before installing a newer one. For example, if you are using a version of MySQL 5.1 and want to upgrade to 5.5, rename your current server from `mysqld` to `mysqld-5.1`. If your new `mysqld` then does something unexpected, you can simply shut it down and restart with your old `mysqld`.

If, after an upgrade, you experience problems with compiled client programs, such as `Commands out of sync` or unexpected core dumps, you probably have used old header or library files when compiling your programs. In this case, you should check the date for your `mysql.h` file and `libmysqlclient.a` library to verify that they are from the new MySQL distribution. If not, recompile your programs with the new headers and libraries. Recompilation might also be necessary for programs compiled against the shared client library if the library major version number has changed (for example from `libmysqlclient.so.15` to `libmysqlclient.so.16`.

If problems occur, such as that the new `mysqld` server does not start or that you cannot connect without a password, verify that you do not have an old `my.cnf` file from your previous installation. You can check this with the `--print-defaults` option (for example, `mysqld --print-defaults`). If this command displays anything other than the program name, you have an active `my.cnf` file that affects server or client operation.

If your MySQL installation contains a large amount of data that might take a long time to convert after an in-place upgrade, you might find it useful to create a “dummy” database instance for assessing what conversions might be needed and the work involved to perform them. Make a copy of your MySQL instance that contains a full copy of the `mysql` database, plus all other databases without data. Run your upgrade procedure on this dummy instance to see what actions might be needed so that you can better evaluate the work involved when performing actual data conversion on your original database instance.

It is a good idea to rebuild and reinstall the Perl `DBD::mysql` module whenever you install a new release of MySQL. The same applies to other MySQL interfaces as well, such as PHP `mysql` extensions and the Python `MySQLdb` module.

2.11.1.1. Upgrading from MySQL 5.1 to 5.5

> **Note**
>
> It is good practice to back up your data before installing any new version of software. Although MySQL works very hard to ensure a high level of quality, you should protect your data by making a backup.

> To upgrade to 5.5 from any previous version, MySQL recommends that you dump your tables with `mysqldump` before upgrading and reload the dump file after upgrading.

In general, you should do the following when upgrading from MySQL 5.1 to 5.5:

- Read *all* the items in the following sections to see whether any of them might affect your applications:
  - Section 2.11.1, "Upgrading MySQL", has general update information.
  - The items in the change lists found later in this section enable you to identify upgrade issues that apply to your current MySQL installation.
  - The MySQL 5.5 change history describes significant new features you can use in 5.5 or that differ from those found in earlier MySQL releases. Some of these changes may result in incompatibilities. See Section D.1, "Changes in Release 5.5.x (Production)".

  Note particularly any changes that are marked **Known issue** or **Incompatible change**. These incompatibilities with earlier versions of MySQL may require your attention *before you upgrade*. Our aim is to avoid these changes, but occasionally they are necessary to correct problems that would be worse than an incompatibility between releases. If any upgrade issue applicable to your installation involves an incompatibility that requires special handling, follow the instructions given in the incompatibility description. Often this will involve dumping and reloading tables, or use of a statement such as `CHECK TABLE` or `REPAIR TABLE`.

  For dump and reload instructions, see Section 2.11.4, "Rebuilding or Repairing Tables or Indexes". Any procedure that involves `REPAIR TABLE` with the `USE_FRM` option *must* be done before upgrading. Use of this statement with a version of MySQL different from the one used to create the table (that is, using it after upgrading) may damage the table. See Section 12.4.2.5, "`REPAIR TABLE` Syntax".

- Before upgrading to a new version of MySQL, Section 2.11.3, "Checking Whether Tables or Indexes Must Be Rebuilt", to see whether changes to table formats or to character sets or collations were made between your current version of MySQL and the version to which you are upgrading. If so and these changes result in an incompatibility between MySQL versions, you will need to upgrade the affected tables using the instructions in Section 2.11.4, "Rebuilding or Repairing Tables or Indexes".
- After upgrading to a new version of MySQL, run `mysql_upgrade` (see Section 4.4.7, "`mysql_upgrade` — Check Tables for MySQL Upgrade"). This program checks your tables, and attempts to repair them if necessary. It also updates your grant tables to make sure that they have the current structure so that you can take advantage of any new capabilities. (Some releases of MySQL introduce changes to the structure of the grant tables to add new privileges or features.)

  `mysql_upgrade` does not upgrade the contents of the help tables. For upgrade instructions, see Section 5.1.8, "Server-Side Help".

- If you run MySQL Server on Windows, see Section 2.3.7, "Upgrading MySQL on Windows".
- If you use replication, see Section 15.4.3, "Upgrading a Replication Setup", for information on upgrading your replication setup.

If your MySQL installation contains a large amount of data that might take a long time to convert after an in-place upgrade, you might find it useful to create a "dummy" database instance for assessing what conversions might be needed and the work involved to perform them. Make a copy of your MySQL instance that contains a full copy of the `mysql` database, plus all other databases without data. Run your upgrade procedure on this dummy instance to see what actions might be needed so that you can better evaluate the work involved when performing actual data conversion on your original database instance.

The following lists describe changes that may affect applications and that you should watch out for when upgrading from MySQL 5.1 to 5.5.

Configuration Changes

- **Incompatible change**: The `InnoDB Plugin` is included in MySQL 5.5 releases. It becomes the built-in version of `InnoDB` in MySQL Server, replacing the version previously included as the built-in `InnoDB` engine. `InnoDB Plugin` is also available in MySQL 5.1 as of 5.1.38, but it is an optional storage engine that must be enabled explicitly using two server options:

  ```
  [mysqld]
  ignore-builtin-innodb
  plugin-load=innodb=ha_innodb_plugin.so
  ```

  If you were using `InnoDB Plugin` in MySQL 5.1 by means of those options, you must remove them after an upgrade to 5.5 or the server will fail to start.

In addition, in `InnoDB Plugin`, the `innodb_file_io_threads` system variable has been removed and replaced with `innodb_read_io_threads` and `innodb_write_io_threads`. If you upgrade from MySQL 5.1 to MySQL 5.5 and previously explicitly set `innodb_file_io_threads` at server startup, you must change your configuration. Either remove any reference to `innodb_file_io_threads` or replace it with references to `innodb_read_io_threads` and `innodb_write_io_threads`.

- **Incompatible change**: In MySQL 5.5, the server includes a plugin services interface that complements the plugin API. The services interface enables server functionality to be exposed as a "service" that plugins can access through a function-call interface. The `libmysqlservices` library provides access to the available services and dynamic plugins now must be linked against this library (use the `-lmysqlservices` flag). For an example showing how to configure for `CMake`, see Section 21.2.5, "MySQL Services for Plugins".

Server Changes

- **Incompatible change**: As of MySQL 5.5.3, due to work done for Bug #989, `FLUSH TABLES` is not permitted when there is an active `LOCK TABLES ... READ`. To provide a workaround for this restriction, `FLUSH TABLES` has a new variant, `FLUSH TABLES tbl_list WITH READ LOCK`, that enables tables to be flushed and locked in a single operation. As a result of this change, applications that previously used this statement sequence to lock and flush tables will fail:

  ```
  LOCK TABLES tbl_list READ;
  FLUSH TABLES tbl_list;
  ```

  Such applications should now use this statement instead:

  ```
  FLUSH TABLES tbl_list WITH READ LOCK;
  ```

- **Incompatible change**: As of MySQL 5.5.7, the server requires that a new grant table, `proxies_priv`, be present in the `mysql` database. If you are upgrading to 5.5.7 from a previous MySQL release rather than performing a new installation, the server will find that this table is missing and exit during startup with the following message:

  ```
  Table 'mysql.proxies_priv' doesn't exist
  ```

  To create the `proxies_priv` table, start the server with the `--skip-grant-tables` option to cause it to skip the normal grant table checks, then run `mysql_upgrade`. For example:

  ```
  shell> mysqld --skip-grant-tables &
  shell> mysql_upgrade
  ```

  Then stop the server and restart it normally.

  You can specify other options on the `mysqld` command line if necessary. Alternatively, if your installation is configured so that the server normally reads options from an option file, use the `--defaults-file` option to specify the file (enter each command on a single line):

  ```
  shell> mysqld --defaults-file=/usr/local/mysql/etc/my.cnf
           --skip-grant-tables &
  shell> mysql_upgrade
  ```

  With the `--skip-grant-tables` option, the server does no password or privilege checking, so any client can connect and effectively have all privilges. For additional security, use the `--skip-networking` option as well to prevent remote clients from connecting.

  > **Note**
  >
  > This problem is fixed in MySQL 5.5.8; the server treats a missing `proxies_priv` table as equivalent to an empty table. However, after starting the server, you should still run `mysql_upgrade` to create the table.

- **Incompatible change**: As of MySQL 5.5.7, `InnoDB` always uses the fast truncation technique, equivalent to `DROP TABLE` and `CREATE TABLE`. It no longer performs a row-by-row delete for tables with parent-child foreign key relationships. `TRUNCATE TABLE` returns an error for such tables. Modify your SQL to issue `DELETE FROM table_name` for such tables instead.

- **Incompatible change**: Prior to MySQL 5.5.7, if you flushed the logs using `FLUSH LOGS` or `mysqladmin flush-logs` and `mysqld` was writing the error log to a file (for example, if it was started with the `--log-error` option), it renames the current log file with the suffix `-old`, then created a new empty log file. This had the problem that a second log-flushing operation thus caused the original error log file to be lost unless you saved it under a different name. For example, you could use the following commands to save the file:

```
shell> mysqladmin flush-logs
shell> mv host_name.err-old backup-directory
```

To avoid the preceding file-loss problem, no renaming occurs as of MySQL 5.5.7; the server merely closes and reopens the log file. To rename the file, you can do so manually before flushing. Then flushing the logs reopens a new file with the original file name. For example, you can rename the file and create a new one using the following commands:

```
shell> mv host_name.err host_name.err-old
shell> mysqladmin flush-logs
shell> mv host_name.err-old backup-directory
```

- **Incompatible change**: As of MySQL 5.5.6, handling of `CREATE TABLE IF NOT EXISTS ... SELECT` statements has been changed for the case that the destination table already exists:

  - Previously, for `CREATE TABLE IF NOT EXISTS ... SELECT`, MySQL produced a warning that the table exists, but inserted the rows and wrote the statement to the binary log anyway. By contrast, `CREATE TABLE ... SELECT` (without `IF NOT EXISTS`) failed with an error, but MySQL inserted no rows and did not write the statement to the binary log.

  - MySQL now handles both statements the same way when the destination table exists, in that neither statement inserts rows or is written to the binary log. The difference between them is that MySQL produces a warning when `IF NOT EXISTS` is present and an error when it is not.

  This change in handling of `IF NOT EXISTS` results in an incompatibility for statement-based replication from a MySQL 5.1 master with the original behavior and a MySQL 5.5 slave with the new behavior. Suppose that `CREATE TABLE IF NOT EXISTS ... SELECT` is executed on the master and the destination table exists. The result is that rows are inserted on the master but not on the slave. (Row-based replication does not have this problem.)

  To address this issue, statement-based binary logging for `CREATE TABLE IF NOT EXISTS ... SELECT` is changed in MySQL 5.1 as of 5.1.51:

  - If the destination table does not exist, there is no change: The statement is logged as is.

  - If the destination table does exist, the statement is logged as the equivalent pair of `CREATE TABLE IF NOT EXISTS` and `INSERT ... SELECT` statements. (If the `SELECT` in the original statement is preceded by `IGNORE` or `REPLACE`, the `INSERT` becomes `INSERT IGNORE` or `REPLACE`, respectively.)

  This change provides forward compatibility for statement-based replication from MySQL 5.1 to 5.5 because when the destination table exists, the rows will be inserted on both the master and slave. To take advantage of this compatibility measure, the 5.1 server must be at least 5.1.51 and the 5.5 server must be at least 5.5.6.

  To upgrade an existing 5.1-to-5.5 replication scenario, upgrade the master first to 5.1.51 or higher. Note that this differs from the usual replication upgrade advice of upgrading the slave first.

  A workaround for applications that wish to achieve the original effect (rows inserted regardless of whether the destination table exists) is to use `CREATE TABLE IF NOT EXISTS` and `INSERT ... SELECT` statements rather than `CREATE TABLE IF NOT EXISTS ... SELECT` statements.

  Along with the change just described, the following related change was made: Previously, if an existing view was named as the destination table for `CREATE TABLE IF NOT EXISTS ... SELECT`, rows were inserted into the underlying base table and the statement was written to the binary log. As of MySQL 5.1.51 and 5.5.6, nothing is inserted or logged.

- **Incompatible change**: Prior to MySQL 5.5.6, if the server was started with `character_set_server` set to `utf16`, it crashed during full-text stopword initialization. Now the stopword file is loaded and searched using `latin1` if `character_set_server` is `ucs2`, `utf16`, or `utf32`. If any table was created with `FULLTEXT` indexes while the server character set was `ucs2`, `utf16`, or `utf32`, it should be repaired using this statement:

  ```
  REPAIR TABLE tbl_name QUICK;
  ```

- **Incompatible change**: As of MySQL 5.5.5, all numeric operators and functions on integer, floating-point and `DECIMAL` values throw an “out of range” error (`ER_DATA_OUT_OF_RANGE`) rather than returning an incorrect value or `NULL`, when the result is out of the supported range for the corresponding data type. See Section 10.6, “Out-of-Range and Overflow Handling”.

- **Incompatible change**: In very old versions of MySQL (prior to 4.1), the `TIMESTAMP` data type supported a display width, which was silenty ignored beginning with MySQL 4.1. This is deprecated in MySQL 5.1, and removed altogether in MySQL 5.5. These changes in behavior can lead to two problem scenarios when trying to use `TIMESTAMP(N)` columns with a MySQL 5.5 or later server:

  - When importing a dump file (for example, one created using `mysqldump`) created in a MySQL 5.0 or earlier server into a server from a newer release series, a `CREATE TABLE` or `ALTER TABLE` statement containing `TIMESTAMP(N)` causes the import to fail with a syntax error.

    To fix this problem, edit the dump file in a text editor to replace any instances of `TIMESTAMP(N)` with `TIMESTAMP` prior to importing the file. Be sure to use a plain text editor for this, and not a word processor; otherwise, the result is almost certain to be unusable for importing into the MySQL server.

  - When trying replicate any `CREATE TABLE` or `ALTER TABLE` statement containing `TIMESTAMP(N)` from a master MySQL server that supports the `TIMESTAMP(N)` syntax to a MySQL 5.5.3 or newer slave, the statement causes replication to fail. Similarly, when you try to restore from a binary log written by a server that supports `TIMESTAMP(N)` to a MySQL 5.5.3 or newer server, any `CREATE TABLE` or `ALTER TABLE` statement containing `TIMESTAMP(N)` causes the backup to fail. This holds true regardless of the logging format.

    It may be possible to fix such issues using a hex editor, by replacing any width arguments used with `TIMESTAMP`, and the parentheses containing them, with space characters (hexadecimal `20`). Be sure to use a programmer's binary hex editor and not a regular text editor or word processor for this; otherwise, the result is almost certain to be a corrupted binary log file. To guard against accidental corruption of the binary log, you should always work on a copy of the file rather than the original.

  You should try to handle potential issues of these types proactively by updating with `ALTER TABLE` any `TIMESTAMP(N)` columns in your databases so that they use `TIMESTAMP` instead, before performing any upgrades.

- **Incompatible change**: As of MySQL 5.5.3, the Unicode implementation has been extended to provide support for supplementary characters that lie outside the Basic Multilingual Plane (BMP). Noteworthy features:

  - `utf16` and `utf32` character sets have been added. These correspond to the UTF-16 and UTF-32 encodings of the Unicode character set, and they both support supplementary characters.

  - The `utf8mb4` character set has been added. This is similar to `utf8`, but its encoding allows up to four bytes per character to enable support for supplementary characters.

  - The `ucs2` character set is essentially unchanged except for the inclusion of some newer BMP characters.

  In most respects, upgrading to MySQL 5.5 should present few problems with regard to Unicode usage, although there are some potential areas of incompatibility. These are the primary areas of concern:

  - For the variable-length character data types (`VARCHAR` and the `TEXT` types), the maximum length in characters is less for `utf8mb4` columns than for `utf8` columns.

  - For all character data types (`CHAR`, `VARCHAR`, and the `TEXT` types), the maximum number of characters that can be indexed is less for `utf8mb4` columns than for `utf8` columns.

  Consequently, if you want to upgrade tables from `utf8` to `utf8mb4` to take advantage of supplementary-character support, it may be necessary to change some column or index definitions.

  For additional details about the new Unicode character sets and potential incompatibilities, see Section 9.1.10, “Unicode Support”, and Section 9.1.11, “Upgrading from Previous to Current Unicode Support”.

- **Incompatible change**: As of MySQL 5.5.3, the server includes `dtoa`, a library for conversion between strings and numbers by David M. Gay. In MySQL, this library provides the basis for improved conversion between string or `DECIMAL` values and approximate-value (`FLOAT` or `DOUBLE`) numbers.

  Because the conversions produced by this library differ in some cases from previous results, the potential exists for incompatibilities in applications that rely on previous results. For example, applications that depend on a specific exact result from previous conversions might need adjustment to accommodate additional precision.

  For additional information about the properties of `dtoa` conversions, see Section 11.2, “Type Conversion in Expression Evaluation”.

- **Incompatible change**: In MySQL 5.5, several changes were made regarding the language and character set of error messages:

  - The `--language` option for specifying the directory for the error message file is now deprecated. The new `--lc-messages-dir` and `--lc-messages` options should be used instead, and `--language` is handled as an alias for `--lc-messages-dir`.

  - The `language` system variable has been removed and replaced with the new `lc_messages_dir` and `lc_messages` system variables. `lc_messages_dir` has only a global value and is read only. `lc_messages` has global and session values and can be modified at runtime, so the error message language can be changed while the server is running, and individual clients each can have a different error message language by changing their session `lc_messages` value to a different locale name.

- Error messages previously were constructed in a mix of character sets. This issue is resolved by constructing error messages internally within the server using UTF-8 and returning them to the client in the character set specified by the `character_set_results` system variable. The content of error messages therefore may in some cases differ from the messags returned previously.

For more information, see Section 9.2, “Setting the Error Message Language”, and Section 9.1.6, “Character Set for Error Messages”.

SQL Changes

- **Incompatible change**: Previously, the parser accepted an `INTO` clause in nested `SELECT` statements, which is invalid because such statements must return their results to the outer context. As of MySQL 5.5.3, this syntax is no longer permitted and statements that use it must be changed.
- **Incompatible change**: In MySQL 5.5.3, several changes were made to alias resolution in multiple-table `DELETE` statements so that it is no longer possible to have inconsistent or ambiguous table aliases.
  - In MySQL 5.1.23, alias declarations outside the *`table_references`* part of the statement were disallowed for the `USING` variant of multiple-table `DELETE` syntax, to reduce the possibility of ambiguous aliases that could lead to ambiguous statements that have unexpected results such as deleting rows from the wrong table.

    As of MySQL 5.5.3, alias declarations outside *`table_references`* are disallowed for all multiple-table `DELETE` statements. Alias declarations are permitted only in the *`table_references`* part.

    Incorrect:

    ```
    DELETE FROM t1 AS a2 USING t1 AS a1 INNER JOIN t2 AS a2;
    DELETE t1 AS a2 FROM t1 AS a1 INNER JOIN t2 AS a2;
    ```

    Correct:

    ```
    DELETE FROM t1 USING t1 AS a1 INNER JOIN t2 AS a2;
    DELETE t1 FROM t1 AS a1 INNER JOIN t2 AS a2;
    ```

  - Previously, for alias references in the list of tables from which to delete rows in a multiple-table delete, the default database is used unless one is specified explicitly. For example, if the default database is `db1`, the following statement does not work because the unqualified alias reference `a2` is interpreted as having a database of `db1`:

    ```
    DELETE a1, a2 FROM db1.t1 AS a1 INNER JOIN db2.t2 AS a2
    WHERE a1.id=a2.id;
    ```

    To correctly match an alias that refers to a table outside the default database, you must explicitly qualify the reference with the name of the proper database:

    ```
    DELETE a1, db2.a2 FROM db1.t1 AS a1 INNER JOIN db2.t2 AS a2
    WHERE a1.id=a2.id;
    ```

    As of MySQL 5.5.3, alias resolution does not require qualification and alias references should not be qualified with the database name. Qualified names are interpreted as referring to tables, not aliases.

  Statements containing alias constructs that are no longer permitted must be rewritten.
- Some keywords may be reserved in MySQL 5.5 that were not reserved in MySQL 5.1. See Section 8.3, “Reserved Words”.

2.11.1.2. Upgrading from MySQL 5.4 to 5.5

This section is for the special case of upgrading to MySQL 5.5 from the short-lived MySQL 5.4 development series, which is no longer being worked on.

> **Note**
>
> It is good practice to back up your data before installing any new version of software. Although MySQL works very hard to ensure a high level of quality, you should protect your data by making a backup.

> To upgrade to 5.5 from any previous version, MySQL recommends that you dump your tables with `mysqldump` before upgrading and reload the dump file after upgrading.

In general, you should do the following when upgrading from MySQL 5.4 to 5.5:

- Read *all* the items in the following sections to see whether any of them might affect your applications:
  - Section 2.11.1, “Upgrading MySQL”, has general update information.
  - The items in the change lists found later in this section enable you to identify upgrade issues that apply to your current MySQL installation.
  - The MySQL 5.5 change history describes significant new features you can use in 5.5 or that differ from those found in earlier MySQL releases. Some of these changes may result in incompatibilities. See Section D.1, “Changes in Release 5.5.x (Production)”.

  Note particularly any changes that are marked **Known issue** or **Incompatible change**. These incompatibilities with earlier versions of MySQL may require your attention *before you upgrade*. Our aim is to avoid these changes, but occasionally they are necessary to correct problems that would be worse than an incompatibility between releases. If any upgrade issue applicable to your installation involves an incompatibility that requires special handling, follow the instructions given in the incompatibility description. Often this will involve dumping and reloading tables, or use of a statement such as `CHECK TABLE` or `REPAIR TABLE`.

  For dump and reload instructions, see Section 2.11.4, “Rebuilding or Repairing Tables or Indexes”. Any procedure that involves `REPAIR TABLE` with the `USE_FRM` option *must* be done before upgrading. Use of this statement with a version of MySQL different from the one used to create the table (that is, using it after upgrading) may damage the table. See Section 12.4.2.5, “`REPAIR TABLE` Syntax”.

- Before upgrading to a new version of MySQL, Section 2.11.3, “Checking Whether Tables or Indexes Must Be Rebuilt”, to see whether changes to table formats or to character sets or collations were made between your current version of MySQL and the version to which you are upgrading. If so and these changes result in an incompatibility between MySQL versions, you will need to upgrade the affected tables using the instructions in Section 2.11.4, “Rebuilding or Repairing Tables or Indexes”.

- After upgrading to a new version of MySQL, run `mysql_upgrade` (see Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”). This program checks your tables, and attempts to repair them if necessary. It also updates your grant tables to make sure that they have the current structure so that you can take advantage of any new capabilities. (Some releases of MySQL introduce changes to the structure of the grant tables to add new privileges or features.)

  `mysql_upgrade` does not upgrade the contents of the help tables. For upgrade instructions, see Section 5.1.8, “Server-Side Help”.

- If you run MySQL Server on Windows, see Section 2.3.7, “Upgrading MySQL on Windows”.

- If you use replication, see Section 15.4.3, “Upgrading a Replication Setup”, for information on upgrading your replication setup.

If your MySQL installation contains a large amount of data that might take a long time to convert after an in-place upgrade, you might find it useful to create a “dummy” database instance for assessing what conversions might be needed and the work involved to perform them. Make a copy of your MySQL instance that contains a full copy of the `mysql` database, plus all other databases without data. Run your upgrade procedure on this dummy instance to see what actions might be needed so that you can better evaluate the work involved when performing actual data conversion on your original database instance.

The following lists describe changes that may affect applications and that you should watch out for when upgrading from MySQL 5.4 to 5.5.

Configuration Changes

- **Incompatible change**: In MySQL 5.5, the server includes a plugin services interface that complements the plugin API. The services interface enables server functionality to be exposed as a “service” that plugins can access through a function-call interface. The `libmysqlservices` library provides access to the available services and dynamic plugins now must be linked against this library (use the `-lmysqlservices` flag). For an example showing how to configure for `CMake`, see Section 21.2.5, “MySQL Services for Plugins”.

Server Changes

- **Incompatible change**: As of MySQL 5.5.7, the server requires that a new grant table, `proxies_priv`, be present in the `mysql` database. If you are upgrading from a previous MySQL release rather than performing a new installation, the server will find that this table is missing and exit during startup with the following message:

```
Table 'mysql.proxies_priv' doesn't exist
```

To create the `proxies_priv` table, start the server with the `--skip-grant-tables` option to cause it to skip the normal grant table checks, then run `mysql_upgrade`. For example:

```
shell> mysqld --skip-grant-tables &
shell> mysql_upgrade
```

Then stop the server and restart it normally.

You can specify other options on the `mysqld` command line if necessary. Alternatively, if your installation is configured so that the server normally reads options from an option file, use the `--defaults-file` option to specify the file (enter each command on a single line):

```
shell> mysqld --defaults-file=/usr/local/mysql/etc/my.cnf
         --skip-grant-tables &
shell> mysql_upgrade
```

With the `--skip-grant-tables` option, the server does no password or privilege checking, so any client can connect and effectively have all privilges. For additional security, use the `--skip-networking` option as well to prevent remote clients from connecting.

- **Incompatible change**: As of MySQL 5.5.3, the Unicode implementation has been extended to provide support for supplementary characters that lie outside the Basic Multilingual Plane (BMP). Noteworthy features:

    - `utf16` and `utf32` character sets have been added. These correspond to the UTF-16 and UTF-32 encodings of the Unicode character set, and they both support supplementary characters.

    - The `utf8mb4` character set has been added. This is similar to `utf8`, but its encoding allows up to four bytes per character to enable support for supplementary characters.

    - The `ucs2` character set is essentially unchanged except for the inclusion of some newer BMP characters.

    In most respects, upgrading to MySQL 5.5 should present few problems with regard to Unicode usage, although there are some potential areas of incompatibility. These are the primary areas of concern:

    - For the variable-length character data types (`VARCHAR` and the `TEXT` types), the maximum length in characters is less for `utf8mb4` columns than for `utf8` columns.

    - For all character data types (`CHAR`, `VARCHAR`, and the `TEXT` types), the maximum number of characters that can be indexed is less for `utf8mb4` columns than for `utf8` columns.

    Consequently, if you want to upgrade tables from `utf8` to `utf8mb4` to take advantage of supplementary-character support, it may be necessary to change some column or index definitions.

    For additional details about the new Unicode character sets and potential incompatibilities, see Section 9.1.10, “Unicode Support”, and Section 9.1.11, “Upgrading from Previous to Current Unicode Support”.

- **Incompatible change**: As of MySQL 5.5.3, the server includes `dtoa`, a library for conversion between strings and numbers by David M. Gay. In MySQL, this library provides the basis for improved conversion between string or `DECIMAL` values and approximate-value (`FLOAT`/`DOUBLE`) numbers.

    Because the conversions produced by this library differ in some cases from previous results, the potential exists for incompatibilities in applications that rely on previous results. For example, applications that depend on a specific exact result from previous conversions might need adjustment to accommodate additional precision.

    For additional information about the properties of `dtoa` conversions, see Section 11.2, “Type Conversion in Expression Evaluation”.

- **Incompatible change**: In MySQL 5.5, several changes were made regarding the language and character set of error messages:

    - The `--language` option for specifying the directory for the error message file is now deprecated. The new `--lc-messages-dir` and `--lc-messages` options should be used instead, and `--language` is handled as an alias for `--lc-messages-dir`.

    - The `language` system variable has been removed and replaced with the new `lc_messages_dir` and `lc_messages` system variables. `lc_messages_dir` has only a global value and is read only. `lc_messages` has global and session values and can be modified at runtime, so the error message language can be changed while the server is running, and individual clients each can have a different error message language by changing their session `lc_messages` value to a different locale name.

- Error messages previously were constructed in a mix of character sets. This issue is resolved by constructing error messages internally within the server using UTF-8 and returning them to the client in the character set specified by the `character_set_results` system variable. The content of error messages therefore may in some cases differ from the messags returned previously.

For more information, see Section 9.2, “Setting the Error Message Language”, and Section 9.1.6, “Character Set for Error Messages”.

- Before MySQL 5.1.36, plugin options were boolean options (see Section 4.2.3.2, “Program Option Modifiers”). If you upgrade to MySQL 5.5 from a version older than 5.1.36 and previously used options of the form `--plugin_name=0` or `--plugin_name=1`, the equivalent options are now `--plugin_name=OFF` and `--plugin_name=ON`, respectively. You also have the choice of requiring plugins to start successfully by using `--plugin_name=FORCE` or `--plugin_name=FORCE_PLUS_PERMANENT`.

SQL Changes

- **Incompatible change**: Previously, the parser accepted an `INTO` clause in nested `SELECT` statements, which is invalid because such statements must return their results to the outer context. As of MySQL 5.5.3, this syntax is no longer permitted and statements that use it must be changed.
- Some keywords may be reserved in MySQL 5.5 that were not reserved in MySQL 5.4. See Section 8.3, “Reserved Words”.

2.11.2. Downgrading MySQL

This section describes what you should do to downgrade to an older MySQL version in the unlikely case that the previous version worked better than the new one.

If you are downgrading within the same release series (for example, from 5.1.13 to 5.1.12) the general rule is that you just have to install the new binaries on top of the old ones. There is no need to do anything with the databases. As always, however, it is always a good idea to make a backup.

The following items form a checklist of things you should do whenever you perform a downgrade:

- Read the upgrading section for the release series from which you are downgrading to be sure that it does not have any features you really need. See Section 2.11.1, “Upgrading MySQL”.
- If there is a downgrading section for that version, you should read that as well.
- To see which new features were added between the version to which you are downgrading and your current version, see the change logs (Appendix D, *MySQL Change History*).
- Check Section 2.11.3, “Checking Whether Tables or Indexes Must Be Rebuilt”, to see whether changes to table formats or to character sets or collations were made between your current version of MySQL and the version to which you are downgrading. If so and these changes result in an incompatibility between MySQL versions, you will need to downgrade the affected tables using the instructions in Section 2.11.4, “Rebuilding or Repairing Tables or Indexes”.

In most cases, you can move the MySQL format files and data files between different versions on the same architecture as long as you stay within versions for the same release series of MySQL.

If you downgrade from one release series to another, there may be incompatibilities in table storage formats. In this case, use `mysqldump` to dump your tables before downgrading. After downgrading, reload the dump file using `mysql` or `mysqlimport` to re-create your tables. For examples, see Section 2.11.5, “Copying MySQL Databases to Another Machine”.

A typical symptom of a downward-incompatible table format change when you downgrade is that you cannot open tables. In that case, use the following procedure:

1. Stop the older MySQL server that you are downgrading to.
2. Restart the newer MySQL server you are downgrading from.

3. Dump any tables that were inaccessible to the older server by using `mysqldump` to create a dump file.
4. Stop the newer MySQL server and restart the older one.
5. Reload the dump file into the older server. Your tables should be accessible.

It might also be the case that system tables in the `mysql` database have changed and that downgrading introduces some loss of functionality or requires some adjustments. Here are some examples:

- Trigger creation requires the `TRIGGER` privilege as of MySQL 5.1. In MySQL 5.0, there is no `TRIGGER` privilege and `SUPER` is required instead. If you downgrade from MySQL 5.1 to 5.0, you will need to give the `SUPER` privilege to those accounts that had the `TRIGGER` privilege in 5.1.
- Triggers were added in MySQL 5.0, so if you downgrade from 5.0 to 4.1, you cannot use triggers at all.
- The `mysql.proc.comment` column definition changed between MySQL 5.1 and 5.5. After a downgrade from 5.5 to 5.1, this table is seen as corrupt and in need of repair. To workaround this problem, execute `mysql_upgrade` from the version of MySQL to which you downgraded.

2.11.2.1. Downgrading to MySQL 5.1

When downgrading to MySQL 5.1 from MySQL 5.5, you should keep in mind the following issues relating to features found in MySQL 5.5, but not in MySQL 5.1:

- **InnoDB.** MySQL 5.5 uses `InnoDB Plugin` as the built-in version of `InnoDB`. MySQL 5.1 includes `InnoDB Plugin` as of 5.1.38, but as an option that must be enabled explicitly. See Changes in MySQL 5.1.38.

2.11.3. Checking Whether Tables or Indexes Must Be Rebuilt

A binary upgrade or downgrade is one that installs one version of MySQL “in place” over an existing version, without dumping and reloading tables:

1. Stop the server for the existing version if it is running.
2. Install a different version of MySQL. This is an upgrade if the new version is higher than the original version, a downgrade if the version is lower.
3. Start the server for the new version.

In many cases, the tables from the previous version of MySQL can be used without problem by the new version. However, sometimes changes occur that require tables or table indexes to be rebuilt, as described in this section. If you have tables that are affected by any of the issues described here, rebuild the tables or indexes as necessary using the instructions given in Section 2.11.4, “Rebuilding or Repairing Tables or Indexes”.

Table Incompatibilities

After a binary upgrade to MySQL 5.1 from a MySQL 5.0 installation that contains `ARCHIVE` tables, accessing those tables causes the server to crash, even if you have run `mysql_upgrade` or `CHECK TABLE ... FOR UPGRADE`. To work around this problem, use `mysqldump` to dump all `ARCHIVE` tables before upgrading, and reload them into MySQL 5.1 after upgrading. The same problem occurs for binary downgrades from MySQL 5.1 to 5.0.

Index Incompatibilities

In MySQL 5.5.14, the length limit for index prefix keys is increased from 767 bytes to 3072 bytes, for `InnoDB` tables using `ROW_FORMAT=DYNAMIC` or `ROW_FORMAT=COMPRESSED`. See Section 13.3.15, “Limits on `InnoDB` Tables” for details. This change is also backported to MySQL 5.5.14. If you downgrade from one of these releases or higher, to an earlier release with a lower length limit, the index prefix keys could be truncated at 767 bytes or the downgrade could fail. This issue could only occur if the configuration option `innodb_large_prefix` was enabled on the server being downgraded.

If you perform a binary upgrade without dumping and reloading tables, you cannot upgrade directly from MySQL 4.1 to 5.1 or higher. This occurs due to an incompatible change in the `MyISAM` table index format in MySQL 5.0. Upgrade from MySQL 4.1 to 5.0 and repair all `MyISAM` tables. Then upgrade from MySQL 5.0 to 5.1 and check and repair your tables.

Modifications to the handling of character sets or collations might change the character sort order, which causes the ordering of entries in any index that uses an affected character set or collation to be incorrect. Such changes result in several possible problems:

- Comparison results that differ from previous results
- Inability to find some index values due to misordered index entries
- Misordered `ORDER BY` results
- Tables that `CHECK TABLE` reports as being in need of repair

The solution to these problems is to rebuild any indexes that use an affected character set or collation, either by dropping and re-creating the indexes, or by dumping and reloading the entire table. For information about rebuilding indexes, see Section 2.11.4, “Rebuilding or Repairing Tables or Indexes”.

To check whether a table has indexes that must be rebuilt, consult the following list. It indicates which versions of MySQL introduced character set or collation changes that require indexes to be rebuilt. Each entry indicates the version in which the change occurred and the character sets or collations that the change affects. If the change is associated with a particular bug report, the bug number is given.

The list applies both for binary upgrades and downgrades. For example, Bug #27877 was fixed in MySQL 5.1.24 and 5.4.0, so it applies to upgrades from versions older than 5.1.24 to 5.1.24 or newer, and to downgrades from 5.1.24 or newer to versions older than 5.1.24.

In many cases, you can use `CHECK TABLE ... FOR UPGRADE` to identify tables for which index rebuilding is required. (It will report: `Table upgrade required. Please do "REPAIR TABLE `tbl_name`" or dump/reload to fix it!`) In these cases, you can also use `mysqlcheck --check-upgrade` or `mysql_upgrade`, which execute `CHECK TABLE`. However, the use of `CHECK TABLE` applies only after upgrades, not downgrades. Also, `CHECK TABLE` is not applicable to all storage engines. For details about which storage engines `CHECK TABLE` supports, see Section 12.4.2.2, “`CHECK TABLE` Syntax”.

Changes that cause index rebuilding to be necessary:

- MySQL 5.0.48, 5.1.21 (Bug #29461)

  Affects indexes for columns that use any of these character sets: `eucjpms`, `euc_kr`, `gb2312`, `latin7`, `macce`, `ujis`

  Affected tables can be detected by `CHECK TABLE ... FOR UPGRADE` as of MySQL 5.1.29, 5.4.0 (see Bug #39585).

- MySQL 5.0.48, 5.1.23 (Bug #27562)

  Affects indexes that use the `ascii_general_ci` collation for columns that contain any of these characters: ``'`'`` GRAVE ACCENT, `'['` LEFT SQUARE BRACKET, `'\'` REVERSE SOLIDUS, `']'` RIGHT SQUARE BRACKET, `'~'` TILDE

  Affected tables can be detected by `CHECK TABLE ... FOR UPGRADE` as of MySQL 5.1.29, 5.4.0 (see Bug #39585).

- MySQL 5.1.24, 5.4.0 (Bug #27877)

  Affects indexes that use the `utf8_general_ci` or `ucs2_general_ci` collation for columns that contain `'ß'` LATIN SMALL LETTER SHARP S (German).

  Affected tables can be detected by `CHECK TABLE ... FOR UPGRADE` as of MySQL 5.1.30, 5.4.0 (see Bug #40053).

2.11.4. Rebuilding or Repairing Tables or Indexes

This section describes how to rebuild a table. This can be necessitated by changes to MySQL such as how data types are handled or changes to character set handling. For example, an error in a collation might have been corrected, necessitating a table rebuild to update the indexes for character columns that use the collation. (For examples, see Section 2.11.3, “Checking Whether Tables or Indexes Must Be Rebuilt”.) It might also be that a table repair or upgrade should be done as indicated by a table check operation such as that performed by `CHECK TABLE`, `mysqlcheck`, or `mysql_upgrade`.

Methods for rebuilding a table include dumping and reloading it, or using `ALTER TABLE` or `REPAIR TABLE`.

> **Note**
>
> If you are rebuilding tables because a different version of MySQL will not handle them after a binary (in-place) upgrade or downgrade, you must use the dump-and-reload method. Dump the tables *before* upgrading or downgrading

> using your original version of MySQL. Then reload the tables *after* upgrading or downgrading.
>
> If you use the dump-and-reload method of rebuilding tables only for the purpose of rebuilding indexes, you can perform the dump either before or after upgrading or downgrading. Reloading still must be done afterward.

To rebuild a table by dumping and reloading it, use `mysqldump` to create a dump file and `mysql` to reload the file:

```
shell> mysqldump db_name t1 > dump.sql
shell> mysql db_name < dump.sql
```

To rebuild all the tables in a single database, specify the database name without any following table name:

```
shell> mysqldump db_name > dump.sql
shell> mysql db_name < dump.sql
```

To rebuild all tables in all databases, use the `--all-databases` option:

```
shell> mysqldump --all-databases > dump.sql
shell> mysql < dump.sql
```

To rebuild a table with `ALTER TABLE`, use a “null” alteration; that is, an `ALTER TABLE` statement that “changes” the table to use the storage engine that it already has. For example, if `t1` is a `MyISAM` table, use this statement:

```
mysql> ALTER TABLE t1 ENGINE = MyISAM;
```

If you are not sure which storage engine to specify in the `ALTER TABLE` statement, use `SHOW CREATE TABLE` to display the table definition.

If you must rebuild a table because a table checking operation indicates that the table is corrupt or needs an upgrade, you can use `REPAIR TABLE` if that statement supports the table's storage engine. For example, to repair a `MyISAM` table, use this statement:

```
mysql> REPAIR TABLE t1;
```

For storage engines such as `InnoDB` that `REPAIR TABLE` does not support, use `mysqldump` to create a dump file and `mysql` to reload the file, as described earlier.

For specifics about which storage engines `REPAIR TABLE` supports, see Section 12.4.2.5, “`REPAIR TABLE` Syntax”.

`mysqlcheck --repair` provides command-line access to the `REPAIR TABLE` statement. This can be a more convenient means of repairing tables because you can use the `--databases` or `--all-databases` option to repair all tables in specific databases or all databases, respectively:

```
shell> mysqlcheck --repair --databases db_name ...
shell> mysqlcheck --repair --all-databases
```

2.11.5. Copying MySQL Databases to Another Machine

You can copy the `.frm`, `.MYI`, and `.MYD` files for `MyISAM` tables between different architectures that support the same floating-point format. (MySQL takes care of any byte-swapping issues.) See Section 13.5, “The `MyISAM` Storage Engine”.

In cases where you need to transfer databases between different architectures, you can use `mysqldump` to create a file containing SQL statements. You can then transfer the file to the other machine and feed it as input to the `mysql` client.

Use `mysqldump --help` to see what options are available.

The easiest (although not the fastest) way to move a database between two machines is to run the following commands on the machine on which the database is located:

```
shell> mysqladmin -h 'other_hostname' create db_name
shell> mysqldump db_name | mysql -h 'other_hostname' db_name
```

If you want to copy a database from a remote machine over a slow network, you can use these commands:

```
shell> mysqladmin create db_name
shell> mysqldump -h 'other_hostname' --compress db_name | mysql db_name
```

You can also store the dump in a file, transfer the file to the target machine, and then load the file into the database there. For example, you can dump a database to a compressed file on the source machine like this:

```
shell> mysqldump --quick db_name | gzip > db_name.gz
```

Transfer the file containing the database contents to the target machine and run these commands there:

```
shell> mysqladmin create db_name
shell> gunzip < db_name.gz | mysql db_name
```

You can also use `mysqldump` and `mysqlimport` to transfer the database. For large tables, this is much faster than simply using `mysqldump`. In the following commands, *`DUMPDIR`* represents the full path name of the directory you use to store the output from `mysqldump`.

First, create the directory for the output files and dump the database:

```
shell> mkdir DUMPDIR
shell> mysqldump --tab=DUMPDIR db_name
```

Then transfer the files in the *`DUMPDIR`* directory to some corresponding directory on the target machine and load the files into MySQL there:

```
shell> mysqladmin create db_name           # create database
shell> cat DUMPDIR/*.sql | mysql db_name   # create tables in database
shell> mysqlimport db_name DUMPDIR/*.txt   # load data into tables
```

Do not forget to copy the `mysql` database because that is where the grant tables are stored. You might have to run commands as the MySQL `root` user on the new machine until you have the `mysql` database in place.

After you import the `mysql` database on the new machine, execute `mysqladmin flush-privileges` so that the server reloads the grant table information.

2.12. Environment Variables

This section lists all the environment variables that are used directly or indirectly by MySQL. Most of these can also be found in other places in this manual.

Note that any options on the command line take precedence over values specified in option files and environment variables, and values in option files take precedence over values in environment variables.

In many cases, it is preferable to use an option file instead of environment variables to modify the behavior of MySQL. See Section 4.2.3.3, "Using Option Files".

Variable	Description
`CXX`	The name of your C++ compiler (for running `CMake`).
`CC`	The name of your C compiler (for running `CMake`).
`CFLAGS`	Flags for your C compiler (for running `CMake`).
`CXXFLAGS`	Flags for your C++ compiler (for running `CMake`).
`DBI_USER`	The default user name for Perl DBI.
`DBI_TRACE`	Trace options for Perl DBI.
`HOME`	The default path for the `mysql` history file is `$HOME/.mysql_history`.
`LD_RUN_PATH`	Used to specify the location of `libmysqlclient.so`.
`MYSQL_DEBUG`	Debug trace options when debugging.
`MYSQL_GROUP_SUFFIX`	Option group suffix value (like specifying `--defaults-group-suffix`).
`MYSQL_HISTFILE`	The path to the `mysql` history file. If this variable is set, its value overrides the default for `$HOME/.mysql_history`.
`MYSQL_HOME`	The path to the directory in which the server-specific `my.cnf` file resides (as of MySQL 5.0.3).
`MYSQL_HOST`	The default host name used by the `mysql` command-line client.
`MYSQL_PS1`	The command prompt to use in the `mysql` command-line client.
`MYSQL_PWD`	The default password when connecting to `mysqld`. Note that using this is insecure. See Section 5.3.2.2, "End-User Guidelines for Password Security".
`MYSQL_TCP_PORT`	The default TCP/IP port number.
`MYSQL_UNIX_PORT`	The default Unix socket file name; used for connections to `localhost`.
`PATH`	Used by the shell to find MySQL programs.
`TMPDIR`	The directory where temporary files are created.

Variable	Description
`TZ`	This should be set to your local time zone. See Section C.5.4.6, “Time Zone Problems”.
`UMASK`	The user-file creation mode when creating files. See note following table.
`UMASK_DIR`	The user-directory creation mode when creating directories. See note following table.
`USER`	The default user name on Windows when connecting to `mysqld`.

For information about the `mysql` history file, see Section 4.5.1.3, “`mysql` History File”.

The `UMASK` and `UMASK_DIR` variables, despite their names, are used as modes, not masks:

- If `UMASK` is set, `mysqld` uses `($UMASK | 0600)` as the mode for file creation, so that newly created files have a mode in the range from 0600 to 0666 (all values octal).
- If `UMASK_DIR` is set, `mysqld` uses `($UMASK_DIR | 0700)` as the base mode for directory creation, which then is AND-ed with `~(~$UMASK & 0666)`, so that newly created directories have a mode in the range from 0700 to 0777 (all values octal). The AND operation may remove read and write permissions from the directory mode, but not execute permissions.

MySQL assumes that the value for `UMASK` or `UMASK_DIR` is in octal if it starts with a zero.

2.13. Perl Installation Notes

The Perl `DBI` module provides a generic interface for database access. You can write a `DBI` script that works with many different database engines without change. To use `DBI`, you must install the `DBI` module, as well as a DataBase Driver (DBD) module for each type of databas server you want to access. For MySQL, this driver is the `DBD::mysql` module.

Perl, and the `DBD::MySQL` module for `DBI` must be installed if you want to run the MySQL benchmark scripts; see Section 7.12.2, “The MySQL Benchmark Suite”.

> **Note**
>
> Perl support is not included with MySQL distributions. You can obtain the necessary modules from http://search.cpan.org for Unix, or by using the ActiveState `ppm` program on Windows. The following sections describe how to do this.

The `DBI`/`DBD` interface requires Perl 5.6.0, and 5.6.1 or later is preferred. DBI *does not work* if you have an older version of Perl. You should use `DBD::mysql` 4.009 or higher. Although earlier versions are available, they do not support the full functionality of MySQL 5.5.

2.13.1. Installing Perl on Unix

MySQL Perl support requires that you have installed MySQL client programming support (libraries and header files). Most installation methods install the necessary files. If you install MySQL from RPM files on Linux, be sure to install the developer RPM as well. The client programs are in the client RPM, but client programming support is in the developer RPM.

The files you need for Perl support can be obtained from the CPAN (Comprehensive Perl Archive Network) at http://search.cpan.org.

The easiest way to install Perl modules on Unix is to use the `CPAN` module. For example:

```
shell> perl -MCPAN -e shell
cpan> install DBI
cpan> install DBD::mysql
```

The `DBD::mysql` installation runs a number of tests. These tests attempt to connect to the local MySQL server using the default user name and password. (The default user name is your login name on Unix, and `ODBC` on Windows. The default password is “no password.”) If you cannot connect to the server with those values (for example, if your account has a password), the tests fail. You can use `force install DBD::mysql` to ignore the failed tests.

`DBI` requires the `Data::Dumper` module. It may be installed; if not, you should install it before installing `DBI`.

It is also possible to download the module distributions in the form of compressed `tar` archives and build the modules manually. For example, to unpack and build a DBI distribution, use a procedure such as this:

1. Unpack the distribution into the current directory:

```
shell> gunzip < DBI-VERSION.tar.gz | tar xvf -
```

This command creates a directory named `DBI-VERSION`.

2. Change location into the top-level directory of the unpacked distribution:

   ```
   shell> cd DBI-VERSION
   ```

3. Build the distribution and compile everything:

   ```
   shell> perl Makefile.PL
   shell> make
   shell> make test
   shell> make install
   ```

The `make test` command is important because it verifies that the module is working. Note that when you run that command during the `DBD::mysql` installation to exercise the interface code, the MySQL server must be running or the test fails.

It is a good idea to rebuild and reinstall the `DBD::mysql` distribution whenever you install a new release of MySQL. This ensures that the latest versions of the MySQL client libraries are installed correctly.

If you do not have access rights to install Perl modules in the system directory or if you want to install local Perl modules, the following reference may be useful: http://servers.digitaldaze.com/extensions/perl/modules.html#modules

Look under the heading “Installing New Modules that Require Locally Installed Modules.”

2.13.2. Installing ActiveState Perl on Windows

On Windows, you should do the following to install the MySQL `DBD` module with ActiveState Perl:

1. Get ActiveState Perl from http://www.activestate.com/Products/ActivePerl/ and install it.

2. Open a console window.

3. If necessary, set the `HTTP_proxy` variable. For example, you might try a setting like this:

   ```
   C:\> set HTTP_proxy=my.proxy.com:3128
   ```

4. Start the PPM program:

   ```
   C:\> C:\perl\bin\ppm.pl
   ```

5. If you have not previously done so, install `DBI`:

   ```
   ppm> install DBI
   ```

6. If this succeeds, run the following command:

   ```
   ppm> install DBD-mysql
   ```

This procedure should work with ActiveState Perl 5.6 or newer.

If you cannot get the procedure to work, you should install the MyODBC driver instead and connect to the MySQL server through ODBC:

```
use DBI;
$dbh= DBI->connect("DBI:ODBC:$dsn",$user,$password) ||
  die "Got error $DBI::errstr when connecting to $dsn\n";
```

2.13.3. Problems Using the Perl `DBI`/`DBD` Interface

If Perl reports that it cannot find the `../mysql/mysql.so` module, the problem is probably that Perl cannot locate the `libmysqlclient.so` shared library. You should be able to fix this problem by one of the following methods:

- Copy `libmysqlclient.so` to the directory where your other shared libraries are located (probably `/usr/lib` or `/lib`).
- Modify the `-L` options used to compile `DBD::mysql` to reflect the actual location of `libmysqlclient.so`.
- On Linux, you can add the path name of the directory where `libmysqlclient.so` is located to the `/etc/ld.so.conf` file.
- Add the path name of the directory where `libmysqlclient.so` is located to the `LD_RUN_PATH` environment variable. Some systems use `LD_LIBRARY_PATH` instead.

Note that you may also need to modify the `-L` options if there are other libraries that the linker fails to find. For example, if the linker cannot find `libc` because it is in `/lib` and the link command specifies `-L/usr/lib`, change the `-L` option to `-L/lib` or add `-L/lib` to the existing link command.

If you get the following errors from `DBD::mysql`, you are probably using `gcc` (or using an old binary compiled with `gcc`):

```
/usr/bin/perl: can't resolve symbol '__moddi3'
/usr/bin/perl: can't resolve symbol '__divdi3'
```

Add `-L/usr/lib/gcc-lib/... -lgcc` to the link command when the `mysql.so` library gets built (check the output from `make` for `mysql.so` when you compile the Perl client). The `-L` option should specify the path name of the directory where `libgcc.a` is located on your system.

Another cause of this problem may be that Perl and MySQL are not both compiled with `gcc`. In this case, you can solve the mismatch by compiling both with `gcc`.

You may see the following error from `DBD::mysql` when you run the tests:

```
t/00base............install_driver(mysql) failed:
Can't load '../blib/arch/auto/DBD/mysql/mysql.so' for module DBD::mysql:
../blib/arch/auto/DBD/mysql/mysql.so: undefined symbol:
uncompress at /usr/lib/perl5/5.00503/i586-linux/DynaLoader.pm line 169.
```

This means that you need to include the `-lz` compression library on the link line. That can be done by changing the following line in the file `lib/DBD/mysql/Install.pm`:

```
$sysliblist .= " -lm";
```

Change that line to:

```
$sysliblist .= " -lm -lz";
```

After this, you *must* run `make realclean` and then proceed with the installation from the beginning.

Chapter 3. Tutorial

This chapter provides a tutorial introduction to MySQL by showing how to use the `mysql` client program to create and use a simple database. `mysql` (sometimes referred to as the “terminal monitor” or just “monitor”) is an interactive program that enables you to connect to a MySQL server, run queries, and view the results. `mysql` may also be used in batch mode: you place your queries in a file beforehand, then tell `mysql` to execute the contents of the file. Both ways of using `mysql` are covered here.

To see a list of options provided by `mysql`, invoke it with the `--help` option:

```
shell> mysql --help
```

This chapter assumes that `mysql` is installed on your machine and that a MySQL server is available to which you can connect. If this is not true, contact your MySQL administrator. (If *you* are the administrator, you need to consult the relevant portions of this manual, such as Chapter 5, *MySQL Server Administration*.)

This chapter describes the entire process of setting up and using a database. If you are interested only in accessing an existing database, you may want to skip over the sections that describe how to create the database and the tables it contains.

Because this chapter is tutorial in nature, many details are necessarily omitted. Consult the relevant sections of the manual for more information on the topics covered here.

3.1. Connecting to and Disconnecting from the Server

To connect to the server, you will usually need to provide a MySQL user name when you invoke `mysql` and, most likely, a password. If the server runs on a machine other than the one where you log in, you will also need to specify a host name. Contact your administrator to find out what connection parameters you should use to connect (that is, what host, user name, and password to use). Once you know the proper parameters, you should be able to connect like this:

```
shell> mysql -h host -u user -p
Enter password: ********
```

`host` and `user` represent the host name where your MySQL server is running and the user name of your MySQL account. Substitute appropriate values for your setup. The `********` represents your password; enter it when `mysql` displays the `Enter password:` prompt.

If that works, you should see some introductory information followed by a `mysql>` prompt:

```
shell> mysql -h host -u user -p
Enter password: ********
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 25338 to server version: 5.5.16-standard

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql>
```

The `mysql>` prompt tells you that `mysql` is ready for you to enter commands.

If you are logging in on the same machine that MySQL is running on, you can omit the host, and simply use the following:

```
shell> mysql -u user -p
```

If, when you attempt to log in, you get an error message such as `ERROR 2002 (HY000): Can't connect to local MySQL server through socket '/tmp/mysql.sock' (2)`, it means that the MySQL server daemon (Unix) or service (Windows) is not running. Consult the administrator or see the section of Chapter 2, *Installing and Upgrading MySQL* that is appropriate to your operating system.

For help with other problems often encountered when trying to log in, see Section C.5.2, “Common Errors When Using MySQL Programs”.

Some MySQL installations permit users to connect as the anonymous (unnamed) user to the server running on the local host. If this is the case on your machine, you should be able to connect to that server by invoking `mysql` without any options:

```
shell> mysql
```

After you have connected successfully, you can disconnect any time by typing `QUIT` (or `\q`) at the `mysql>` prompt:

```
mysql> QUIT
Bye
```

On Unix, you can also disconnect by pressing Control+D.

Most examples in the following sections assume that you are connected to the server. They indicate this by the `mysql>` prompt.

3.2. Entering Queries

Make sure that you are connected to the server, as discussed in the previous section. Doing so does not in itself select any database to work with, but that is okay. At this point, it is more important to find out a little about how to issue queries than to jump right in creating tables, loading data into them, and retrieving data from them. This section describes the basic principles of entering commands, using several queries you can try out to familiarize yourself with how `mysql` works.

Here is a simple command that asks the server to tell you its version number and the current date. Type it in as shown here following the `mysql>` prompt and press Enter:

```
mysql> SELECT VERSION(), CURRENT_DATE;
+--------------+--------------+
| VERSION()    | CURRENT_DATE |
+--------------+--------------+
| 5.5.0-m2-log | 2009-05-04   |
+--------------+--------------+
1 row in set (0.01 sec)
mysql>
```

This query illustrates several things about `mysql`:

- A command normally consists of an SQL statement followed by a semicolon. (There are some exceptions where a semicolon may be omitted. `QUIT`, mentioned earlier, is one of them. We'll get to others later.)
- When you issue a command, `mysql` sends it to the server for execution and displays the results, then prints another `mysql>` prompt to indicate that it is ready for another command.
- `mysql` displays query output in tabular form (rows and columns). The first row contains labels for the columns. The rows following are the query results. Normally, column labels are the names of the columns you fetch from database tables. If you're retrieving the value of an expression rather than a table column (as in the example just shown), `mysql` labels the column using the expression itself.
- `mysql` shows how many rows were returned and how long the query took to execute, which gives you a rough idea of server performance. These values are imprecise because they represent wall clock time (not CPU or machine time), and because they are affected by factors such as server load and network latency. (For brevity, the “rows in set” line is sometimes not shown in the remaining examples in this chapter.)

Keywords may be entered in any lettercase. The following queries are equivalent:

```
mysql> SELECT VERSION(), CURRENT_DATE;
mysql> select version(), current_date;
mysql> SeLeCt vErSiOn(), current_DATE;
```

Here is another query. It demonstrates that you can use `mysql` as a simple calculator:

```
mysql> SELECT SIN(PI()/4), (4+1)*5;
+------------------+---------+
| SIN(PI()/4)      | (4+1)*5 |
+------------------+---------+
| 0.70710678118655 |      25 |
+------------------+---------+
1 row in set (0.02 sec)
```

The queries shown thus far have been relatively short, single-line statements. You can even enter multiple statements on a single line. Just end each one with a semicolon:

```
mysql> SELECT VERSION(); SELECT NOW();
+--------------+
| VERSION()    |
+--------------+
| 5.5.0-m2-log |
+--------------+
1 row in set (0.00 sec)

+---------------------+
| NOW()               |
+---------------------+
| 2009-05-04 15:15:00 |
+---------------------+
1 row in set (0.00 sec)
```

A command need not be given all on a single line, so lengthy commands that require several lines are not a problem. `mysql` determines where your statement ends by looking for the terminating semicolon, not by looking for the end of the input line. (In other words, `mysql` accepts free-format input: it collects input lines but does not execute them until it sees the semicolon.)

Here is a simple multiple-line statement:

```
mysql> SELECT
    -> USER()
    -> ,
    -> CURRENT_DATE;
+---------------+--------------+
| USER()        | CURRENT_DATE |
+---------------+--------------+
| jon@localhost | 2005-10-11   |
+---------------+--------------+
```

In this example, notice how the prompt changes from `mysql>` to `->` after you enter the first line of a multiple-line query. This is how `mysql` indicates that it has not yet seen a complete statement and is waiting for the rest. The prompt is your friend, because it provides valuable feedback. If you use that feedback, you can always be aware of what `mysql` is waiting for.

If you decide you do not want to execute a command that you are in the process of entering, cancel it by typing `\c`:

```
mysql> SELECT
    -> USER()
    -> \c
mysql>
```

Here, too, notice the prompt. It switches back to `mysql>` after you type `\c`, providing feedback to indicate that `mysql` is ready for a new command.

The following table shows each of the prompts you may see and summarizes what they mean about the state that `mysql` is in.

Prompt	Meaning
`mysql>`	Ready for new command.
`->`	Waiting for next line of multiple-line command.
`'>`	Waiting for next line, waiting for completion of a string that began with a single quote ("`'`").
`">`	Waiting for next line, waiting for completion of a string that began with a double quote ("`"`").
`` `> ``	Waiting for next line, waiting for completion of an identifier that began with a backtick ("`` ` ``").
`/*>`	Waiting for next line, waiting for completion of a comment that began with `/*`.

Multiple-line statements commonly occur by accident when you intend to issue a command on a single line, but forget the terminating semicolon. In this case, `mysql` waits for more input:

```
mysql> SELECT USER()
    ->
```

If this happens to you (you think you've entered a statement but the only response is a `->` prompt), most likely `mysql` is waiting for the semicolon. If you don't notice what the prompt is telling you, you might sit there for a while before realizing what you need to do. Enter a semicolon to complete the statement, and `mysql` executes it:

```
mysql> SELECT USER()
    -> ;
+---------------+
| USER()        |
+---------------+
| jon@localhost |
+---------------+
```

The `'>` and `">` prompts occur during string collection (another way of saying that MySQL is waiting for completion of a string). In MySQL, you can write strings surrounded by either "`'`" or "`"`" characters (for example, `'hello'` or `"goodbye"`), and `mysql` lets you enter strings that span multiple lines. When you see a `'>` or `">` prompt, it means that you have entered a line containing a string that begins with a "`'`" or "`"`" quote character, but have not yet entered the matching quote that terminates the string. This often indicates that you have inadvertently left out a quote character. For example:

```
mysql> SELECT * FROM my_table WHERE name = 'Smith AND age < 30;
    '>
```

If you enter this `SELECT` statement, then press **Enter** and wait for the result, nothing happens. Instead of wondering why this query takes so long, notice the clue provided by the `'>` prompt. It tells you that `mysql` expects to see the rest of an unterminated string. (Do you see the error in the statement? The string `'Smith` is missing the second single quotation mark.)

At this point, what do you do? The simplest thing is to cancel the command. However, you cannot just type `\c` in this case, because `mysql` interprets it as part of the string that it is collecting. Instead, enter the closing quote character (so `mysql` knows you've finished the string), then type `\c`:

```
mysql> SELECT * FROM my_table WHERE name = 'Smith AND age < 30;
    '> '\c
mysql>
```

The prompt changes back to `mysql>`, indicating that `mysql` is ready for a new command.

The `` `> `` prompt is similar to the `'>` and `">` prompts, but indicates that you have begun but not completed a backtick-quoted identifier.

It is important to know what the `'>`, `">`, and `` `> `` prompts signify, because if you mistakenly enter an unterminated string, any further lines you type appear to be ignored by `mysql`—including a line containing `QUIT`. This can be quite confusing, especially if you do not know that you need to supply the terminating quote before you can cancel the current command.

3.3. Creating and Using a Database

Once you know how to enter commands, you are ready to access a database.

Suppose that you have several pets in your home (your menagerie) and you would like to keep track of various types of information about them. You can do so by creating tables to hold your data and loading them with the desired information. Then you can answer different sorts of questions about your animals by retrieving data from the tables. This section shows you how to perform the following operations:

- Create a database
- Create a table
- Load data into the table
- Retrieve data from the table in various ways
- Use multiple tables

The menagerie database is simple (deliberately), but it is not difficult to think of real-world situations in which a similar type of database might be used. For example, a database like this could be used by a farmer to keep track of livestock, or by a veterinarian to keep track of patient records. A menagerie distribution containing some of the queries and sample data used in the following sections can be obtained from the MySQL Web site. It is available in both compressed `tar` file and Zip formats at http://dev.mysql.com/doc/.

Use the `SHOW` statement to find out what databases currently exist on the server:

```
mysql> SHOW DATABASES;
+----------+
| Database |
+----------+
| mysql    |
| test     |
| tmp      |
+----------+
```

The `mysql` database describes user access privileges. The `test` database often is available as a workspace for users to try things out.

The list of databases displayed by the statement may be different on your machine; `SHOW DATABASES` does not show databases that you have no privileges for if you do not have the `SHOW DATABASES` privilege. See Section 12.4.5.15, “`SHOW DATABASES` Syntax”.

If the `test` database exists, try to access it:

```
mysql> USE test
Database changed
```

`USE`, like `QUIT`, does not require a semicolon. (You can terminate such statements with a semicolon if you like; it does no harm.) The `USE` statement is special in another way, too: it must be given on a single line.

You can use the `test` database (if you have access to it) for the examples that follow, but anything you create in that database can be removed by anyone else with access to it. For this reason, you should probably ask your MySQL administrator for permission to use a database of your own. Suppose that you want to call yours `menagerie`. The administrator needs to execute a command like this:

```
mysql> GRANT ALL ON menagerie.* TO 'your_mysql_name'@'your_client_host';
```

where `your_mysql_name` is the MySQL user name assigned to you and `your_client_host` is the host from which you connect to the server.

3.3.1. Creating and Selecting a Database

If the administrator creates your database for you when setting up your permissions, you can begin using it. Otherwise, you need to create it yourself:

```
mysql> CREATE DATABASE menagerie;
```

Under Unix, database names are case sensitive (unlike SQL keywords), so you must always refer to your database as `menagerie`, not as `Menagerie`, `MENAGERIE`, or some other variant. This is also true for table names. (Under Windows, this restriction does not apply, although you must refer to databases and tables using the same lettercase throughout a given query. However, for a variety of reasons, the recommended best practice is always to use the same lettercase that was used when the database was created.)

> ### Note
>
> If you get an error such as `ERROR 1044 (42000): ACCESS DENIED FOR USER 'MONTY'@'LOCALHOST' TO DATABASE 'MENAGERIE'` when attempting to create a database, this means that your user account does not have the necessary privileges to do so. Discuss this with the administrator or see Section 5.4, "The MySQL Access Privilege System".

Creating a database does not select it for use; you must do that explicitly. To make `menagerie` the current database, use this command:

```
mysql> USE menagerie
Database changed
```

Your database needs to be created only once, but you must select it for use each time you begin a `mysql` session. You can do this by issuing a `USE` statement as shown in the example. Alternatively, you can select the database on the command line when you invoke `mysql`. Just specify its name after any connection parameters that you might need to provide. For example:

```
shell> mysql -h host -u user -p menagerie
Enter password: ********
```

> ### Important
>
> `menagerie` in the command just shown is **not** your password. If you want to supply your password on the command line after the `-p` option, you must do so with no intervening space (for example, as `-pmypassword`, not as `-p mypassword`). However, putting your password on the command line is not recommended, because doing so exposes it to snooping by other users logged in on your machine.

> ### Note
>
> You can see at any time which database is currently selected using `SELECT DATABASE()`.

3.3.2. Creating a Table

Creating the database is the easy part, but at this point it is empty, as `SHOW TABLES` tells you:

```
mysql> SHOW TABLES;
Empty set (0.00 sec)
```

The harder part is deciding what the structure of your database should be: what tables you need and what columns should be in each of them.

You want a table that contains a record for each of your pets. This can be called the `pet` table, and it should contain, as a bare minimum, each animal's name. Because the name by itself is not very interesting, the table should contain other information. For example, if more than one person in your family keeps pets, you might want to list each animal's owner. You might also want to record some basic descriptive information such as species and sex.

How about age? That might be of interest, but it is not a good thing to store in a database. Age changes as time passes, which means you'd have to update your records often. Instead, it is better to store a fixed value such as date of birth. Then, whenever you need age, you can calculate it as the difference between the current date and the birth date. MySQL provides functions for doing date arithmetic, so this is not difficult. Storing birth date rather than age has other advantages, too:

- You can use the database for tasks such as generating reminders for upcoming pet birthdays. (If you think this type of query is somewhat silly, note that it is the same question you might ask in the context of a business database to identify clients to whom you need to send out birthday greetings in the current week or month, for that computer-assisted personal touch.)
- You can calculate age in relation to dates other than the current date. For example, if you store death date in the database, you can easily calculate how old a pet was when it died.

You can probably think of other types of information that would be useful in the `pet` table, but the ones identified so far are sufficient: name, owner, species, sex, birth, and death.

Use a `CREATE TABLE` statement to specify the layout of your table:

```
mysql> CREATE TABLE pet (name VARCHAR(20), owner VARCHAR(20),
    -> species VARCHAR(20), sex CHAR(1), birth DATE, death DATE);
```

`VARCHAR` is a good choice for the `name`, `owner`, and `species` columns because the column values vary in length. The lengths in those column definitions need not all be the same, and need not be `20`. You can normally pick any length from `1` to `65535`, whatever seems most reasonable to you. If you make a poor choice and it turns out later that you need a longer field, MySQL provides an `ALTER TABLE` statement.

Several types of values can be chosen to represent sex in animal records, such as `'m'` and `'f'`, or perhaps `'male'` and `'female'`. It is simplest to use the single characters `'m'` and `'f'`.

The use of the `DATE` data type for the `birth` and `death` columns is a fairly obvious choice.

Once you have created a table, `SHOW TABLES` should produce some output:

```
mysql> SHOW TABLES;
+---------------------+
| Tables in menagerie |
+---------------------+
| pet                 |
+---------------------+
```

To verify that your table was created the way you expected, use a `DESCRIBE` statement:

```
mysql> DESCRIBE pet;
+---------+-------------+------+-----+---------+-------+
| Field   | Type        | Null | Key | Default | Extra |
+---------+-------------+------+-----+---------+-------+
| name    | varchar(20) | YES  |     | NULL    |       |
| owner   | varchar(20) | YES  |     | NULL    |       |
| species | varchar(20) | YES  |     | NULL    |       |
| sex     | char(1)     | YES  |     | NULL    |       |
| birth   | date        | YES  |     | NULL    |       |
| death   | date        | YES  |     | NULL    |       |
+---------+-------------+------+-----+---------+-------+
```

You can use `DESCRIBE` any time, for example, if you forget the names of the columns in your table or what types they have.

For more information about MySQL data types, see Chapter 10, *Data Types*.

3.3.3. Loading Data into a Table

After creating your table, you need to populate it. The `LOAD DATA` and `INSERT` statements are useful for this.

Suppose that your pet records can be described as shown here. (Observe that MySQL expects dates in `'YYYY-MM-DD'` format; this may be different from what you are used to.)

name	**owner**	**species**	**sex**	**birth**	**death**
Fluffy	Harold	cat	f	1993-02-04	
Claws	Gwen	cat	m	1994-03-17	
Buffy	Harold	dog	f	1989-05-13	
Fang	Benny	dog	m	1990-08-27	
Bowser	Diane	dog	m	1979-08-31	1995-07-29
Chirpy	Gwen	bird	f	1998-09-11	

name	**owner**	**species**	**sex**	**birth**	**death**
Whistler	Gwen	bird		1997-12-09	
Slim	Benny	snake	m	1996-04-29	

Because you are beginning with an empty table, an easy way to populate it is to create a text file containing a row for each of your animals, then load the contents of the file into the table with a single statement.

You could create a text file `pet.txt` containing one record per line, with values separated by tabs, and given in the order in which the columns were listed in the `CREATE TABLE` statement. For missing values (such as unknown sexes or death dates for animals that are still living), you can use `NULL` values. To represent these in your text file, use `\N` (backslash, capital-N). For example, the record for Whistler the bird would look like this (where the whitespace between values is a single tab character):

```
Whistler        Gwen    bird    \N      1997-12-09      \N
```

To load the text file `pet.txt` into the `pet` table, use this statement:

```
mysql> LOAD DATA LOCAL INFILE '/path/pet.txt' INTO TABLE pet;
```

If you created the file on Windows with an editor that uses `\r\n` as a line terminator, you should use this statement instead:

```
mysql> LOAD DATA LOCAL INFILE '/path/pet.txt' INTO TABLE pet
    -> LINES TERMINATED BY '\r\n';
```

(On an Apple machine running OS X, you would likely want to use `LINES TERMINATED BY '\r'`.)

You can specify the column value separator and end of line marker explicitly in the `LOAD DATA` statement if you wish, but the defaults are tab and linefeed. These are sufficient for the statement to read the file `pet.txt` properly.

If the statement fails, it is likely that your MySQL installation does not have local file capability enabled by default. See Section 5.3.5, “Security Issues with `LOAD DATA LOCAL`”, for information on how to change this.

When you want to add new records one at a time, the `INSERT` statement is useful. In its simplest form, you supply values for each column, in the order in which the columns were listed in the `CREATE TABLE` statement. Suppose that Diane gets a new hamster named “Puffball.” You could add a new record using an `INSERT` statement like this:

```
mysql> INSERT INTO pet
    -> VALUES ('Puffball','Diane','hamster','f','1999-03-30',NULL);
```

String and date values are specified as quoted strings here. Also, with `INSERT`, you can insert `NULL` directly to represent a missing value. You do not use `\N` like you do with `LOAD DATA`.

From this example, you should be able to see that there would be a lot more typing involved to load your records initially using several `INSERT` statements rather than a single `LOAD DATA` statement.

3.3.4. Retrieving Information from a Table

The `SELECT` statement is used to pull information from a table. The general form of the statement is:

```
SELECT what_to_select
FROM which_table
WHERE conditions_to_satisfy;
```

`what_to_select` indicates what you want to see. This can be a list of columns, or `*` to indicate “all columns.” *`which_table`* indicates the table from which you want to retrieve data. The `WHERE` clause is optional. If it is present, *`conditions_to_satisfy`* specifies one or more conditions that rows must satisfy to qualify for retrieval.

3.3.4.1. Selecting All Data

The simplest form of `SELECT` retrieves everything from a table:

```
mysql> SELECT * FROM pet;
+----------+--------+---------+------+------------+------------+
| name     | owner  | species | sex  | birth      | death      |
+----------+--------+---------+------+------------+------------+
| Fluffy   | Harold | cat     | f    | 1993-02-04 | NULL       |
| Claws    | Gwen   | cat     | m    | 1994-03-17 | NULL       |
| Buffy    | Harold | dog     | f    | 1989-05-13 | NULL       |
| Fang     | Benny  | dog     | m    | 1990-08-27 | NULL       |
| Bowser   | Diane  | dog     | m    | 1979-08-31 | 1995-07-29 |
| Chirpy   | Gwen   | bird    | f    | 1998-09-11 | NULL       |
| Whistler | Gwen   | bird    | NULL | 1997-12-09 | NULL       |
| Slim     | Benny  | snake   | m    | 1996-04-29 | NULL       |
| Puffball | Diane  | hamster | f    | 1999-03-30 | NULL       |
+----------+--------+---------+------+------------+------------+
```

This form of `SELECT` is useful if you want to review your entire table, for example, after you've just loaded it with your initial data set. For example, you may happen to think that the birth date for Bowser doesn't seem quite right. Consulting your original pedigree papers, you find that the correct birth year should be 1989, not 1979.

There are at least two ways to fix this:

- Edit the file `pet.txt` to correct the error, then empty the table and reload it using `DELETE` and `LOAD DATA`:

  ```
  mysql> DELETE FROM pet;
  mysql> LOAD DATA LOCAL INFILE 'pet.txt' INTO TABLE pet;
  ```

  However, if you do this, you must also re-enter the record for Puffball.

- Fix only the erroneous record with an `UPDATE` statement:

  ```
  mysql> UPDATE pet SET birth = '1989-08-31' WHERE name = 'Bowser';
  ```

  The `UPDATE` changes only the record in question and does not require you to reload the table.

3.3.4.2. Selecting Particular Rows

As shown in the preceding section, it is easy to retrieve an entire table. Just omit the `WHERE` clause from the `SELECT` statement. But typically you don't want to see the entire table, particularly when it becomes large. Instead, you're usually more interested in answering a particular question, in which case you specify some constraints on the information you want. Let's look at some selection queries in terms of questions about your pets that they answer.

You can select only particular rows from your table. For example, if you want to verify the change that you made to Bowser's birth date, select Bowser's record like this:

```
mysql> SELECT * FROM pet WHERE name = 'Bowser';
+--------+-------+---------+------+------------+------------+
| name   | owner | species | sex  | birth      | death      |
+--------+-------+---------+------+------------+------------+
| Bowser | Diane | dog     | m    | 1989-08-31 | 1995-07-29 |
+--------+-------+---------+------+------------+------------+
```

The output confirms that the year is correctly recorded as 1989, not 1979.

String comparisons normally are case-insensitive, so you can specify the name as `'bowser'`, `'BOWSER'`, and so forth. The query result is the same.

You can specify conditions on any column, not just `name`. For example, if you want to know which animals were born during or after 1998, test the `birth` column:

```
mysql> SELECT * FROM pet WHERE birth >= '1998-1-1';
+----------+-------+---------+------+------------+-------+
| name     | owner | species | sex  | birth      | death |
+----------+-------+---------+------+------------+-------+
| Chirpy   | Gwen  | bird    | f    | 1998-09-11 | NULL  |
| Puffball | Diane | hamster | f    | 1999-03-30 | NULL  |
+----------+-------+---------+------+------------+-------+
```

You can combine conditions, for example, to locate female dogs:

```
mysql> SELECT * FROM pet WHERE species = 'dog' AND sex = 'f';
+-------+--------+---------+------+------------+-------+
| name  | owner  | species | sex  | birth      | death |
+-------+--------+---------+------+------------+-------+
| Buffy | Harold | dog     | f    | 1989-05-13 | NULL  |
+-------+--------+---------+------+------------+-------+
```

The preceding query uses the `AND` logical operator. There is also an `OR` operator:

```
mysql> SELECT * FROM pet WHERE species = 'snake' OR species = 'bird';
+----------+-------+---------+------+------------+-------+
| name     | owner | species | sex  | birth      | death |
+----------+-------+---------+------+------------+-------+
| Chirpy   | Gwen  | bird    | f    | 1998-09-11 | NULL  |
```

```
| Whistler | Gwen   | bird    | NULL | 1997-12-09 | NULL  |
| Slim     | Benny  | snake   | m    | 1996-04-29 | NULL  |
+----------+-------+---------+------+------------+-------+
```

`AND` and `OR` may be intermixed, although `AND` has higher precedence than `OR`. If you use both operators, it is a good idea to use parentheses to indicate explicitly how conditions should be grouped:

```
mysql> SELECT * FROM pet WHERE (species = 'cat' AND sex = 'm')
    -> OR (species = 'dog' AND sex = 'f');
+-------+--------+---------+------+------------+-------+
| name  | owner  | species | sex  | birth      | death |
+-------+--------+---------+------+------------+-------+
| Claws | Gwen   | cat     | m    | 1994-03-17 | NULL  |
| Buffy | Harold | dog     | f    | 1989-05-13 | NULL  |
+-------+--------+---------+------+------------+-------+
```

3.3.4.3. Selecting Particular Columns

If you do not want to see entire rows from your table, just name the columns in which you are interested, separated by commas. For example, if you want to know when your animals were born, select the `name` and `birth` columns:

```
mysql> SELECT name, birth FROM pet;
+----------+------------+
| name     | birth      |
+----------+------------+
| Fluffy   | 1993-02-04 |
| Claws    | 1994-03-17 |
| Buffy    | 1989-05-13 |
| Fang     | 1990-08-27 |
| Bowser   | 1989-08-31 |
| Chirpy   | 1998-09-11 |
| Whistler | 1997-12-09 |
| Slim     | 1996-04-29 |
| Puffball | 1999-03-30 |
+----------+------------+
```

To find out who owns pets, use this query:

```
mysql> SELECT owner FROM pet;
+--------+
| owner  |
+--------+
| Harold |
| Gwen   |
| Harold |
| Benny  |
| Diane  |
| Gwen   |
| Gwen   |
| Benny  |
| Diane  |
+--------+
```

Notice that the query simply retrieves the `owner` column from each record, and some of them appear more than once. To minimize the output, retrieve each unique output record just once by adding the keyword `DISTINCT`:

```
mysql> SELECT DISTINCT owner FROM pet;
+--------+
| owner  |
+--------+
| Benny  |
| Diane  |
| Gwen   |
| Harold |
+--------+
```

You can use a `WHERE` clause to combine row selection with column selection. For example, to get birth dates for dogs and cats only, use this query:

```
mysql> SELECT name, species, birth FROM pet
    -> WHERE species = 'dog' OR species = 'cat';
+--------+---------+------------+
| name   | species | birth      |
+--------+---------+------------+
| Fluffy | cat     | 1993-02-04 |
| Claws  | cat     | 1994-03-17 |
| Buffy  | dog     | 1989-05-13 |
| Fang   | dog     | 1990-08-27 |
| Bowser | dog     | 1989-08-31 |
+--------+---------+------------+
```

3.3.4.4. Sorting Rows

You may have noticed in the preceding examples that the result rows are displayed in no particular order. It is often easier to examine query output when the rows are sorted in some meaningful way. To sort a result, use an `ORDER BY` clause.

Here are animal birthdays, sorted by date:

```
mysql> SELECT name, birth FROM pet ORDER BY birth;
+----------+------------+
| name     | birth      |
+----------+------------+
| Buffy    | 1989-05-13 |
| Bowser   | 1989-08-31 |
| Fang     | 1990-08-27 |
| Fluffy   | 1993-02-04 |
| Claws    | 1994-03-17 |
| Slim     | 1996-04-29 |
| Whistler | 1997-12-09 |
| Chirpy   | 1998-09-11 |
| Puffball | 1999-03-30 |
+----------+------------+
```

On character type columns, sorting—like all other comparison operations—is normally performed in a case-insensitive fashion. This means that the order is undefined for columns that are identical except for their case. You can force a case-sensitive sort for a column by using `BINARY` like so: `ORDER BY BINARY col_name`.

The default sort order is ascending, with smallest values first. To sort in reverse (descending) order, add the `DESC` keyword to the name of the column you are sorting by:

```
mysql> SELECT name, birth FROM pet ORDER BY birth DESC;
+----------+------------+
| name     | birth      |
+----------+------------+
| Puffball | 1999-03-30 |
| Chirpy   | 1998-09-11 |
| Whistler | 1997-12-09 |
| Slim     | 1996-04-29 |
| Claws    | 1994-03-17 |
| Fluffy   | 1993-02-04 |
| Fang     | 1990-08-27 |
| Bowser   | 1989-08-31 |
| Buffy    | 1989-05-13 |
+----------+------------+
```

You can sort on multiple columns, and you can sort different columns in different directions. For example, to sort by type of animal in ascending order, then by birth date within animal type in descending order (youngest animals first), use the following query:

```
mysql> SELECT name, species, birth FROM pet
    -> ORDER BY species, birth DESC;
+----------+---------+------------+
| name     | species | birth      |
+----------+---------+------------+
| Chirpy   | bird    | 1998-09-11 |
| Whistler | bird    | 1997-12-09 |
| Claws    | cat     | 1994-03-17 |
| Fluffy   | cat     | 1993-02-04 |
| Fang     | dog     | 1990-08-27 |
| Bowser   | dog     | 1989-08-31 |
| Buffy    | dog     | 1989-05-13 |
| Puffball | hamster | 1999-03-30 |
| Slim     | snake   | 1996-04-29 |
+----------+---------+------------+
```

The `DESC` keyword applies only to the column name immediately preceding it (`birth`); it does not affect the `species` column sort order.

3.3.4.5. Date Calculations

MySQL provides several functions that you can use to perform calculations on dates, for example, to calculate ages or extract parts of dates.

To determine how many years old each of your pets is, compute the difference in the year part of the current date and the birth date, then subtract one if the current date occurs earlier in the calendar year than the birth date. The following query shows, for each pet, the birth date, the current date, and the age in years.

```
mysql> SELECT name, birth, CURDATE(),
    -> (YEAR(CURDATE())-YEAR(birth))
    -> - (RIGHT(CURDATE(),5)<RIGHT(birth,5))
    -> AS age
    -> FROM pet;
+----------+------------+------------+------+
| name     | birth      | CURDATE()  | age  |
+----------+------------+------------+------+
| Fluffy   | 1993-02-04 | 2003-08-19 |   10 |
| Claws    | 1994-03-17 | 2003-08-19 |    9 |
| Buffy    | 1989-05-13 | 2003-08-19 |   14 |
| Fang     | 1990-08-27 | 2003-08-19 |   12 |
| Bowser   | 1989-08-31 | 2003-08-19 |   13 |
| Chirpy   | 1998-09-11 | 2003-08-19 |    4 |
| Whistler | 1997-12-09 | 2003-08-19 |    5 |
| Slim     | 1996-04-29 | 2003-08-19 |    7 |
| Puffball | 1999-03-30 | 2003-08-19 |    4 |
+----------+------------+------------+------+
```

Here, `YEAR()` pulls out the year part of a date and `RIGHT()` pulls off the rightmost five characters that represent the `MM-DD` (calendar year) part of the date. The part of the expression that compares the `MM-DD` values evaluates to 1 or 0, which adjusts the year difference down a year if `CURDATE()` occurs earlier in the year than `birth`. The full expression is somewhat ungainly, so an *alias* (`age`) is used to make the output column label more meaningful.

The query works, but the result could be scanned more easily if the rows were presented in some order. This can be done by adding an `ORDER BY name` clause to sort the output by name:

```
mysql> SELECT name, birth, CURDATE(),
    -> (YEAR(CURDATE())-YEAR(birth))
    -> - (RIGHT(CURDATE(),5)<RIGHT(birth,5))
    -> AS age
    -> FROM pet ORDER BY name;
+----------+------------+------------+------+
| name     | birth      | CURDATE()  | age  |
+----------+------------+------------+------+
| Bowser   | 1989-08-31 | 2003-08-19 |   13 |
| Buffy    | 1989-05-13 | 2003-08-19 |   14 |
| Chirpy   | 1998-09-11 | 2003-08-19 |    4 |
| Claws    | 1994-03-17 | 2003-08-19 |    9 |
| Fang     | 1990-08-27 | 2003-08-19 |   12 |
| Fluffy   | 1993-02-04 | 2003-08-19 |   10 |
| Puffball | 1999-03-30 | 2003-08-19 |    4 |
| Slim     | 1996-04-29 | 2003-08-19 |    7 |
| Whistler | 1997-12-09 | 2003-08-19 |    5 |
+----------+------------+------------+------+
```

To sort the output by `age` rather than `name`, just use a different `ORDER BY` clause:

```
mysql> SELECT name, birth, CURDATE(),
    -> (YEAR(CURDATE())-YEAR(birth))
    -> - (RIGHT(CURDATE(),5)<RIGHT(birth,5))
    -> AS age
    -> FROM pet ORDER BY age;
+----------+------------+------------+------+
| name     | birth      | CURDATE()  | age  |
+----------+------------+------------+------+
| Chirpy   | 1998-09-11 | 2003-08-19 |    4 |
| Puffball | 1999-03-30 | 2003-08-19 |    4 |
| Whistler | 1997-12-09 | 2003-08-19 |    5 |
| Slim     | 1996-04-29 | 2003-08-19 |    7 |
| Claws    | 1994-03-17 | 2003-08-19 |    9 |
| Fluffy   | 1993-02-04 | 2003-08-19 |   10 |
| Fang     | 1990-08-27 | 2003-08-19 |   12 |
| Bowser   | 1989-08-31 | 2003-08-19 |   13 |
| Buffy    | 1989-05-13 | 2003-08-19 |   14 |
+----------+------------+------------+------+
```

A similar query can be used to determine age at death for animals that have died. You determine which animals these are by checking whether the `death` value is `NULL`. Then, for those with non-`NULL` values, compute the difference between the `death` and `birth` values:

```
mysql> SELECT name, birth, death,
    -> (YEAR(death)-YEAR(birth)) - (RIGHT(death,5)<RIGHT(birth,5))
    -> AS age
    -> FROM pet WHERE death IS NOT NULL ORDER BY age;
+--------+------------+------------+------+
| name   | birth      | death      | age  |
+--------+------------+------------+------+
| Bowser | 1989-08-31 | 1995-07-29 |    5 |
+--------+------------+------------+------+
```

The query uses `death IS NOT NULL` rather than `death <> NULL` because `NULL` is a special value that cannot be compared using the usual comparison operators. This is discussed later. See Section 3.3.4.6, "Working with `NULL` Values".

What if you want to know which animals have birthdays next month? For this type of calculation, year and day are irrelevant; you simply want to extract the month part of the `birth` column. MySQL provides several functions for extracting parts of dates, such as `YEAR()`, `MONTH()`, and `DAYOFMONTH()`. `MONTH()` is the appropriate function here. To see how it works, run a simple query that displays the value of both `birth` and `MONTH(birth)`:

```
mysql> SELECT name, birth, MONTH(birth) FROM pet;
+----------+------------+--------------+
| name     | birth      | MONTH(birth) |
+----------+------------+--------------+
| Fluffy   | 1993-02-04 |            2 |
| Claws    | 1994-03-17 |            3 |
| Buffy    | 1989-05-13 |            5 |
| Fang     | 1990-08-27 |            8 |
| Bowser   | 1989-08-31 |            8 |
| Chirpy   | 1998-09-11 |            9 |
| Whistler | 1997-12-09 |           12 |
| Slim     | 1996-04-29 |            4 |
| Puffball | 1999-03-30 |            3 |
+----------+------------+--------------+
```

Finding animals with birthdays in the upcoming month is also simple. Suppose that the current month is April. Then the month value is `4` and you can look for animals born in May (month `5`) like this:

```
mysql> SELECT name, birth FROM pet WHERE MONTH(birth) = 5;
+-------+------------+
| name  | birth      |
+-------+------------+
| Buffy | 1989-05-13 |
+-------+------------+
```

There is a small complication if the current month is December. You cannot merely add one to the month number (`12`) and look for animals born in month `13`, because there is no such month. Instead, you look for animals born in January (month `1`).

You can write the query so that it works no matter what the current month is, so that you do not have to use the number for a particular month. `DATE_ADD()` enables you to add a time interval to a given date. If you add a month to the value of `CURDATE()`, then extract the month part with `MONTH()`, the result produces the month in which to look for birthdays:

```
mysql> SELECT name, birth FROM pet
    -> WHERE MONTH(birth) = MONTH(DATE_ADD(CURDATE(),INTERVAL 1 MONTH));
```

A different way to accomplish the same task is to add `1` to get the next month after the current one after using the modulo function (`MOD`) to wrap the month value to `0` if it is currently `12`:

```
mysql> SELECT name, birth FROM pet
    -> WHERE MONTH(birth) = MOD(MONTH(CURDATE()), 12) + 1;
```

`MONTH()` returns a number between `1` and `12`. And `MOD(something,12)` returns a number between `0` and `11`. So the addition has to be after the `MOD()`, otherwise we would go from November (`11`) to January (`1`).

3.3.4.6. Working with `NULL` Values

The `NULL` value can be surprising until you get used to it. Conceptually, `NULL` means “a missing unknown value” and it is treated somewhat differently from other values. To test for `NULL`, you cannot use the arithmetic comparison operators such as `=`, `<`, or `<>`. To demonstrate this for yourself, try the following query:

```
mysql> SELECT 1 = NULL, 1 <> NULL, 1 < NULL, 1 > NULL;
+----------+-----------+----------+----------+
| 1 = NULL | 1 <> NULL | 1 < NULL | 1 > NULL |
+----------+-----------+----------+----------+
|     NULL |      NULL |     NULL |     NULL |
+----------+-----------+----------+----------+
```

Clearly you get no meaningful results from these comparisons. Use the `IS NULL` and `IS NOT NULL` operators instead:

```
mysql> SELECT 1 IS NULL, 1 IS NOT NULL;
+-----------+---------------+
| 1 IS NULL | 1 IS NOT NULL |
+-----------+---------------+
|         0 |             1 |
+-----------+---------------+
```

In MySQL, `0` or `NULL` means false and anything else means true. The default truth value from a boolean operation is `1`.

This special treatment of `NULL` is why, in the previous section, it was necessary to determine which animals are no longer alive using `death IS NOT NULL` instead of `death <> NULL`.

Two `NULL` values are regarded as equal in a `GROUP BY`.

When doing an `ORDER BY`, `NULL` values are presented first if you do `ORDER BY ... ASC` and last if you do `ORDER BY ... DESC`.

A common error when working with `NULL` is to assume that it is not possible to insert a zero or an empty string into a column defined as `NOT NULL`, but this is not the case. These are in fact values, whereas `NULL` means “not having a value.” You can test this easily enough by using `IS [NOT] NULL` as shown:

```
mysql> SELECT 0 IS NULL, 0 IS NOT NULL, '' IS NULL, '' IS NOT NULL;
```

```
+-----------+---------------+------------+----------------+
| 0 IS NULL | 0 IS NOT NULL | '' IS NULL | '' IS NOT NULL |
+-----------+---------------+------------+----------------+
|         0 |             1 |          0 |              1 |
+-----------+---------------+------------+----------------+
```

Thus it is entirely possible to insert a zero or empty string into a `NOT NULL` column, as these are in fact `NOT NULL`. See Section C.5.5.3, “Problems with `NULL` Values”.

3.3.4.7. Pattern Matching

MySQL provides standard SQL pattern matching as well as a form of pattern matching based on extended regular expressions similar to those used by Unix utilities such as `vi`, `grep`, and `sed`.

SQL pattern matching enables you to use “`_`” to match any single character and “`%`” to match an arbitrary number of characters (including zero characters). In MySQL, SQL patterns are case-insensitive by default. Some examples are shown here. You do not use `=` or `<>` when you use SQL patterns; use the `LIKE` or `NOT LIKE` comparison operators instead.

To find names beginning with “`b`”:

```
mysql> SELECT * FROM pet WHERE name LIKE 'b%';
+--------+--------+---------+------+------------+------------+
| name   | owner  | species | sex  | birth      | death      |
+--------+--------+---------+------+------------+------------+
| Buffy  | Harold | dog     | f    | 1989-05-13 | NULL       |
| Bowser | Diane  | dog     | m    | 1989-08-31 | 1995-07-29 |
+--------+--------+---------+------+------------+------------+
```

To find names ending with “`fy`”:

```
mysql> SELECT * FROM pet WHERE name LIKE '%fy';
+--------+--------+---------+------+------------+-------+
| name   | owner  | species | sex  | birth      | death |
+--------+--------+---------+------+------------+-------+
| Fluffy | Harold | cat     | f    | 1993-02-04 | NULL  |
| Buffy  | Harold | dog     | f    | 1989-05-13 | NULL  |
+--------+--------+---------+------+------------+-------+
```

To find names containing a “`w`”:

```
mysql> SELECT * FROM pet WHERE name LIKE '%w%';
+----------+-------+---------+------+------------+------------+
| name     | owner | species | sex  | birth      | death      |
+----------+-------+---------+------+------------+------------+
| Claws    | Gwen  | cat     | m    | 1994-03-17 | NULL       |
| Bowser   | Diane | dog     | m    | 1989-08-31 | 1995-07-29 |
| Whistler | Gwen  | bird    | NULL | 1997-12-09 | NULL       |
+----------+-------+---------+------+------------+------------+
```

To find names containing exactly five characters, use five instances of the “`_`” pattern character:

```
mysql> SELECT * FROM pet WHERE name LIKE '_____';
+-------+--------+---------+------+------------+-------+
| name  | owner  | species | sex  | birth      | death |
+-------+--------+---------+------+------------+-------+
| Claws | Gwen   | cat     | m    | 1994-03-17 | NULL  |
| Buffy | Harold | dog     | f    | 1989-05-13 | NULL  |
+-------+--------+---------+------+------------+-------+
```

The other type of pattern matching provided by MySQL uses extended regular expressions. When you test for a match for this type of pattern, use the `REGEXP` and `NOT REGEXP` operators (or `RLIKE` and `NOT RLIKE`, which are synonyms).

The following list describes some characteristics of extended regular expressions:

- “`.`” matches any single character.
- A character class “`[...]`” matches any character within the brackets. For example, “`[abc]`” matches “`a`”, “`b`”, or “`c`”. To name a range of characters, use a dash. “`[a-z]`” matches any letter, whereas “`[0-9]`” matches any digit.
- “`*`” matches zero or more instances of the thing preceding it. For example, “`x*`” matches any number of “`x`” characters, “`[0-9]*`” matches any number of digits, and “`.*`” matches any number of anything.
- A `REGEXP` pattern match succeeds if the pattern matches anywhere in the value being tested. (This differs from a `LIKE` pattern match, which succeeds only if the pattern matches the entire value.)
- To anchor a pattern so that it must match the beginning or end of the value being tested, use “`^`” at the beginning or “`$`” at the

end of the pattern.

To demonstrate how extended regular expressions work, the `LIKE` queries shown previously are rewritten here to use `REGEXP`.

To find names beginning with “`b`”, use “`^`” to match the beginning of the name:

```
mysql> SELECT * FROM pet WHERE name REGEXP '^b';
+--------+--------+---------+------+------------+------------+
| name   | owner  | species | sex  | birth      | death      |
+--------+--------+---------+------+------------+------------+
| Buffy  | Harold | dog     | f    | 1989-05-13 | NULL       |
| Bowser | Diane  | dog     | m    | 1989-08-31 | 1995-07-29 |
+--------+--------+---------+------+------------+------------+
```

If you really want to force a `REGEXP` comparison to be case sensitive, use the `BINARY` keyword to make one of the strings a binary string. This query matches only lowercase “`b`” at the beginning of a name:

```
mysql> SELECT * FROM pet WHERE name REGEXP BINARY '^b';
```

To find names ending with “`fy`”, use “`$`” to match the end of the name:

```
mysql> SELECT * FROM pet WHERE name REGEXP 'fy$';
+--------+--------+---------+------+------------+-------+
| name   | owner  | species | sex  | birth      | death |
+--------+--------+---------+------+------------+-------+
| Fluffy | Harold | cat     | f    | 1993-02-04 | NULL  |
| Buffy  | Harold | dog     | f    | 1989-05-13 | NULL  |
+--------+--------+---------+------+------------+-------+
```

To find names containing a “`w`”, use this query:

```
mysql> SELECT * FROM pet WHERE name REGEXP 'w';
+----------+-------+---------+------+------------+------------+
| name     | owner | species | sex  | birth      | death      |
+----------+-------+---------+------+------------+------------+
| Claws    | Gwen  | cat     | m    | 1994-03-17 | NULL       |
| Bowser   | Diane | dog     | m    | 1989-08-31 | 1995-07-29 |
| Whistler | Gwen  | bird    | NULL | 1997-12-09 | NULL       |
+----------+-------+---------+------+------------+------------+
```

Because a regular expression pattern matches if it occurs anywhere in the value, it is not necessary in the previous query to put a wildcard on either side of the pattern to get it to match the entire value like it would be if you used an SQL pattern.

To find names containing exactly five characters, use “`^`” and “`$`” to match the beginning and end of the name, and five instances of “`.`” in between:

```
mysql> SELECT * FROM pet WHERE name REGEXP '^.....$';
+-------+--------+---------+------+------------+-------+
| name  | owner  | species | sex  | birth      | death |
+-------+--------+---------+------+------------+-------+
| Claws | Gwen   | cat     | m    | 1994-03-17 | NULL  |
| Buffy | Harold | dog     | f    | 1989-05-13 | NULL  |
+-------+--------+---------+------+------------+-------+
```

You could also write the previous query using the `{n}` (“repeat-*n*-times”) operator:

```
mysql> SELECT * FROM pet WHERE name REGEXP '^.{5}$';
+-------+--------+---------+------+------------+-------+
| name  | owner  | species | sex  | birth      | death |
+-------+--------+---------+------+------------+-------+
| Claws | Gwen   | cat     | m    | 1994-03-17 | NULL  |
| Buffy | Harold | dog     | f    | 1989-05-13 | NULL  |
+-------+--------+---------+------+------------+-------+
```

Section 11.5.2, “Regular Expressions”, provides more information about the syntax for regular expressions.

3.3.4.8. Counting Rows

Databases are often used to answer the question, “How often does a certain type of data occur in a table?” For example, you might want to know how many pets you have, or how many pets each owner has, or you might want to perform various kinds of census operations on your animals.

Counting the total number of animals you have is the same question as “How many rows are in the `pet` table?” because there is one record per pet. `COUNT(*)` counts the number of rows, so the query to count your animals looks like this:

```
mysql> SELECT COUNT(*) FROM pet;
```

```
+----------+
| COUNT(*) |
+----------+
|        9 |
+----------+
```

Earlier, you retrieved the names of the people who owned pets. You can use `COUNT()` if you want to find out how many pets each owner has:

```
mysql> SELECT owner, COUNT(*) FROM pet GROUP BY owner;
+--------+----------+
| owner  | COUNT(*) |
+--------+----------+
| Benny  |        2 |
| Diane  |        2 |
| Gwen   |        3 |
| Harold |        2 |
+--------+----------+
```

The preceding query uses `GROUP BY` to group all records for each `owner`. The use of `COUNT()` in conjunction with `GROUP BY` is useful for characterizing your data under various groupings. The following examples show different ways to perform animal census operations.

Number of animals per species:

```
mysql> SELECT species, COUNT(*) FROM pet GROUP BY species;
+---------+----------+
| species | COUNT(*) |
+---------+----------+
| bird    |        2 |
| cat     |        2 |
| dog     |        3 |
| hamster |        1 |
| snake   |        1 |
+---------+----------+
```

Number of animals per sex:

```
mysql> SELECT sex, COUNT(*) FROM pet GROUP BY sex;
+------+----------+
| sex  | COUNT(*) |
+------+----------+
| NULL |        1 |
| f    |        4 |
| m    |        4 |
+------+----------+
```

(In this output, `NULL` indicates that the sex is unknown.)

Number of animals per combination of species and sex:

```
mysql> SELECT species, sex, COUNT(*) FROM pet GROUP BY species, sex;
+---------+------+----------+
| species | sex  | COUNT(*) |
+---------+------+----------+
| bird    | NULL |        1 |
| bird    | f    |        1 |
| cat     | f    |        1 |
| cat     | m    |        1 |
| dog     | f    |        1 |
| dog     | m    |        2 |
| hamster | f    |        1 |
| snake   | m    |        1 |
+---------+------+----------+
```

You need not retrieve an entire table when you use `COUNT()`. For example, the previous query, when performed just on dogs and cats, looks like this:

```
mysql> SELECT species, sex, COUNT(*) FROM pet
    -> WHERE species = 'dog' OR species = 'cat'
    -> GROUP BY species, sex;
+---------+------+----------+
| species | sex  | COUNT(*) |
+---------+------+----------+
| cat     | f    |        1 |
| cat     | m    |        1 |
| dog     | f    |        1 |
| dog     | m    |        2 |
+---------+------+----------+
```

Or, if you wanted the number of animals per sex only for animals whose sex is known:

```
mysql> SELECT species, sex, COUNT(*) FROM pet
```

```
    -> WHERE sex IS NOT NULL
    -> GROUP BY species, sex;
+---------+------+----------+
| species | sex  | COUNT(*) |
+---------+------+----------+
| bird    | f    |        1 |
| cat     | f    |        1 |
| cat     | m    |        1 |
| dog     | f    |        1 |
| dog     | m    |        2 |
| hamster | f    |        1 |
| snake   | m    |        1 |
+---------+------+----------+
```

If you name columns to select in addition to the `COUNT()` value, a `GROUP BY` clause should be present that names those same columns. Otherwise, the following occurs:

- If the `ONLY_FULL_GROUP_BY` SQL mode is enabled, an error occurs:

  ```
  mysql> SET sql_mode = 'ONLY_FULL_GROUP_BY';
  Query OK, 0 rows affected (0.00 sec)

  mysql> SELECT owner, COUNT(*) FROM pet;
  ERROR 1140 (42000): Mixing of GROUP columns (MIN(),MAX(),COUNT()...)
  with no GROUP columns is illegal if there is no GROUP BY clause
  ```

- If `ONLY_FULL_GROUP_BY` is not enabled, the query is processed by treating all rows as a single group, but the value selected for each named column is indeterminate. The server is free to select the value from any row:

  ```
  mysql> SET sql_mode = '';
  Query OK, 0 rows affected (0.00 sec)

  mysql> SELECT owner, COUNT(*) FROM pet;
  +--------+----------+
  | owner  | COUNT(*) |
  +--------+----------+
  | Harold |        8 |
  +--------+----------+
  1 row in set (0.00 sec)
  ```

See also Section 11.16.3, “`GROUP BY` and `HAVING` with Hidden Columns”.

3.3.4.9. Using More Than one Table

The `pet` table keeps track of which pets you have. If you want to record other information about them, such as events in their lives like visits to the vet or when litters are born, you need another table. What should this table look like? It needs to contain the following information:

- The pet name so that you know which animal each event pertains to.
- A date so that you know when the event occurred.
- A field to describe the event.
- An event type field, if you want to be able to categorize events.

Given these considerations, the `CREATE TABLE` statement for the `event` table might look like this:

```
mysql> CREATE TABLE event (name VARCHAR(20), date DATE,
    -> type VARCHAR(15), remark VARCHAR(255));
```

As with the `pet` table, it is easiest to load the initial records by creating a tab-delimited text file containing the following information.

name	date	type	remark
Fluffy	1995-05-15	litter	4 kittens, 3 female, 1 male
Buffy	1993-06-23	litter	5 puppies, 2 female, 3 male
Buffy	1994-06-19	litter	3 puppies, 3 female
Chirpy	1999-03-21	vet	needed beak straightened
Slim	1997-08-03	vet	broken rib

name	date	type	remark
Bowser	1991-10-12	kennel	
Fang	1991-10-12	kennel	
Fang	1998-08-28	birthday	Gave him a new chew toy
Claws	1998-03-17	birthday	Gave him a new flea collar
Whistler	1998-12-09	birthday	First birthday

Load the records like this:

```
mysql> LOAD DATA LOCAL INFILE 'event.txt' INTO TABLE event;
```

Based on what you have learned from the queries that you have run on the `pet` table, you should be able to perform retrievals on the records in the `event` table; the principles are the same. But when is the `event` table by itself insufficient to answer questions you might ask?

Suppose that you want to find out the ages at which each pet had its litters. We saw earlier how to calculate ages from two dates. The litter date of the mother is in the `event` table, but to calculate her age on that date you need her birth date, which is stored in the `pet` table. This means the query requires both tables:

```
mysql> SELECT pet.name,
    -> (YEAR(date)-YEAR(birth)) - (RIGHT(date,5)<RIGHT(birth,5)) AS age,
    -> remark
    -> FROM pet INNER JOIN event
    ->   ON pet.name = event.name
    -> WHERE event.type = 'litter';
+--------+------+-----------------------------+
| name   | age  | remark                      |
+--------+------+-----------------------------+
| Fluffy |    2 | 4 kittens, 3 female, 1 male |
| Buffy  |    4 | 5 puppies, 2 female, 3 male |
| Buffy  |    5 | 3 puppies, 3 female         |
+--------+------+-----------------------------+
```

There are several things to note about this query:

- The `FROM` clause joins two tables because the query needs to pull information from both of them.
- When combining (joining) information from multiple tables, you need to specify how records in one table can be matched to records in the other. This is easy because they both have a `name` column. The query uses an `ON` clause to match up records in the two tables based on the `name` values.

  The query uses an `INNER JOIN` to combine the tables. An `INNER JOIN` permits rows from either table to appear in the result if and only if both tables meet the conditions specified in the `ON` clause. In this example, the `ON` clause specifies that the `name` column in the `pet` table must match the `name` column in the `event` table. If a name appears in one table but not the other, the row will not appear in the result because the condition in the `ON` clause fails.
- Because the `name` column occurs in both tables, you must be specific about which table you mean when referring to the column. This is done by prepending the table name to the column name.

You need not have two different tables to perform a join. Sometimes it is useful to join a table to itself, if you want to compare records in a table to other records in that same table. For example, to find breeding pairs among your pets, you can join the `pet` table with itself to produce candidate pairs of males and females of like species:

```
mysql> SELECT p1.name, p1.sex, p2.name, p2.sex, p1.species
    -> FROM pet AS p1 INNER JOIN pet AS p2
    ->   ON p1.species = p2.species AND p1.sex = 'f' AND p2.sex = 'm';
+--------+------+--------+------+---------+
| name   | sex  | name   | sex  | species |
+--------+------+--------+------+---------+
| Fluffy | f    | Claws  | m    | cat     |
| Buffy  | f    | Fang   | m    | dog     |
| Buffy  | f    | Bowser | m    | dog     |
+--------+------+--------+------+---------+
```

In this query, we specify aliases for the table name to refer to the columns and keep straight which instance of the table each column reference is associated with.

3.4. Getting Information About Databases and Tables

What if you forget the name of a database or table, or what the structure of a given table is (for example, what its columns are called)? MySQL addresses this problem through several statements that provide information about the databases and tables it supports.

You have previously seen `SHOW DATABASES`, which lists the databases managed by the server. To find out which database is currently selected, use the `DATABASE()` function:

```
mysql> SELECT DATABASE();
+------------+
| DATABASE() |
+------------+
| menagerie  |
+------------+
```

If you have not yet selected any database, the result is `NULL`.

To find out what tables the default database contains (for example, when you are not sure about the name of a table), use this command:

```
mysql> SHOW TABLES;
+---------------------+
| Tables_in_menagerie |
+---------------------+
| event               |
| pet                 |
+---------------------+
```

The name of the column in the output produced by this statement is always `Tables_in_db_name`, where *`db_name`* is the name of the database. See Section 12.4.5.38, “`SHOW TABLES` Syntax”, for more information.

If you want to find out about the structure of a table, the `DESCRIBE` statement is useful; it displays information about each of a table's columns:

```
mysql> DESCRIBE pet;
+---------+-------------+------+-----+---------+-------+
| Field   | Type        | Null | Key | Default | Extra |
+---------+-------------+------+-----+---------+-------+
| name    | varchar(20) | YES  |     | NULL    |       |
| owner   | varchar(20) | YES  |     | NULL    |       |
| species | varchar(20) | YES  |     | NULL    |       |
| sex     | char(1)     | YES  |     | NULL    |       |
| birth   | date        | YES  |     | NULL    |       |
| death   | date        | YES  |     | NULL    |       |
+---------+-------------+------+-----+---------+-------+
```

`Field` indicates the column name, `Type` is the data type for the column, `NULL` indicates whether the column can contain `NULL` values, `Key` indicates whether the column is indexed, and `Default` specifies the column's default value. `Extra` displays special information about columns: If a column was created with the `AUTO_INCREMENT` option, the value will be `auto_increment` rather than empty.

`DESC` is a short form of `DESCRIBE`. See Section 12.8.1, “`DESCRIBE` Syntax”, for more information.

You can obtain the `CREATE TABLE` statement necessary to create an existing table using the `SHOW CREATE TABLE` statement. See Section 12.4.5.12, “`SHOW CREATE TABLE` Syntax”.

If you have indexes on a table, `SHOW INDEX FROM tbl_name` produces information about them. See Section 12.4.5.23, “`SHOW INDEX` Syntax”, for more about this statement.

3.5. Using `mysql` in Batch Mode

In the previous sections, you used `mysql` interactively to enter queries and view the results. You can also run `mysql` in batch mode. To do this, put the commands you want to run in a file, then tell `mysql` to read its input from the file:

```
shell> mysql < batch-file
```

If you are running `mysql` under Windows and have some special characters in the file that cause problems, you can do this:

```
C:\> mysql -e "source batch-file"
```

If you need to specify connection parameters on the command line, the command might look like this:

```
shell> mysql -h host -u user -p < batch-file
Enter password: ********
```

When you use `mysql` this way, you are creating a script file, then executing the script.

If you want the script to continue even if some of the statements in it produce errors, you should use the `--force` command-line option.

Why use a script? Here are a few reasons:

- If you run a query repeatedly (say, every day or every week), making it a script enables you to avoid retyping it each time you execute it.
- You can generate new queries from existing ones that are similar by copying and editing script files.
- Batch mode can also be useful while you're developing a query, particularly for multiple-line commands or multiple-statement sequences of commands. If you make a mistake, you don't have to retype everything. Just edit your script to correct the error, then tell `mysql` to execute it again.
- If you have a query that produces a lot of output, you can run the output through a pager rather than watching it scroll off the top of your screen:

  ```
  shell> mysql < batch-file | more
  ```

- You can catch the output in a file for further processing:

  ```
  shell> mysql < batch-file > mysql.out
  ```

- You can distribute your script to other people so that they can also run the commands.
- Some situations do not allow for interactive use, for example, when you run a query from a `cron` job. In this case, you must use batch mode.

The default output format is different (more concise) when you run `mysql` in batch mode than when you use it interactively. For example, the output of `SELECT DISTINCT species FROM pet` looks like this when `mysql` is run interactively:

```
+---------+
| species |
+---------+
| bird    |
| cat     |
| dog     |
| hamster |
| snake   |
+---------+
```

In batch mode, the output looks like this instead:

```
species
bird
cat
dog
hamster
snake
```

If you want to get the interactive output format in batch mode, use `mysql -t`. To echo to the output the commands that are executed, use `mysql -vvv`.

You can also use scripts from the `mysql` prompt by using the `source` command or `\.` command:

```
mysql> source filename;
mysql> \. filename
```

See Section 4.5.1.5, “Executing SQL Statements from a Text File”, for more information.

3.6. Examples of Common Queries

Here are examples of how to solve some common problems with MySQL.

Some of the examples use the table `shop` to hold the price of each article (item number) for certain traders (dealers). Supposing that each trader has a single fixed price per article, then (`article`, `dealer`) is a primary key for the records.

Start the command-line tool `mysql` and select a database:

```
shell> mysql your-database-name
```

(In most MySQL installations, you can use the database named `test`).

You can create and populate the example table with these statements:

```
CREATE TABLE shop (
    article INT(4) UNSIGNED ZEROFILL DEFAULT '0000' NOT NULL,
    dealer  CHAR(20)                 DEFAULT ''     NOT NULL,
    price   DOUBLE(16,2)             DEFAULT '0.00' NOT NULL,
    PRIMARY KEY(article, dealer));
INSERT INTO shop VALUES
    (1,'A',3.45),(1,'B',3.99),(2,'A',10.99),(3,'B',1.45),
    (3,'C',1.69),(3,'D',1.25),(4,'D',19.95);
```

After issuing the statements, the table should have the following contents:

```
SELECT * FROM shop;

+---------+--------+-------+
| article | dealer | price |
+---------+--------+-------+
|    0001 | A      |  3.45 |
|    0001 | B      |  3.99 |
|    0002 | A      | 10.99 |
|    0003 | B      |  1.45 |
|    0003 | C      |  1.69 |
|    0003 | D      |  1.25 |
|    0004 | D      | 19.95 |
+---------+--------+-------+
```

3.6.1. The Maximum Value for a Column

“What is the highest item number?”

```
SELECT MAX(article) AS article FROM shop;

+---------+
| article |
+---------+
|       4 |
+---------+
```

3.6.2. The Row Holding the Maximum of a Certain Column

Task: Find the number, dealer, and price of the most expensive article.

This is easily done with a subquery:

```
SELECT article, dealer, price
FROM   shop
WHERE  price=(SELECT MAX(price) FROM shop);

+---------+--------+-------+
| article | dealer | price |
+---------+--------+-------+
|    0004 | D      | 19.95 |
+---------+--------+-------+
```

Other solutions are to use a `LEFT JOIN` or to sort all rows descending by price and get only the first row using the MySQL-specific `LIMIT` clause:

```
SELECT s1.article, s1.dealer, s1.price
FROM shop s1
LEFT JOIN shop s2 ON s1.price < s2.price
WHERE s2.article IS NULL;

SELECT article, dealer, price
FROM shop
ORDER BY price DESC
LIMIT 1;
```

> **Note**
>
> If there were several most expensive articles, each with a price of 19.95, the `LIMIT` solution would show only one of them.

3.6.3. Maximum of Column per Group

Task: Find the highest price per article.

```
SELECT article, MAX(price) AS price
FROM   shop
GROUP BY article;

+---------+-------+
| article | price |
+---------+-------+
|    0001 |  3.99 |
|    0002 | 10.99 |
|    0003 |  1.69 |
|    0004 | 19.95 |
+---------+-------+
```

3.6.4. The Rows Holding the Group-wise Maximum of a Certain Column

Task: For each article, find the dealer or dealers with the most expensive price.

This problem can be solved with a subquery like this one:

```
SELECT article, dealer, price
FROM   shop s1
WHERE  price=(SELECT MAX(s2.price)
              FROM shop s2
              WHERE s1.article = s2.article);

+---------+--------+-------+
| article | dealer | price |
+---------+--------+-------+
|    0001 | B      |  3.99 |
|    0002 | A      | 10.99 |
|    0003 | C      |  1.69 |
|    0004 | D      | 19.95 |
+---------+--------+-------+
```

The preceding example uses a correlated subquery, which can be inefficient (see Section 12.2.10.7, “Correlated Subqueries”). Other possibilities for solving the problem are to use an uncorrelated subquery in the `FROM` clause or a `LEFT JOIN`:

```
SELECT s1.article, dealer, s1.price
FROM shop s1
JOIN (
  SELECT article, MAX(price) AS price
  FROM shop
  GROUP BY article) AS s2
  ON s1.article = s2.article AND s1.price = s2.price;

SELECT s1.article, s1.dealer, s1.price
FROM shop s1
LEFT JOIN shop s2 ON s1.article = s2.article AND s1.price < s2.price
WHERE s2.article IS NULL;
```

The `LEFT JOIN` works on the basis that when `s1.price` is at its maximum value, there is no `s2.price` with a greater value and the `s2` rows values will be `NULL`. See Section 12.2.9.1, “`JOIN` Syntax”.

3.6.5. Using User-Defined Variables

You can employ MySQL user variables to remember results without having to store them in temporary variables in the client. (See Section 8.4, “User-Defined Variables”.)

For example, to find the articles with the highest and lowest price you can do this:

```
mysql> SELECT @min_price:=MIN(price),@max_price:=MAX(price) FROM shop;
mysql> SELECT * FROM shop WHERE price=@min_price OR price=@max_price;
+---------+--------+-------+
| article | dealer | price |
+---------+--------+-------+
|    0003 | D      |  1.25 |
|    0004 | D      | 19.95 |
+---------+--------+-------+
```

> **Note**
>
> It is also possible to store the name of a database object such as a table or a column in a user variable and then to use this variable in an SQL statement; however, this requires the use of a prepared statement. See Section 12.6, “SQL Syntax for Prepared Statements”, for more information.

3.6.6. Using Foreign Keys

In MySQL, `InnoDB` tables support checking of foreign key constraints. See Section 13.3, “The `InnoDB` Storage Engine”, and Section 1.8.5.4, “Foreign Key Differences”.

A foreign key constraint is not required merely to join two tables. For storage engines other than `InnoDB`, it is possible when defining a column to use a `REFERENCES` *`tbl_name`*`(`*`col_name`*`)` clause, which has no actual effect, and *serves only as a memo or comment to you that the column which you are currently defining is intended to refer to a column in another table*. It is extremely important to realize when using this syntax that:

- MySQL does not perform any sort of `CHECK` to make sure that *`col_name`* actually exists in *`tbl_name`* (or even that *`tbl_name`* itself exists).
- MySQL does not perform any sort of action on *`tbl_name`* such as deleting rows in response to actions taken on rows in the table which you are defining; in other words, this syntax induces no `ON DELETE` or `ON UPDATE` behavior whatsoever. (Although you can write an `ON DELETE` or `ON UPDATE` clause as part of the `REFERENCES` clause, it is also ignored.)
- This syntax creates a *column*; it does **not** create any sort of index or key.

You can use a column so created as a join column, as shown here:

```
CREATE TABLE person (
    id SMALLINT UNSIGNED NOT NULL AUTO_INCREMENT,
    name CHAR(60) NOT NULL,
    PRIMARY KEY (id)
);

CREATE TABLE shirt (
    id SMALLINT UNSIGNED NOT NULL AUTO_INCREMENT,
    style ENUM('t-shirt', 'polo', 'dress') NOT NULL,
    color ENUM('red', 'blue', 'orange', 'white', 'black') NOT NULL,
    owner SMALLINT UNSIGNED NOT NULL REFERENCES person(id),
    PRIMARY KEY (id)
);

INSERT INTO person VALUES (NULL, 'Antonio Paz');

SELECT @last := LAST_INSERT_ID();

INSERT INTO shirt VALUES
(NULL, 'polo', 'blue', @last),
(NULL, 'dress', 'white', @last),
(NULL, 't-shirt', 'blue', @last);

INSERT INTO person VALUES (NULL, 'Lilliana Angelovska');

SELECT @last := LAST_INSERT_ID();

INSERT INTO shirt VALUES
(NULL, 'dress', 'orange', @last),
(NULL, 'polo', 'red', @last),
(NULL, 'dress', 'blue', @last),
(NULL, 't-shirt', 'white', @last);

SELECT * FROM person;
+----+---------------------+
| id | name                |
+----+---------------------+
|  1 | Antonio Paz         |
|  2 | Lilliana Angelovska |
+----+---------------------+

SELECT * FROM shirt;
+----+---------+--------+-------+
| id | style   | color  | owner |
+----+---------+--------+-------+
|  1 | polo    | blue   |     1 |
|  2 | dress   | white  |     1 |
|  3 | t-shirt | blue   |     1 |
|  4 | dress   | orange |     2 |
|  5 | polo    | red    |     2 |
|  6 | dress   | blue   |     2 |
|  7 | t-shirt | white  |     2 |
+----+---------+--------+-------+


SELECT s.* FROM person p INNER JOIN shirt s
   ON s.owner = p.id
 WHERE p.name LIKE 'Lilliana%'
   AND s.color <> 'white';

+----+-------+--------+-------+
| id | style | color  | owner |
+----+-------+--------+-------+
|  4 | dress | orange |     2 |
|  5 | polo  | red    |     2 |
|  6 | dress | blue   |     2 |
+----+-------+--------+-------+
```

When used in this fashion, the `REFERENCES` clause is not displayed in the output of `SHOW CREATE TABLE` or `DESCRIBE`:

```
SHOW CREATE TABLE shirt\G
*************************** 1. row ***************************
Table: shirt
Create Table: CREATE TABLE `shirt` (
`id` smallint(5) unsigned NOT NULL auto_increment,
`style` enum('t-shirt','polo','dress') NOT NULL,
`color` enum('red','blue','orange','white','black') NOT NULL,
`owner` smallint(5) unsigned NOT NULL,
PRIMARY KEY  (`id`)
) ENGINE=MyISAM DEFAULT CHARSET=latin1
```

The use of `REFERENCES` in this way as a comment or “reminder” in a column definition works with `MyISAM` tables.

3.6.7. Searching on Two Keys

An `OR` using a single key is well optimized, as is the handling of `AND`.

The one tricky case is that of searching on two different keys combined with `OR`:

```
SELECT field1_index, field2_index FROM test_table
WHERE field1_index = '1' OR  field2_index = '1'
```

This case is optimized. See Section 7.13.2, “Index Merge Optimization”.

You can also solve the problem efficiently by using a `UNION` that combines the output of two separate `SELECT` statements. See Section 12.2.9.3, “`UNION` Syntax”.

Each `SELECT` searches only one key and can be optimized:

```
SELECT field1_index, field2_index
    FROM test_table WHERE field1_index = '1'
UNION
SELECT field1_index, field2_index
    FROM test_table WHERE field2_index = '1';
```

3.6.8. Calculating Visits Per Day

The following example shows how you can use the bit group functions to calculate the number of days per month a user has visited a Web page.

```
CREATE TABLE t1 (year YEAR(4), month INT(2) UNSIGNED ZEROFILL,
             day INT(2) UNSIGNED ZEROFILL);
INSERT INTO t1 VALUES(2000,1,1),(2000,1,20),(2000,1,30),(2000,2,2),
            (2000,2,23),(2000,2,23);
```

The example table contains year-month-day values representing visits by users to the page. To determine how many different days in each month these visits occur, use this query:

```
SELECT year,month,BIT_COUNT(BIT_OR(1<<day)) AS days FROM t1
       GROUP BY year,month;
```

Which returns:

```
+------+-------+------+
| year | month | days |
+------+-------+------+
| 2000 |    01 |    3 |
| 2000 |    02 |    2 |
+------+-------+------+
```

The query calculates how many different days appear in the table for each year/month combination, with automatic removal of duplicate entries.

3.6.9. Using `AUTO_INCREMENT`

The `AUTO_INCREMENT` attribute can be used to generate a unique identity for new rows:

```
CREATE TABLE animals (
     id MEDIUMINT NOT NULL AUTO_INCREMENT,
     name CHAR(30) NOT NULL,
     PRIMARY KEY (id)
) ENGINE=MyISAM;

INSERT INTO animals (name) VALUES
    ('dog'),('cat'),('penguin'),
    ('lax'),('whale'),('ostrich');

SELECT * FROM animals;
```

Which returns:

```
+----+---------+
| id | name    |
+----+---------+
|  1 | dog     |
|  2 | cat     |
|  3 | penguin |
|  4 | lax     |
|  5 | whale   |
|  6 | ostrich |
+----+---------+
```

No value was specified for the `AUTO_INCREMENT` column, so MySQL assigned sequence numbers automatically. You can also explicitly assign `NULL` or 0 to the column to generate sequence numbers.

You can retrieve the most recent `AUTO_INCREMENT` value with the `LAST_INSERT_ID()` SQL function or the `mysql_insert_id()` C API function. These functions are connection-specific, so their return values are not affected by another connection which is also performing inserts.

Use a large enough integer data type for the `AUTO_INCREMENT` column to hold the maximum sequence value you will need. When the column reaches the upper limit of the data type, the next attempt to generate a sequence number fails. For example, if you use `TINYINT`, the maximum permissible sequence number is 127. For `TINYINT UNSIGNED`, the maximum is 255.

> **Note**
>
> For a multiple-row insert, `LAST_INSERT_ID()` and `mysql_insert_id()` actually return the `AUTO_INCREMENT` key from the *first* of the inserted rows. This enables multiple-row inserts to be reproduced correctly on other servers in a replication setup.

For `MyISAM` tables you can specify `AUTO_INCREMENT` on a secondary column in a multiple-column index. In this case, the generated value for the `AUTO_INCREMENT` column is calculated as `MAX(`*`auto_increment_column`*`) + 1 WHERE prefix=`*`given-prefix`*. This is useful when you want to put data into ordered groups.

```
CREATE TABLE animals (
    grp ENUM('fish','mammal','bird') NOT NULL,
    id MEDIUMINT NOT NULL AUTO_INCREMENT,
    name CHAR(30) NOT NULL,
    PRIMARY KEY (grp,id)
) ENGINE=MyISAM;

INSERT INTO animals (grp,name) VALUES
    ('mammal','dog'),('mammal','cat'),
    ('bird','penguin'),('fish','lax'),('mammal','whale'),
    ('bird','ostrich');

SELECT * FROM animals ORDER BY grp,id;
```

Which returns:

```
+--------+----+---------+
| grp    | id | name    |
+--------+----+---------+
| fish   |  1 | lax     |
| mammal |  1 | dog     |
| mammal |  2 | cat     |
| mammal |  3 | whale   |
| bird   |  1 | penguin |
| bird   |  2 | ostrich |
+--------+----+---------+
```

In this case (when the `AUTO_INCREMENT` column is part of a multiple-column index), `AUTO_INCREMENT` values are reused if you delete the row with the biggest `AUTO_INCREMENT` value in any group. This happens even for `MyISAM` tables, for which `AUTO_INCREMENT` values normally are not reused.

If the `AUTO_INCREMENT` column is part of multiple indexes, MySQL will generate sequence values using the index that begins with the `AUTO_INCREMENT` column, if there is one. For example, if the `animals` table contained indexes `PRIMARY KEY (grp, id)` and `INDEX (id)`, MySQL would ignore the `PRIMARY KEY` for generating sequence values. As a result, the table would contain a single sequence, not a sequence per `grp` value.

To start with an `AUTO_INCREMENT` value other than 1, you can set that value with `CREATE TABLE` or `ALTER TABLE`, like this:

```
mysql> ALTER TABLE tbl AUTO_INCREMENT = 100;
```

More information about `AUTO_INCREMENT` is available here:

- How to assign the `AUTO_INCREMENT` attribute to a column: Section 12.1.14, “`CREATE TABLE` Syntax”, and Section 12.1.6, “`ALTER TABLE` Syntax”.
- How `AUTO_INCREMENT` behaves depending on the `NO_AUTO_VALUE_ON_ZERO` SQL mode: Section 5.1.6, “Server SQL Modes”.
- How to use the `LAST_INSERT_ID()` function to find the row that contains the most recent `AUTO_INCREMENT` value: Section 11.14, “Information Functions”.
- Setting the `AUTO_INCREMENT` value to be used: Section 5.1.3, “Server System Variables”.
- `AUTO_INCREMENT` and replication: Section 15.4.1.1, “Replication and `AUTO_INCREMENT`”.
- Server-system variables related to `AUTO_INCREMENT` (`auto_increment_increment` and `auto_increment_offset`) that can be used for replication: Section 5.1.3, “Server System Variables”.

3.7. Using MySQL with Apache

There are programs that let you authenticate your users from a MySQL database and also let you write your log files into a MySQL table.

You can change the Apache logging format to be easily readable by MySQL by putting the following into the Apache configuration file:

```
LogFormat \
        "\"%h\",%{%Y%m%d%H%M%S}t,%>s,\"%b\",\"%{Content-Type}o\",  \
        \"%U\",\"%{Referer}i\",\"%{User-Agent}i\""
```

To load a log file in that format into MySQL, you can use a statement something like this:

```
LOAD DATA INFILE '/local/access_log' INTO TABLE tbl_name
FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"' ESCAPED BY '\\'
```

The named table should be created to have columns that correspond to those that the `LogFormat` line writes to the log file.

Chapter 4. MySQL Programs

This chapter provides a brief overview of the MySQL command-line programs provided by Oracle Corporation. It also discusses the general syntax for specifying options when you run these programs. Most programs have options that are specific to their own operation, but the option syntax is similar for all of them. Finally, the chapter provides more detailed descriptions of individual programs, including which options they recognize.

4.1. Overview of MySQL Programs

There are many different programs in a MySQL installation. This section provides a brief overview of them. Later sections provide a more detailed description of each one. Each program's description indicates its invocation syntax and the options that it supports.

Most MySQL distributions include all of these programs, except for those programs that are platform-specific. (For example, the server startup scripts are not used on Windows.) The exception is that RPM distributions are more specialized. There is one RPM for the server, another for client programs, and so forth. If you appear to be missing one or more programs, see Chapter 2, *Installing and Upgrading MySQL*, for information on types of distributions and what they contain. It may be that you have a distribution that does not include all programs and you need to install an additional package.

Each MySQL program takes many different options. Most programs provide a `--help` option that you can use to get a description of the program's different options. For example, try `mysql --help`.

You can override default option values for MySQL programs by specifying options on the command line or in an option file. See Section 4.2, “Using MySQL Programs”, for general information on invoking programs and specifying program options.

The MySQL server, `mysqld`, is the main program that does most of the work in a MySQL installation. The server is accompanied by several related scripts that assist you in starting and stopping the server:

- `mysqld`

  The SQL daemon (that is, the MySQL server). To use client programs, `mysqld` must be running, because clients gain access to databases by connecting to the server. See Section 4.3.1, “`mysqld` — The MySQL Server”.

- `mysqld_safe`

  A server startup script. `mysqld_safe` attempts to start `mysqld`. See Section 4.3.2, “`mysqld_safe` — MySQL Server Startup Script”.

- `mysql.server`

  A server startup script. This script is used on systems that use System V-style run directories containing scripts that start system services for particular run levels. It invokes `mysqld_safe` to start the MySQL server. See Section 4.3.3, “`mysql.server` — MySQL Server Startup Script”.

- `mysqld_multi`

  A server startup script that can start or stop multiple servers installed on the system. See Section 4.3.4, “`mysqld_multi` — Manage Multiple MySQL Servers”.

Several programs perform setup operations during MySQL installation or upgrading:

- `comp_err`

  This program is used during the MySQL build/installation process. It compiles error message files from the error source files. See Section 4.4.1, “`comp_err` — Compile MySQL Error Message File”.

- `mysql_install_db`

  This script creates the MySQL database and initializes the grant tables with default privileges. It is usually executed only once, when first installing MySQL on a system. See Section 4.4.4, “`mysql_install_db` — Initialize MySQL Data Directory”, Section 2.10.1, “Unix Postinstallation Procedures”, and Section 4.4.4, “`mysql_install_db` — Initialize MySQL Data Directory”.

- `mysql_secure_installation`

  This program enables you to improve the security of your MySQL installation. SQL. See Section 4.4.5, “`mysql_secure_installation` — Improve MySQL Installation Security”.

- `mysql_tzinfo_to_sql`

  This program loads the time zone tables in the `mysql` database using the contents of the host system *zoneinfo* database (the set of files describing time zones). SQL. See Section 4.4.6, “`mysql_tzinfo_to_sql` — Load the Time Zone Tables”.

- `mysql_upgrade`

  This program is used after a MySQL upgrade operation. It checks tables for incompatibilities and repairs them if necessary, and updates the grant tables with any changes that have been made in newer versions of MySQL. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

MySQL client programs that connect to the MySQL server:

- `mysql`

  The command-line tool for interactively entering SQL statements or executing them from a file in batch mode. See Section 4.5.1, “`mysql` — The MySQL Command-Line Tool”.

- `mysqladmin`

  A client that performs administrative operations, such as creating or dropping databases, reloading the grant tables, flushing tables to disk, and reopening log files. `mysqladmin` can also be used to retrieve version, process, and status information from the server. See Section 4.5.2, “`mysqladmin` — Client for Administering a MySQL Server”.

- `mysqlcheck`

  A table-maintenance client that checks, repairs, analyzes, and optimizes tables. See Section 4.5.3, “`mysqlcheck` — A Table Maintenance Program”.

- `mysqldump`

  A client that dumps a MySQL database into a file as SQL, text, or XML. See Section 4.5.4, “`mysqldump` — A Database Backup Program”.

- `mysqlimport`

  A client that imports text files into their respective tables using `LOAD DATA INFILE`. See Section 4.5.5, “`mysqlimport` — A Data Import Program”.

- `mysqlshow`

  A client that displays information about databases, tables, columns, and indexes. See Section 4.5.6, “`mysqlshow` — Display Database, Table, and Column Information”.

- `mysqlslap`

  A client that is designed to emulate client load for a MySQL server and report the timing of each stage. It works as if multiple clients are accessing the server. See Section 4.5.7, “`mysqlslap` — Load Emulation Client”.

MySQL administrative and utility programs:

- `innochecksum`

  An offline `InnoDB` offline file checksum utility. See Section 4.6.1, “`innochecksum` — Offline InnoDB File Checksum Utility”.

- `myisam_ftdump`

  A utility that displays information about full-text indexes in `MyISAM` tables. See Section 4.6.2, “`myisam_ftdump` — Display Full-Text Index information”.

- `myisamchk`

  A utility to describe, check, optimize, and repair `MyISAM` tables. See Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”.

- `myisamlog`, `isamlog`

A utility that processes the contents of a `MyISAM` log file. See Section 4.6.4, “`myisamlog` — Display MyISAM Log File Contents”.

- `myisampack`

  A utility that compresses `MyISAM` tables to produce smaller read-only tables. See Section 4.6.5, “`myisampack` — Generate Compressed, Read-Only MyISAM Tables”.

- `mysqlaccess`

  A script that checks the access privileges for a host name, user name, and database combination. See Section 4.6.6, “`mysqlaccess` — Client for Checking Access Privileges”.

- `mysqlbinlog`

  A utility for reading statements from a binary log. The log of executed statements contained in the binary log files can be used to help recover from a crash. See Section 4.6.7, “`mysqlbinlog` — Utility for Processing Binary Log Files”.

- `mysqldumpslow`

  A utility to read and summarize the contents of a slow query log. See Section 4.6.8, “`mysqldumpslow` — Summarize Slow Query Log Files”.

- `mysqlhotcopy`

  A utility that quickly makes backups of `MyISAM` tables while the server is running. See Section 4.6.9, “`mysqlhotcopy` — A Database Backup Program”.

- `mysql_convert_table_format`

  A utility that converts tables in a database to use a given storage engine. See Section 4.6.10, “`mysql_convert_table_format` — Convert Tables to Use a Given Storage Engine”.

- `mysql_find_rows`

  A utility that reads files containing SQL statements (such as update logs) and extracts statements that match a given regular expression. See Section 4.6.11, “`mysql_find_rows` — Extract SQL Statements from Files”.

- `mysql_fix_extensions`

  A utility that converts the extensions for `MyISAM` table files to lowercase. This can be useful after transferring the files from a system with case-insensitive file names to a system with case-sensitive file names. See Section 4.6.12, “`mysql_fix_extensions` — Normalize Table File Name Extensions”.

- `mysql_setpermission`

  A utility for interactively setting permissions in the MySQL grant tables. See Section 4.6.13, “`mysql_setpermission` — Interactively Set Permissions in Grant Tables”.

- `mysql_waitpid`

  A utility that kills the process with a given process ID. See Section 4.6.14, “`mysql_waitpid` — Kill Process and Wait for Its Termination”.

- `mysql_zap`

  A utility that kills processes that match a pattern. See Section 4.6.15, “`mysql_zap` — Kill Processes That Match a Pattern”.

MySQL program-development utilities:

- `msql2mysql`

  A shell script that converts `mSQL` programs to MySQL. It doesn't handle every case, but it gives a good start when converting. See Section 4.7.1, “`msql2mysql` — Convert mSQL Programs for Use with MySQL”.

- `mysql_config`

  A shell script that produces the option values needed when compiling MySQL programs. See Section 4.7.2, “`mysql_config` — Get Compile Options for Compiling Clients”.

- `my_print_defaults`

  A utility that shows which options are present in option groups of option files. See Section 4.7.3, “`my_print_defaults` — Display Options from Option Files”.

- `resolve_stack_dump`

  A utility program that resolves a numeric stack trace dump to symbols. See Section 4.7.4, “`resolve_stack_dump` — Resolve Numeric Stack Trace Dump to Symbols”.

Miscellaneous utilities:

- `perror`

  A utility that displays the meaning of system or MySQL error codes. See Section 4.8.1, “`perror` — Explain Error Codes”.

- `replace`

  A utility program that performs string replacement in the input text. See Section 4.8.2, “`replace` — A String-Replacement Utility”.

- `resolveip`

  A utility program that resolves a host name to an IP address or vice versa. See Section 4.8.3, “`resolveip` — Resolve Host name to IP Address or Vice Versa”.

Oracle Corporation also provides several GUI tools for administering and otherwise working with MySQL Server:

- MySQL Workbench: This is the latest graphical tool for working with MySQL databases.
- MySQL Administrator: This tool is used for administering MySQL servers, databases, tables, and user accounts.
- MySQL Query Browser: This graphical tool is used for creating, executing, and optimizing queries on MySQL databases.
- MySQL Migration Toolkit: This tool helps you migrate schemas and data from other relational database management systems for use with MySQL.

These GUI programs are available at http://dev.mysql.com/downloads/. Each has its own manual that you can access at http://dev.mysql.com/doc/.

MySQL client programs that communicate with the server using the MySQL client/server library use the following environment variables.

Environment Variable	**Meaning**
`MYSQL_UNIX_PORT`	The default Unix socket file; used for connections to `localhost`
`MYSQL_TCP_PORT`	The default port number; used for TCP/IP connections
`MYSQL_PWD`	The default password
`MYSQL_DEBUG`	Debug trace options when debugging
`TMPDIR`	The directory where temporary tables and files are created

For a full list of environment variables used by MySQL programs, see Section 2.12, “Environment Variables”.

Use of `MYSQL_PWD` is insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”.

4.2. Using MySQL Programs

4.2.1. Invoking MySQL Programs

To invoke a MySQL program from the command line (that is, from your shell or command prompt), enter the program name followed by any options or other arguments needed to instruct the program what you want it to do. The following commands show some sample program invocations. “`shell>`” represents the prompt for your command interpreter; it is not part of what you type. The particular prompt you see depends on your command interpreter. Typical prompts are `$` for `sh` or `bash`, `%` for `csh` or `tcsh`, and `C:\>` for the Windows `command.com` or `cmd.exe` command interpreters.

```
shell> mysql --user=root test
shell> mysqladmin extended-status variables
shell> mysqlshow --help
shell> mysqldump -u root personnel
```

Arguments that begin with a single or double dash ("`-`", "`--`") specify program options. Options typically indicate the type of connection a program should make to the server or affect its operational mode. Option syntax is described in Section 4.2.3, "Specifying Program Options".

Nonoption arguments (arguments with no leading dash) provide additional information to the program. For example, the `mysql` program interprets the first nonoption argument as a database name, so the command `mysql --user=root test` indicates that you want to use the `test` database.

Later sections that describe individual programs indicate which options a program supports and describe the meaning of any additional nonoption arguments.

Some options are common to a number of programs. The most frequently used of these are the `--host` (or `-h`), `--user` (or `-u`), and `--password` (or `-p`) options that specify connection parameters. They indicate the host where the MySQL server is running, and the user name and password of your MySQL account. All MySQL client programs understand these options; they enable you to specify which server to connect to and the account to use on that server. Other connection options are `--port` (or `-P`) to specify a TCP/IP port number and `--socket` (or `-S`) to specify a Unix socket file on Unix (or named pipe name on Windows). For more information on options that specify connection options, see Section 4.2.2, "Connecting to the MySQL Server".

You may find it necessary to invoke MySQL programs using the path name to the `bin` directory in which they are installed. This is likely to be the case if you get a "program not found" error whenever you attempt to run a MySQL program from any directory other than the `bin` directory. To make it more convenient to use MySQL, you can add the path name of the `bin` directory to your `PATH` environment variable setting. That enables you to run a program by typing only its name, not its entire path name. For example, if `mysql` is installed in `/usr/local/mysql/bin`, you can run the program by invoking it as `mysql`, and it is not necessary to invoke it as `/usr/local/mysql/bin/mysql`.

Consult the documentation for your command interpreter for instructions on setting your `PATH` variable. The syntax for setting environment variables is interpreter-specific. (Some information is given in Section 4.2.4, "Setting Environment Variables".) After modifying your `PATH` setting, open a new console window on Windows or log in again on Unix so that the setting goes into effect.

4.2.2. Connecting to the MySQL Server

For a client program to be able to connect to the MySQL server, it must use the proper connection parameters, such as the name of the host where the server is running and the user name and password of your MySQL account. Each connection parameter has a default value, but you can override them as necessary using program options specified either on the command line or in an option file.

The examples here use the `mysql` client program, but the principles apply to other clients such as `mysqldump`, `mysqladmin`, or `mysqlshow`.

This command invokes `mysql` without specifying any connection parameters explicitly:

```
shell> mysql
```

Because there are no parameter options, the default values apply:

- The default host name is `localhost`. On Unix, this has a special meaning, as described later.
- The default user name is `ODBC` on Windows or your Unix login name on Unix.
- No password is sent if neither `-p` nor `--password` is given.
- For `mysql`, the first nonoption argument is taken as the name of the default database. If there is no such option, `mysql` does not select a default database.

To specify the host name and user name explicitly, as well as a password, supply appropriate options on the command line:

```
shell> mysql --host=localhost --user=myname --password=mypass mydb
shell> mysql -h localhost -u myname -pmypass mydb
```

For password options, the password value is optional:

- If you use a `-p` or `--password` option and specify the password value, there must be *no space* between `-p` or `-`

`-password=` and the password following it.

- If you use a `-p` or `--password` option but do not specify the password value, the client program prompts you to enter the password. The password is not displayed as you enter it. This is more secure than giving the password on the command line. Other users on your system may be able to see a password specified on the command line by executing a command such as `ps auxw`. See Section 5.3.2.2, "End-User Guidelines for Password Security".

As just mentioned, including the password value on the command line can be a security risk. To avoid this problem, specify the `--password` or `-p` option without any following password value:

```
shell> mysql --host=localhost --user=myname --password mydb
shell> mysql -h localhost -u myname -p mydb
```

When the password option has no password value, the client program prints a prompt and waits for you to enter the password. (In these examples, `mydb` is *not* interpreted as a password because it is separated from the preceding password option by a space.)

On some systems, the library routine that MySQL uses to prompt for a password automatically limits the password to eight characters. That is a problem with the system library, not with MySQL. Internally, MySQL does not have any limit for the length of the password. To work around the problem, change your MySQL password to a value that is eight or fewer characters long, or put your password in an option file.

On Unix, MySQL programs treat the host name `localhost` specially, in a way that is likely different from what you expect compared to other network-based programs. For connections to `localhost`, MySQL programs attempt to connect to the local server by using a Unix socket file. This occurs even if a `--port` or `-P` option is given to specify a port number. To ensure that the client makes a TCP/IP connection to the local server, use `--host` or `-h` to specify a host name value of `127.0.0.1`, or the IP address or name of the local server. You can also specify the connection protocol explicitly, even for `localhost`, by using the `--protocol=TCP` option. For example:

```
shell> mysql --host=127.0.0.1
shell> mysql --protocol=TCP
```

The `--protocol` option enables you to establish a particular type of connection even when the other options would normally default to some other protocol.

On Windows, you can force a MySQL client to use a named-pipe connection by specifying the `--pipe` or `--protocol=PIPE` option, or by specifying `.` (period) as the host name. If named-pipe connections are not enabled, an error occurs. Use the `--socket` option to specify the name of the pipe if you do not want to use the default pipe name.

Connections to remote servers always use TCP/IP. This command connects to the server running on `remote.example.com` using the default port number (3306):

```
shell> mysql --host=remote.example.com
```

To specify a port number explicitly, use the `--port` or `-P` option:

```
shell> mysql --host=remote.example.com --port=13306
```

You can specify a port number for connections to a local server, too. However, as indicated previously, connections to `localhost` on Unix will use a socket file by default. You will need to force a TCP/IP connection as already described or any option that specifies a port number will be ignored.

For this command, the program uses a socket file on Unix and the `--port` option is ignored:

```
shell> mysql --port=13306 --host=localhost
```

To cause the port number to be used, invoke the program in either of these ways:

```
shell> mysql --port=13306 --host=127.0.0.1
shell> mysql --port=13306 --protocol=TCP
```

The following list summarizes the options that can be used to control how client programs connect to the server:

- `--host=`*`host_name`*, `-h` *`host_name`*

  The host where the server is running. The default value is `localhost`.

- `--password[=`*`pass_val`*`]`, `-p[`*`pass_val`*`]`

The password of the MySQL account. As described earlier, the password value is optional, but if given, there must be *no space* between `-p` or `--password=` and the password following it. The default is to send no password.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. The server must be started with the `--enable-named-pipe` option to enable named-pipe connections.

- `--port=`*`port_num`*, `-P` *`port_num`*

  The port number to use for the connection, for connections made using TCP/IP. The default port number is 3306.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  This option explicitly specifies a protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For example, connections on Unix to `localhost` are made using a Unix socket file by default:

  ```
  shell> mysql --host=localhost
  ```

  To force a TCP/IP connection to be used instead, specify a `--protocol` option:

  ```
  shell> mysql --host=localhost --protocol=TCP
  ```

  The following table shows the permissible `--protocol` option values and indicates the platforms on which each value may be used. The values are not case sensitive.

`--protocol` Value	**Connection Protocol**	**Permissible Operating Systems**
`TCP`	TCP/IP connection to local or remote server	All
`SOCKET`	Unix socket file connection to local server	Unix only
`PIPE`	Named-pipe connection to local or remote server	Windows only
`MEMORY`	Shared-memory connection to local server	Windows only

- `--shared-memory-base-name=`*`name`*

  On Windows, the shared-memory name to use, for connections made using shared memory to a local server. The default value is `MYSQL`. The shared-memory name is case sensitive.

  The server must be started with the `--shared-memory` option to enable shared-memory connections.

- `--socket=`*`file_name`*, `-S` *`file_name`*

  On Unix, the name of the Unix socket file to use, for connections made using a named pipe to a local server. The default Unix socket file name is `/tmp/mysql.sock`.

  On Windows, the name of the named pipe to use, for connections to a local server. The default Windows pipe name is `MySQL`. The pipe name is not case sensitive.

  The server must be started with the `--enable-named-pipe` option to enable named-pipe connections.

- `--ssl*`

  Options that begin with `--ssl` are used for establishing a secure connection to the server using SSL, if the server is configured with SSL support. For details, see Section 5.5.8.3, "SSL Command Options".

- `--user=`*`user_name`*, `-u` *`user_name`*

  The user name of the MySQL account you want to use. The default user name is `ODBC` on Windows or your Unix login name on Unix.

It is possible to specify different default values to be used when you make a connection so that you need not enter them on the command line each time you invoke a client program. This can be done in a couple of ways:

- You can specify connection parameters in the `[client]` section of an option file. The relevant section of the file might look like this:

```
[client]
host=host_name
user=user_name
password=your_pass
```

Section 4.2.3.3, “Using Option Files”, discusses option files further.

- You can specify some connection parameters using environment variables. The host can be specified for `mysql` using `MYSQL_HOST`. The MySQL user name can be specified using `USER` (this is for Windows only). The password can be specified using `MYSQL_PWD`, although this is insecure; see Section 5.3.2.2, “End-User Guidelines for Password Security”. For a list of variables, see Section 2.12, “Environment Variables”.

4.2.3. Specifying Program Options

There are several ways to specify options for MySQL programs:

- List the options on the command line following the program name. This is common for options that apply to a specific invocation of the program.
- List the options in an option file that the program reads when it starts. This is common for options that you want the program to use each time it runs.
- List the options in environment variables (see Section 4.2.4, “Setting Environment Variables”). This method is useful for options that you want to apply each time the program runs. In practice, option files are used more commonly for this purpose, but Section 5.6.3, “Running Multiple MySQL Instances on Unix”, discusses one situation in which environment variables can be very helpful. It describes a handy technique that uses such variables to specify the TCP/IP port number and Unix socket file for the server and for client programs.

Options are processed in order, so if an option is specified multiple times, the last occurrence takes precedence. The following command causes `mysql` to connect to the server running on `localhost`:

```
shell> mysql -h example.com -h localhost
```

If conflicting or related options are given, later options take precedence over earlier options. The following command runs `mysql` in “no column names” mode:

```
shell> mysql --column-names --skip-column-names
```

MySQL programs determine which options are given first by examining environment variables, then by reading option files, and then by checking the command line. This means that environment variables have the lowest precedence and command-line options the highest.

You can take advantage of the way that MySQL programs process options by specifying default option values for a program in an option file. That enables you to avoid typing them each time you run the program while enabling you to override the defaults if necessary by using command-line options.

An option can be specified by writing it in full or as any unambiguous prefix. For example, the `--compress` option can be given to `mysqldump` as `--compr`, but not as `--comp` because the latter is ambiguous:

```
shell> mysqldump --comp
mysqldump: ambiguous option '--comp' (compatible, compress)
```

Be aware that the use of option prefixes can cause problems in the event that new options are implemented for a program. A prefix that is unambiguous now might become ambiguous in the future.

4.2.3.1. Using Options on the Command Line

Program options specified on the command line follow these rules:

- Options are given after the command name.
- An option argument begins with one dash or two dashes, depending on whether it is a short form or long form of the option name. Many options have both short and long forms. For example, `-?` and `--help` are the short and long forms of the option that instructs a MySQL program to display its help message.

- Option names are case sensitive. `-v` and `-V` are both legal and have different meanings. (They are the corresponding short forms of the `--verbose` and `--version` options.)
- Some options take a value following the option name. For example, `-h localhost` or `--host=localhost` indicate the MySQL server host to a client program. The option value tells the program the name of the host where the MySQL server is running.
- For a long option that takes a value, separate the option name and the value by an "`=`" sign. For a short option that takes a value, the option value can immediately follow the option letter, or there can be a space between: `-hlocalhost` and `-h localhost` are equivalent. An exception to this rule is the option for specifying your MySQL password. This option can be given in long form as `--password=pass_val` or as `--password`. In the latter case (with no password value given), the program prompts you for the password. The password option also may be given in short form as `-ppass_val` or as `-p`. However, for the short form, if the password value is given, it must follow the option letter with *no intervening space*. The reason for this is that if a space follows the option letter, the program has no way to tell whether a following argument is supposed to be the password value or some other kind of argument. Consequently, the following two commands have two completely different meanings:

  ```
  shell> mysql -ptest
  shell> mysql -p test
  ```

  The first command instructs `mysql` to use a password value of `test`, but specifies no default database. The second instructs `mysql` to prompt for the password value and to use `test` as the default database.
- Within option names, dash ("`-`") and underscore ("`_`") may be used interchangeably. For example, `--skip-grant-tables` and `--skip_grant_tables` are equivalent. (However, the leading dashes cannot be given as underscores.)
- For options that take a numeric value, the value can be given with a suffix of `K`, `M`, or `G` (either uppercase or lowercase) to indicate a multiplier of 1024, 1024^2 or 1024^3. For example, the following command tells `mysqladmin` to ping the server 1024 times, sleeping 10 seconds between each ping:

  ```
  mysql> mysqladmin --count=1K --sleep=10 ping
  ```

Option values that contain spaces must be quoted when given on the command line. For example, the `--execute` (or `-e`) option can be used with `mysql` to pass SQL statements to the server. When this option is used, `mysql` executes the statements in the option value and exits. The statements must be enclosed by quotation marks. For example, you can use the following command to obtain a list of user accounts:

```
mysql> mysql -u root -p --execute="SELECT User, Host FROM mysql.user"
Enter password: ******
+------+-----------+
| User | Host      |
+------+-----------+
|      | gigan     |
| root | gigan     |
|      | localhost |
| jon  | localhost |
| root | localhost |
+------+-----------+
shell>
```

Note that the long form (`--execute`) is followed by an equal sign (`=`).

If you wish to use quoted values within a statement, you will either need to escape the inner quotation marks, or use a different type of quotation marks within the statement from those used to quote the statement itself. The capabilities of your command processor dictate your choices for whether you can use single or double quotation marks and the syntax for escaping quote characters. For example, if your command processor supports quoting with single or double quotation marks, you can use double quotation marks around the statement, and single quotation marks for any quoted values within the statement.

Multiple SQL statements may be passed in the option value on the command line, separated by semicolons:

```
shell> mysql -u root -p -e "SELECT VERSION();SELECT NOW()"
Enter password: ******
+-----------------+
| VERSION()       |
+-----------------+
| 5.1.5-alpha-log |
+-----------------+
+---------------------+
| NOW()               |
+---------------------+
| 2006-01-05 21:19:04 |
+---------------------+
```

4.2.3.2. Program Option Modifiers

Some options are “boolean” and control behavior that can be turned on or off. For example, the `mysql` client supports a `--column-names` option that determines whether or not to display a row of column names at the beginning of query results. By default, this option is enabled. However, you may want to disable it in some instances, such as when sending the output of `mysql` into another program that expects to see only data and not an initial header line.

To disable column names, you can specify the option using any of these forms:

```
--disable-column-names
--skip-column-names
--column-names=0
```

The `--disable` and `--skip` prefixes and the `=0` suffix all have the same effect: They turn the option off.

The “enabled” form of the option may be specified in any of these ways:

```
--column-names
--enable-column-names
--column-names=1
```

As of MySQL 5.5.10, the values `ON`, `TRUE`, `OFF`, and `FALSE` are also recognized for boolean options (not case sensitive).

If an option is prefixed by `--loose`, a program does not exit with an error if it does not recognize the option, but instead issues only a warning:

```
shell> mysql --loose-no-such-option
mysql: WARNING: unknown option '--no-such-option'
```

The `--loose` prefix can be useful when you run programs from multiple installations of MySQL on the same machine and list options in an option file, An option that may not be recognized by all versions of a program can be given using the `--loose` prefix (or `loose` in an option file). Versions of the program that recognize the option process it normally, and versions that do not recognize it issue a warning and ignore it.

`mysqld` enables a limit to be placed on how large client programs can set dynamic system variables. To do this, use a `--maximum` prefix with the variable name. For example, `--maximum-query_cache_size=4M` prevents any client from making the query cache size larger than 4MB.

4.2.3.3. Using Option Files

Most MySQL programs can read startup options from option files (also sometimes called configuration files). Option files provide a convenient way to specify commonly used options so that they need not be entered on the command line each time you run a program. For the MySQL server, MySQL provides a number of preconfigured option files.

To determine whether a program reads option files, invoke it with the `--help` option. (For `mysqld`, use `--verbose` and `--help`.) If the program reads option files, the help message indicates which files it looks for and which option groups it recognizes.

On Windows, MySQL programs read startup options from the following files, in the specified order (top items are used first).

File Name	**Purpose**
`*WINDIR*\my.ini`, `*WINDIR*\my.cnf`	Global options
`C:\my.ini`, `C:\my.cnf`	Global options
`*INSTALLDIR*\my.ini`, `*INSTALLDIR*\my.cnf`	Global options
`defaults-extra-file`	The file specified with `--defaults-extra-file=*path*`, if any

`WINDIR` represents the location of your Windows directory. This is commonly `C:\WINDOWS`. You can determine its exact location from the value of the `WINDIR` environment variable using the following command:

```
C:\> echo %WINDIR%
```

`INSTALLDIR` represents the MySQL installation directory. This is typically `C:\PROGRAMDIR\MySQL\MySQL 5.5 Server` where *`PROGRAMDIR`* represents the programs directory (usually `Program Files` on English-language versions of Windows), when MySQL 5.5 has been installed using the installation and configuration wizards. See The Location of the my.ini File.

On Unix, Linux and Mac OS X, MySQL programs read startup options from the following files, in the specified order (top items are used first).

File Name	Purpose
`/etc/my.cnf`	Global options
`/etc/mysql/my.cnf`	Global options
`SYSCONFDIR/my.cnf`	Global options
`$MYSQL_HOME/my.cnf`	Server-specific options
`defaults-extra-file`	The file specified with `--defaults-extra-file=path`, if any
`~/.my.cnf`	User-specific options

`~` represents the current user's home directory (the value of `$HOME`).

`SYSCONFDIR` represents the directory specified with the `SYSCONFDIR` option to `CMake` when MySQL was built. By default, this is the `etc` directory located under the compiled-in installation directory.

`MYSQL_HOME` is an environment variable containing the path to the directory in which the server-specific `my.cnf` file resides. If `MYSQL_HOME` is not set and you start the server using the `mysqld_safe` program, `mysqld_safe` attempts to set `MYSQL_HOME` as follows:

- Let `BASEDIR` and `DATADIR` represent the path names of the MySQL base directory and data directory, respectively.
- If there is a `my.cnf` file in `DATADIR` but not in `BASEDIR`, `mysqld_safe` sets `MYSQL_HOME` to `DATADIR`.
- Otherwise, if `MYSQL_HOME` is not set and there is no `my.cnf` file in `DATADIR`, `mysqld_safe` sets `MYSQL_HOME` to `BASEDIR`.

In MySQL 5.5, use of `DATADIR` as the location for `my.cnf` is deprecated.

Typically, `DATADIR` is `/usr/local/mysql/data` for a binary installation or `/usr/local/var` for a source installation. Note that this is the data directory location that was specified at configuration time, not the one specified with the `--datadir` option when `mysqld` starts. Use of `--datadir` at runtime has no effect on where the server looks for option files, because it looks for them before processing any options.

MySQL looks for option files in the order just described and reads any that exist. If an option file that you want to use does not exist, create it with a plain text editor.

If multiple instances of a given option are found, the last instance takes precedence. There is one exception: For `mysqld`, the *first* instance of the `--user` option is used as a security precaution, to prevent a user specified in an option file from being overridden on the command line.

> **Note**
>
> On Unix platforms, MySQL ignores configuration files that are world-writable. This is intentional as a security measure.

Any long option that may be given on the command line when running a MySQL program can be given in an option file as well. To get the list of available options for a program, run it with the `--help` option.

The syntax for specifying options in an option file is similar to command-line syntax (see Section 4.2.3.1, “Using Options on the Command Line”). However, in an option file, you omit the leading two dashes from the option name and you specify only one option per line. For example, `--quick` and `--host=localhost` on the command line should be specified as `quick` and `host=localhost` on separate lines in an option file. To specify an option of the form `--loose-opt_name` in an option file, write it as `loose-opt_name`.

Empty lines in option files are ignored. Nonempty lines can take any of the following forms:

- `#comment`, `;comment`

  Comment lines start with “`#`” or “`;`”. A “`#`” comment can start in the middle of a line as well.

- `[group]`

  `group` is the name of the program or group for which you want to set options. After a group line, any option-setting lines apply to the named group until the end of the option file or another group line is given.

- `opt_name`

This is equivalent to `--opt_name` on the command line.

- `opt_name=value`

  This is equivalent to `--opt_name=value` on the command line. In an option file, you can have spaces around the "`=`" character, something that is not true on the command line. You can optionally enclose the value within single quotation marks or double quotation marks, which is useful if the value contains a "`#`" comment character.

Leading and trailing spaces are automatically deleted from option names and values.

You can use the escape sequences "`\b`", "`\t`", "`\n`", "`\r`", "`\\`", and "`\s`" in option values to represent the backspace, tab, newline, carriage return, backslash, and space characters. The escaping rules in option files are:

- If a backslash is followed by a valid escape sequence character, the sequence is converted to the character represented by the sequence. For example, "`\s`" is converted to a space.
- If a backslash is not followed by a valid escape sequence character, it remains unchanged. For example, "`\S`" is retained as is.

The preceding rules mean that a literal backslash can be given as "`\\`", or as "`\`" if it is not followed by a valid escape sequence character.

The rules for escape sequences in option files differ slightly from the rules for escape sequences in string literals in SQL statements. In the latter context, if "`x`" is not a value escape sequence character, "`\x`" becomes "`x`" rather than "`\x`". See Section 8.1.1, "Strings".

The escaping rules for option file values are especially pertinent for Windows path names, which use "`\`" as a path name separator. A separator in a Windows path name must be written as "`\\`" if it is followed by an escape sequence character. It can be written as "`\\`" or "`\`" if it is not. Alternatively, "`/`" may be used in Windows path names and will be treated as "`\`". Suppose that you want to specify a base directory of `C:\Program Files\MySQL\MySQL Server 5.5` in an option file. This can be done several ways. Some examples:

```
basedir="C:\Program Files\MySQL\MySQL Server 5.5"
basedir="C:\\Program Files\\MySQL\\MySQL Server 5.5"
basedir="C:/Program Files/MySQL/MySQL Server 5.5"
basedir=C:\\Program\sFiles\\MySQL\\MySQL\sServer\s5.5
```

If an option group name is the same as a program name, options in the group apply specifically to that program. For example, the `[mysqld]` and `[mysql]` groups apply to the `mysqld` server and the `mysql` client program, respectively.

The `[client]` option group is read by all client programs (but *not* by `mysqld`). This enables you to specify options that apply to all clients. For example, `[client]` is the perfect group to use to specify the password that you use to connect to the server. (But make sure that the option file is readable and writable only by yourself, so that other people cannot find out your password.) Be sure not to put an option in the `[client]` group unless it is recognized by *all* client programs that you use. Programs that do not understand the option quit after displaying an error message if you try to run them.

Here is a typical global option file:

```
[client]
port=3306
socket=/tmp/mysql.sock

[mysqld]
port=3306
socket=/tmp/mysql.sock
key_buffer_size=16M
max_allowed_packet=8M

[mysqldump]
quick
```

The preceding option file uses `var_name=value` syntax for the lines that set the `key_buffer_size` and `max_allowed_packet` variables.

Here is a typical user option file:

```
[client]
# The following password will be sent to all standard MySQL clients
password="my_password"

[mysql]
no-auto-rehash
connect_timeout=2
```

```
[mysqlhotcopy]
interactive-timeout
```

If you want to create option groups that should be read by `mysqld` servers from a specific MySQL release series only, you can do this by using groups with names of `[mysqld-5.1]`, `[mysqld-5.5]`, and so forth. The following group indicates that the `--new` option should be used only by MySQL servers with 5.5.x version numbers:

```
[mysqld-5.5]
new
```

It is possible to use `!include` directives in option files to include other option files and `!includedir` to search specific directories for option files. For example, to include the `/home/mydir/myopt.cnf` file, use the following directive:

```
!include /home/mydir/myopt.cnf
```

To search the `/home/mydir` directory and read option files found there, use this directive:

```
!includedir /home/mydir
```

There is no guarantee about the order in which the option files in the directory will be read.

> **Note**
>
> Currently, any files to be found and included using the `!includedir` directive on Unix operating systems *must* have file names ending in `.cnf`. On Windows, this directive checks for files with the `.ini` or `.cnf` extension.

Write the contents of an included option file like any other option file. That is, it should contain groups of options, each preceded by a `[group]` line that indicates the program to which the options apply.

While an included file is being processed, only those options in groups that the current program is looking for are used. Other groups are ignored. Suppose that a `my.cnf` file contains this line:

```
!include /home/mydir/myopt.cnf
```

And suppose that `/home/mydir/myopt.cnf` looks like this:

```
[mysqladmin]
force

[mysqld]
key_buffer_size=16M
```

If `my.cnf` is processed by `mysqld`, only the `[mysqld]` group in `/home/mydir/myopt.cnf` is used. If the file is processed by `mysqladmin`, only the `[mysqladmin]` group is used. If the file is processed by any other program, no options in `/home/mydir/myopt.cnf` are used.

The `!includedir` directive is processed similarly except that all option files in the named directory are read.

4.2.3.3.1. Command-Line Options that Affect Option-File Handling

Most MySQL programs that support option files handle the following options. They affect option-file handling, so they must be given on the command line and not in an option file. To work properly, each of these options must immediately follow the command name, with these exceptions:

- `--print-defaults` may be used immediately after `--defaults-file` or `--defaults-extra-file`.
- On Windows, if the `--defaults-file` and `--install` options are given, `--install` option must be first. See Section 2.3.5.7, “Starting MySQL as a Windows Service”.

When specifying file names, you should avoid the use of the “`~`” shell metacharacter because it might not be interpreted as you expect.

- `--defaults-extra-file=file_name`

  Read this option file after the global option file but (on Unix) before the user option file. If the file does not exist or is otherwise inaccessible, the program exits with an error. Before MySQL 5.5.8, *`file_name`* must be the full path name to the file. As of

MySQL 5.5.8, the name is interpreted relative to the current directory if given as a relative path name.

- `--defaults-file=file_name`

  Use only the given option file. If the file does not exist or is otherwise inaccessible, the program exits with an error. Before MySQL 5.5.8, *`file_name`* must be the full path name to the file. As of MySQL 5.5.8, the name is interpreted relative to the current directory if given as a relative path name.

- `--defaults-group-suffix=str`

  If this option is given, the program reads not only its usual option groups, but also groups with the usual names and a suffix of *`str`*. For example, the `mysql` client normally reads the `[client]` and `[mysql]` groups. If the `--defaults-group-suffix=_other` option is given, `mysql` also reads the `[client_other]` and `[mysql_other]` groups.

- `--no-defaults`

  Do not read any option files. If a program does not start because it is reading unknown options from an option file, `--no-defaults` can be used to prevent the program from reading them.

- `--print-defaults`

  Print the program name and all options that it gets from option files.

4.2.3.3.2. Preconfigured Option Files

MySQL provides a number of preconfigured option files that can be used as a basis for tuning the MySQL server. Look for files such as `my-small.cnf`, `my-medium.cnf`, `my-large.cnf`, and `my-huge.cnf`, which are sample option files for small, medium, large, and very large systems. On Windows, the extension is `.ini` rather than `.cnf`.

> **Note**
>
> On Windows, the `.ini` or `.cnf` option file extension might not be displayed.

For a binary distribution, look for the files in or under your installation directory. If you have a source distribution, look in the `support-files` directory. You can rename a copy of a sample file and place it in the appropriate location for use as a base configuration file. Regarding names and appropriate location, see the general information provided in Section 4.2.3.3, “Using Option Files”.

4.2.3.4. Using Options to Set Program Variables

Many MySQL programs have internal variables that can be set at runtime using the `SET` statement. See Section 12.4.4, “SET Syntax”, and Section 5.1.4, “Using System Variables”.

Most of these program variables also can be set at server startup by using the same syntax that applies to specifying program options. For example, `mysql` has a `max_allowed_packet` variable that controls the maximum size of its communication buffer. To set the `max_allowed_packet` variable for `mysql` to a value of 16MB, use either of the following commands:

```
shell> mysql --max_allowed_packet=16777216
shell> mysql --max_allowed_packet=16M
```

The first command specifies the value in bytes. The second specifies the value in megabytes. For variables that take a numeric value, the value can be given with a suffix of `K`, `M`, or `G` (either uppercase or lowercase) to indicate a multiplier of 1024, 1024^2 or 1024^3. (For example, when used to set `max_allowed_packet`, the suffixes indicate units of kilobytes, megabytes, or gigabytes.)

In an option file, variable settings are given without the leading dashes:

```
[mysql]
max_allowed_packet=16777216
```

Or:

```
[mysql]
max_allowed_packet=16M
```

If you like, underscores in a variable name can be specified as dashes. The following option groups are equivalent. Both set the size of the server's key buffer to 512MB:

```
[mysqld]
key_buffer_size=512M

[mysqld]
key-buffer-size=512M
```

A variable can be specified by writing it in full or as any unambiguous prefix. For example, the `max_allowed_packet` variable can be set for `mysql` as `--max_a`, but not as `--max` because the latter is ambiguous:

```
shell> mysql --max=1000000
mysql: ambiguous option '--max=1000000' (max_allowed_packet, max_join_size)
```

Be aware that the use of variable prefixes can cause problems in the event that new variables are implemented for a program. A prefix that is unambiguous now might become ambiguous in the future.

Suffixes for specifying a value multiplier can be used when setting a variable at server startup, but not to set the value with `SET` at runtime. On the other hand, with `SET` you can assign a variable's value using an expression, which is not true when you set a variable at server startup. For example, the first of the following lines is legal at server startup, but the second is not:

```
shell> mysql --max_allowed_packet=16M
shell> mysql --max_allowed_packet=16*1024*1024
```

Conversely, the second of the following lines is legal at runtime, but the first is not:

```
mysql> SET GLOBAL max_allowed_packet=16M;
mysql> SET GLOBAL max_allowed_packet=16*1024*1024;
```

> **Note**
>
> Before MySQL 4.0.2, the only syntax for setting program variables was `--set-variable=option=value` (or `set-variable=option=value` in option files). Underscores cannot be given as dashes, and the variable name must be specified in full. This syntax is deprecated and was removed in MySQL 5.5.3.

4.2.3.5. Option Defaults, Options Expecting Values, and the = Sign

By convention, long forms of options that assign a value are written with an equals (`=`) sign, like this:

```
shell> mysql --host=tonfisk --user=jon
```

For options that require a value (that is, not having a default value), the equal sign is not required, and so the following is also valid:

```
shell> mysql --host tonfisk --user jon
```

In both cases, the `mysql` client attempts to connect to a MySQL server running on the host named “tonfisk” using an account with the user name “jon”.

Due to this behavior, problems can occasionally arise when no value is provided for an option that expects one. Consider the following example, where a user connects to a MySQL server running on host `tonfisk` as user `jon`:

```
shell> mysql --host 85.224.35.45 --user jon
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 3
Server version: 5.5.16 Source distribution

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql> SELECT CURRENT_USER();
+----------------+
| CURRENT_USER() |
+----------------+
| jon@%          |
+----------------+
1 row in set (0.00 sec)
```

Omitting the required value for one of these option yields an error, such as the one shown here:

```
shell> mysql --host 85.224.35.45 --user
MYSQL: OPTION '--USER' REQUIRES AN ARGUMENT
```

In this case, `mysql` was unable to find a value following the `--user` option because nothing came after it on the command line. However, if you omit the value for an option that is *not* the last option to be used, you obtain a different error that you may not be expecting:

```
shell> mysql --host --user jon
ERROR 2005 (HY000): Unknown MySQL server host '--user' (1)
```

Because `mysql` assumes that any string following `--host` on the command line is a host name, `--host --user` is interpreted as `--host=--user`, and the client attempts to connect to a MySQL server running on a host named “--user”.

Options having default values always require an equal sign when assigning a value; failing to do so causes an error. For example, the MySQL server `--log-error` option has the default value `host_name.err`, where `host_name` is the name of the host on which MySQL is running. Assume that you are running MySQL on a computer whose host name is “tonfisk”, and consider the following invocation of `mysqld_safe`:

```
shell> mysqld_safe &
[1] 11699
shell> 080112 12:53:40 mysqld_safe Logging to '/usr/local/mysql/var/tonfisk.err'.
080112 12:53:40 mysqld_safe Starting mysqld daemon with databases from /usr/local/mysql/var
shell>
```

After shutting down the server, restart it as follows:

```
shell> mysqld_safe --log-error &
[1] 11699
shell> 080112 12:53:40 mysqld_safe Logging to '/usr/local/mysql/var/tonfisk.err'.
080112 12:53:40 mysqld_safe Starting mysqld daemon with databases from /usr/local/mysql/var
shell>
```

The result is the same, since `--log-error` is not followed by anything else on the command line, and it supplies its own default value. (The `&` character tells the operating system to run MySQL in the background; it is ignored by MySQL itself.) Now suppose that you wish to log errors to a file named `my-errors.err`. You might try starting the server with `--log-error my-errors`, but this does not have the intended effect, as shown here:

```
shell> mysqld_safe --log-error my-errors &
[1] 31357
shell> 080111 22:53:31 mysqld_safe Logging to '/usr/local/mysql/var/tonfisk.err'.
080111 22:53:32 mysqld_safe Starting mysqld daemon with databases from /usr/local/mysql/var
080111 22:53:34 mysqld_safe mysqld from pid file /usr/local/mysql/var/tonfisk.pid ended

[1]+  Done                    ./mysqld_safe --log-error my-errors
```

The server attempted to start using `/usr/local/mysql/var/tonfisk.err` as the error log, but then shut down. Examining the last few lines of this file shows the reason:

```
shell> tail /usr/local/mysql/var/tonfisk.err
080111 22:53:32  InnoDB: Started; log sequence number 0 46409
/usr/local/mysql/libexec/mysqld: Too many arguments (first extra is 'my-errors').
Use --verbose --help to get a list of available options
080111 22:53:32 [ERROR] Aborting

080111 22:53:32  InnoDB: Starting shutdown...
080111 22:53:34  InnoDB: Shutdown completed; log sequence number 0 46409
080111 22:53:34 [Note] /usr/local/mysql/libexec/mysqld: Shutdown complete

080111 22:53:34 mysqld_safe mysqld from pid file /usr/local/mysql/var/tonfisk.pid ended
```

Because the `--log-error` option supplies a default value, you must use an equal sign to assign a different value to it, as shown here:

```
shell> mysqld_safe --log-error=my-errors &
[1] 31437
shell> 080111 22:54:15 mysqld_safe Logging to '/usr/local/mysql/var/my-errors.err'.
080111 22:54:15 mysqld_safe Starting mysqld daemon with databases from /usr/local/mysql/var

shell>
```

Now the server has been started successfully, and is logging errors to the file `/usr/local/mysql/var/my-errors.err`.

Similar issues can arise when specifying option values in option files. For example, consider a `my.cnf` file that contains the following:

```
[mysql]

host
user
```

When the `mysql` client reads this file, these entries are parsed as `--host --user` or `--host=--user`, with the result shown here:

```
shell> mysql
```

```
ERROR 2005 (HY000): Unknown MySQL server host '--user' (1)
```

However, in option files, an equal sign is not assumed. Suppose the `my.cnf` file is as shown here:

```
[mysql]

user jon
```

Trying to start `mysql` in this case causes a different error:

```
shell> mysql
mysql: unknown option '--user jon'
```

A similar error would occur if you were to write `host tonfisk` in the option file rather than `host=tonfisk`. Instead, you must use the equal sign:

```
[mysql]

user=jon
```

Now the login attempt succeeds:

```
shell> mysql
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 5
Server version: 5.5.16 Source distribution

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql> SELECT USER();
+---------------+
| USER()        |
+---------------+
| jon@localhost |
+---------------+
1 row in set (0.00 sec)
```

This is not the same behavior as with the command line, where the equals sign is not required:

```
shell> mysql --user jon --host tonfisk
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 6
Server version: 5.5.16 Source distribution

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql> SELECT USER();
+---------------+
| USER()        |
+---------------+
| jon@tonfisk   |
+---------------+
1 row in set (0.00 sec)
```

In MySQL 5.5, specifying an option requiring a value without a value in an option file causes the server to abort with an error. Suppose that `my.cnf` contains the following:

```
[mysqld]
log_error
relay_log
relay_log_index
```

This causes the server to fail on startup, as shown here:

```
shell> mysqld_safe &

090514 09:48:39 mysqld_safe Logging to '/home/jon/bin/mysql-5.5/var/tonfisk.err'.
090514 09:48:39 mysqld_safe Starting mysqld daemon with databases from /home/jon/bin/mysql-5.5/var
090514 09:48:39 mysqld_safe mysqld from pid file /home/jon/bin/mysql-5.5/var/tonfisk.pid ended
```

The `--log-error` option does not require an argument; however, the `--relay-log` option requires one, as shown in the error log (which in the absence of a specified value, defaults to *`datadir/hostname`*`.err`):

```
shell> tail -n 3 ../var/tonfisk.err

090514 09:48:39 mysqld_safe Starting mysqld daemon with databases from /home/jon/bin/mysql-5.5/var
090514  9:48:39 [ERROR] /home/jon/bin/mysql-5.5/libexec/mysqld: option '--relay-log' requires an argument
090514  9:48:39 [ERROR] Aborting
```

This is a change from previous behavior, where the server would have interpreted the last two lines in the example `my.cnf` file as `--relay-log=relay_log_index` and created a relay log file using “relay_log_index” as the basename. (Bug #25192)

4.2.4. Setting Environment Variables

Environment variables can be set at the command prompt to affect the current invocation of your command processor, or set permanently to affect future invocations. To set a variable permanently, you can set it in a startup file or by using the interface provided by your system for this purpose. Consult the documentation for your command interpreter for specific details. Section 2.12, “Environment Variables”, lists all environment variables that affect MySQL program operation.

To specify a value for an environment variable, use the syntax appropriate for your command processor. For example, on Windows, you can set the `USER` variable to specify your MySQL account name. To do so, use this syntax:

```
SET USER=your_name
```

The syntax on Unix depends on your shell. Suppose that you want to specify the TCP/IP port number using the `MYSQL_TCP_PORT` variable. Typical syntax (such as for `sh`, `bash`, `zsh`, and so on) is as follows:

```
MYSQL_TCP_PORT=3306
export MYSQL_TCP_PORT
```

The first command sets the variable, and the `export` command exports the variable to the shell environment so that its value becomes accessible to MySQL and other processes.

For `csh` and `tcsh`, use `setenv` to make the shell variable available to the environment:

```
setenv MYSQL_TCP_PORT 3306
```

The commands to set environment variables can be executed at your command prompt to take effect immediately, but the settings persist only until you log out. To have the settings take effect each time you log in, use the interface provided by your system or place the appropriate command or commands in a startup file that your command interpreter reads each time it starts.

On Windows, you can set environment variables using the System Control Panel (under Advanced).

On Unix, typical shell startup files are `.bashrc` or `.bash_profile` for `bash`, or `.tcshrc` for `tcsh`.

Suppose that your MySQL programs are installed in `/usr/local/mysql/bin` and that you want to make it easy to invoke these programs. To do this, set the value of the `PATH` environment variable to include that directory. For example, if your shell is `bash`, add the following line to your `.bashrc` file:

```
PATH=${PATH}:/usr/local/mysql/bin
```

`bash` uses different startup files for login and nonlogin shells, so you might want to add the setting to `.bashrc` for login shells and to `.bash_profile` for nonlogin shells to make sure that `PATH` is set regardless.

If your shell is `tcsh`, add the following line to your `.tcshrc` file:

```
setenv PATH ${PATH}:/usr/local/mysql/bin
```

If the appropriate startup file does not exist in your home directory, create it with a text editor.

After modifying your `PATH` setting, open a new console window on Windows or log in again on Unix so that the setting goes into effect.

4.3. MySQL Server and Server-Startup Programs

This section describes `mysqld`, the MySQL server, and several programs that are used to start the server.

4.3.1. `mysqld` — The MySQL Server

`mysqld`, also known as MySQL Server, is the main program that does most of the work in a MySQL installation. MySQL Server manages access to the MySQL data directory that contains databases and tables. The data directory is also the default location for other information such as log files and status files.

When MySQL server starts, it listens for network connections from client programs and manages access to databases on behalf of those clients.

The `mysqld` program has many options that can be specified at startup. For a complete list of options, run this command:

```
shell> mysqld --verbose --help
```

MySQL Server also has a set of system variables that affect its operation as it runs. System variables can be set at server startup, and many of them can be changed at runtime to effect dynamic server reconfiguration. MySQL Server also has a set of status variables that provide information about its operation. You can monitor these status variables to access runtime performance characteristics.

For a full description of MySQL Server command options, system variables, and status variables, see Section 5.1, “The MySQL Server”. For information about installing MySQL and setting up the initial configuration, see Chapter 2, *Installing and Upgrading MySQL*.

4.3.2. `mysqld_safe` — MySQL Server Startup Script

`mysqld_safe` is the recommended way to start a `mysqld` server on Unix. `mysqld_safe` adds some safety features such as restarting the server when an error occurs and logging runtime information to an error log file. A description of error logging is given later in this section.

`mysqld_safe` tries to start an executable named `mysqld`. To override the default behavior and specify explicitly the name of the server you want to run, specify a `--mysqld` or `--mysqld-version` option to `mysqld_safe`. You can also use `--ledir` to indicate the directory where `mysqld_safe` should look for the server.

Many of the options to `mysqld_safe` are the same as the options to `mysqld`. See Section 5.1.2, “Server Command Options”.

Options unknown to `mysqld_safe` are passed to `mysqld` if they are specified on the command line, but ignored if they are specified in the `[mysqld_safe]` group of an option file. See Section 4.2.3.3, “Using Option Files”.

`mysqld_safe` reads all options from the `[mysqld]`, `[server]`, and `[mysqld_safe]` sections in option files. For example, if you specify a `[mysqld]` section like this, `mysqld_safe` will find and use the `--log-error` option:

```
[mysqld]
log-error=error.log
```

For backward compatibility, `mysqld_safe` also reads `[safe_mysqld]` sections, although you should rename such sections to `[mysqld_safe]` in MySQL 5.5 installations.

`mysqld_safe` supports the following options. It also reads option files and supports the options for processing them described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.1. `mysqld_safe` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--basedir=path	basedir	The path to the MySQL installation directory			
--core-file-size=size	core-file-size	The size of the core file that mysqld should be able to create			
--datadir=path	datadir	The path to the data directory			
--defaults-extra-file=path	defaults-extra-file	The name of an option file to be read in addition to the usual option files			
--defaults-file=file_name	defaults-file	The name of an option file to be read instead of the usual option files			
--help		Display a help message and exit			
--ledir=path	ledir	Use this option to indicate the path name to the directory where the server is located			
--log-error=file_name	log-error	Write the error log to the given file			
-	malloc-lib	Alternative malloc library to use for mysqld			

Format	Option File	Description	Introduction	Deprecated	Removed
-malloc-lib=[lib-name]					
--mysqld=prog_name	mysqld	The name of the server program (in the ledir directory) that you want to start			
--mysqld-version=suffix	mysqld-version	This option is similar to the --mysqld option, but you specify only the suffix for the server program name			
--nice=priority	nice	Use the nice program to set the server's scheduling priority to the given value			
--no-defaults	no-defaults	Do not read any option files			
--open-files-limit=count	open-files-limit	The number of files that mysqld should be able to open			
--pid-file=file_name	pid-file=file_name	The path name of the process ID file			
--port=number	port	The port number that the server should use when listening for TCP/IP connections			
--skip-kill-mysqld	skip-kill-mysqld	Do not try to kill stray mysqld processes			
--skip-syslog	skip-syslog	Do not write error messages to syslog; use error log file			
--socket=path	socket	The Unix socket file that the server should use when listening for local connections			
--syslog	syslog	Write error messages to syslog			
--timezone=timezone	timezone	Set the TZ time zone environment variable to the given option value			
--user={user_name|user_id}	user	Run the mysqld server as the user having the name user_name or the numeric user ID user_id			

- `--help`

  Display a help message and exit.

- `--basedir=path`

  The path to the MySQL installation directory.

- `--core-file-size=size`

  The size of the core file that `mysqld` should be able to create. The option value is passed to `ulimit -c`.

- `--datadir=path`

  The path to the data directory.

- `--defaults-extra-file=path`

  The name of an option file to be read in addition to the usual option files. This must be the first option on the command line if it is used. If the file does not exist or is otherwise inaccessible, the server will exit with an error.

- `--defaults-file=file_name`

The name of an option file to be read instead of the usual option files. This must be the first option on the command line if it is used.

- `--ledir=path`

  If `mysqld_safe` cannot find the server, use this option to indicate the path name to the directory where the server is located.

- `--log-error=file_name`

  Write the error log to the given file. See Section 5.2.2, “The Error Log”.

- `--malloc-lib=[lib_name]`

  The name of the library to use for memory allocation instead of the system `malloc()` library. Any library can be used by specifying its path name, but there is a shortcut form to enable use of the `tcmalloc` library that is shipped with binary MySQL distributions for Linux in MySQL 5.5.

  The `--malloc-lib` option works by modifying the `LD_PRELOAD` environment value to affect dynamic linking to enable the loader to find the memory-allocation library when `mysqld` runs:

  - If the option is not given, or is given without a value (`--malloc-lib=`), `LD_PRELOAD` is not modified and no attempt is made to use `tcmalloc`.

  - If the option is given as `--malloc-lib=tcmalloc`, `mysqld_safe` looks for a `tcmalloc` library in `/usr/lib` and then in the MySQL `pkglibdir` location (for example, `/usr/local/mysql/lib` or whatever is appropriate). If `tmalloc` is found, its path name is added to the beginning of the `LD_PRELOAD` value for `mysqld`. If `tcmalloc` is not found, `mysqld_safe` aborts with an error.

  - If the option is given as `--malloc-lib=/path/to/some/library`, that full path is added to the beginning of the `LD_PRELOAD` value. If the full path points to a nonexistent or unreadable file, `mysqld_safe` aborts with an error.

  - For cases where `mysqld_safe` adds a path name to `LD_PRELOAD`, it adds the path to the beginning of any existing value the variable already has.

  Linux users can use the `libtcmalloc_minimal.so` included in binary packages by adding these lines to the `my.cnf` file:

  ```
  [mysqld_safe]
  malloc-lib=tcmalloc
  ```

  Those lines also suffice for users on any platform who have installed a `tcmalloc` package in `/usr/lib`. To use a specific `tcmalloc` library, specify its full path name. Example:

  ```
  [mysqld_safe]
  malloc-lib=/opt/lib/libtcmalloc_minimal.so
  ```

- `--mysqld=prog_name`

  The name of the server program (in the `ledir` directory) that you want to start. This option is needed if you use the MySQL binary distribution but have the data directory outside of the binary distribution. If `mysqld_safe` cannot find the server, use the `--ledir` option to indicate the path name to the directory where the server is located.

- `--mysqld-version=suffix`

  This option is similar to the `--mysqld` option, but you specify only the suffix for the server program name. The basename is assumed to be `mysqld`. For example, if you use `--mysqld-version=debug`, `mysqld_safe` starts the `mysqld-debug` program in the `ledir` directory. If the argument to `--mysqld-version` is empty, `mysqld_safe` uses `mysqld` in the `ledir` directory.

- `--nice=priority`

  Use the `nice` program to set the server's scheduling priority to the given value.

- `--no-defaults`

  Do not read any option files. This must be the first option on the command line if it is used.

- `--open-files-limit=count`

  The number of files that `mysqld` should be able to open. The option value is passed to `ulimit -n`. Note that you need to start `mysqld_safe` as `root` for this to work properly!

- `--pid-file=file_name`

  The path name of the process ID file.

- `--port=port_num`

  The port number that the server should use when listening for TCP/IP connections. The port number must be 1024 or higher unless the server is started by the `root` system user.

- `--skip-kill-mysqld`

  Do not try to kill stray `mysqld` processes at startup. This option works only on Linux.

- `--socket=path`

  The Unix socket file that the server should use when listening for local connections.

- `--syslog`, `--skip-syslog`

  `--syslog` causes error messages to be sent to `syslog` on systems that support the `logger` program. `--skip-syslog` suppresses the use of `syslog`; messages are written to an error log file.

- `--syslog-tag=tag`

  For logging to `syslog`, messages from `mysqld_safe` and `mysqld` are written with a tag of `mysqld_safe` and `mysqld`, respectively. To specify a suffix for the tag, use `--syslog-tag=tag`, which modifies the tags to be `mysqld_safe-tag` and `mysqld-tag`.

- `--timezone=timezone`

  Set the `TZ` time zone environment variable to the given option value. Consult your operating system documentation for legal time zone specification formats.

- `--user={user_name|user_id}`

  Run the `mysqld` server as the user having the name *`user_name`* or the numeric user ID *`user_id`*. (“User” in this context refers to a system login account, not a MySQL user listed in the grant tables.)

If you execute `mysqld_safe` with the `--defaults-file` or `--defaults-extra-file` option to name an option file, the option must be the first one given on the command line or the option file will not be used. For example, this command will not use the named option file:

```
mysql> mysqld_safe --port=port_num --defaults-file=file_name
```

Instead, use the following command:

```
mysql> mysqld_safe --defaults-file=file_name --port=port_num
```

The `mysqld_safe` script is written so that it normally can start a server that was installed from either a source or a binary distribution of MySQL, even though these types of distributions typically install the server in slightly different locations. (See Section 2.1.5, “Installation Layouts”.) `mysqld_safe` expects one of the following conditions to be true:

- The server and databases can be found relative to the working directory (the directory from which `mysqld_safe` is invoked). For binary distributions, `mysqld_safe` looks under its working directory for `bin` and `data` directories. For source distributions, it looks for `libexec` and `var` directories. This condition should be met if you execute `mysqld_safe` from your MySQL installation directory (for example, `/usr/local/mysql` for a binary distribution).

- If the server and databases cannot be found relative to the working directory, `mysqld_safe` attempts to locate them by absolute path names. Typical locations are `/usr/local/libexec` and `/usr/local/var`. The actual locations are determined from the values configured into the distribution at the time it was built. They should be correct if MySQL is installed in the location specified at configuration time.

Because `mysqld_safe` tries to find the server and databases relative to its own working directory, you can install a binary distribution of MySQL anywhere, as long as you run `mysqld_safe` from the MySQL installation directory:

```
shell> cd mysql_installation_directory
shell> bin/mysqld_safe &
```

If `mysqld_safe` fails, even when invoked from the MySQL installation directory, you can specify the `--ledir` and `--datadir` options to indicate the directories in which the server and databases are located on your system.

When you use `mysqld_safe` to start `mysqld`, `mysqld_safe` arranges for error (and notice) messages from itself and from `mysqld` to go to the same destination.

There are several `mysqld_safe` options for controlling the destination of these messages:

- `--syslog`: Write error messages to `syslog` on systems that support the `logger` program.
- `--skip-syslog`: Do not write error messages to `syslog`. Messages are written to the default error log file (`*host_name*.err` in the data directory), or to a named file if the `--log-error` option is given.
- `--log-error=*file_name*`: Write error messages to the named error file.

If none of these options is given, the default is `--skip-syslog`.

If `--syslog` and `--log-error` are both given, a warning is issued and `--log-error` takes precedence.

When `mysqld_safe` writes a message, notices go to the logging destination (`syslog` or the error log file) and `stdout`. Errors go to the logging destination and `stderr`.

Normally, you should not edit the `mysqld_safe` script. Instead, configure `mysqld_safe` by using command-line options or options in the `[mysqld_safe]` section of a `my.cnf` option file. In rare cases, it might be necessary to edit `mysqld_safe` to get it to start the server properly. However, if you do this, your modified version of `mysqld_safe` might be overwritten if you upgrade MySQL in the future, so you should make a copy of your edited version that you can reinstall.

4.3.3. `mysql.server` — MySQL Server Startup Script

MySQL distributions on Unix include a script named `mysql.server`. It can be used on systems such as Linux and Solaris that use System V-style run directories to start and stop system services. It is also used by the Mac OS X Startup Item for MySQL.

`mysql.server` can be found in the `support-files` directory under your MySQL installation directory or in a MySQL source distribution.

If you use the Linux server RPM package (`MySQL-server-*VERSION*.rpm`), the `mysql.server` script will be installed in the `/etc/init.d` directory with the name `mysql`. You need not install it manually. See Section 2.5.1, “Installing MySQL from RPM Packages on Linux”, for more information on the Linux RPM packages.

Some vendors provide RPM packages that install a startup script under a different name such as `mysqld`.

If you install MySQL from a source distribution or using a binary distribution format that does not install `mysql.server` automatically, you can install it manually. Instructions are provided in Section 2.10.1.2, “Starting and Stopping MySQL Automatically”.

`mysql.server` reads options from the `[mysql.server]` and `[mysqld]` sections of option files. For backward compatibility, it also reads `[mysql_server]` sections, although you should rename such sections to `[mysql.server]` when using MySQL 5.5.

`mysql.server` supports the following options.

- `--basedir=*path*`

  The path to the MySQL installation directory.

- `--datadir=*path*`

  The path to the MySQL data directory.

- `--pid-file=*file_name*`

  The path name of the file in which the server should write its process ID.

- `--service-startup-timeout=*file_name*`

  How long in seconds to wait for confirmation of server startup. If the server does not start within this time, `mysql.server` exits with an error. The default value is 900. A value of 0 means not to wait at all for startup. Negative values mean to wait forever (no timeout).

- `--use-mysqld_safe`

  Use `mysqld_safe` to start the server. This is the default.

- `--user=user_name`

  The login user name to use for running `mysqld`.

4.3.4. `mysqld_multi` — Manage Multiple MySQL Servers

`mysqld_multi` is designed to manage several `mysqld` processes that listen for connections on different Unix socket files and TCP/IP ports. It can start or stop servers, or report their current status.

`mysqld_multi` searches for groups named `[mysqldN]` in `my.cnf` (or in the file named by the `--config-file` option). `N` can be any positive integer. This number is referred to in the following discussion as the option group number, or `GNR`. Group numbers distinguish option groups from one another and are used as arguments to `mysqld_multi` to specify which servers you want to start, stop, or obtain a status report for. Options listed in these groups are the same that you would use in the `[mysqld]` group used for starting `mysqld`. (See, for example, Section 2.10.1.2, “Starting and Stopping MySQL Automatically”.) However, when using multiple servers, it is necessary that each one use its own value for options such as the Unix socket file and TCP/IP port number. For more information on which options must be unique per server in a multiple-server environment, see Section 5.6, “Running Multiple MySQL Instances on One Machine”.

To invoke `mysqld_multi`, use the following syntax:

```
shell> mysqld_multi [options] {start|stop|report} [GNR[,GNR] ...]
```

`start`, `stop`, and `report` indicate which operation to perform. You can perform the designated operation for a single server or multiple servers, depending on the `GNR` list that follows the option name. If there is no list, `mysqld_multi` performs the operation for all servers in the option file.

Each `GNR` value represents an option group number or range of group numbers. The value should be the number at the end of the group name in the option file. For example, the `GNR` for a group named `[mysqld17]` is `17`. To specify a range of numbers, separate the first and last numbers by a dash. The `GNR` value `10-13` represents groups `[mysqld10]` through `[mysqld13]`. Multiple groups or group ranges can be specified on the command line, separated by commas. There must be no whitespace characters (spaces or tabs) in the `GNR` list; anything after a whitespace character is ignored.

This command starts a single server using option group `[mysqld17]`:

```
shell> mysqld_multi start 17
```

This command stops several servers, using option groups `[mysqld8]` and `[mysqld10]` through `[mysqld13]`:

```
shell> mysqld_multi stop 8,10-13
```

For an example of how you might set up an option file, use this command:

```
shell> mysqld_multi --example
```

`mysqld_multi` searches for option files as follows:

- With `--no-defaults`, no option files are read.
- With `--defaults-file=file_name`, only the named file is read.
- Otherwise, option files in the standard list of locations are read, including any file named by the `--defaults-extra-file=file_name` option, if one is given. (If the option is given multiple times, the last value is used.)

Option files read are searched for `[mysqld_multi]` and `[mysqldN]` option groups. The `[mysqld_multi]` group can be used for options to `mysqld_multi` itself. `[mysqldN]` groups can be used for options passed to specific `mysqld` instances.

The `[mysqld]` or `[mysqld_safe]` groups can be used for common options read by all instances of `mysqld` or `mysqld_safe`. You can specify a `--defaults-file=file_name` option to use a different configuration file for that instance, in which case the `[mysqld]` or `[mysqld_safe]` groups from that file will be used for that instance.

`mysqld_multi` supports the following options.

- `--help`

  Display a help message and exit.

- `--config-file=file_name`

  This option is deprecated. If given, it is treated the same way as `--defaults-extra-file`, described earlier. `--config-file` was removed in MySQL 5.5.3.

- `--example`

  Display a sample option file.

- `--log=file_name`

  Specify the name of the log file. If the file exists, log output is appended to it.

- `--mysqladmin=prog_name`

  The `mysqladmin` binary to be used to stop servers.

- `--mysqld=prog_name`

  The `mysqld` binary to be used. Note that you can specify `mysqld_safe` as the value for this option also. If you use `mysqld_safe` to start the server, you can include the `mysqld` or `ledir` options in the corresponding `[mysqldN]` option group. These options indicate the name of the server that `mysqld_safe` should start and the path name of the directory where the server is located. (See the descriptions for these options in Section 4.3.2, "`mysqld_safe` — MySQL Server Startup Script".) Example:

  ```
  [mysqld38]
  mysqld = mysqld-debug
  ledir  = /opt/local/mysql/libexec
  ```

- `--no-log`

  Print log information to `stdout` rather than to the log file. By default, output goes to the log file.

- `--password=password`

  The password of the MySQL account to use when invoking `mysqladmin`. Note that the password value is not optional for this option, unlike for other MySQL programs.

- `--silent`

  Silent mode; disable warnings.

- `--tcp-ip`

  Connect to each MySQL server through the TCP/IP port instead of the Unix socket file. (If a socket file is missing, the server might still be running, but accessible only through the TCP/IP port.) By default, connections are made using the Unix socket file. This option affects `stop` and `report` operations.

- `--user=user_name`

  The user name of the MySQL account to use when invoking `mysqladmin`.

- `--verbose`

  Be more verbose.

- `--version`

  Display version information and exit.

Some notes about `mysqld_multi`:

- **Most important**: Before using `mysqld_multi` be sure that you understand the meanings of the options that are passed to the `mysqld` servers and *why* you would want to have separate `mysqld` processes. Beware of the dangers of using multiple `mysqld` servers with the same data directory. Use separate data directories, unless you *know* what you are doing. Starting multiple servers with the same data directory does *not* give you extra performance in a threaded system. See Section 5.6, "Running

Multiple MySQL Instances on One Machine”.

- **Important**

  Make sure that the data directory for each server is fully accessible to the Unix account that the specific `mysqld` process is started as. *Do not* use the Unix *`root`* account for this, unless you *know* what you are doing. See Section 5.3.6, “How to Run MySQL as a Normal User”.

- Make sure that the MySQL account used for stopping the `mysqld` servers (with the `mysqladmin` program) has the same user name and password for each server. Also, make sure that the account has the `SHUTDOWN` privilege. If the servers that you want to manage have different user names or passwords for the administrative accounts, you might want to create an account on each server that has the same user name and password. For example, you might set up a common `multi_admin` account by executing the following commands for each server:

  ```
  shell> mysql -u root -S /tmp/mysql.sock -p
  Enter password:
  mysql> GRANT SHUTDOWN ON *.*
      -> TO 'multi_admin'@'localhost' IDENTIFIED BY 'multipass';
  ```

  See Section 5.4, “The MySQL Access Privilege System”. You have to do this for each `mysqld` server. Change the connection parameters appropriately when connecting to each one. Note that the host name part of the account name must permit you to connect as `multi_admin` from the host where you want to run `mysqld_multi`.

- The Unix socket file and the TCP/IP port number must be different for every `mysqld`. (Alternatively, if the host has multiple network addresses, you can use `--bind-address` to cause different servers to listen to different interfaces.)

- The `--pid-file` option is very important if you are using `mysqld_safe` to start `mysqld` (for example, `--mysqld=mysqld_safe`) Every `mysqld` should have its own process ID file. The advantage of using `mysqld_safe` instead of `mysqld` is that `mysqld_safe` monitors its `mysqld` process and restarts it if the process terminates due to a signal sent using `kill -9` or for other reasons, such as a segmentation fault. Please note that the `mysqld_safe` script might require that you start it from a certain place. This means that you might have to change location to a certain directory before running `mysqld_multi`. If you have problems starting, please see the `mysqld_safe` script. Check especially the lines:

  ```
  -----------------------------------------------------------------
  MY_PWD=`pwd`
  # Check if we are starting this relative (for the binary release)
  if test -d $MY_PWD/data/mysql -a \
     -f ./share/mysql/english/errmsg.sys -a \
     -x ./bin/mysqld
  -----------------------------------------------------------------
  ```

  The test performed by these lines should be successful, or you might encounter problems. See Section 4.3.2, “`mysqld_safe` — MySQL Server Startup Script”.

- You might want to use the `--user` option for `mysqld`, but to do this you need to run the `mysqld_multi` script as the Unix superuser (`root`). Having the option in the option file doesn't matter; you just get a warning if you are not the superuser and the `mysqld` processes are started under your own Unix account.

The following example shows how you might set up an option file for use with `mysqld_multi`. The order in which the `mysqld` programs are started or stopped depends on the order in which they appear in the option file. Group numbers need not form an unbroken sequence. The first and fifth `[mysqldN]` groups were intentionally omitted from the example to illustrate that you can have “gaps” in the option file. This gives you more flexibility.

```
# This file should probably be in your home dir (~/.my.cnf)
# or /etc/my.cnf
# Version 2.1 by Jani Tolonen

[mysqld_multi]
mysqld     = /usr/local/bin/mysqld_safe
mysqladmin = /usr/local/bin/mysqladmin
user       = multi_admin
password   = multipass

[mysqld2]
socket     = /tmp/mysql.sock2
port       = 3307
pid-file   = /usr/local/mysql/var2/hostname.pid2
datadir    = /usr/local/mysql/var2
language   = /usr/local/share/mysql/english
user       = john

[mysqld3]
socket     = /tmp/mysql.sock3
port       = 3308
pid-file   = /usr/local/mysql/var3/hostname.pid3
datadir    = /usr/local/mysql/var3
language   = /usr/local/share/mysql/swedish
```

```
user       = monty

[mysqld4]
socket     = /tmp/mysql.sock4
port       = 3309
pid-file   = /usr/local/mysql/var4/hostname.pid4
datadir    = /usr/local/mysql/var4
language   = /usr/local/share/mysql/estonia
user       = tonu

[mysqld6]
socket     = /tmp/mysql.sock6
port       = 3311
pid-file   = /usr/local/mysql/var6/hostname.pid6
datadir    = /usr/local/mysql/var6
language   = /usr/local/share/mysql/japanese
user       = jani
```

See Section 4.2.3.3, “Using Option Files”.

4.4. MySQL Installation-Related Programs

The programs in this section are used when installing or upgrading MySQL.

4.4.1. `comp_err` — Compile MySQL Error Message File

`comp_err` creates the `errmsg.sys` file that is used by `mysqld` to determine the error messages to display for different error codes. `comp_err` normally is run automatically when MySQL is built. It compiles the `errmsg.sys` file from the plaintext file located at `sql/share/errmsg.txt` in MySQL source distributions.

`comp_err` also generates `mysqld_error.h`, `mysqld_ername.h`, and `sql_state.h` header files.

For more information about how error messages are defined, see the MySQL Internals Manual, available at http://forge.mysql.com/wiki/MySQL_Internals.

Invoke `comp_err` like this:

```
shell> comp_err [options]
```

`comp_err` supports the following options.

- `--help`, `-?`

  Display a help message and exit.

- `--charset=path`, `-C path`

  The character set directory. The default is `../sql/share/charsets`.

- `--debug=debug_options`, `-# debug_options`

  Write a debugging log. A typical *`debug_options`* string is `'d:t:O,file_name'`. The default is `'d:t:O,/tmp/comp_err.trace'`.

- `--debug-info`, `-T`

  Print some debugging information when the program exits.

- `--header_file=file_name`, `-H file_name`

  The name of the error header file. The default is `mysqld_error.h`.

- `--in_file=file_name`, `-F file_name`

  The name of the input file. The default is `../sql/share/errmsg.txt`.

- `--name_file=file_name`, `-N file_name`

  The name of the error name file. The default is `mysqld_ername.h`.

- `--out_dir=path`, `-D path`

  The name of the output base directory. The default is `../sql/share/`.

- `--out_file=file_name`, `-O file_name`

  The name of the output file. The default is `errmsg.sys`.

- `--statefile=file_name`, `-S file_name`

  The name for the SQLSTATE header file. The default is `sql_state.h`.

- `--version`, `-V`

  Display version information and exit.

4.4.2. `make_win_bin_dist` — Package MySQL Distribution as Zip Archive

Previously, this script was used on Windows after building a MySQL distribution from source to create executable programs. It packaged the binaries and support files into a Zip archive that can be unpacked at the location where you want to install MySQL.

To create a binary distribution now, execute `make package` in the top-level directory of the source tree.

4.4.3. `mysqlbug` — Generate Bug Report

This program is obsolete.

The normal way to report bugs is to visit http://bugs.mysql.com/, which is the address for our bugs database. This database is public and can be browsed and searched by anyone. If you log in to the system, you can enter new reports.

4.4.4. `mysql_install_db` — Initialize MySQL Data Directory

`mysql_install_db` initializes the MySQL data directory and creates the system tables that it contains, if they do not exist.

To invoke `mysql_install_db`, use the following syntax:

```
shell> mysql_install_db [options]
```

Because the MySQL server, `mysqld`, needs to access the data directory when it runs later, you should either run `mysql_install_db` from the same account that will be used for running `mysqld` or run it as `root` and use the `--user` option to indicate the user name that `mysqld` will run as. It might be necessary to specify other options such as `--basedir` or `--datadir` if `mysql_install_db` does not use the correct locations for the installation directory or data directory. For example:

```
shell> scripts/mysql_install_db --user=mysql \
         --basedir=/opt/mysql/mysql \
         --datadir=/opt/mysql/mysql/data
```

`mysql_install_db` needs to invoke `mysqld` with the `--bootstrap` and `--skip-grant-tables` options. If MySQL was configured with the `DISABLE_GRANT_OPTIONS` compiler flag, `--bootstrap` and `--skip-grant-tables` will be disabled (see Section 2.9.4, “MySQL Source-Configuration Options”). To handle this, set the `MYSQLD_BOOTSTRAP` environment variable to the full path name of a server that has all options enabled. `mysql_install_db` will use that server.

> **Note**
>
> If you have set a custom `TMPDIR` variable when performing the installation, and the specified directory is not accessible, the execution of `mysql_install_db` may fail. You should unset `TMPDIR`, or set `TMPDIR` to point to the system temporary directory (usually `/tmp`).

`mysql_install_db` supports the following options, which can be specified on the command line or in the `[mysql_install_db]` and (if they are common to `mysqld`) `[mysqld]` groups of an option file. For information about option files, see Section 4.2.3.3, “Using Option Files”.

- `--basedir=path`

  The path to the MySQL installation directory.

- `--force`

  Cause `mysql_install_db` to run even if DNS does not work. In that case, grant table entries that normally use host names will use IP addresses.

- `--datadir=path`, `--ldata=path`

  The path to the MySQL data directory.

- `--rpm`

  For internal use. This option is used by RPM files during the MySQL installation process.

- `--skip-name-resolve`

  Use IP addresses rather than host names when creating grant table entries. This option can be useful if your DNS does not work.

- `--srcdir=path`

  For internal use. The directory under which `mysql_install_db` looks for support files such as the error message file and the file for populating the help tables.

- `--user=user_name`

  The login user name to use for running `mysqld`. Files and directories created by `mysqld` will be owned by this user. You must be `root` to use this option. By default, `mysqld` runs using your current login name and files and directories that it creates will be owned by you.

- `--verbose`

  Verbose mode. Print more information about what the program does.

- `--windows`

  For internal use. This option is used for creating Windows distributions.

4.4.5. `mysql_secure_installation` — Improve MySQL Installation Security

This program enables you to improve the security of your MySQL installation in the following ways:

- You can set a password for `root` accounts.
- You can remove `root` accounts that are accessible from outside the local host.
- You can remove anonymous-user accounts.
- You can remove the `test` database (which by default can be accessed by all users, even anonymous users), and privileges that permit anyone to access databases with names that start with `test_`.

`mysql_secure_installation` helps you implement security recommendations similar to those described at Section 2.10.2, “Securing the Initial MySQL Accounts”.

Invoke `mysql_secure_installation` without arguments:

```
shell> mysql_secure_installation
```

The script will prompt you to determine which actions to perform.

`mysql_secure_installation` is not available on Windows.

4.4.6. `mysql_tzinfo_to_sql` — Load the Time Zone Tables

The `mysql_tzinfo_to_sql` program loads the time zone tables in the `mysql` database. It is used on systems that have a *zoneinfo* database (the set of files describing time zones). Examples of such systems are Linux, FreeBSD, Solaris, and Mac OS X. One likely location for these files is the `/usr/share/zoneinfo` directory (`/usr/share/lib/zoneinfo` on Solaris). If your system does not have a zoneinfo database, you can use the downloadable package described in Section 9.6, “MySQL Server Time Zone Support”.

`mysql_tzinfo_to_sql` can be invoked several ways:

```
shell> mysql_tzinfo_to_sql tz_dir
shell> mysql_tzinfo_to_sql tz_file tz_name
shell> mysql_tzinfo_to_sql --leap tz_file
```

For the first invocation syntax, pass the zoneinfo directory path name to `mysql_tzinfo_to_sql` and send the output into the `mysql` program. For example:

```
shell> mysql_tzinfo_to_sql /usr/share/zoneinfo | mysql -u root mysql
```

`mysql_tzinfo_to_sql` reads your system's time zone files and generates SQL statements from them. `mysql` processes those statements to load the time zone tables.

The second syntax causes `mysql_tzinfo_to_sql` to load a single time zone file *`tz_file`* that corresponds to a time zone name *`tz_name`*:

```
shell> mysql_tzinfo_to_sql tz_file tz_name | mysql -u root mysql
```

If your time zone needs to account for leap seconds, invoke `mysql_tzinfo_to_sql` using the third syntax, which initializes the leap second information. *`tz_file`* is the name of your time zone file:

```
shell> mysql_tzinfo_to_sql --leap tz_file | mysql -u root mysql
```

After running `mysql_tzinfo_to_sql`, it is best to restart the server so that it does not continue to use any previously cached time zone data.

4.4.7. `mysql_upgrade` — Check Tables for MySQL Upgrade

`mysql_upgrade` examines all tables in all databases for incompatibilities with the current version of MySQL Server. `mysql_upgrade` also upgrades the system tables so that you can take advantage of new privileges or capabilities that might have been added.

`mysql_upgrade` should be executed each time you upgrade MySQL. It supersedes the older `mysql_fix_privilege_tables` script, which has been removed in MySQL 5.5.

If `mysql_upgrade` finds that a table has a possible incompatibility, it performs a table check and, if problems are found, attempts a table repair. If the table cannot be repaired, see Section 2.11.4, “Rebuilding or Repairing Tables or Indexes” for manual table repair strategies.

> ### Note
>
> On Windows Server 2008, Vista, and newer, you must run `mysql_upgrade` with administrator privileges. You can do this by running a Command Prompt as Administrator and running the command. Failure to do so may result in the upgrade failing to execute correctly.

> ### Caution
>
> You should always back up your current MySQL installation *before* performing an upgrade. See Section 6.2, “Database Backup Methods”.
>
> Some upgrade incompatibilities may require special handling before you upgrade your MySQL installation and run `mysql_upgrade`. See Section 2.11.1, “Upgrading MySQL”, for instructions on determining whether any such incompatibilities apply to your installation and how to handle them.

To use `mysql_upgrade`, make sure that the server is running, and then invoke it like this:

```
shell> mysql_upgrade [options]
```

After running `mysql_upgrade`, stop the server and restart it so that any changes made to the system tables take effect.

`mysql_upgrade` executes the following commands to check and repair tables and to upgrade the system tables:

```
mysqlcheck --all-databases --check-upgrade --auto-repair
mysql < fix_priv_tables
mysqlcheck --all-databases --check-upgrade --fix-db-names --fix-table-names
```

Notes about the preceding commands:

- Because `mysql_upgrade` invokes `mysqlcheck` with the `--all-databases` option, it processes all tables in all databases, which might take a long time to complete. Each table is locked and therefore unavailable to other sessions while it is being processed. Check and repair operations can be time-consuming, particularly for large tables.

- For details about what checks the `--check-upgrade` option entails, see the description of the `FOR UPGRADE` option of the `CHECK TABLE` statement (see Section 12.4.2.2, "`CHECK TABLE` Syntax").
- *`fix_priv_tables`* represents a script generated internally by `mysql_upgrade` that contains SQL statements to upgrade the tables in the `mysql` database.

All checked and repaired tables are marked with the current MySQL version number. This ensures that next time you run `mysql_upgrade` with the same version of the server, it can tell whether there is any need to check or repair the table again.

`mysql_upgrade` also saves the MySQL version number in a file named `mysql_upgrade_info` in the data directory. This is used to quickly check whether all tables have been checked for this release so that table-checking can be skipped. To ignore this file and perform the check regardless, use the `--force` option.

If you install MySQL from RPM packages on Linux, you must install the server and client RPMs. `mysql_upgrade` is included in the server RPM but requires the client RPM because the latter includes `mysqlcheck`. (See Section 2.5.1, "Installing MySQL from RPM Packages on Linux".)

`mysql_upgrade` does not upgrade the contents of the help tables. For upgrade instructions, see Section 5.1.8, "Server-Side Help".

`mysql_upgrade` supports the following options, which can be specified on the command line or in the `[mysql_upgrade]` and `[client]` groups of an option file. Other options are passed to `mysqlcheck`. For example, it might be necessary to specify the `--password[=password]` option. `mysql_upgrade` also supports the options for processing option files described at Section 4.2.3.3.1, "Command-Line Options that Affect Option-File Handling".

- `--help`

  Display a short help message and exit.

- `--basedir=path`

  The path to the MySQL installation directory. This option is accepted for backward compatibility but ignored.

- `--datadir=path`

  The path to the data directory. This option is accepted for backward compatibility but ignored.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`, `-T`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-auth=plugin`

  The client-side authentication plugin to use. See Section 5.5.6, "Pluggable Authentication".

  This option was added in MySQL 5.5.10.

- `--force`

  Ignore the `mysql_upgrade_info` file and force execution of `mysqlcheck` even if `mysql_upgrade` has already been executed for the current version of MySQL.

- `--plugin-dir=path`

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysql_upgrade` does not find it. See Section 5.5.6, "Pluggable Authentication".

  This option was added in MySQL 5.5.10.

- `--tmpdir=path`, `-t path`

  The path name of the directory to use for creating temporary files.

- `--upgrade-system-tables`, `-s`

  Upgrade only the system tables, do not upgrade data.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to the server. The default user name is `root`.

- `--verbose`

  Verbose mode. Print more information about what the program does.

- `--write-binlog`

  Cause binary logging to be enabled while `mysql_upgrade` runs. This is the default behavior; to disable binary logging during the upgrade, use the inverse of this option (that is, start the program with `--skip-write-binlog`).

4.5. MySQL Client Programs

This section describes client programs that connect to the MySQL server.

4.5.1. `mysql` — The MySQL Command-Line Tool

`mysql` is a simple SQL shell (with GNU `readline` capabilities). It supports interactive and noninteractive use. When used interactively, query results are presented in an ASCII-table format. When used noninteractively (for example, as a filter), the result is presented in tab-separated format. The output format can be changed using command options.

If you have problems due to insufficient memory for large result sets, use the `--quick` option. This forces `mysql` to retrieve results from the server a row at a time rather than retrieving the entire result set and buffering it in memory before displaying it. This is done by returning the result set using the `mysql_use_result()` C API function in the client/server library rather than `mysql_store_result()`.

Using `mysql` is very easy. Invoke it from the prompt of your command interpreter as follows:

```
shell> mysql db_name
```

Or:

```
shell> mysql --user=user_name --password=your_password db_name
```

Then type an SQL statement, end it with “`;`”, `\g`, or `\G` and press Enter.

Typing Control+C causes `mysql` to attempt to kill the current statement. If this cannot be done, or Control+C is typed again before the statement is killed, `mysql` exits. Previously, Control+C caused `mysql` to exit in all cases.

You can execute SQL statements in a script file (batch file) like this:

```
shell> mysql db_name < script.sql > output.tab
```

On Unix, the `mysql` client writes a record of executed statements to a history file. See Section 4.5.1.3, “`mysql` History File”.

4.5.1.1. `mysql` Options

`mysql` supports the following options, which can be specified on the command line or in the `[mysql]` and `[client]` groups of an option file. `mysql` also supports the options for processing option files described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.2. `mysql` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--auto-rehash	auto-rehash	Enable automatic rehashing			
--auto-vertical-output	auto-vertical-output	Enable automatic vertical result set display	5.5.3		
--batch	batch	Don't use history file			
--charac-	character-sets-dir	Set the default character set			

Format	Option File	Description	Introduction	Deprecated	Removed
ter-sets-dir=path					
--column-names	column-names	Write column names in results			
--column-type-info	column-type-info	Display result set metadata			
--comments	comments	Whether to retain or strip comments in statements sent to the server			
--compress	compress	Compress all information sent between the client and the server			
--connect_timeout=value	connect_timeout	The number of seconds before connection timeout			
--database=dbname	database	The database to use			
--debug[=debug_options]	debug	Write a debugging log			
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.7		
--default-character-set=charset_name	default-character-set	Use charset_name as the default character set			
--delimiter=str	delimiter	Set the statement delimiter			
--execute=statement	execute	Execute the statement and quit			
--force	force	Continue even if an SQL error occurs			
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--html	html	Produce HTML output			
--ignore-spaces	ignore-spaces	Ignore spaces after function names			
--line-numbers	line-numbers	Write line numbers for errors			
--local-infile[={0|1}]	local-infile	Enable or disable for LOCAL capability for LOAD DATA INFILE			
--max_allowed_packet=value	max_allowed_packet	The maximum packet length to send to or receive from the server			
--max_join_size=value	max_join_size	The automatic limit for rows in a join when using --safe-updates			
--named-commands	named-commands	Enable named mysql commands			
- -	net_buffer_length	The buffer size for TCP/IP and socket communication			

Format	Option File	Description	Introduction	Deprecated	Removed
net_buffer_length=value					
--no-auto-rehash		Disable automatic rehashing			
--no-beep	no-beep	Do not beep when errors occur			
--no-named-commands	no-named-commands	Disable named mysql commands			5.5.3
--no-pager	no-pager	Deprecated form of --skip-pager			5.5.3
--no-tee	no-tee	Do not copy output to a file			5.5.3
--one-database	one-database	Ignore statements except those for the default database named on the command line			
--pager[=command]	pager	Use the given command for paging query output			
--password[=password]	password	The password to use when connecting to the server			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.7		
--port=port_num	port	The TCP/IP port number to use for the connection			
--prompt=format_str	prompt	Set the prompt to the specified format			
--protocol=type	protocol	The connection protocol to use			
--quick	quick	Do not cache each query result			
--raw	raw	Write column values without escape conversion			
--reconnect	reconnect	If the connection to the server is lost, automatically try to reconnect			
--safe-updates	safe-updates	Allow only UPDATE and DELETE statements that specify key values			
--secure-auth	secure-auth	Do not send passwords to the server in old (pre-4.1.1) format			
--select_limit=value	select_limit	The automatic limit for SELECT statements when using --safe-updates			
--show-warnings	show-warnings	Show warnings after each statement if there are any			
--sigint-ignore	sigint-ignore	Ignore SIGINT signals (typically the result of typing Control+C)			
--silent	silent	Silent mode			
--skip-auto-rehash	skip-auto-rehash	Disable automatic rehashing			
--skip-column-names	skip-column-names	Do not write column names in results			
--skip-line-numbers	skip-line-numbers	Skip line numbers for errors			
--skip-named-commands	skip-named-commands	Disable named mysql commands			
--skip-pager	skip-pager	Disable paging			
--skip-reconnect	skip-reconnect	Disable reconnecting			

Format	Option File	Description	Introduction	Deprecated	Removed
--socket=path	socket	For connections to localhost			
--ssl-ca=file_name	ssl-ca	The path to a file that contains a list of trusted SSL CAs			
--ssl-capath=directory_name	ssl-capath	The path to a directory that contains trusted SSL CA certificates in PEM format			
--ssl-cert=file_name	ssl-cert	The name of the SSL certificate file to use for establishing a secure connection			
--ssl-cipher=cipher_list	ssl-cipher	A list of allowable ciphers to use for SSL encryption			
--ssl-key=file_name	ssl-key	The name of the SSL key file to use for establishing a secure connection			
--ssl-verify-server-cert	ssl-verify-server-cert	The server's Common Name value in its certificate is verified against the host name used when connecting to the server			
--table	table	Display output in tabular format			
--tee=file_name	tee	Append a copy of output to the given file			
--unbuffered	unbuffered	Flush the buffer after each query			
--user=user_name	user	The MySQL user name to use when connecting to the server			
--verbose		Verbose mode			
--version		Display version information and exit			
--vertical	vertical	Print query output rows vertically (one line per column value)			
--wait	wait	If the connection cannot be established, wait and retry instead of aborting			
--xml	xml	Produce XML output			

- `--help`, `-?`

  Display a help message and exit.

- `--auto-rehash`

  Enable automatic rehashing. This option is on by default, which enables database, table, and column name completion. Use `--disable-auto-rehash` to disable rehashing. That causes `mysql` to start faster, but you must issue the `rehash` command if you want to use name completion.

  To complete a name, enter the first part and press Tab. If the name is unambiguous, `mysql` completes it. Otherwise, you can press Tab again to see the possible names that begin with what you have typed so far. Completion does not occur if there is no default database.

- `--auto-vertical-output`

  Cause result sets to be displayed vertically if they are too wide for the current window, and using normal tabular format otherwise. (This applies to statements terminated by `;` or `\G`.) This option was added in MySQL 5.5.3.

- `--batch`, `-B`

  Print results using tab as the column separator, with each row on a new line. With this option, `mysql` does not use the history file.

Batch mode results in nontabular output format and escaping of special characters. Escaping may be disabled by using raw mode; see the description for the `--raw` option.

- `--character-sets-dir=path`

  The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--column-names`

  Write column names in results.

- `--column-type-info`, `-m`

  Display result set metadata.

- `--comments`, `-c`

  Whether to preserve comments in statements sent to the server. The default is --skip-comments (discard comments), enable with --comments (preserve comments).

- `--compress`, `-C`

  Compress all information sent between the client and the server if both support compression.

- `--database=db_name`, `-D db_name`

  The database to use. This is useful primarily in an option file.

- `--debug[=debug_options]`, `-# [debug_options]`

  Write a debugging log. A typical `debug_options` string is `'d:t:o,file_name'`. The default is `'d:t:o,/tmp/mysql.trace'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`, `-T`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-auth=plugin`

  The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.7.

- `--default-character-set=charset_name`

  Use `charset_name` as the default character set for the client and connection.

  A common issue that can occur when the operating system uses `utf8` or another multi-byte character set is that output from the `mysql` client is formatted incorrectly, due to the fact that the MySQL client uses the `latin1` character set by default. You can usually fix such issues by using this option to force the client to use the system character set instead.

  See Section 9.5, “Character Set Configuration”, for more information.

- `--delimiter=str`

  Set the statement delimiter. The default is the semicolon character (“`;`”).

- `--disable-named-commands`

  Disable named commands. Use the `\*` form only, or use named commands only at the beginning of a line ending with a semicolon (“`;`”). `mysql` starts with this option *enabled* by default. However, even with this option, long-format commands still work from the first line. See Section 4.5.1.2, “`mysql` Commands”.

- `--execute=statement`, `-e statement`

  Execute the statement and quit. The default output format is like that produced with `--batch`. See Section 4.2.3.1, “Using Options on the Command Line”, for some examples. With this option, `mysql` does not use the history file.

- `--force`, `-f`

  Continue even if an SQL error occurs.

- `--host=host_name`, `-h host_name`

  Connect to the MySQL server on the given host.

- `--html`, `-H`

  Produce HTML output.

- `--ignore-spaces`, `-i`

  Ignore spaces after function names. The effect of this is described in the discussion for the `IGNORE_SPACE` SQL mode (see Section 5.1.6, “Server SQL Modes”).

- `--line-numbers`

  Write line numbers for errors. Disable this with `--skip-line-numbers`.

- `--local-infile[={0|1}]`

  Enable or disable `LOCAL` capability for `LOAD DATA INFILE`. With no value, the option enables `LOCAL`. The option may be given as `--local-infile=0` or `--local-infile=1` to explicitly disable or enable `LOCAL`. Enabling `LOCAL` has no effect if the server does not also support it.

- `--named-commands`, `-G`

  Enable named `mysql` commands. Long-format commands are permitted, not just short-format commands. For example, `quit` and `\q` both are recognized. Use `--skip-named-commands` to disable named commands. See Section 4.5.1.2, “`mysql` Commands”.

- `--no-auto-rehash`, `-A`

  This has the same effect as `-skip-auto-rehash`. See the description for `--auto-rehash`.

- `--no-beep`, `-b`

  Do not beep when errors occur.

- `--no-named-commands`, `-g`

  Deprecated, use `--disable-named-commands` instead. `--no-named-commands` was removed in MySQL 5.5.3.

- `--no-pager`

  Deprecated form of `--skip-pager`. See the `--pager` option. `--no-pager` was removed in MySQL 5.5.3.

- `--no-tee`

  Deprecated form of `--skip-tee`. See the `--tee` option. `--no-tee` is removed in MySQL 5.5.3.

- `--one-database`, `-o`

  Ignore statements except those that occur while the default database is the one named on the command line. This option is rudimentary and should be used with care. Statement filtering is based only on `USE` statements.

  Initially, `mysql` executes statements in the input because specifying a database `db_name` on the command line is equivalent to inserting `USE db_name` at the beginning of the input. Then, for each `USE` statement encountered, `mysql` accepts or rejects following statements depending on whether the database named is the one on the command line. The content of the statements is immaterial.

  Suppose that `mysql` is invoked to process this set of statements:

  ```
  DELETE FROM db2.t2;
  USE db2;
  DROP TABLE db1.t1;
  CREATE TABLE db1.t1 (i INT);
  USE db1;
  INSERT INTO t1 (i) VALUES(1);
  CREATE TABLE db2.t1 (j INT);
  ```

If the command line is `mysql --force --one-database db1`, `mysql` handles the input as follows:

- The `DELETE` statement is executed because the default database is `db1`, even though the statement names a table in a different database.
- The `DROP TABLE` and `CREATE TABLE` statements are not executed because the default database is not `db1`, even though the statements name a table in `db1`.
- The `INSERT` and `CREATE TABLE` statements are executed because the default database is `db1`, even though the `CREATE TABLE` statement names a table in a different database.

- `--pager[=`*`command`*`]`

  Use the given command for paging query output. If the command is omitted, the default pager is the value of your `PAGER` environment variable. Valid pagers are `less`, `more`, `cat [> filename]`, and so forth. This option works only on Unix and only in interactive mode. To disable paging, use `--skip-pager`. Section 4.5.1.2, "`mysql` Commands", discusses output paging further.

- `--password[=`*`password`*`]`, `-p[`*`password`*`]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the *`password`* value following the `--password` or `-p` option on the command line, `mysql` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, "End-User Guidelines for Password Security". You can use an option file to avoid giving the password on the command line.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. This option applies only if the server supports named-pipe connections.

- `--plugin-dir=`*`path`*

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysql` does not find it. See Section 5.5.6, "Pluggable Authentication".

  This option was added in MySQL 5.5.7.

- `--port=`*`port_num`*, `-P` *`port_num`*

  The TCP/IP port number to use for the connection.

- `--prompt=`*`format_str`*

  Set the prompt to the specified format. The default is `mysql>`. The special sequences that the prompt can contain are described in Section 4.5.1.2, "`mysql` Commands".

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, "Connecting to the MySQL Server".

- `--quick`, `-q`

  Do not cache each query result, print each row as it is received. This may slow down the server if the output is suspended. With this option, `mysql` does not use the history file.

- `--raw`, `-r`

  For tabular output, the "boxing" around columns enables one column value to be distinguished from another. For nontabular output (such as is produced in batch mode or when the `--batch` or `--silent` option is given), special characters are escaped in the output so they can be identified easily. Newline, tab, `NUL`, and backslash are written as `\n`, `\t`, `\0`, and `\\`. The `--raw` option disables this character escaping.

  The following example demonstrates tabular versus nontabular output and the use of raw mode to disable escaping:

```
% mysql
mysql> SELECT CHAR(92);
+----------+
| CHAR(92) |
+----------+
| \        |
+----------+

% mysql -s
mysql> SELECT CHAR(92);
CHAR(92)
\\

% mysql -s -r
mysql> SELECT CHAR(92);
CHAR(92)
\
```

- `--reconnect`

  If the connection to the server is lost, automatically try to reconnect. A single reconnect attempt is made each time the connection is lost. To suppress reconnection behavior, use `--skip-reconnect`.

- `--safe-updates`, `--i-am-a-dummy`, `-U`

  Permit only those `UPDATE` and `DELETE` statements that specify which rows to modify by using key values. If you have set this option in an option file, you can override it by using `--safe-updates` on the command line. See Section 4.5.1.6, “`mysql` Tips”, for more information about this option.

- `--secure-auth`

  Do not send passwords to the server in old (pre-4.1.1) format. This prevents connections except for servers that use the newer password format.

- `--show-warnings`

  Cause warnings to be shown after each statement if there are any. This option applies to interactive and batch mode.

- `--sigint-ignore`

  Ignore `SIGINT` signals (typically the result of typing Control+C).

- `--silent`, `-s`

  Silent mode. Produce less output. This option can be given multiple times to produce less and less output.

  This option results in nontabular output format and escaping of special characters. Escaping may be disabled by using raw mode; see the description for the `--raw` option.

- `--skip-column-names`, `-N`

  Do not write column names in results.

- `--skip-line-numbers`, `-L`

  Do not write line numbers for errors. Useful when you want to compare result files that include error messages.

- `--socket=`*`path`*, `-S` *`path`*

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--ssl*`

  Options that begin with `--ssl` specify whether to connect to the server using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, “SSL Command Options”.

- `--table`, `-t`

  Display output in table format. This is the default for interactive use, but can be used to produce table output in batch mode.

- `--tee=`*`file_name`*

  Append a copy of output to the given file. This option works only in interactive mode. Section 4.5.1.2, “`mysql` Commands”, discusses tee files further.

- `--unbuffered`, `-n`

  Flush the buffer after each query.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to the server.

- `--verbose`, `-v`

  Verbose mode. Produce more output about what the program does. This option can be given multiple times to produce more and more output. (For example, `-v -v -v` produces table output format even in batch mode.)

- `--version`, `-V`

  Display version information and exit.

- `--vertical`, `-E`

  Print query output rows vertically (one line per column value). Without this option, you can specify vertical output for individual statements by terminating them with `\G`.

- `--wait`, `-w`

  If the connection cannot be established, wait and retry instead of aborting.

- `--xml`, `-X`

  Produce XML output.

  ```
  <field name="column_name">NULL</field>
  ```

  The output when `--xml` is used with `mysql` matches that of `mysqldump --xml`. See Section 4.5.4, “`mysqldump` — A Database Backup Program” for details.

  The XML output also uses an XML namespace, as shown here:

  ```
  shell> mysql --xml -uroot -e "SHOW VARIABLES LIKE 'version%'"
  <?xml version="1.0"?>

  <resultset statement="SHOW VARIABLES LIKE 'version%'" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <row>
  <field name="Variable_name">version</field>
  <field name="Value">5.0.40-debug</field>
  </row>

  <row>
  <field name="Variable_name">version_comment</field>
  <field name="Value">Source distribution</field>
  </row>

  <row>
  <field name="Variable_name">version_compile_machine</field>
  <field name="Value">i686</field>
  </row>

  <row>
  <field name="Variable_name">version_compile_os</field>
  <field name="Value">suse-linux-gnu</field>
  </row>
  </resultset>
  ```

  (See Bug #25946.)

You can also set the following variables by using `--var_name=value`. The `--set-variable` format is deprecated and was removed in MySQL 5.5.3.

- `connect_timeout`

  The number of seconds before connection timeout. (Default value is `0`.)

- `max_allowed_packet`

  The maximum packet length to send to or receive from the server. (Default value is 16MB.)

- `max_join_size`

  The automatic limit for rows in a join when using `--safe-updates`. (Default value is 1,000,000.)

- `net_buffer_length`

  The buffer size for TCP/IP and socket communication. (Default value is 16KB.)

- `select_limit`

  The automatic limit for `SELECT` statements when using `--safe-updates`. (Default value is 1,000.)

4.5.1.2. `mysql` Commands

`mysql` sends each SQL statement that you issue to the server to be executed. There is also a set of commands that `mysql` itself interprets. For a list of these commands, type `help` or `\h` at the `mysql>` prompt:

```
mysql> help

List of all MySQL commands:
Note that all text commands must be first on line and end with ';'
?         (\?) Synonym for `help'.
clear     (\c) Clear command.
connect   (\r) Reconnect to the server. Optional arguments are db and host.
delimiter (\d) Set statement delimiter.
edit      (\e) Edit command with $EDITOR.
ego       (\G) Send command to mysql server, display result vertically.
exit      (\q) Exit mysql. Same as quit.
go        (\g) Send command to mysql server.
help      (\h) Display this help.
nopager   (\n) Disable pager, print to stdout.
notee     (\t) Don't write into outfile.
pager     (\P) Set PAGER [to_pager]. Print the query results via PAGER.
print     (\p) Print current command.
prompt    (\R) Change your mysql prompt.
quit      (\q) Quit mysql.
rehash    (\#) Rebuild completion hash.
source    (\.) Execute an SQL script file. Takes a file name as an argument.
status    (\s) Get status information from the server.
system    (\!) Execute a system shell command.
tee       (\T) Set outfile [to_outfile]. Append everything into given
               outfile.
use       (\u) Use another database. Takes database name as argument.
charset   (\C) Switch to another charset. Might be needed for processing
               binlog with multi-byte charsets.
warnings  (\W) Show warnings after every statement.
nowarning (\w) Don't show warnings after every statement.

For server side help, type 'help contents'
```

Each command has both a long and short form. The long form is not case sensitive; the short form is. The long form can be followed by an optional semicolon terminator, but the short form should not.

The use of short-form commands within multi-line `/* ... */` comments is not supported.

- `help [`*`arg`*`]`, `\h [`*`arg`*`]`, `\? [`*`arg`*`]`, `? [`*`arg`*`]`

  Display a help message listing the available `mysql` commands.

  If you provide an argument to the `help` command, `mysql` uses it as a search string to access server-side help from the contents of the MySQL Reference Manual. For more information, see Section 4.5.1.4, "`mysql` Server-Side Help".

- `charset` *`charset_name`*, `\C` *`charset_name`*

  Change the default character set and issue a `SET NAMES` statement. This enables the character set to remain synchronized on the client and server if `mysql` is run with auto-reconnect enabled (which is not recommended), because the specified character set is used for reconnects.

- `clear`, `\c`

  Clear the current input. Use this if you change your mind about executing the statement that you are entering.

- `connect [`*`db_name host_name`*`]]`, `\r [`*`db_name host_name`*`]]`

  Reconnect to the server. The optional database name and host name arguments may be given to specify the default database or the host where the server is running. If omitted, the current values are used.

- `delimiter` *`str`*, `\d` *`str`*

  Change the string that `mysql` interprets as the separator between SQL statements. The default is the semicolon character ("`;`").

The delimiter string can be specified as an unquoted or quoted argument on the `delimiter` command line. Quoting can be done with either single quote (`'`), douple quote (`"`), or backtick (`` ` ``) characters. To include a quote within a quoted string, either quote the string with a different quote character or escape the quote with a backslash ("`\`") character. Backslash should be avoided outside of quoted strings because it is the escape character for MySQL. For an unquoted argument, the delimiter is read up to the first space or end of line. For a quoted argument, the delimiter is read up to the matching quote on the line.

`mysql` interprets instances of the delimiter string as a statement delimiter anywhere it occurs, except within quoted strings. Be careful about defining a delimiter that might occur within other words. For example, if you define the delimiter as `X`, you will be unable to use the word `INDEX` in statements. `mysql` interprets this as `INDE` followed by the delimiter `X`.

When the delimiter recognized by `mysql` is set to something other than the default of "`;`", instances of that character are sent to the server without interpretation. However, the server itself still interprets "`;`" as a statement delimiter and processes statements accordingly. This behavior on the server side comes into play for multiple-statement execution (see Section 20.9.13, "C API Support for Multiple Statement Execution"), and for parsing the body of stored procedures and functions, triggers, and events (see Section 17.1, "Defining Stored Programs").

- `edit`, `\e`

  Edit the current input statement. `mysql` checks the values of the `EDITOR` and `VISUAL` environment variables to determine which editor to use. The default editor is `vi` if neither variable is set.

  The `edit` command works only in Unix.

- `ego`, `\G`

  Send the current statement to the server to be executed and display the result using vertical format.

- `exit`, `\q`

  Exit `mysql`.

- `go`, `\g`

  Send the current statement to the server to be executed.

- `nopager`, `\n`

  Disable output paging. See the description for `pager`.

  The `nopager` command works only in Unix.

- `notee`, `\t`

  Disable output copying to the tee file. See the description for `tee`.

- `nowarning`, `\w`

  Enable display of warnings after each statement.

- `pager [command]`, `\P [command]`

  Enable output paging. By using the `--pager` option when you invoke `mysql`, it is possible to browse or search query results in interactive mode with Unix programs such as `less`, `more`, or any other similar program. If you specify no value for the option, `mysql` checks the value of the `PAGER` environment variable and sets the pager to that. Pager functionality works only in interactive mode.

  Output paging can be enabled interactively with the `pager` command and disabled with `nopager`. The command takes an optional argument; if given, the paging program is set to that. With no argument, the pager is set to the pager that was set on the command line, or `stdout` if no pager was specified.

  Output paging works only in Unix because it uses the `popen()` function, which does not exist on Windows. For Windows, the `tee` option can be used instead to save query output, although it is not as convenient as `pager` for browsing output in some situations.

- `print`, `\p`

  Print the current input statement without executing it.

- `prompt [str]`, `\R [str]`

Reconfigure the `mysql` prompt to the given string. The special character sequences that can be used in the prompt are described later in this section.

If you specify the `prompt` command with no argument, `mysql` resets the prompt to the default of `mysql>`.

- `quit`, `\q`

  Exit `mysql`.

- `rehash`, `\#`

  Rebuild the completion hash that enables database, table, and column name completion while you are entering statements. (See the description for the `--auto-rehash` option.)

- `source` *`file_name`*, `\.` *`file_name`*

  Read the named file and executes the statements contained therein. On Windows, you can specify path name separators as `/` or `\\`.

- `status`, `\s`

  Provide status information about the connection and the server you are using. If you are running in `--safe-updates` mode, `status` also prints the values for the `mysql` variables that affect your queries.

- `system` *`command`*, `\!` *`command`*

  Execute the given command using your default command interpreter.

  The `system` command works only in Unix.

- `tee [`*`file_name`*`]`, `\T [`*`file_name`*`]`

  By using the `--tee` option when you invoke `mysql`, you can log statements and their output. All the data displayed on the screen is appended into a given file. This can be very useful for debugging purposes also. `mysql` flushes results to the file after each statement, just before it prints its next prompt. Tee functionality works only in interactive mode.

  You can enable this feature interactively with the `tee` command. Without a parameter, the previous file is used. The `tee` file can be disabled with the `notee` command. Executing `tee` again re-enables logging.

- `use` *`db_name`*, `\u` *`db_name`*

  Use *`db_name`* as the default database.

- `warnings`, `\W`

  Enable display of warnings after each statement (if there are any).

Here are a few tips about the `pager` command:

- You can use it to write to a file and the results go only to the file:

  ```
  mysql> pager cat > /tmp/log.txt
  ```

  You can also pass any options for the program that you want to use as your pager:

  ```
  mysql> pager less -n -i -S
  ```

- In the preceding example, note the `-S` option. You may find it very useful for browsing wide query results. Sometimes a very wide result set is difficult to read on the screen. The `-S` option to `less` can make the result set much more readable because you can scroll it horizontally using the left-arrow and right-arrow keys. You can also use `-S` interactively within `less` to switch the horizontal-browse mode on and off. For more information, read the `less` manual page:

  ```
  shell> man less
  ```

- The `-F` and `-X` options may be used with `less` to cause it to exit if output fits on one screen, which is convenient when no scrolling is necessary:

  ```
  mysql> pager less -n -i -S -F -X
  ```

- You can specify very complex pager commands for handling query output:

  ```
  mysql> pager cat | tee /dr1/tmp/res.txt \
            | tee /dr2/tmp/res2.txt | less -n -i -S
  ```

  In this example, the command would send query results to two files in two different directories on two different file systems mounted on `/dr1` and `/dr2`, yet still display the results onscreen using `less`.

You can also combine the `tee` and `pager` functions. Have a `tee` file enabled and `pager` set to `less`, and you are able to browse the results using the `less` program and still have everything appended into a file the same time. The difference between the Unix `tee` used with the `pager` command and the `mysql` built-in `tee` command is that the built-in `tee` works even if you do not have the Unix `tee` available. The built-in `tee` also logs everything that is printed on the screen, whereas the Unix `tee` used with `pager` does not log quite that much. Additionally, `tee` file logging can be turned on and off interactively from within `mysql`. This is useful when you want to log some queries to a file, but not others.

The `prompt` command reconfigures the default `mysql>` prompt. The string for defining the prompt can contain the following special sequences.

Option	**Description**
`\c`	A counter that increments for each statement you issue
`\D`	The full current date
`\d`	The default database
`\h`	The server host
`\l`	The current delimiter
`\m`	Minutes of the current time
`\n`	A newline character
`\O`	The current month in three-letter format (Jan, Feb, …)
`\o`	The current month in numeric format
`\P`	am/pm
`\p`	The current TCP/IP port or socket file
`\R`	The current time, in 24-hour military time (0–23)
`\r`	The current time, standard 12-hour time (1–12)
`\S`	Semicolon
`\s`	Seconds of the current time
`\t`	A tab character
`\U`	Your full *`user_name@host_name`* account name
`\u`	Your user name
`\v`	The server version
`\w`	The current day of the week in three-letter format (Mon, Tue, …)
`\Y`	The current year, four digits
`\y`	The current year, two digits
`\_`	A space
`\ `	A space (a space follows the backslash)
`\'`	Single quote
`\"`	Double quote
`\\`	A literal “`\`” backslash character
`\x`	*`x`*, for any “*`x`*” not listed above

You can set the prompt in several ways:

- *Use an environment variable.* You can set the `MYSQL_PS1` environment variable to a prompt string. For example:

```
shell> export MYSQL_PS1="(\u@\h) [\d]> "
```

- *Use a command-line option.* You can set the `--prompt` option on the command line to `mysql`. For example:

```
shell> mysql --prompt="(\u@\h) [\d]> "
(user@host) [database]>
```

- *Use an option file.* You can set the `prompt` option in the `[mysql]` group of any MySQL option file, such as `/etc/my.cnf` or the `.my.cnf` file in your home directory. For example:

```
[mysql]
prompt=(\\u@\\h) [\\d]>\\_
```

In this example, note that the backslashes are doubled. If you set the prompt using the `prompt` option in an option file, it is advisable to double the backslashes when using the special prompt options. There is some overlap in the set of permissible prompt options and the set of special escape sequences that are recognized in option files. (The rules for escape sequences in option files are listed in Section 4.2.3.3, “Using Option Files”.) The overlap may cause you problems if you use single backslashes. For example, `\s` is interpreted as a space rather than as the current seconds value. The following example shows how to define a prompt within an option file to include the current time in `HH:MM:SS>` format:

```
[mysql]
prompt="\\r:\\m:\\s> "
```

- *Set the prompt interactively.* You can change your prompt interactively by using the `prompt` (or `\R`) command. For example:

```
mysql> prompt (\u@\h) [\d]>\_
PROMPT set to '(\u@\h) [\d]>\_'
(user@host) [database]>
(user@host) [database]> prompt
Returning to default PROMPT of mysql>
mysql>
```

4.5.1.3. `mysql` History File

On Unix, the `mysql` client writes a record of executed statements to a history file. By default, this file is named `.mysql_history` and is created in your home directory. To specify a different file, set the value of the `MYSQL_HISTFILE` environment variable.

The `.mysql_history` should be protected with a restrictive access mode because sensitive information might be written to it, such as the text of SQL statements that contain passwords. See Section 5.3.2.2, “End-User Guidelines for Password Security”.

It is possible to suppress logging of statements to the history file by using the `--batch` or `--execute` option.

If you do not want to maintain a history file, first remove `.mysql_history` if it exists, and then use either of the following techniques:

- Set the `MYSQL_HISTFILE` variable to `/dev/null`. To cause this setting to take effect each time you log in, put the setting in one of your shell's startup files.
- Create `.mysql_history` as a symbolic link to `/dev/null`:

```
shell> ln -s /dev/null $HOME/.mysql_history
```

You need do this only once.

4.5.1.4. `mysql` Server-Side Help

```
mysql> help search_string
```

If you provide an argument to the `help` command, `mysql` uses it as a search string to access server-side help from the contents of the MySQL Reference Manual. The proper operation of this command requires that the help tables in the `mysql` database be initialized with help topic information (see Section 5.1.8, “Server-Side Help”).

If there is no match for the search string, the search fails:

```
mysql> help me
```

```
Nothing found
Please try to run 'help contents' for a list of all accessible topics
```

Use `help contents` to see a list of the help categories:

```
mysql> help contents
You asked for help about help category: "Contents"
For more information, type 'help <item>', where <item> is one of the
following categories:
   Account Management
   Administration
   Data Definition
   Data Manipulation
   Data Types
   Functions
   Functions and Modifiers for Use with GROUP BY
   Geographic Features
   Language Structure
   Plugins
   Storage Engines
   Stored Routines
   Table Maintenance
   Transactions
   Triggers
```

If the search string matches multiple items, `mysql` shows a list of matching topics:

```
mysql> help logs
Many help items for your request exist.
To make a more specific request, please type 'help <item>',
where <item> is one of the following topics:
   SHOW
   SHOW BINARY LOGS
   SHOW ENGINE
   SHOW LOGS
```

Use a topic as the search string to see the help entry for that topic:

```
mysql> help show binary logs
Name: 'SHOW BINARY LOGS'
Description:
Syntax:
SHOW BINARY LOGS
SHOW MASTER LOGS

Lists the binary log files on the server. This statement is used as
part of the procedure described in [purge-binary-logs], that shows how
to determine which logs can be purged.

mysql> SHOW BINARY LOGS;
+---------------+-----------+
| Log_name      | File_size |
+---------------+-----------+
| binlog.000015 |    724935 |
| binlog.000016 |    733481 |
+---------------+-----------+
```

4.5.1.5. Executing SQL Statements from a Text File

The `mysql` client typically is used interactively, like this:

```
shell> mysql db_name
```

However, it is also possible to put your SQL statements in a file and then tell `mysql` to read its input from that file. To do so, create a text file *`text_file`* that contains the statements you wish to execute. Then invoke `mysql` as shown here:

```
shell> mysql db_name < text_file
```

If you place a `USE db_name` statement as the first statement in the file, it is unnecessary to specify the database name on the command line:

```
shell> mysql < text_file
```

If you are already running `mysql`, you can execute an SQL script file using the `source` command or `\.` command:

```
mysql> source file_name
mysql> \. file_name
```

Sometimes you may want your script to display progress information to the user. For this you can insert statements like this:

```
SELECT '<info_to_display>' AS ' ';
```

The statement shown outputs `<info_to_display>`.

You can also invoke `mysql` with the `--verbose` option, which causes each statement to be displayed before the result that it produces.

`mysql` ignores Unicode byte order mark (BOM) characters at the beginning of input files. Previously, it read them and sent them to the server, resulting in a syntax error. Presence of a BOM does not cause `mysql` to change its default character set. To do that, invoke `mysql` with an option such as `--default-character-set=utf8`.

For more information about batch mode, see Section 3.5, "Using `mysql` in Batch Mode".

4.5.1.6. `mysql` Tips

This section describes some techniques that can help you use `mysql` more effectively.

4.5.1.6.1. Displaying Query Results Vertically

Some query results are much more readable when displayed vertically, instead of in the usual horizontal table format. Queries can be displayed vertically by terminating the query with \G instead of a semicolon. For example, longer text values that include newlines often are much easier to read with vertical output:

```
mysql> SELECT * FROM mails WHERE LENGTH(txt) < 300 LIMIT 300,1\G
*************************** 1. row ***************************
  msg_nro: 3068
     date: 2000-03-01 23:29:50
time_zone: +0200
mail_from: Monty
    reply: monty@no.spam.com
  mail_to: "Thimble Smith" <tim@no.spam.com>
      sbj: UTF-8
      txt: >>>>> "Thimble" == Thimble Smith writes:

Thimble> Hi.  I think this is a good idea.  Is anyone familiar
Thimble> with UTF-8 or Unicode? Otherwise, I'll put this on my
Thimble> TODO list and see what happens.

Yes, please do that.

Regards,
Monty
     file: inbox-jani-1
     hash: 190402944
1 row in set (0.09 sec)
```

4.5.1.6.2. Using the `--safe-updates` Option

For beginners, a useful startup option is `--safe-updates` (or `--i-am-a-dummy`, which has the same effect). It is helpful for cases when you might have issued a `DELETE FROM` *`tbl_name`* statement but forgotten the `WHERE` clause. Normally, such a statement deletes all rows from the table. With `--safe-updates`, you can delete rows only by specifying the key values that identify them. This helps prevent accidents.

When you use the `--safe-updates` option, `mysql` issues the following statement when it connects to the MySQL server:

```
SET sql_safe_updates=1, sql_select_limit=1000, sql_max_join_size=1000000;
```

See Section 5.1.3, "Server System Variables".

The `SET` statement has the following effects:

- You are not permitted to execute an `UPDATE` or `DELETE` statement unless you specify a key constraint in the `WHERE` clause or provide a `LIMIT` clause (or both). For example:

  ```
  UPDATE tbl_name SET not_key_column=val WHERE key_column=val;

  UPDATE tbl_name SET not_key_column=val LIMIT 1;
  ```

- The server limits all large `SELECT` results to 1,000 rows unless the statement includes a `LIMIT` clause.
- The server aborts multiple-table `SELECT` statements that probably need to examine more than 1,000,000 row combinations.

To specify limits different from 1,000 and 1,000,000, you can override the defaults by using the `--select_limit` and -

`-max_join_size` options:

```
shell> mysql --safe-updates --select_limit=500 --max_join_size=10000
```

4.5.1.6.3. Disabling `mysql` Auto-Reconnect

If the `mysql` client loses its connection to the server while sending a statement, it immediately and automatically tries to reconnect once to the server and send the statement again. However, even if `mysql` succeeds in reconnecting, your first connection has ended and all your previous session objects and settings are lost: temporary tables, the autocommit mode, and user-defined and session variables. Also, any current transaction rolls back. This behavior may be dangerous for you, as in the following example where the server was shut down and restarted between the first and second statements without you knowing it:

```
mysql> SET @a=1;
Query OK, 0 rows affected (0.05 sec)

mysql> INSERT INTO t VALUES(@a);
ERROR 2006: MySQL server has gone away
No connection. Trying to reconnect...
Connection id:    1
Current database: test

Query OK, 1 row affected (1.30 sec)

mysql> SELECT * FROM t;
+------+
| a    |
+------+
| NULL |
+------+
1 row in set (0.05 sec)
```

The `@a` user variable has been lost with the connection, and after the reconnection it is undefined. If it is important to have `mysql` terminate with an error if the connection has been lost, you can start the `mysql` client with the `--skip-reconnect` option.

For more information about auto-reconnect and its effect on state information when a reconnection occurs, see Section 20.9.12, “Controlling Automatic Reconnection Behavior”.

4.5.2. `mysqladmin` — Client for Administering a MySQL Server

`mysqladmin` is a client for performing administrative operations. You can use it to check the server's configuration and current status, to create and drop databases, and more.

Invoke `mysqladmin` like this:

```
shell> mysqladmin [options] command [command-arg] [command [command-arg]] ...
```

`mysqladmin` supports the following commands. Some of the commands take an argument following the command name.

- `create db_name`

  Create a new database named *`db_name`*.

- `debug`

  Tell the server to write debug information to the error log.

  This includes information about the Event Scheduler. See Section 17.4.5, “Event Scheduler Status”.

- `drop db_name`

  Delete the database named *`db_name`* and all its tables.

- `extended-status`

  Display the server status variables and their values.

- `flush-hosts`

  Flush all information in the host cache.

- `flush-logs`

  Flush all logs.

- `flush-privileges`

  Reload the grant tables (same as `reload`).

- `flush-status`

  Clear status variables.

- `flush-tables`

  Flush all tables.

- `flush-threads`

  Flush the thread cache.

- `kill` *`id,id,...`*

  Kill server threads. If multiple thread ID values are given, there must be no spaces in the list.

- `old-password` *`new-password`*

  This is like the `password` command but stores the password using the old (pre-4.1) password-hashing format. (See Section 5.3.2.3, “Password Hashing in MySQL”.)

- `password` *`new-password`*

  Set a new password. This changes the password to *`new-password`* for the account that you use with `mysqladmin` for connecting to the server. Thus, the next time you invoke `mysqladmin` (or any other client program) using the same account, you will need to specify the new password.

  If the *`new-password`* value contains spaces or other characters that are special to your command interpreter, you need to enclose it within quotation marks. On Windows, be sure to use double quotation marks rather than single quotation marks; single quotation marks are not stripped from the password, but rather are interpreted as part of the password. For example:

  ```
  shell> mysqladmin password "my new password"
  ```

  As of MySQL 5.5.3, the new password can be omitted following the `password` command. In this case, `mysqladmin` prompts for the password value, which enables you to avoid specifying the password on the command line. Omitting the password value should be done only if `password` is the final command on the `mysqladmin` command line. Otherwise, the next argument is taken as the password.

  > **Caution**
  >
  > Do not use this command used if the server was started with the `--skip-grant-tables` option. No password change will be applied. This is true even if you precede the `password` command with `flush-privileges` on the same command line to re-enable the grant tables because the flush operation occurs after you connect. However, you can use `mysqladmin flush-privileges` to re-enable the grant table and then use a separate `mysqladmin password` command to change the password.

- `ping`

  Check whether the server is available. The return status from `mysqladmin` is 0 if the server is running, 1 if it is not. This is 0 even in case of an error such as `Access denied`, because this means that the server is running but refused the connection, which is different from the server not running.

- `processlist`

  Show a list of active server threads. This is like the output of the `SHOW PROCESSLIST` statement. If the `--verbose` option is given, the output is like that of `SHOW FULL PROCESSLIST`. (See Section 12.4.5.30, “`SHOW PROCESSLIST` Syntax”.)

- `reload`

  Reload the grant tables.

- `refresh`

  Flush all tables and close and open log files.

- `shutdown`

Stop the server.

- `start-slave`

  Start replication on a slave server.

- `status`

  Display a short server status message.

- `stop-slave`

  Stop replication on a slave server.

- `variables`

  Display the server system variables and their values.

- `version`

  Display version information from the server.

All commands can be shortened to any unique prefix. For example:

```
shell> mysqladmin proc stat
+----+-------+-----------+----+---------+------+-------+------------------+
| Id | User  | Host      | db | Command | Time | State | Info             |
+----+-------+-----------+----+---------+------+-------+------------------+
| 51 | monty | localhost |    | Query   | 0    |       | show processlist |
+----+-------+-----------+----+---------+------+-------+------------------+
Uptime: 1473624  Threads: 1  Questions: 39487
Slow queries: 0  Opens: 541  Flush tables: 1
Open tables: 19  Queries per second avg: 0.0268
```

The `mysqladmin status` command result displays the following values:

- `Uptime`

  The number of seconds the MySQL server has been running.

- `Threads`

  The number of active threads (clients).

- `Questions`

  The number of questions (queries) from clients since the server was started.

- `Slow queries`

  The number of queries that have taken more than `long_query_time` seconds. See Section 5.2.5, “The Slow Query Log”.

- `Opens`

  The number of tables the server has opened.

- `Flush tables`

  The number of `flush-*`, `refresh`, and `reload` commands the server has executed.

- `Open tables`

  The number of tables that currently are open.

- `Memory in use`

  The amount of memory allocated directly by `mysqld`. This value is displayed only when MySQL has been compiled with `safemalloc`, which is available only before MySQL 5.5.6.

- `Maximum memory used`

The maximum amount of memory allocated directly by `mysqld`. This value is displayed only when MySQL has been compiled with `safemalloc`, which is available only before MySQL 5.5.6.

If you execute `mysqladmin shutdown` when connecting to a local server using a Unix socket file, `mysqladmin` waits until the server's process ID file has been removed, to ensure that the server has stopped properly.

`mysqladmin` supports the following options, which can be specified on the command line or in the `[mysqladmin]` and `[client]` groups of an option file. `mysqladmin` also supports the options for processing option files described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.3. `mysqladmin` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--compress	compress	Compress all information sent between the client and the server			
--connect_timeout=seconds	connect_timeout	The number of seconds before connection timeout			
--count=#	count	The number of iterations to make for repeated command execution			
--debug[=debug_options]	debug	Write a debugging log			
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.9		
--default-character-set=charset_name	default-character-set	Use charset_name as the default character set			
--force	force	Continue even if an SQL error occurs			
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--no-beep	no-beep	Do not beep when errors occur			
--password[=password]	password	The password to use when connecting to the server			
--pipe		On Windows, connect to server using a named pipe			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.9		
--port=port_num	port	The TCP/IP port number to use for the connection			
--protocol=type	protocol	The connection protocol to use			
--relative	relative	Show the difference between the current and previous values when used with the --sleep option			
--shutdown_timeout=seconds	shutdown_timeout	The maximum number of seconds to wait for server shutdown			
--silent	silent	Silent mode			
--sleep=delay	sleep	Execute commands repeatedly, sleeping for delay seconds in between			

Format	Option File	Description	Introduction	Deprecated	Removed
--socket=path	socket	For connections to localhost			
--ssl-ca=file_name	ssl-ca	The path to a file that contains a list of trusted SSL CAs			
--ssl-capath=directory_name	ssl-capath	The path to a directory that contains trusted SSL CA certificates in PEM format			
--ssl-cert=file_name	ssl-cert	The name of the SSL certificate file to use for establishing a secure connection			
--ssl-cipher=cipher_list	ssl-cipher	A list of allowable ciphers to use for SSL encryption			
--ssl-key=file_name	ssl-key	The name of the SSL key file to use for establishing a secure connection			
--ssl-verify-server-cert	ssl-verify-server-cert	The server's Common Name value in its certificate is verified against the host name used when connecting to the server			
--user=user_name,	user	The MySQL user name to use when connecting to the server			
--verbose		Verbose mode			
--version		Display version information and exit			
--vertical	vertical	Print query output rows vertically (one line per column value)			
--wait	wait	If the connection cannot be established, wait and retry instead of aborting			

- `--help`, `-?`

  Display a help message and exit.

- `--character-sets-dir=path`

  The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--compress`, `-C`

  Compress all information sent between the client and the server if both support compression.

- `--count=N`, `-c N`

  The number of iterations to make for repeated command execution if the `--sleep` option is given.

- `--debug[=debug_options]`, `-# [debug_options]`

  Write a debugging log. A typical *`debug_options`* string is `'d:t:o,file_name'`. The default is `'d:t:o,/tmp/mysqladmin.trace'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-auth=plugin`

The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

This option was added in MySQL 5.5.9.

- `--default-character-set=charset_name`

  Use `charset_name` as the default character set. See Section 9.5, “Character Set Configuration”.

- `--force`, `-f`

  Do not ask for confirmation for the `drop db_name` command. With multiple commands, continue even if an error occurs.

- `--host=host_name`, `-h host_name`

  Connect to the MySQL server on the given host.

- `--no-beep`, `-b`

  Suppress the warning beep that is emitted by default for errors such as a failure to connect to the server.

- `--password[=password]`, `-p[password]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the `password` value following the `--password` or `-p` option on the command line, `mysqladmin` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”. You can use an option file to avoid giving the password on the command line.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. This option applies only if the server supports named-pipe connections.

- `--plugin-dir=path`

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysqladmin` does not find it. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.9.

- `--port=port_num`, `-P port_num`

  The TCP/IP port number to use for the connection.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, “Connecting to the MySQL Server”.

- `--relative`, `-r`

  Show the difference between the current and previous values when used with the `--sleep` option. This option works only with the `extended-status` command.

- `--silent`, `-s`

  Exit silently if a connection to the server cannot be established.

- `--sleep=delay`, `-i delay`

  Execute commands repeatedly, sleeping for `delay` seconds in between. The `--count` option determines the number of iterations. If `--count` is not given, `mysqladmin` executes commands indefinitely until interrupted.

- `--socket=path`, `-S path`

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--ssl*`

  Options that begin with `--ssl` specify whether to connect to the server using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, “SSL Command Options”.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to the server.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does.

- `--version`, `-V`

  Display version information and exit.

- `--vertical`, `-E`

  Print output vertically. This is similar to `--relative`, but prints output vertically.

- `--wait[=count]`, `-w[count]`

  If the connection cannot be established, wait and retry instead of aborting. If a `count` value is given, it indicates the number of times to retry. The default is one time.

You can also set the following variables by using `--var_name=value` The `--set-variable` format is deprecated and was removed in MySQL 5.5.3. syntax:

- `connect_timeout`

  The maximum number of seconds before connection timeout. The default value is 43200 (12 hours).

- `shutdown_timeout`

  The maximum number of seconds to wait for server shutdown. The default value is 3600 (1 hour).

4.5.3. `mysqlcheck` — A Table Maintenance Program

The `mysqlcheck` client performs table maintenance: It checks, repairs, optimizes, or analyzes tables.

Each table is locked and therefore unavailable to other sessions while it is being processed, although for check operations, the table is locked with a `READ` lock only (see Section 12.3.5, “`LOCK TABLES` and `UNLOCK TABLES` Syntax”, for more information about `READ` and `WRITE` locks). Table maintenance operations can be time-consuming, particularly for large tables. If you use the `--databases` or `--all-databases` option to process all tables in one or more databases, an invocation of `mysqlcheck` might take a long time. (This is also true for `mysql_upgrade` because that program invokes `mysqlcheck` to check all tables and repair them if necessary.)

`mysqlcheck` is similar in function to `myisamchk`, but works differently. The main operational difference is that `mysqlcheck` must be used when the `mysqld` server is running, whereas `myisamchk` should be used when it is not. The benefit of using `mysqlcheck` is that you do not have to stop the server to perform table maintenance.

`mysqlcheck` uses the SQL statements `CHECK TABLE`, `REPAIR TABLE`, `ANALYZE TABLE`, and `OPTIMIZE TABLE` in a convenient way for the user. It determines which statements to use for the operation you want to perform, and then sends the statements to the server to be executed. For details about which storage engines each statement works with, see the descriptions for those statements in Section 12.4.2, “Table Maintenance Statements”.

The `MyISAM` storage engine supports all four maintenance operations, so `mysqlcheck` can be used to perform any of them on `MyISAM` tables. Other storage engines do not necessarily support all operations. In such cases, an error message is displayed. For example, if `test.t` is a `MEMORY` table, an attempt to check it produces this result:

```
shell> mysqlcheck test t
test.t
note     : The storage engine for the table doesn't support check
```

If `mysqlcheck` is unable to repair a table, see Section 2.11.4, “Rebuilding or Repairing Tables or Indexes” for manual table repair strategies. This will be the case, for example, for `InnoDB` tables, which can be checked with `CHECK TABLE`, but not repaired with `REPAIR TABLE`.

Caution

> It is best to make a backup of a table before performing a table repair operation; under some circumstances the operation might cause data loss. Possible causes include but are not limited to file system errors.

There are three general ways to invoke `mysqlcheck`:

```
shell> mysqlcheck [options] db_name [tbl_name ...]
shell> mysqlcheck [options] --databases db_name ...
shell> mysqlcheck [options] --all-databases
```

If you do not name any tables following *`db_name`* or if you use the `--databases` or `--all-databases` option, entire databases are checked.

`mysqlcheck` has a special feature compared to other client programs. The default behavior of checking tables (`--check`) can be changed by renaming the binary. If you want to have a tool that repairs tables by default, you should just make a copy of `mysqlcheck` named `mysqlrepair`, or make a symbolic link to `mysqlcheck` named `mysqlrepair`. If you invoke `mysqlrepair`, it repairs tables.

The names shown in the following table can be used to change `mysqlcheck` default behavior.

Command	Meaning
`mysqlrepair`	The default option is `--repair`
`mysqlanalyze`	The default option is `--analyze`
`mysqloptimize`	The default option is `--optimize`

`mysqlcheck` supports the following options, which can be specified on the command line or in the `[mysqlcheck]` and `[client]` groups of an option file. `mysqlcheck` also supports the options for processing option files described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.4. `mysqlcheck` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--all-databases	all-databases	Check all tables in all databases			
--all-in-1	all-in-1	Execute a single statement for each database that names all the tables from that database			
--analyze	analyze	Analyze the tables			
--auto-repair	auto-repair	If a checked table is corrupted, automatically fix it			
--character-sets-dir=path	character-sets-dir	The directory where character sets are installed			
--check	check	Check the tables for errors			
--check-only-changed	check-only-changed	Check only tables that have changed since the last check			
--check-upgrade	check-upgrade	Invoke CHECK TABLE with the FOR UPGRADE option			
--compress	compress	Compress all information sent between the client and the server			
--databases	databases	Process all tables in the named databases			
--debug[=debug_options]	debug	Write a debugging log			
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.10		

Format	Option File	Description	Introduction	Deprecated	Removed
--default-character-set=charset_name	default-character-set	Use charset_name as the default character set			
--extended	extended	Check and repair tables			
--fast	fast	Check only tables that have not been closed properly			
--fix-db-names	fix-db-names	Convert database names to 5.1 format			
--fix-table-names	fix-table-names	Convert table names to 5.1 format			
--force	force	Continue even if an SQL error occurs			
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--medium-check	medium-check	Do a check that is faster than an --extended operation			
--optimize	optimize	Optimize the tables			
--password[=password]	password	The password to use when connecting to the server			
--pipe		On Windows, connect to server using a named pipe			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.10		
--port=port_num	port	The TCP/IP port number to use for the connection			
--protocol=type	protocol	The connection protocol to use			
--quick	quick	The fastest method of checking			
--repair	repair	Perform a repair that can fix almost anything except unique keys that are not unique			
--silent	silent	Silent mode			
--socket=path	socket	For connections to localhost			
--ssl-ca=file_name	ssl-ca	The path to a file that contains a list of trusted SSL CAs			
--ssl-capath=directory_name	ssl-capath	The path to a directory that contains trusted SSL CA certificates in PEM format			
--ssl-cert=file_name	ssl-cert	The name of the SSL certificate file to use for establishing a secure connection			
--ssl-cipher=cipher_list	ssl-cipher	A list of allowable ciphers to use for SSL encryption			
--ssl-key=file_name	ssl-key	The name of the SSL key file to use for establishing a secure connection			
--ssl-verify-server-cert	ssl-verify-server-cert	The server's Common Name value in its certificate is verified against the host name used when connecting to the server			
--tables	tables	Overrides the --databases or -B option			
--use-frm	use-frm	For repair operations on MyISAM tables			
--user=user_name,	user	The MySQL user name to use when connecting to the server			
--verbose		Verbose mode			

Format	Option File	Description	Introduction	Deprecated	Removed
--version		Display version information and exit			
--write-binlog	write-binlog	Log ANALYZE, OPTIMIZE, REPAIR statements to binary log. --skip-write-binlog adds NO_WRITE_TO_BINLOG to these statements.			

- `--help`, `-?`

  Display a help message and exit.

- `--all-databases`, `-A`

  Check all tables in all databases. This is the same as using the `--databases` option and naming all the databases on the command line.

- `--all-in-1`, `-1`

  Instead of issuing a statement for each table, execute a single statement for each database that names all the tables from that database to be processed.

- `--analyze`, `-a`

  Analyze the tables.

- `--auto-repair`

  If a checked table is corrupted, automatically fix it. Any necessary repairs are done after all tables have been checked.

- `--character-sets-dir=path`

  The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--check`, `-c`

  Check the tables for errors. This is the default operation.

- `--check-only-changed`, `-C`

  Check only tables that have changed since the last check or that have not been closed properly.

- `--check-upgrade`, `-g`

  Invoke `CHECK TABLE` with the `FOR UPGRADE` option to check tables for incompatibilities with the current version of the server. This option automatically enables the `--fix-db-names` and `--fix-table-names` options.

- `--compress`

  Compress all information sent between the client and the server if both support compression.

- `--databases`, `-B`

  Process all tables in the named databases. Normally, `mysqlcheck` treats the first name argument on the command line as a database name and following names as table names. With this option, it treats all name arguments as database names.

- `--debug[=debug_options]`, `-# [debug_options]`

  Write a debugging log. A typical *`debug_options`* string is `'d:t:o,file_name'`. The default is `'d:t:o'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-character-set=charset_name`

Use *`charset_name`* as the default character set. See Section 9.5, “Character Set Configuration”.

- `--extended`, `-e`

  If you are using this option to check tables, it ensures that they are 100% consistent but takes a long time.

  If you are using this option to repair tables, it runs an extended repair that may not only take a long time to execute, but may produce a lot of garbage rows also!

- `--default-auth=`*`plugin`*

  The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.10.

- `--fast`, `-F`

  Check only tables that have not been closed properly.

- `--fix-db-names`

  Convert database names to 5.1 format. Only database names that contain special characters are affected.

- `--fix-table-names`

  Convert table names to 5.1 format. Only table names that contain special characters are affected. This option also applies to views.

- `--force`, `-f`

  Continue even if an SQL error occurs.

- `--host=`*`host_name`*, `-h` *`host_name`*

  Connect to the MySQL server on the given host.

- `--medium-check`, `-m`

  Do a check that is faster than an `--extended` operation. This finds only 99.99% of all errors, which should be good enough in most cases.

- `--optimize`, `-o`

  Optimize the tables.

- `--password[=`*`password`*`]`, `-p[`*`password`*`]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the *`password`* value following the `--password` or `-p` option on the command line, `mysqlcheck` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”. You can use an option file to avoid giving the password on the command line.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. This option applies only if the server supports named-pipe connections.

- `--plugin-dir=`*`path`*

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysqlcheck` does not find it. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.10.

- `--port=`*`port_num`*, `-P` *`port_num`*

  The TCP/IP port number to use for the connection.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, “Connecting to the MySQL Server”.

- `--quick`, `-q`

  If you are using this option to check tables, it prevents the check from scanning the rows to check for incorrect links. This is the fastest check method.

  If you are using this option to repair tables, it tries to repair only the index tree. This is the fastest repair method.

- `--repair`, `-r`

  Perform a repair that can fix almost anything except unique keys that are not unique.

- `--silent`, `-s`

  Silent mode. Print only error messages.

- `--socket=path`, `-S path`

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--ssl*`

  Options that begin with `--ssl` specify whether to connect to the server using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, “SSL Command Options”.

- `--tables`

  Override the `--databases` or `-B` option. All name arguments following the option are regarded as table names.

- `--use-frm`

  For repair operations on `MyISAM` tables, get the table structure from the `.frm` file so that the table can be repaired even if the `.MYI` header is corrupted.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to the server.

- `--verbose`, `-v`

  Verbose mode. Print information about the various stages of program operation.

- `--version`, `-V`

  Display version information and exit.

- `--write-binlog`

  This option is enabled by default, so that `ANALYZE TABLE`, `OPTIMIZE TABLE`, and `REPAIR TABLE` statements generated by `mysqlcheck` are written to the binary log. Use `--skip-write-binlog` to cause `NO_WRITE_TO_BINLOG` to be added to the statements so that they are not logged. Use the `--skip-write-binlog` when these statements should not be sent to replication slaves or run when using the binary logs for recovery from backup.

4.5.4. `mysqldump` — A Database Backup Program

The `mysqldump` client is a backup program originally written by Igor Romanenko. It can be used to dump a database or a collection of databases for backup or transfer to another SQL server (not necessarily a MySQL server). The dump typically contains SQL statements to create the table, populate it, or both. However, `mysqldump` can also be used to generate files in CSV, other delimited text, or XML format.

If you are doing a backup on the server and your tables all are `MyISAM` tables, consider using the `mysqlhotcopy` instead because it can accomplish faster backups and faster restores. See Section 4.6.9, “`mysqlhotcopy` — A Database Backup Program”.

There are three general ways to invoke `mysqldump`:

```
shell> mysqldump [options] db_name [tbl_name ...]
shell> mysqldump [options] --databases db_name ...
shell> mysqldump [options] --all-databases
```

If you do not name any tables following *`db_name`* or if you use the `--databases` or `--all-databases` option, entire databases are dumped.

`mysqldump` does not dump the `INFORMATION_SCHEMA` database by default. `mysqldump` dumps `INFORMATION_SCHEMA` only if you name it explicitly on the command line, although currently you must also use the `--skip-lock-tables` option. Before MySQL 5.5 `mysqldump` silently ignores `INFORMATION_SCHEMA` even if you name it explicitly on the command line.

`mysqldump` does not dump the `performance_schema` database.

To see a list of the options your version of `mysqldump` supports, execute `mysqldump --help`.

Some `mysqldump` options are shorthand for groups of other options:

- Use of `--opt` is the same as specifying `--add-drop-table`, `--add-locks`, `--create-options`, `--disable-keys`, `--extended-insert`, `--lock-tables`, `--quick`, and `--set-charset`. All of the options that `--opt` stands for also are on by default because `--opt` is on by default.
- Use of `--compact` is the same as specifying `--skip-add-drop-table`, `--skip-add-locks`, `--skip-comments`, `--skip-disable-keys`, and `--skip-set-charset` options.

To reverse the effect of a group option, uses its `--skip-`*`xxx`* form (`--skip-opt` or `--skip-compact`). It is also possible to select only part of the effect of a group option by following it with options that enable or disable specific features. Here are some examples:

- To select the effect of `--opt` except for some features, use the `--skip` option for each feature. To disable extended inserts and memory buffering, use `--opt --skip-extended-insert --skip-quick`. (Actually, `--skip-extended-insert --skip-quick` is sufficient because `--opt` is on by default.)
- To reverse `--opt` for all features except index disabling and table locking, use `--skip-opt --disable-keys --lock-tables`.

When you selectively enable or disable the effect of a group option, order is important because options are processed first to last. For example, `--disable-keys --lock-tables --skip-opt` would not have the intended effect; it is the same as `--skip-opt` by itself.

`mysqldump` can retrieve and dump table contents row by row, or it can retrieve the entire content from a table and buffer it in memory before dumping it. Buffering in memory can be a problem if you are dumping large tables. To dump tables row by row, use the `--quick` option (or `--opt`, which enables `--quick`). The `--opt` option (and hence `--quick`) is enabled by default, so to enable memory buffering, use `--skip-quick`.

If you are using a recent version of `mysqldump` to generate a dump to be reloaded into a very old MySQL server, you should not use the `--opt` or `--extended-insert` option. Use `--skip-opt` instead.

For additional information about `mysqldump`, see Section 6.4, “Using `mysqldump` for Backups”.

`mysqldump` supports the following options, which can be specified on the command line or in the `[mysqldump]` and `[client]` groups of an option file. `mysqldump` also supports the options for processing option files described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.5. `mysqldump` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--add-drop-database	add-drop-database	Add a DROP DATABASE statement before each CREATE DATABASE statement			
--add-drop-table	add-drop-table	Add a DROP TABLE statement before each CREATE TABLE statement			
--add-locks	add-locks	Surround each table dump with LOCK TABLES and UNLOCK TABLES statements			
--all-databases	all-databases	Dump all tables in all databases			
--allow-keywords	allow-keywords	Allow creation of column names that are keywords			

Format	Option File	Description	Introduction	Deprecated	Removed
--apply-slave-statements	apply-slave-statements	Include STOP SLAVE prior to CHANGE MASTER statement and START SLAVE at end of output	5.5.3		
--bind-address=ip_address	bind-address	Use the specified network interface to connect to the MySQL Server	5.5.8		
--comments	comments	Add comments to the dump file			
--compact	compact	Produce more compact output			
--compatible=name[,name,...]	compatible	Produce output that is more compatible with other database systems or with older MySQL servers			
--complete-insert	complete-insert	Use complete INSERT statements that include column names			
--create-options	create-options	Include all MySQL-specific table options in CREATE TABLE statements			
--databases	databases	Dump several databases			
--debug[=debug_options]	debug	Write a debugging log			
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.9		
--default-character-set=charset_name	default-character-set	Use charset_name as the default character set			
--delayed-insert	delayed-insert	Write INSERT DELAYED statements rather than INSERT statements			
--delete-master-logs	delete-master-logs	On a master replication server, delete the binary logs after performing the dump operation			
--disable-keys	disable-keys	For each table, surround the INSERT statements with statements to disable and enable keys			
--dump-date	dump-date	Include dump date as "Dump completed on" comment if --comments is given			
--dump-slave[=value]	dump-slave	Include CHANGE MASTER statement that lists binary log coordinates of slave's master	5.5.3		
--events	events	Dump events from the dumped databases			
--extended-insert	extended-insert	Use multiple-row INSERT syntax that include several VALUES lists			
--fields-enclosed-by=string	fields-enclosed-by	This option is used with the --tab option and has the same meaning as the corresponding clause for LOAD DATA INFILE			
--fields-escaped-by	fields-escaped-by	This option is used with the --tab option and has the same meaning as the corresponding clause for			

Format	Option File	Description	Introduction	Deprecated	Removed
		LOAD DATA INFILE			
--fields-optionally-enclosed-by=string	fields-optionally-enclosed-by	This option is used with the --tab option and has the same meaning as the corresponding clause for LOAD DATA INFILE			
--fields-terminated-by=string	fields-terminated-by	This option is used with the --tab option and has the same meaning as the corresponding clause for LOAD DATA INFILE			
--first-slave	first-slave	Deprecated; use --lock-all-tables instead			5.5.3
--flush-logs	flush-logs	Flush the MySQL server log files before starting the dump			
--flush-privileges	flush-privileges	Emit a FLUSH PRIVILEGES statement after dumping the mysql database			
--help		Display help message and exit			
--hex-blob	hex-blob	Dump binary columns using hexadecimal notation (for example, 'abc' becomes 0x616263)			
--host	host	Host to connect to (IP address or hostname)			
--ignore-table=db_name.tbl_name	ignore-table	Do not dump the given table			
--include-master-host-port	include-master-host-port	Include MASTER_HOST/MASTER_PORT options in CHANGE MASTER statement produced with --dump-slave	5.5.3		
--insert-ignore	insert-ignore	Write INSERT IGNORE statements rather than INSERT statements			
--lines-terminated-by=string	lines-terminated-by	This option is used with the --tab option and has the same meaning as the corresponding clause for LOAD DATA INFILE			
--lock-all-tables	lock-all-tables	Lock all tables across all databases			
--lock-tables	lock-tables	Lock all tables before dumping them			
--log-error=file_name	log-error	Append warnings and errors to the named file			
--master-data[=value]	master-data	Write the binary log file name and position to the output			
--max_allowed_packet=value	max_allowed_packet	The maximum packet length to send to or receive from the server			
--net_buffer_length=value	net_buffer_length	The buffer size for TCP/IP and socket communication			
--no-autocommit	no-autocommit	Enclose the INSERT statements for each dumped table within SET autocommit = 0 and COMMIT statements			
--no-create-db	no-create-db	This option suppresses the CREATE DATABASE statements			
--no-create-info	no-create-info	Do not write CREATE TABLE statements that re-create each dumped table			

Format	Option File	Description	Introduction	Deprecated	Removed
--no-data	no-data	Do not dump table contents			
--no-set-names	no-set-names	Same as --skip-set-charset			
--no-tablespaces	no-tablespaces	Do not write any CREATE LOGFILE GROUP or CREATE TABLESPACE statements in output			
--opt	opt	Shorthand for --add-drop-table --add-locks --create-options --disable-keys --extended-insert --lock-tables --quick --set-charset.			
--order-by-primary	order-by-primary	Dump each table's rows sorted by its primary key, or by its first unique index			
--password[=password]	password	The password to use when connecting to the server			
--pipe		On Windows, connect to server using a named pipe			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.9		
--port=port_num	port	The TCP/IP port number to use for the connection			
--quick	quick	Retrieve rows for a table from the server a row at a time			
--quote-names	quote-names	Quote identifiers within backtick characters			
--replace	replace	Write REPLACE statements rather than INSERT statements			
--result-file=file	result-file	Direct output to a given file			
--routines	routines	Dump stored routines (procedures and functions) from the dumped databases			
--set-charset	set-charset	Add SET NAMES default_character_set to the output			
--single-transaction	single-transaction	This option issues a BEGIN SQL statement before dumping data from the server			
--skip-add-drop-table	skip-add-drop-table	Do not add a DROP TABLE statement before each CREATE TABLE statement			
--skip-add-locks	skip-add-locks	Do not add locks			
--skip-comments	skip-comments	Do not add comments to the dump file			
--skip-compact	skip-compact	Do not produce more compact output			
--skip-disable-keys	skip-disable-keys	Do not disable keys			
--skip-extended-insert	skip-extended-insert	Turn off extended-insert			
--skip-opt	skip-opt	Turn off the options set by --opt			
--skip-quick	skip-quick	Do not retrieve rows for a table from the server a row at a time			
--skip-quote-names	skip-quote-names	Do not quote identifiers			
--skip-set-charset	skip-set-charset	Suppress the SET NAMES statement			
--skip-triggers	skip-triggers	Do not dump triggers			
--skip-tz-utc	skip-tz-utc	Turn off tz-utc			
--ssl-ca=file_name	ssl-ca	The path to a file that contains a list of trusted SSL CAs			
--ssl-capath=directory_name	ssl-capath	The path to a directory that contains trusted SSL CA certificates in PEM format			

Format	Option File	Description	Introduction	Deprecated	Removed
--ssl-cert=file_name	ssl-cert	The name of the SSL certificate file to use for establishing a secure connection			
--ssl-cipher=cipher_list	ssl-cipher	A list of allowable ciphers to use for SSL encryption			
--ssl-key=file_name	ssl-key	The name of the SSL key file to use for establishing a secure connection			
--ssl-verify-server-cert	ssl-verify-server-cert	The server's Common Name value in its certificate is verified against the host name used when connecting to the server			
--tab=path	tab	Produce tab-separated data files			
--tables	tables	Override the --databases or -B option			
--triggers	triggers	Dump triggers for each dumped table			
--tz-utc	tz-utc	Add SET TIME_ZONE='+00:00' to the dump file			
--user=user_name	user	The MySQL user name to use when connecting to the server			
--verbose		Verbose mode			
--version		Display version information and exit			
--where='where_condition'	where	Dump only rows selected by the given WHERE condition			
--xml	xml	Produce XML output			

- `--help`, `-?`

  Display a help message and exit.

- `--add-drop-database`

  Add a `DROP DATABASE` statement before each `CREATE DATABASE` statement. This option is typically used in conjunction with the `--all-databases` or `--databases` option because no `CREATE DATABASE` statements are written unless one of those options is specified.

- `--add-drop-table`

  Add a `DROP TABLE` statement before each `CREATE TABLE` statement.

- `--add-locks`

  Surround each table dump with `LOCK TABLES` and `UNLOCK TABLES` statements. This results in faster inserts when the dump file is reloaded. See Section 7.2.2.1, “Speed of `INSERT` Statements”.

- `--all-databases`, `-A`

  Dump all tables in all databases. This is the same as using the `--databases` option and naming all the databases on the command line.

- `--all-tablespaces`, `-Y`

  Adds to a table dump all SQL statements needed to create any tablespaces used by an `NDBCLUSTER` table. This information is not otherwise included in the output from `mysqldump`. This option is currently relevant only to MySQL Cluster tables.

- `--allow-keywords`

  Permit creation of column names that are keywords. This works by prefixing each column name with the table name.

- `--apply-slave-statements`

  For a slave dump produced with the `--dump-slave` option, add a `STOP SLAVE` statement before the `CHANGE MASTER TO` statement and a `START SLAVE` statement at the end of the output. This option was added in MySQL 5.5.3.

- `--character-sets-dir=`*`path`*

  The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--comments`, `-i`

  Write additional information in the dump file such as program version, server version, and host. This option is enabled by default. To suppress this additional information, use `--skip-comments`.

- `--compact`

  Produce more compact output. This option enables the `--skip-add-drop-table`, `--skip-add-locks`, `--skip-comments`, `--skip-disable-keys`, and `--skip-set-charset` options.

- `--compatible=`*`name`*

  Produce output that is more compatible with other database systems or with older MySQL servers. The value of *`name`* can be `ansi`, `mysql323`, `mysql40`, `postgresql`, `oracle`, `mssql`, `db2`, `maxdb`, `no_key_options`, `no_table_options`, or `no_field_options`. To use several values, separate them by commas. These values have the same meaning as the corresponding options for setting the server SQL mode. See Section 5.1.6, “Server SQL Modes”.

  This option does not guarantee compatibility with other servers. It only enables those SQL mode values that are currently available for making dump output more compatible. For example, `--compatible=oracle` does not map data types to Oracle types or use Oracle comment syntax.

  This option requires a server version of 4.1.0 or higher. With older servers, it does nothing.

- `--complete-insert`, `-c`

  Use complete `INSERT` statements that include column names.

- `--compress`, `-C`

  Compress all information sent between the client and the server if both support compression.

- `--create-options`

  Include all MySQL-specific table options in the `CREATE TABLE` statements.

- `--databases`, `-B`

  Dump several databases. Normally, `mysqldump` treats the first name argument on the command line as a database name and following names as table names. With this option, it treats all name arguments as database names. `CREATE DATABASE` and `USE` statements are included in the output before each new database.

- `--debug[=`*`debug_options`*`]`, `-# [`*`debug_options`*`]`

  Write a debugging log. A typical *`debug_options`* string is `'d:t:o,`*`file_name`*`'`. The default value is `'d:t:o,/tmp/mysqldump.trace'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-auth=`*`plugin`*

  The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.9.

- `--default-character-set=`*`charset_name`*

  Use *`charset_name`* as the default character set. See Section 9.5, “Character Set Configuration”. If no character set is specified, `mysqldump` uses `utf8`, and earlier versions use `latin1`.

- `--delayed-insert`

  Write `INSERT DELAYED` statements rather than `INSERT` statements.

- `--delete-master-logs`

  On a master replication server, delete the binary logs by sending a `PURGE BINARY LOGS` statement to the server after performing the dump operation. This option automatically enables `--master-data`.

- `--disable-keys`, `-K`

  For each table, surround the `INSERT` statements with `/*!40000 ALTER TABLE tbl_name DISABLE KEYS */;` and `/*!40000 ALTER TABLE tbl_name ENABLE KEYS */;` statements. This makes loading the dump file faster because the indexes are created after all rows are inserted. This option is effective only for nonunique indexes of `MyISAM` tables.

- `--dump-date`

  If the `--comments` option is given, `mysqldump` produces a comment at the end of the dump of the following form:

  ```
  -- Dump completed on DATE
  ```

  However, the date causes dump files taken at different times to appear to be different, even if the data are otherwise identical. `--dump-date` and `--skip-dump-date` control whether the date is added to the comment. The default is `--dump-date` (include the date in the comment). `--skip-dump-date` suppresses date printing.

- `--dump-slave[=value]`

  This option is similar to `--master-data` except that it is used to dump a replication slave server to produce a dump file that can be used to set up another server as a slave that has the same master as the dumped server. It causes the dump output to include a `CHANGE MASTER TO` statement that indicates the binary log coordinates (file name and position) of the dumped slave's master (rather than the coordinates of the dumped server, as is done by the `--master-data` option). These are the master server coordinates from which the slave should start replicating. This option was added in MySQL 5.5.3.

  The option value is handled the same way as for `--master-data` and has the same effect as `--master-data` in terms of enabling or disabling other options and in how locking is handled.

  In conjunction with `--dump-slave`, the `--apply-slave-statements` and `--include-master-host-port` options can also be used.

- `--events`, `-E`

  Include Event Scheduler events for the dumped databases in the output.

- `--extended-insert`, `-e`

  Use multiple-row `INSERT` syntax that include several `VALUES` lists. This results in a smaller dump file and speeds up inserts when the file is reloaded.

- `--fields-terminated-by=...`, `--fields-enclosed-by=...`, `--fields-optionally-enclosed-by=...`, `--fields-escaped-by=...`

  These options are used with the `--tab` option and have the same meaning as the corresponding `FIELDS` clauses for `LOAD DATA INFILE`. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”.

- `--first-slave`

  Deprecated. Use `--lock-all-tables` instead. `--first-slave` was removed in MySQL 5.5.3.

- `--flush-logs`, `-F`

  Flush the MySQL server log files before starting the dump. This option requires the `RELOAD` privilege. If you use this option in combination with the `--all-databases` option, the logs are flushed *for each database dumped*. The exception is when using `--lock-all-tables` or `--master-data`: In this case, the logs are flushed only once, corresponding to the moment that all tables are locked. If you want your dump and the log flush to happen at exactly the same moment, you should use `--flush-logs` together with either `--lock-all-tables` or `--master-data`.

- `--flush-privileges`

  Send a `FLUSH PRIVILEGES` statement to the server after dumping the `mysql` database. This option should be used any time the dump contains the `mysql` database and any other database that depends on the data in the `mysql` database for proper restoration.

- `--force`, `-f`

  Continue even if an SQL error occurs during a table dump.

  One use for this option is to cause `mysqldump` to continue executing even when it encounters a view that has become invalid because the definition refers to a table that has been dropped. Without `--force`, `mysqldump` exits with an error message. With `--force`, `mysqldump` prints the error message, but it also writes an SQL comment containing the view definition to the dump output and continues executing.

- `--host=`*`host_name`*, `-h` *`host_name`*

  Dump data from the MySQL server on the given host. The default host is `localhost`.

- `--hex-blob`

  Dump binary columns using hexadecimal notation (for example, `'abc'` becomes `0x616263`). The affected data types are `BINARY`, `VARBINARY`, the `BLOB` types, and `BIT`.

- `--include-master-host-port`

  For the `CHANGE MASTER TO` statement in a slave dump produced with the `--dump-slave` option, add `MASTER_PORT` and `MASTER_PORT` options for the host name and TCP/IP port number of the slave's master. This option was added in MySQL 5.5.3.

- `--ignore-table=`*`db_name.tbl_name`*

  Do not dump the given table, which must be specified using both the database and table names. To ignore multiple tables, use this option multiple times. This option also can be used to ignore views.

- `--insert-ignore`

  Write `INSERT IGNORE` statements rather than `INSERT` statements.

- `--lines-terminated-by=...`

  This option is used with the `--tab` option and has the same meaning as the corresponding `LINES` clause for `LOAD DATA INFILE`. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”.

- `--lock-all-tables`, `-x`

  Lock all tables across all databases. This is achieved by acquiring a global read lock for the duration of the whole dump. This option automatically turns off `--single-transaction` and `--lock-tables`.

- `--lock-tables`, `-l`

  For each dumped database, lock all tables to be dumped before dumping them. The tables are locked with `READ LOCAL` to permit concurrent inserts in the case of `MyISAM` tables. For transactional tables such as `InnoDB`, `--single-transaction` is a much better option than `--lock-tables` because it does not need to lock the tables at all.

  Because `--lock-tables` locks tables for each database separately, this option does not guarantee that the tables in the dump file are logically consistent between databases. Tables in different databases may be dumped in completely different states.

- `--log-error=`*`file_name`*

  Log warnings and errors by appending them to the named file. The default is to do no logging.

- `--master-data[=`*`value`*`]`

  Use this option to dump a master replication server to produce a dump file that can be used to set up another server as a slave of the master. It causes the dump output to include a `CHANGE MASTER TO` statement that indicates the binary log coordinates (file name and position) of the dumped server. These are the master server coordinates from which the slave should start replicating after you load the dump file into the slave.

  If the option value is 2, the `CHANGE MASTER TO` statement is written as an SQL comment, and thus is informative only; it has no effect when the dump file is reloaded. If the option value is 1, the statement is not written as a comment and takes effect when the dump file is reloaded. If no option value is specified, the default value is 1.

  This option requires the `RELOAD` privilege and the binary log must be enabled.

The `--master-data` option automatically turns off `--lock-tables`. It also turns on `--lock-all-tables`, unless `--single-transaction` also is specified, in which case, a global read lock is acquired only for a short time at the beginning of the dump (see the description for `--single-transaction`). In all cases, any action on logs happens at the exact moment of the dump.

It is also possible to set up a slave by dumping an existing slave of the master. To do this, use the following procedure on the existing slave:

1. Stop the slave's SQL thread and get its current status:

   ```
   mysql> STOP SLAVE SQL_THREAD;
   mysql> SHOW SLAVE STATUS;
   ```

2. From the output of the `SHOW SLAVE STATUS` statement, the binary log coordinates of the master server from which the new slave should start replicating are the values of the `Relay_Master_Log_File` and `Exec_Master_Log_Pos` fields. Denote those values as *`file_name`* and *`file_pos`*.

3. Dump the slave server:

   ```
   shell> mysqldump --master-data=2 --all-databases > dumpfile
   ```

   Using `--master-data=2` works only if binary logging has been enabled on the slave. Otherwise, `mysqldump` fails with the error BINLOGGING ON SERVER NOT ACTIVE. In this case you must handle any locking issues in another manner, using one or more of `--add-locks`, `--lock-tables`, `--lock-all-tables`, or `--single-transaction`, as required by your application and environment.

4. Restart the slave:

   ```
   mysql> START SLAVE;
   ```

5. On the new slave, load the dump file:

   ```
   shell> mysql < dumpfile
   ```

6. On the new slave, set the replication coordinates to those of the master server obtained earlier:

   ```
   mysql> CHANGE MASTER TO
       -> MASTER_LOG_FILE = 'file_name', MASTER_LOG_POS = file_pos;
   ```

   The `CHANGE MASTER TO` statement might also need other parameters, such as `MASTER_HOST` to point the slave to the correct master server host. Add any such parameters as necessary.

- `--no-autocommit`

  Enclose the `INSERT` statements for each dumped table within `SET autocommit = 0` and `COMMIT` statements.

- `--no-create-db`, `-n`

  This option suppresses the `CREATE DATABASE` statements that are otherwise included in the output if the `--databases` or `--all-databases` option is given.

- `--no-create-info`, `-t`

  Do not write `CREATE TABLE` statements that re-create each dumped table.

  > **Note**
  >
  > This option does *not* not exclude statements creating log file groups or tablespaces from `mysqldump` output; however, you can use the `--no-tablespaces` option for this purpose.

- `--no-data`, `-d`

  Do not write any table row information (that is, do not dump table contents). This is useful if you want to dump only the `CREATE TABLE` statement for the table (for example, to create an empty copy of the table by loading the dump file).

- `--no-set-names`, `-N`

  This has the same effect as `--skip-set-charset`.

- `--no-tablespaces`, `-y`

  This option suppresses all `CREATE LOGFILE GROUP` and `CREATE TABLESPACE` statements in the output of `mysqldump`.

- `--opt`

  This option is shorthand. It is the same as specifying `--add-drop-table --add-locks --create-options --disable-keys --extended-insert --lock-tables --quick --set-charset`. It should give you a fast dump operation and produce a dump file that can be reloaded into a MySQL server quickly.

  The `--opt` option is enabled by default. Use `--skip-opt` to disable it. See the discussion at the beginning of this section for information about selectively enabling or disabling a subset of the options affected by `--opt`.

- `--order-by-primary`

  Dump each table's rows sorted by its primary key, or by its first unique index, if such an index exists. This is useful when dumping a `MyISAM` table to be loaded into an `InnoDB` table, but will make the dump operation take considerably longer.

- `--password[=password]`, `-p[password]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the *`password`* value following the `--password` or `-p` option on the command line, `mysqldump` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”. You can use an option file to avoid giving the password on the command line.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. This option applies only if the server supports named-pipe connections.

- `--plugin-dir=path`

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysqldump` does not find it. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.9.

- `--port=port_num`, `-P port_num`

  The TCP/IP port number to use for the connection.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, “Connecting to the MySQL Server”.

- `--quick`, `-q`

  This option is useful for dumping large tables. It forces `mysqldump` to retrieve rows for a table from the server a row at a time rather than retrieving the entire row set and buffering it in memory before writing it out.

- `--quote-names`, `-Q`

  Quote identifiers (such as database, table, and column names) within “`` ` ``” characters. If the `ANSI_QUOTES` SQL mode is enabled, identifiers are quoted within “`"`” characters. This option is enabled by default. It can be disabled with `--skip-quote-names`, but this option should be given after any option such as `--compatible` that may enable `--quote-names`.

- `--replace`

  Write `REPLACE` statements rather than `INSERT` statements.

- `--result-file=file_name`, `-r file_name`

  Direct output to a given file. This option should be used on Windows to prevent newline “`\n`” characters from being converted to “`\r\n`” carriage return/newline sequences. The result file is created and its previous contents overwritten, even if an error occurs while generating the dump.

- `--routines`, `-R`

  Included stored routines (procedures and functions) for the dumped databases in the output. Use of this option requires the `SELECT` privilege for the `mysql.proc` table. The output generated by using `--routines` contains `CREATE PROCEDURE` and `CREATE FUNCTION` statements to re-create the routines. However, these statements do not include attributes such as the routine creation and modification timestamps. This means that when the routines are reloaded, they will be created with the timestamps equal to the reload time.

  If you require routines to be re-created with their original timestamp attributes, do not use `--routines`. Instead, dump and reload the contents of the `mysql.proc` table directly, using a MySQL account that has appropriate privileges for the `mysql` database.

- `--set-charset`

  Add `SET NAMES` *`default_character_set`* to the output. This option is enabled by default. To suppress the `SET NAMES` statement, use `--skip-set-charset`.

- `--single-transaction`

  This option sends a `START TRANSACTION` SQL statement to the server before dumping data. It is useful only with transactional tables such as `InnoDB`, because then it dumps the consistent state of the database at the time when `BEGIN` was issued without blocking any applications.

  When using this option, you should keep in mind that only `InnoDB` tables are dumped in a consistent state. For example, any `MyISAM` or `MEMORY` tables dumped while using this option may still change state.

  While a `--single-transaction` dump is in process, to ensure a valid dump file (correct table contents and binary log coordinates), no other connection should use the following statements: `ALTER TABLE`, `CREATE TABLE`, `DROP TABLE`, `RENAME TABLE`, `TRUNCATE TABLE`. A consistent read is not isolated from those statements, so use of them on a table to be dumped can cause the `SELECT` that is performed by `mysqldump` to retrieve the table contents to obtain incorrect contents or fail.

  The `--single-transaction` option and the `--lock-tables` option are mutually exclusive because `LOCK TABLES` causes any pending transactions to be committed implicitly.

  To dump large tables, you should combine the `--single-transaction` option with `--quick`.

- `--skip-comments`

  See the description for the `--comments` option.

- `--skip-opt`

  See the description for the `--opt` option.

- `--socket=`*`path`*, `-S` *`path`*

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--ssl*`

  Options that begin with `--ssl` specify whether to connect to the server using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, “SSL Command Options”.

- `--tab=`*`path`*, `-T` *`path`*

  Produce tab-separated text-format data files. For each dumped table, `mysqldump` creates a *`tbl_name`*`.sql` file that contains the `CREATE TABLE` statement that creates the table, and the server writes a *`tbl_name`*`.txt` file that contains its data. The option value is the directory in which to write the files.

  > **Note**
  >
  > This option should be used only when `mysqldump` is run on the same machine as the `mysqld` server. You must have the `FILE` privilege, and the server must have permission to write files in the directory that you specify.

  By default, the `.txt` data files are formatted using tab characters between column values and a newline at the end of each line. The format can be specified explicitly using the `--fields-`*`xxx`* and `--lines-terminated-by` options.

  Column values are converted to the character set specified by the `--default-character-set` option.

- `--tables`

Override the `--databases` or `-B` option. `mysqldump` regards all name arguments following the option as table names.

- `--triggers`

  Include triggers for each dumped table in the output. This option is enabled by default; disable it with `--skip-triggers`.

- `--tz-utc`

  This option enables `TIMESTAMP` columns to be dumped and reloaded between servers in different time zones. `mysqldump` sets its connection time zone to UTC and adds `SET TIME_ZONE='+00:00'` to the dump file. Without this option, `TIMESTAMP` columns are dumped and reloaded in the time zones local to the source and destination servers, which can cause the values to change if the servers are in different time zones. `--tz-utc` also protects against changes due to daylight saving time. `--tz-utc` is enabled by default. To disable it, use `--skip-tz-utc`.

- `--user=`*`user_name`*, `-u` *`user_name`*

  The MySQL user name to use when connecting to the server.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does.

- `--version`, `-V`

  Display version information and exit.

- `--where='`*`where_condition`*`'`, `-w '`*`where_condition`*`'`

  Dump only rows selected by the given `WHERE` condition. Quotes around the condition are mandatory if it contains spaces or other characters that are special to your command interpreter.

  Examples:

```
--where="user='jimf'"
-w"userid>1"
-w"userid<1"
```

- `--xml`, `-X`

  Write dump output as well-formed XML.

  `NULL`, `'NULL'`, and Empty Values: For a column named *`column_name`*, the `NULL` value, an empty string, and the string value `'NULL'` are distinguished from one another in the output generated by this option as follows.

Value:	**XML Representation:**
`NULL` (*unknown value*)	`<field name="`*`column_name`*`" xsi:nil="true" />`
`''` (*empty string*)	`<field name="`*`column_name`*`"></field>`
`'NULL'` (*string value*)	`<field name="`*`column_name`*`">NULL</field>`

The output from the `mysql` client when run using the `--xml` option also follows the preceding rules. (See Section 4.5.1.1, “`mysql` Options”.)

XML output from `mysqldump` includes the XML namespace, as shown here:

```
shell> mysqldump --xml -u root world City
<?xml version="1.0"?>
<mysqldump xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<database name="world">
<table_structure name="City">
<field Field="ID" Type="int(11)" Null="NO" Key="PRI" Extra="auto_increment" />
<field Field="Name" Type="char(35)" Null="NO" Key="" Default="" Extra="" />
<field Field="CountryCode" Type="char(3)" Null="NO" Key="" Default="" Extra="" />
<field Field="District" Type="char(20)" Null="NO" Key="" Default="" Extra="" />
<field Field="Population" Type="int(11)" Null="NO" Key="" Default="0" Extra="" />
<key Table="City" Non_unique="0" Key_name="PRIMARY" Seq_in_index="1" Column_name="ID"
Collation="A" Cardinality="4079" Null="" Index_type="BTREE" Comment="" />
<options Name="City" Engine="MyISAM" Version="10" Row_format="Fixed" Rows="4079"
Avg_row_length="67" Data_length="273293" Max_data_length="18858823439613951"
Index_length="43008" Data_free="0" Auto_increment="4080"
```

```
Create_time="2007-03-31 01:47:01" Update_time="2007-03-31 01:47:02"
Collation="latin1_swedish_ci" Create_options="" Comment="" />
</table_structure>
<table_data name="City">
<row>
<field name="ID">1</field>
<field name="Name">Kabul</field>
<field name="CountryCode">AFG</field>
<field name="District">Kabol</field>
<field name="Population">1780000</field>
</row>

...

<row>
<field name="ID">4079</field>
<field name="Name">Rafah</field>
<field name="CountryCode">PSE</field>
<field name="District">Rafah</field>
<field name="Population">92020</field>
</row>
</table_data>
</database>
</mysqldump>
```

You can also set the following variables by using `--var_name=value` syntax:

- `max_allowed_packet`

  The maximum size of the buffer for client/server communication. The maximum is 1GB.

- `net_buffer_length`

  The initial size of the buffer for client/server communication. When creating multiple-row `INSERT` statements (as with the `--extended-insert` or `--opt` option), `mysqldump` creates rows up to `net_buffer_length` length. If you increase this variable, you should also ensure that the `net_buffer_length` variable in the MySQL server is at least this large.

A common use of `mysqldump` is for making a backup of an entire database:

```
shell> mysqldump db_name > backup-file.sql
```

You can load the dump file back into the server like this:

```
shell> mysql db_name < backup-file.sql
```

Or like this:

```
shell> mysql -e "source /path-to-backup/backup-file.sql" db_name
```

`mysqldump` is also very useful for populating databases by copying data from one MySQL server to another:

```
shell> mysqldump --opt db_name | mysql --host=remote_host -C db_name
```

It is possible to dump several databases with one command:

```
shell> mysqldump --databases db_name1 [db_name2 ...] > my_databases.sql
```

To dump all databases, use the `--all-databases` option:

```
shell> mysqldump --all-databases > all_databases.sql
```

For `InnoDB` tables, `mysqldump` provides a way of making an online backup:

```
shell> mysqldump --all-databases --single-transaction > all_databases.sql
```

This backup acquires a global read lock on all tables (using `FLUSH TABLES WITH READ LOCK`) at the beginning of the dump. As soon as this lock has been acquired, the binary log coordinates are read and the lock is released. If long updating statements are running when the `FLUSH` statement is issued, the MySQL server may get stalled until those statements finish. After that, the dump becomes lock free and does not disturb reads and writes on the tables. If the update statements that the MySQL server receives are short (in terms of execution time), the initial lock period should not be noticeable, even with many updates.

For point-in-time recovery (also known as "roll-forward," when you need to restore an old backup and replay the changes that happened since that backup), it is often useful to rotate the binary log (see Section 5.2.4, "The Binary Log") or at least know the binary log coordinates to which the dump corresponds:

```
shell> mysqldump --all-databases --master-data=2 > all_databases.sql
```

Or:

```
shell> mysqldump --all-databases --flush-logs --master-data=2
              > all_databases.sql
```

The `--master-data` and `--single-transaction` options can be used simultaneously, which provides a convenient way to make an online backup suitable for use prior to point-in-time recovery if tables are stored using the `InnoDB` storage engine.

For more information on making backups, see Section 6.2, "Database Backup Methods", and Section 6.3, "Example Backup and Recovery Strategy".

If you encounter problems backing up views, please read the section that covers restrictions on views which describes a workaround for backing up views when this fails due to insufficient privileges. See Section E.5, "Restrictions on Views".

4.5.5. `mysqlimport` — A Data Import Program

The `mysqlimport` client provides a command-line interface to the `LOAD DATA INFILE` SQL statement. Most options to `mysqlimport` correspond directly to clauses of `LOAD DATA INFILE` syntax. See Section 12.2.6, "`LOAD DATA INFILE` Syntax".

Invoke `mysqlimport` like this:

```
shell> mysqlimport [options] db_name textfile1 [textfile2 ...]
```

For each text file named on the command line, `mysqlimport` strips any extension from the file name and uses the result to determine the name of the table into which to import the file's contents. For example, files named `patient.txt`, `patient.text`, and `patient` all would be imported into a table named `patient`.

`mysqlimport` supports the following options, which can be specified on the command line or in the `[mysqlimport]` and `[client]` groups of an option file. `mysqlimport` also supports the options for processing option files described at Section 4.2.3.3.1, "Command-Line Options that Affect Option-File Handling".

Table 4.6. `mysqlimport` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--columns=column_list	columns	This option takes a comma-separated list of column names as its value			
--compress	compress	Compress all information sent between the client and the server			
--debug[=debug_options]	debug	Write a debugging log			
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.10		
--default-character-set=charset_name	default-character-set	Use charset_name as the default character set			
--delete	delete	Empty the table before importing the text file			

Format	Option File	Description	Introduction	Deprecated	Removed
--fields-enclosed-by=string	fields-enclosed-by	This option has the same meaning as the corresponding clause for LOAD DATA INFILE			
--fields-escaped-by	fields-escaped-by	This option has the same meaning as the corresponding clause for LOAD DATA INFILE			
--fields-optionally-enclosed-by=string	fields-optionally-enclosed-by	This option has the same meaning as the corresponding clause for LOAD DATA INFILE			
--fields-terminated-by=string	fields-terminated-by	-- This option has the same meaning as the corresponding clause for LOAD DATA INFILE			
--force	force	Continue even if an SQL error occurs			
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--ignore	ignore	See the description for the --replace option			
--ignore-lines=#	ignore-lines	Ignore the first N lines of the data file			
--lines-terminated-by=string	lines-terminated-by	This option has the same meaning as the corresponding clause for LOAD DATA INFILE			
--local	local	Read input files locally from the client host			
--lock-tables	lock-tables	Lock all tables for writing before processing any text files			
--low-priority	low-priority	Use LOW_PRIORITY when loading the table.			
--password[=password]	password	The password to use when connecting to the server			
--pipe		On Windows, connect to server using a named pipe			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.10		
--port=port_num	port	The TCP/IP port number to use for the connection			
--protocol=type	protocol	The connection protocol to use			
--replace	replace	The --replace and --ignore options control handling of input rows that duplicate existing rows on unique key values			
--silent	silent	Produce output only when errors occur			
--socket=path	socket	For connections to localhost			
--ssl-ca=file_name	ssl-ca	The path to a file that contains a list of trusted SSL CAs			
--ssl-capath=directory_name	ssl-capath	The path to a directory that contains trusted SSL CA certificates in PEM format			
--ssl-cert=file_name	ssl-cert	The name of the SSL certificate file to use for establishing a secure connection			
--ssl-cipher=cipher_list	ssl-cipher	A list of allowable ciphers to use for SSL encryption			
--	ssl-key	The name of the SSL key file to use for establishing a secure connection			

Format	Option File	Description	Introduction	Deprecated	Removed
ssl-key=file_name					
--ssl-verify-server-cert	ssl-verify-server-cert	The server's Common Name value in its certificate is verified against the host name used when connecting to the server			
--use-threads=#	use-threads	The number of threads for parallel file-loading			
--user=user_name,	user	The MySQL user name to use when connecting to the server			
--verbose		Verbose mode			
--version		Display version information and exit			

- `--help`, `-?`

  Display a help message and exit.

- `--character-sets-dir=path`

  The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--columns=column_list`, `-c column_list`

  This option takes a comma-separated list of column names as its value. The order of the column names indicates how to match data file columns with table columns.

- `--compress`, `-C`

  Compress all information sent between the client and the server if both support compression.

- `--debug[=debug_options]`, `-# [debug_options]`

  Write a debugging log. A typical *`debug_options`* string is `'d:t:o,file_name'`. The default is `'d:t:o'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-character-set=charset_name`

  Use *`charset_name`* as the default character set. See Section 9.5, “Character Set Configuration”.

- `--default-auth=plugin`

  The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.10.

- `--delete`, `-D`

  Empty the table before importing the text file.

- `--fields-terminated-by=...`, `--fields-enclosed-by=...`, `--fields-optionally-enclosed-by=...`, `--fields-escaped-by=...`

  These options have the same meaning as the corresponding clauses for `LOAD DATA INFILE`. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”.

- `--force`, `-f`

  Ignore errors. For example, if a table for a text file does not exist, continue processing any remaining files. Without `--force`, `mysqlimport` exits if a table does not exist.

- `--host=host_name`, `-h host_name`

  Import data to the MySQL server on the given host. The default host is `localhost`.

- `--ignore`, `-i`

  See the description for the `--replace` option.

- `--ignore-lines=N`

  Ignore the first `N` lines of the data file.

- `--lines-terminated-by=...`

  This option has the same meaning as the corresponding clause for `LOAD DATA INFILE`. For example, to import Windows files that have lines terminated with carriage return/linefeed pairs, use `--lines-terminated-by="\r\n"`. (You might have to double the backslashes, depending on the escaping conventions of your command interpreter.) See Section 12.2.6, "`LOAD DATA INFILE` Syntax".

- `--local`, `-L`

  Read input files locally from the client host.

- `--lock-tables`, `-l`

  Lock *all* tables for writing before processing any text files. This ensures that all tables are synchronized on the server.

- `--low-priority`

  Use `LOW_PRIORITY` when loading the table. This affects only storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`).

- `--password[=password]`, `-p[password]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the `password` value following the `--password` or `-p` option on the command line, `mysqlimport` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, "End-User Guidelines for Password Security". You can use an option file to avoid giving the password on the command line.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. This option applies only if the server supports named-pipe connections.

- `--plugin-dir=path`

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysqlimport` does not find it. See Section 5.5.6, "Pluggable Authentication".

  This option was added in MySQL 5.5.10.

- `--port=port_num`, `-P port_num`

  The TCP/IP port number to use for the connection.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, "Connecting to the MySQL Server".

- `--replace`, `-r`

  The `--replace` and `--ignore` options control handling of input rows that duplicate existing rows on unique key values. If you specify `--replace`, new rows replace existing rows that have the same unique key value. If you specify `--ignore`, input rows that duplicate an existing row on a unique key value are skipped. If you do not specify either option, an error occurs when a duplicate key value is found, and the rest of the text file is ignored.

- `--silent`, `-s`

  Silent mode. Produce output only when errors occur.

- `--socket=path`, `-S path`

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--ssl*`

  Options that begin with `--ssl` specify whether to connect to the server using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, “SSL Command Options”.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to the server.

- `--use-threads=N`

  Load files in parallel using `N` threads.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does.

- `--version`, `-V`

  Display version information and exit.

Here is a sample session that demonstrates use of `mysqlimport`:

```
shell> mysql -e 'CREATE TABLE imptest(id INT, n VARCHAR(30))' test
shell> ed
a
100     Max Sydow
101     Count Dracula
.
w imptest.txt
32
q
shell> od -c imptest.txt
0000000   1   0   0  \t   M   a   x       S   y   d   o   w  \n   1   0
0000020   1  \t   C   o   u   n   t       D   r   a   c   u   l   a  \n
0000040
shell> mysqlimport --local test imptest.txt
test.imptest: Records: 2  Deleted: 0  Skipped: 0  Warnings: 0
shell> mysql -e 'SELECT * FROM imptest' test
+------+---------------+
| id   | n             |
+------+---------------+
|  100 | Max Sydow     |
|  101 | Count Dracula |
+------+---------------+
```

4.5.6. `mysqlshow` — Display Database, Table, and Column Information

The `mysqlshow` client can be used to quickly see which databases exist, their tables, or a table's columns or indexes.

`mysqlshow` provides a command-line interface to several SQL `SHOW` statements. See Section 12.4.5, “`SHOW` Syntax”. The same information can be obtained by using those statements directly. For example, you can issue them from the `mysql` client program.

Invoke `mysqlshow` like this:

```
shell> mysqlshow [options] [db_name [tbl_name [col_name]]]
```

- If no database is given, a list of database names is shown.
- If no table is given, all matching tables in the database are shown.
- If no column is given, all matching columns and column types in the table are shown.

The output displays only the names of those databases, tables, or columns for which you have some privileges.

If the last argument contains shell or SQL wildcard characters (“`*`”, “`?`”, “`%`”, or “`_`”), only those names that are matched by the wildcard are shown. If a database name contains any underscores, those should be escaped with a backslash (some Unix shells require two) to get a list of the proper tables or columns. “`*`” and “`?`” characters are converted into SQL “`%`” and “`_`” wildcard characters. This might cause some confusion when you try to display the columns for a table with a “`_`” in the name, because in this case, `mysqlshow` shows you only the table names that match the pattern. This is easily fixed by adding an extra “`%`” last on the command line as a separate argument.

`mysqlshow` supports the following options, which can be specified on the command line or in the `[mysqlshow]` and `[client]` groups of an option file. `mysqlshow` also supports the options for processing option files described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.7. `mysqlshow` Options

Format	**Option File**	**Description**	**Introduction**	**Deprecated**	**Removed**
--bind-address=ip_address	bind-address	Use the specified network interface to connect to the MySQL Server	5.5.8		
--compress	compress	Compress all information sent between the client and the server			
--count	count	Show the number of rows per table			
--debug[=debug_options]	debug	Write a debugging log			
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.10		
--default-character-set=charset_name	default-character-set	Use charset_name as the default character set			
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--keys	keys	Show table indexes			
--password[=password]	password	The password to use when connecting to the server			
--pipe		On Windows, connect to server using a named pipe			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.10		
--port=port_num	port	The TCP/IP port number to use for the connection			
--protocol=type	protocol	The connection protocol to use			
--show-table-type		Show a column indicating the table type			
--socket=path	socket	For connections to localhost			
--ssl-ca=file_name	ssl-ca	The path to a file that contains a list of trusted SSL CAs			
--ssl-capath=directory_name	ssl-capath	The path to a directory that contains trusted SSL CA certificates in PEM format			
--ssl-cert=file_name	ssl-cert	The name of the SSL certificate file to use for establishing a secure connection			
--ssl-	ssl-cipher	A list of allowable ciphers to use for SSL encryption			

Format	Option File	Description	Introduction	Deprecated	Removed
cipher=cipher_list					
--ssl-key=file_name	ssl-key	The name of the SSL key file to use for establishing a secure connection			
--ssl-verify-server-cert	ssl-verify-server-cert	The server's Common Name value in its certificate is verified against the host name used when connecting to the server			
--status	status	Display extra information about each table			
--user=user_name,	user	The MySQL user name to use when connecting to the server			
--verbose		Verbose mode			
--version		Display version information and exit			

- `--help`, `-?`

  Display a help message and exit.

- `--character-sets-dir=path`

  The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--compress`, `-C`

  Compress all information sent between the client and the server if both support compression.

- `--count`

  Show the number of rows per table. This can be slow for non-`MyISAM` tables.

- `--debug[=debug_options]`, `-# [debug_options]`

  Write a debugging log. A typical *`debug_options`* string is `'d:t:o,file_name'`. The default is `'d:t:o'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-character-set=charset_name`

  Use *`charset_name`* as the default character set. See Section 9.5, “Character Set Configuration”.

- `--default-auth=plugin`

  The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.10.

- `--host=host_name`, `-h host_name`

  Connect to the MySQL server on the given host.

- `--keys`, `-k`

  Show table indexes.

- `--password[=password]`, `-p[password]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the *`password`* value following the `--password` or `-p` option on the command line, `mysqlshow` prompts for one.

Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”. You can use an option file to avoid giving the password on the command line.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. This option applies only if the server supports named-pipe connections.

- `--plugin-dir=`*`path`*

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysqlshow` does not find it. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.10.

- `--port=`*`port_num`*, `-P` *`port_num`*

  The TCP/IP port number to use for the connection.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, “Connecting to the MySQL Server”.

- `--show-table-type`, `-t`

  Show a column indicating the table type, as in `SHOW FULL TABLES`. The type is `BASE TABLE` or `VIEW`.

- `--socket=`*`path`*, `-S` *`path`*

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--ssl*`

  Options that begin with `--ssl` specify whether to connect to the server using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, “SSL Command Options”.

- `--status`, `-i`

  Display extra information about each table.

- `--user=`*`user_name`*, `-u` *`user_name`*

  The MySQL user name to use when connecting to the server.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does. This option can be used multiple times to increase the amount of information.

- `--version`, `-V`

  Display version information and exit.

4.5.7. `mysqlslap` — Load Emulation Client

`mysqlslap` is a diagnostic program designed to emulate client load for a MySQL server and to report the timing of each stage. It works as if multiple clients are accessing the server.

Invoke `mysqlslap` like this:

```
shell> mysqlslap [options]
```

Some options such as `--create` or `--query` enable you to specify a string containing an SQL statement or a file containing statements. If you specify a file, by default it must contain one statement per line. (That is, the implicit statement delimiter is the newline character.) Use the `--delimiter` option to specify a different delimiter, which enables you to specify statements that span multiple lines or place multiple statements on a single line. You cannot include comments in a file; `mysqlslap` does not understand them.

`mysqlslap` runs in three stages:

1. Create schema, table, and optionally any stored programs or data you want to using for the test. This stage uses a single client connection.
2. Run the load test. This stage can use many client connections.
3. Clean up (disconnect, drop table if specified). This stage uses a single client connection.

Examples:

Supply your own create and query SQL statements, with 50 clients querying and 200 selects for each:

```
mysqlslap --delimiter=";" \
  --create="CREATE TABLE a (b int);INSERT INTO a VALUES (23)" \
  --query="SELECT * FROM a" --concurrency=50 --iterations=200
```

Let `mysqlslap` build the query SQL statement with a table of two `INT` columns and three `VARCHAR` columns. Use five clients querying 20 times each. Do not create the table or insert the data (that is, use the previous test's schema and data):

```
mysqlslap --concurrency=5 --iterations=20 \
  --number-int-cols=2 --number-char-cols=3 \
  --auto-generate-sql
```

Tell the program to load the create, insert, and query SQL statements from the specified files, where the `create.sql` file has multiple table creation statements delimited by `';'` and multiple insert statements delimited by `';'`. The `--query` file will have multiple queries delimited by `';'`. Run all the load statements, then run all the queries in the query file with five clients (five times each):

```
mysqlslap --concurrency=5 \
  --iterations=5 --query=query.sql --create=create.sql \
  --delimiter=";"
```

`mysqlslap` supports the following options, which can be specified on the command line or in the `[mysqlslap]` and `[client]` groups of an option file. `mysqlslap` also supports the options for processing option files described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.8. `mysqlslap` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--auto-generate-sql	auto-generate-sql	Generate SQL statements automatically when they are not supplied in files or using command options			
--auto-generate-sql-add-autoincrement	auto-generate-sql-add-autoincrement	Add AUTO_INCREMENT column to automatically generated tables			
--auto-generate-sql-execute-number=#	auto-generate-sql-execute-number	Specify how many queries to generate automatically			
--auto-generate-sql-guid-primary	auto-generate-sql-guid-primary	Add a GUID-based primary key to automatically generated tables			
--auto-generate-sql-	auto-generate-sql-load-type	Specify how many queries to generate automatically			

Format	Option File	Description	Introduction	Deprecated	Removed
load-type=type					
--auto-generate-sql-secondary-indexes=#	auto-generate-sql-secondary-indexes	Specify how many secondary indexes to add to automatically generated tables			
--auto-generate-sql-unique-query-number=#	auto-generate-sql-unique-query-number	How many different queries to generate for automatic tests.			
--auto-generate-sql-unique-write-number=#	auto-generate-sql-unique-write-number	How many different queries to generate for --auto-generate-sql-write-number			
--auto-generate-sql-write-number=#	auto-generate-sql-write-number	How many row inserts to perform on each thread			
--commit=#	commit	How many statements to execute before committing.			
--compress	compress	Compress all information sent between the client and the server			
--concurrency=#	concurrency	The number of clients to simulate when issuing the SELECT statement			
--create=value	create	The file or string containing the statement to use for creating the table			
--create-and-drop-schema=value	create-and-drop-schema	The schema in which to run the tests; dropped at the end of the test run	5.5.12		
--create-schema=value	create-schema	The schema in which to run the tests			
--csv=[file]	csv	Generate output in comma-separated values format			
--debug[=debug_options]	debug	Write a debugging log			
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.10		
--delimiter=str	delimiter	The delimiter to use in SQL statements			
--detach=#	detach	Detach (close and reopen) each connection after each N statements			
-	engine	The storage engine to use for creating the table			

Format	Option File	Description	Introduction	Deprecated	Removed
-engine=engine_name					
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--iterations=#	iterations	The number of times to run the tests			
--number-char-cols=#	number-char-cols	The number of VARCHAR columns to use if --auto-generate-sql is specified			
--number-int-cols=#	number-int-cols	The number of INT columns to use if --auto-generate-sql is specified			
--number-of-queries=#	number-of-queries	Limit each client to approximately this number of queries			
--only-print	only-print	Do not connect to databases. mysqlslap only prints what it would have done			
--password[=password]	password	The password to use when connecting to the server			
--pipe		On Windows, connect to server using a named pipe			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.10		
--port=port_num	port	The TCP/IP port number to use for the connection			
--post-query=value	post-query	The file or string containing the statement to execute after the tests have completed			
--post-system=str	post-system	The string to execute using system() after the tests have completed			
--pre-query=value	pre-query	The file or string containing the statement to execute before running the tests			
--pre-system=str	pre-system	The string to execute using system() before running the tests			
--protocol=type	protocol	The connection protocol to use			
--query=value	query	The file or string containing the SELECT statement to use for retrieving data			
--silent	silent	Silent mode			
--socket=path	socket	For connections to localhost			
--ssl-ca=file_name	ssl-ca	The path to a file that contains a list of trusted SSL CAs			
--ssl-capath=directory_name	ssl-capath	The path to a directory that contains trusted SSL CA certificates in PEM format			
--ssl-cert=file_name	ssl-cert	The name of the SSL certificate file to use for establishing a secure connection			
--ssl-cipher=cipher_list	ssl-cipher	A list of allowable ciphers to use for SSL encryption			
--ssl-key=file_name	ssl-key	The name of the SSL key file to use for establishing a secure connection			
--ssl-veri-	ssl-verify-server-cert	The server's Common Name value in its certificate is verified against the host name used when connecting to the server			

Format	Option File	Description	Introduction	Deprecated	Removed
fy-server-cert					
- -user=user_name,	user	The MySQL user name to use when connecting to the server			
--verbose		Verbose mode			
--version		Display version information and exit			

- `--help`, `-?`

  Display a help message and exit.

- `--auto-generate-sql`, `-a`

  Generate SQL statements automatically when they are not supplied in files or using command options.

- `--auto-generate-sql-add-autoincrement`

  Add an `AUTO_INCREMENT` column to automatically generated tables.

- `--auto-generate-sql-execute-number=N`

  Specify how many queries to generate automatically.

- `--auto-generate-sql-guid-primary`

  Add a GUID-based primary key to automatically generated tables.

- `--auto-generate-sql-load-type=type`

  Specify the test load type. The permissible values are `read` (scan tables), `write` (insert into tables), `key` (read primary keys), `update` (update primary keys), or `mixed` (half inserts, half scanning selects). The default is `mixed`.

- `--auto-generate-sql-secondary-indexes=N`

  Specify how many secondary indexes to add to automatically generated tables. By default, none are added.

- `--auto-generate-sql-unique-query-number=N`

  How many different queries to generate for automatic tests. For example, if you run a `key` test that performs 1000 selects, you can use this option with a value of 1000 to run 1000 unique queries, or with a value of 50 to perform 50 different selects. The default is 10.

- `--auto-generate-sql-unique-write-number=N`

  How many different queries to generate for `--auto-generate-sql-write-number`. The default is 10.

- `--auto-generate-sql-write-number=N`

  How many row inserts to perform on each thread. The default is 100.

- `--commit=N`

  How many statements to execute before committing. The default is 0 (no commits are done).

- `--compress`, `-C`

  Compress all information sent between the client and the server if both support compression.

- `--concurrency=N`, `-c N`

  The number of clients to simulate when issuing the `SELECT` statement.

- `--create=value`

  The file or string containing the statement to use for creating the table.

- `--create-and-drop-schema=value`

The schema in which to run the tests. `mysqlslap` drops the schema at the end of the test run. This option was added in MySQL 5.5.12.

- `--create-schema=value`

  The schema in which to run the tests.

  > **Note**
  >
  > If the `--auto-generate-sql` option is also given, `mysqlslap` drops the schema at the end of the test run. To avoid this, use the `--create-and-drop-schema` option instead.

- `--csv[=file_name]`

  Generate output in comma-separated values format. The output goes to the named file, or to the standard output if no file is given.

- `--debug[=debug_options]`, `-# [debug_options]`

  Write a debugging log. A typical `debug_options` string is `'d:t:o,file_name'`. The default is `'d:t:o,/tmp/mysqlslap.trace'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`, `-T`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-auth=plugin`

  The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.10.

- `--delimiter=str`, `-F str`

  The delimiter to use in SQL statements supplied in files or using command options.

- `--detach=N`

  Detach (close and reopen) each connection after each `N` statements. The default is 0 (connections are not detached).

- `--engine=engine_name`, `-e engine_name`

  The storage engine to use for creating tables.

- `--host=host_name`, `-h host_name`

  Connect to the MySQL server on the given host.

- `--iterations=N`, `-i N`

  The number of times to run the tests.

- `--number-char-cols=N`, `-x N`

  The number of `VARCHAR` columns to use if `--auto-generate-sql` is specified.

- `--number-int-cols=N`, `-y N`

  The number of `INT` columns to use if `--auto-generate-sql` is specified.

- `--number-of-queries=N`

  Limit each client to approximately this many queries. Query counting takes into account the statement delimiter. For example, if you invoke `mysqlslap` as follows, the `;` delimiter is recognized so that each instance of the query string counts as two queries. As a result, 5 rows (not 10) are inserted.

```
shell> mysqlslap --delimiter=";" --number-of-queries=10
         --query="use test;insert into t values(null)"
```

- `--only-print`

  Do not connect to databases. `mysqlslap` only prints what it would have done.

- `--password[=password]`, `-p[password]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the *`password`* value following the `--password` or `-p` option on the command line, `mysqlslap` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, "End-User Guidelines for Password Security". You can use an option file to avoid giving the password on the command line.

- `--pipe`, `-W`

  On Windows, connect to the server using a named pipe. This option applies only if the server supports named-pipe connections.

- `--plugin-dir=path`

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysqlslap` does not find it. See Section 5.5.6, "Pluggable Authentication".

  This option was added in MySQL 5.5.10.

- `--port=port_num`, `-P port_num`

  The TCP/IP port number to use for the connection.

- `--post-query=value`

  The file or string containing the statement to execute after the tests have completed. This execution is not counted for timing purposes.

- `--shared-memory-base-name=name`

  On Windows, the shared-memory name to use, for connections made using shared memory to a local server. This option applies only if the server supports shared-memory connections.

- `--post-system=str`

  The string to execute using `system()` after the tests have completed. This execution is not counted for timing purposes.

- `--pre-query=value`

  The file or string containing the statement to execute before running the tests. This execution is not counted for timing purposes.

- `--pre-system=str`

  The string to execute using `system()` before running the tests. This execution is not counted for timing purposes.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, "Connecting to the MySQL Server".

- `--query=value`, `-q value`

  The file or string containing the `SELECT` statement to use for retrieving data.

- `--silent`, `-s`

  Silent mode. No output.

- `--socket=path`, `-S path`

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--ssl*`

Options that begin with `--ssl` specify whether to connect to the server using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, “SSL Command Options”.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to the server.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does. This option can be used multiple times to increase the amount of information.

- `--version`, `-V`

  Display version information and exit.

4.6. MySQL Administrative and Utility Programs

This section describes administrative programs and programs that perform miscellaneous utility operations.

4.6.1. `innochecksum` — Offline InnoDB File Checksum Utility

`innochecksum` prints checksums for `InnoDB` files. This tool reads an `InnoDB` tablespace file, calculates the checksum for each page, compares the calculated checksum to the stored checksum, and reports mismatches, which indicate damaged pages. It was originally developed to speed up verifying the integrity of tablespace files after power outages but can also be used after file copies. Because checksum mismatches will cause `InnoDB` to deliberately shut down a running server, it can be preferable to use this tool rather than waiting for a server in production usage to encounter the damaged pages.

`innochecksum` cannot be used on tablespace files that the server already has open. For such files, you should use `CHECK TABLE` to check tables within the tablespace.

If checksum mismatches are found, you would normally restore the tablespace from backup or start the server and attempt to use `mysqldump` to make a backup of the tables within the tablespace.

Invoke `innochecksum` like this:

```
shell> innochecksum [options] file_name
```

`innochecksum` supports the following options. For options that refer to page numbers, the numbers are zero-based.

- `-c`

  Print a count of the number of pages in the file.

- `-d`

  Debug mode; prints checksums for each page.

- `-e num`

  End at this page number.

- `-p num`

  Check only this page number.

- `-s num`

  Start at this page number.

- `-v`

  Verbose mode; print a progress indicator every five seconds.

4.6.2. `myisam_ftdump` — Display Full-Text Index information

`myisam_ftdump` displays information about `FULLTEXT` indexes in `MyISAM` tables. It reads the `MyISAM` index file directly, so it must be run on the server host where the table is located. Before using `myisam_ftdump`, be sure to issue a `FLUSH TABLES` statement first if the server is running.

`myisam_ftdump` scans and dumps the entire index, which is not particularly fast. On the other hand, the distribution of words changes infrequently, so it need not be run often.

Invoke `myisam_ftdump` like this:

```
shell> myisam_ftdump [options] tbl_name index_num
```

The *`tbl_name`* argument should be the name of a `MyISAM` table. You can also specify a table by naming its index file (the file with the `.MYI` suffix). If you do not invoke `myisam_ftdump` in the directory where the table files are located, the table or index file name must be preceded by the path name to the table's database directory. Index numbers begin with 0.

Example: Suppose that the `test` database contains a table named `mytexttablel` that has the following definition:

```
CREATE TABLE mytexttable
(
  id   INT NOT NULL,
  txt  TEXT NOT NULL,
  PRIMARY KEY (id),
  FULLTEXT (txt)
) ENGINE=MyISAM;
```

The index on `id` is index 0 and the `FULLTEXT` index on `txt` is index 1. If your working directory is the `test` database directory, invoke `myisam_ftdump` as follows:

```
shell> myisam_ftdump mytexttable 1
```

If the path name to the `test` database directory is `/usr/local/mysql/data/test`, you can also specify the table name argument using that path name. This is useful if you do not invoke `myisam_ftdump` in the database directory:

```
shell> myisam_ftdump /usr/local/mysql/data/test/mytexttable 1
```

You can use `myisam_ftdump` to generate a list of index entries in order of frequency of occurrence like this:

```
shell> myisam_ftdump -c mytexttable 1 | sort -r
```

`myisam_ftdump` supports the following options:

- `--help`, `-h` `-?`

  Display a help message and exit.

- `--count`, `-c`

  Calculate per-word statistics (counts and global weights).

- `--dump`, `-d`

  Dump the index, including data offsets and word weights.

- `--length`, `-l`

  Report the length distribution.

- `--stats`, `-s`

  Report global index statistics. This is the default operation if no other operation is specified.

- `--verbose`, `-v`

  Verbose mode. Print more output about what the program does.

4.6.3. `myisamchk` — MyISAM Table-Maintenance Utility

The `myisamchk` utility gets information about your database tables or checks, repairs, or optimizes them. `myisamchk` works with `MyISAM` tables (tables that have `.MYD` and `.MYI` files for storing data and indexes).

You can also use the `CHECK TABLE` and `REPAIR TABLE` statements to check and repair `MyISAM` tables. See Section 12.4.2.2, "`CHECK TABLE` Syntax", and Section 12.4.2.5, "`REPAIR TABLE` Syntax".

The use of `myisamchk` with partitioned tables is not supported.

> **Caution**
>
> It is best to make a backup of a table before performing a table repair operation; under some circumstances the operation might cause data loss. Possible causes include but are not limited to file system errors.

Invoke `myisamchk` like this:

```
shell> myisamchk [options] tbl_name ...
```

The *`options`* specify what you want `myisamchk` to do. They are described in the following sections. You can also get a list of options by invoking `myisamchk --help`.

With no options, `myisamchk` simply checks your table as the default operation. To get more information or to tell `myisamchk` to take corrective action, specify options as described in the following discussion.

`tbl_name` is the database table you want to check or repair. If you run `myisamchk` somewhere other than in the database directory, you must specify the path to the database directory, because `myisamchk` has no idea where the database is located. In fact, `myisamchk` does not actually care whether the files you are working on are located in a database directory. You can copy the files that correspond to a database table into some other location and perform recovery operations on them there.

You can name several tables on the `myisamchk` command line if you wish. You can also specify a table by naming its index file (the file with the `.MYI` suffix). This enables you to specify all tables in a directory by using the pattern `*.MYI`. For example, if you are in a database directory, you can check all the `MyISAM` tables in that directory like this:

```
shell> myisamchk *.MYI
```

If you are not in the database directory, you can check all the tables there by specifying the path to the directory:

```
shell> myisamchk /path/to/database_dir/*.MYI
```

You can even check all tables in all databases by specifying a wildcard with the path to the MySQL data directory:

```
shell> myisamchk /path/to/datadir/*/*.MYI
```

The recommended way to quickly check all `MyISAM` tables is:

```
shell> myisamchk --silent --fast /path/to/datadir/*/*.MYI
```

If you want to check all `MyISAM` tables and repair any that are corrupted, you can use the following command:

```
shell> myisamchk --silent --force --fast --update-state \
          --key_buffer_size=64M --sort_buffer_size=64M \
          --read_buffer_size=1M --write_buffer_size=1M \
          /path/to/datadir/*/*.MYI
```

This command assumes that you have more than 64MB free. For more information about memory allocation with `myisamchk`, see Section 4.6.3.6, "`myisamchk` Memory Usage".

For additional information about using `myisamchk`, see Section 6.6, "`MyISAM` Table Maintenance and Crash Recovery".

> **Important**
>
> *You must ensure that no other program is using the tables while you are running `myisamchk`*. The most effective means of doing so is to shut down the MySQL server while running `myisamchk`, or to lock all tables that `myisamchk` is being used on.
>
> Otherwise, when you run `myisamchk`, it may display the following error message:
>
> ```
> warning: clients are using or haven't closed the table properly
> ```
>
> This means that you are trying to check a table that has been updated by another program (such as the `mysqld` server) that hasn't yet closed the file or that has died without closing the file properly, which can sometimes lead to the corruption of one or more `MyISAM` tables.

> If `mysqld` is running, you must force it to flush any table modifications that are still buffered in memory by using `FLUSH TABLES`. You should then ensure that no one is using the tables while you are running `myisamchk`
>
> However, the easiest way to avoid this problem is to use `CHECK TABLE` instead of `myisamchk` to check tables. See Section 12.4.2.2, "`CHECK TABLE` Syntax".

`myisamchk` supports the following options, which can be specified on the command line or in the `[myisamchk]` group of an option file. `myisamchk` also supports the options for processing option files described at Section 4.2.3.3.1, "Command-Line Options that Affect Option-File Handling".

Table 4.9. `myisamchk` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--analyze	analyze	Analyze the distribution of key values			
--backup	backup	Make a backup of the .MYD file as file_name-time.BAK			
--block-search=offset	block-search	Find the record that a block at the given offset belongs to			
--check	check	Check the table for errors			
--check-only-changed	check-only-changed	Check only tables that have changed since the last check			
--correct-checksum	correct-checksum	Correct the checksum information for the table			
--data-file-length=len	data-file-length	Maximum length of the data file (when re-creating data file when it is full)			
--debug[=debug_options]	debug	Write a debugging log			
decode_bits=#	decode_bits	Decode_bits			
--description	description	Print some descriptive information about the table			
--extend-check	extend-check	Do a repair that tries to recover every possible row from the data file			
--extended-check	extended-check	Check the table very thoroughly			
--fast	fast	Check only tables that haven't been closed properly			
--force	force	Do a repair operation automatically if myisamchk finds any errors in the table			
--force	force-recover	Overwrite old temporary files. For use with the -r or -o option			
ft_max_word_len=#	ft_max_word_len	Maximum word length for FULLTEXT indexes			
ft_min_word_len=#	ft_min_word_len	Minimum word length for FULLTEXT indexes			
ft_stopword_file=value	ft_stopword_file	Use stopwords from this file instead of built-in list			
--HELP		Display help message and exit			
--help		Display help message and exit			
--information	information	Print informational statistics about the table that is checked			
key_buffer_size=#	key_buffer_size	The size of the buffer used for index blocks for MyISAM tables			
--keys-used=val	keys-used	A bit-value that indicates which indexes to update			

Format	Option File	Description	Introduction	Deprecated	Removed
--max-record-length=len	max-record-length	Skip rows larger than the given length if myisamchk cannot allocate memory to hold them			
--medium-check	medium-check	Do a check that is faster than an --extend-check operation			
myisam_block_size=#	myisam_block_size	Block size to be used for MyISAM index pages			
--parallel-recover	parallel-recover	Uses the same technique as -r and -n, but creates all the keys in parallel, using different threads (beta)			
--quick	quick	Achieve a faster repair by not modifying the data file.			
read_buffer_size=#	read_buffer_size	Each thread that does a sequential scan allocates a buffer of this size for each table it scans			
--read-only	read-only	Don't mark the table as checked			
--recover	recover	Do a repair that can fix almost any problem except unique keys that aren't unique			
--safe-recover	safe-recover	Do a repair using an old recovery method that reads through all rows in order and updates all index trees based on the rows found			
--set-auto-increment[=value]	set-auto-increment	Force AUTO_INCREMENT numbering for new records to start at the given value			
--set-collation=name	set-collation	Specify the collation to use for sorting table indexes			
--silent	silent	Silent mode			
sort_buffer_size=#	sort_buffer_size	The buffer that is allocated when sorting the index when doing a REPAIR or when creating indexes with CREATE INDEX or ALTER TABLE			
--sort-index	sort-index	Sort the index tree blocks in high-low order			
sort_key_blocks=#	sort_key_blocks	sort_key_blocks			
--sort-records=#	sort-records	Sort records according to a particular index			
--sort-recover	sort-recover	Force myisamchk to use sorting to resolve the keys even if the temporary files would be very large			
stats_method=value	stats_method	Specifies how MyISAM index statistics collection code should treat NULLs			
--tmpdir=path	tmpdir	Path of the directory to be used for storing temporary files			
--unpack	unpack	Unpack a table that was packed with myisampack			
--update-state	update-state	Store information in the .MYI file to indicate when the table was checked and whether the table crashed			
--verbose		Verbose mode			
--version		Display version information and exit			
write_buffer_size=#	write_buffer_size	Write buffer size			

4.6.3.1. `myisamchk` General Options

The options described in this section can be used for any type of table maintenance operation performed by `myisamchk`. The sections following this one describe options that pertain only to specific operations, such as table checking or repairing.

- `--help`, `-?`

  Display a help message and exit. Options are grouped by type of operation.

- `--HELP`, `-H`

  Display a help message and exit. Options are presented in a single list.

- `--debug=debug_options`, `-# debug_options`

  Write a debugging log. A typical `debug_options` string is `'d:t:o,file_name'`. The default is `'d:t:o,/tmp/myisamchk.trace'`.

- `--silent`, `-s`

  Silent mode. Write output only when errors occur. You can use `-s` twice (`-ss`) to make `myisamchk` very silent.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does. This can be used with `-d` and `-e`. Use `-v` multiple times (`-vv`, `-vvv`) for even more output.

- `--version`, `-V`

  Display version information and exit.

- `--wait`, `-w`

  Instead of terminating with an error if the table is locked, wait until the table is unlocked before continuing. If you are running `mysqld` with external locking disabled, the table can be locked only by another `myisamchk` command.

You can also set the following variables by using `--var_name=value` syntax:

Variable	**Default Value**
`decode_bits`	9
`ft_max_word_len`	version-dependent
`ft_min_word_len`	4
`ft_stopword_file`	built-in list
`key_buffer_size`	523264
`myisam_block_size`	1024
`read_buffer_size`	262136
`sort_buffer_size`	2097144
`sort_key_blocks`	16
`stats_method`	nulls_unequal
`write_buffer_size`	262136

The possible `myisamchk` variables and their default values can be examined with `myisamchk --help`:

`sort_buffer_size` is used when the keys are repaired by sorting keys, which is the normal case when you use `--recover`.

`key_buffer_size` is used when you are checking the table with `--extend-check` or when the keys are repaired by inserting keys row by row into the table (like when doing normal inserts). Repairing through the key buffer is used in the following cases:

- You use `--safe-recover`.
- The temporary files needed to sort the keys would be more than twice as big as when creating the key file directly. This is often the case when you have large key values for `CHAR`, `VARCHAR`, or `TEXT` columns, because the sort operation needs to store the complete key values as it proceeds. If you have lots of temporary space and you can force `myisamchk` to repair by sorting, you can use the `--sort-recover` option.

Repairing through the key buffer takes much less disk space than using sorting, but is also much slower.

If you want a faster repair, set the `key_buffer_size` and `sort_buffer_size` variables to about 25% of your available memory. You can set both variables to large values, because only one of them is used at a time.

`myisam_block_size` is the size used for index blocks.

`stats_method` influences how `NULL` values are treated for index statistics collection when the `--analyze` option is given. It acts like the `myisam_stats_method` system variable. For more information, see the description of `myisam_stats_method` in Section 5.1.3, “Server System Variables”, and Section 7.3.7, “`InnoDB` and `MyISAM` Index Statistics Collection”.

`ft_min_word_len` and `ft_max_word_len` indicate the minimum and maximum word length for `FULLTEXT` indexes. `ft_stopword_file` names the stopword file. These need to be set under the following circumstances.

If you use `myisamchk` to perform an operation that modifies table indexes (such as repair or analyze), the `FULLTEXT` indexes are rebuilt using the default full-text parameter values for minimum and maximum word length and the stopword file unless you specify otherwise. This can result in queries failing.

The problem occurs because these parameters are known only by the server. They are not stored in `MyISAM` index files. To avoid the problem if you have modified the minimum or maximum word length or the stopword file in the server, specify the same `ft_min_word_len`, `ft_max_word_len`, and `ft_stopword_file` values to `myisamchk` that you use for `mysqld`. For example, if you have set the minimum word length to 3, you can repair a table with `myisamchk` like this:

```
shell> myisamchk --recover --ft_min_word_len=3 tbl_name.MYI
```

To ensure that `myisamchk` and the server use the same values for full-text parameters, you can place each one in both the `[mysqld]` and `[myisamchk]` sections of an option file:

```
[mysqld]
ft_min_word_len=3

[myisamchk]
ft_min_word_len=3
```

An alternative to using `myisamchk` is to use the `REPAIR TABLE`, `ANALYZE TABLE`, `OPTIMIZE TABLE`, or `ALTER TABLE`. These statements are performed by the server, which knows the proper full-text parameter values to use.

4.6.3.2. `myisamchk` Check Options

`myisamchk` supports the following options for table checking operations:

- `--check`, `-c`

  Check the table for errors. This is the default operation if you specify no option that selects an operation type explicitly.

- `--check-only-changed`, `-C`

  Check only tables that have changed since the last check.

- `--extend-check`, `-e`

  Check the table very thoroughly. This is quite slow if the table has many indexes. This option should only be used in extreme cases. Normally, `myisamchk` or `myisamchk --medium-check` should be able to determine whether there are any errors in the table.

  If you are using `--extend-check` and have plenty of memory, setting the `key_buffer_size` variable to a large value helps the repair operation run faster.

  For a description of the output format, see Section 4.6.3.5, “Obtaining Table Information with `myisamchk`”.

- `--fast`, `-F`

  Check only tables that haven't been closed properly.

- `--force`, `-f`

  Do a repair operation automatically if `myisamchk` finds any errors in the table. The repair type is the same as that specified with the `--recover` or `-r` option.

- `--information`, `-i`

Print informational statistics about the table that is checked.

- `--medium-check`, `-m`

  Do a check that is faster than an `--extend-check` operation. This finds only 99.99% of all errors, which should be good enough in most cases.

- `--read-only`, `-T`

  Do not mark the table as checked. This is useful if you use `myisamchk` to check a table that is in use by some other application that does not use locking, such as `mysqld` when run with external locking disabled.

- `--update-state`, `-U`

  Store information in the `.MYI` file to indicate when the table was checked and whether the table crashed. This should be used to get full benefit of the `--check-only-changed` option, but you shouldn't use this option if the `mysqld` server is using the table and you are running it with external locking disabled.

4.6.3.3. `myisamchk` Repair Options

`myisamchk` supports the following options for table repair operations (operations performed when an option such as `--recover` or `--safe-recover` is given):

- `--backup`, `-B`

  Make a backup of the `.MYD` file as `file_name-time.BAK`

- `--character-sets-dir=path`

  The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--correct-checksum`

  Correct the checksum information for the table.

- `--data-file-length=len`, `-D len`

  The maximum length of the data file (when re-creating data file when it is “full”).

- `--extend-check`, `-e`

  Do a repair that tries to recover every possible row from the data file. Normally, this also finds a lot of garbage rows. Do not use this option unless you are desperate.

  For a description of the output format, see Section 4.6.3.5, “Obtaining Table Information with `myisamchk`”.

- `--force`, `-f`

  Overwrite old intermediate files (files with names like `tbl_name.TMD`) instead of aborting.

- `--keys-used=val`, `-k val`

  For `myisamchk`, the option value is a bit-value that indicates which indexes to update. Each binary bit of the option value corresponds to a table index, where the first index is bit 0. An option value of 0 disables updates to all indexes, which can be used to get faster inserts. Deactivated indexes can be reactivated by using `myisamchk -r`.

- `--no-symlinks`, `-l`

  Do not follow symbolic links. Normally `myisamchk` repairs the table that a symlink points to. This option does not exist as of MySQL 4.0 because versions from 4.0 on do not remove symlinks during repair operations.

- `--max-record-length=len`

  Skip rows larger than the given length if `myisamchk` cannot allocate memory to hold them.

- `--parallel-recover`, `-p`

  Use the same technique as `-r` and `-n`, but create all the keys in parallel, using different threads. *This is beta-quality code. Use at your own risk!*

- `--quick`, `-q`

  Achieve a faster repair by modifying only the index file, not the data file. You can specify this option twice to force `myisamchk` to modify the original data file in case of duplicate keys.

- `--recover`, `-r`

  Do a repair that can fix almost any problem except unique keys that are not unique (which is an extremely unlikely error with `MyISAM` tables). If you want to recover a table, this is the option to try first. You should try `--safe-recover` only if `myisamchk` reports that the table cannot be recovered using `--recover`. (In the unlikely case that `--recover` fails, the data file remains intact.)

  If you have lots of memory, you should increase the value of `sort_buffer_size`.

- `--safe-recover`, `-o`

  Do a repair using an old recovery method that reads through all rows in order and updates all index trees based on the rows found. This is an order of magnitude slower than `--recover`, but can handle a couple of very unlikely cases that `--recover` cannot. This recovery method also uses much less disk space than `--recover`. Normally, you should repair first using `--recover`, and then with `--safe-recover` only if `--recover` fails.

  If you have lots of memory, you should increase the value of `key_buffer_size`.

- `--set-character-set=name`

  Change the character set used by the table indexes. This option was replaced by `--set-collation` in MySQL 5.0.3.

- `--set-collation=name`

  Specify the collation to use for sorting table indexes. The character set name is implied by the first part of the collation name.

- `--sort-recover`, `-n`

  Force `myisamchk` to use sorting to resolve the keys even if the temporary files would be very large.

- `--tmpdir=path`, `-t path`

  The path of the directory to be used for storing temporary files. If this is not set, `myisamchk` uses the value of the `TMPDIR` environment variable. `--tmpdir` can be set to a list of directory paths that are used successively in round-robin fashion for creating temporary files. The separator character between directory names is the colon (“`:`”) on Unix and the semicolon (“`;`”) on Windows.

- `--unpack`, `-u`

  Unpack a table that was packed with `myisampack`.

4.6.3.4. Other `myisamchk` Options

`myisamchk` supports the following options for actions other than table checks and repairs:

- `--analyze`, `-a`

  Analyze the distribution of key values. This improves join performance by enabling the join optimizer to better choose the order in which to join the tables and which indexes it should use. To obtain information about the key distribution, use a `myisamchk --description --verbose tbl_name` command or the `SHOW INDEX FROM tbl_name` statement.

- `--block-search=offset`, `-b offset`

  Find the record that a block at the given offset belongs to.

- `--description`, `-d`

  Print some descriptive information about the table. Specifying the `--verbose` option once or twice produces additional information. See Section 4.6.3.5, “Obtaining Table Information with `myisamchk`”.

- `--set-auto-increment[=value]`, `-A[value]`

  Force `AUTO_INCREMENT` numbering for new records to start at the given value (or higher, if there are existing records with `AUTO_INCREMENT` values this large). If `value` is not specified, `AUTO_INCREMENT` numbers for new records begin with the largest value currently in the table, plus one.

- `--sort-index`, `-S`

  Sort the index tree blocks in high-low order. This optimizes seeks and makes table scans that use indexes faster.

- `--sort-records=N`, `-R N`

  Sort records according to a particular index. This makes your data much more localized and may speed up range-based `SELECT` and `ORDER BY` operations that use this index. (The first time you use this option to sort a table, it may be very slow.) To determine a table's index numbers, use `SHOW INDEX`, which displays a table's indexes in the same order that `myisamchk` sees them. Indexes are numbered beginning with 1.

  If keys are not packed (`PACK_KEYS=0`), they have the same length, so when `myisamchk` sorts and moves records, it just overwrites record offsets in the index. If keys are packed (`PACK_KEYS=1`), `myisamchk` must unpack key blocks first, then re-create indexes and pack the key blocks again. (In this case, re-creating indexes is faster than updating offsets for each index.)

4.6.3.5. Obtaining Table Information with `myisamchk`

To obtain a description of a `MyISAM` table or statistics about it, use the commands shown here. The output from these commands is explained later in this section.

- `myisamchk -d tbl_name`

  Runs `myisamchk` in “describe mode” to produce a description of your table. If you start the MySQL server with external locking disabled, `myisamchk` may report an error for a table that is updated while it runs. However, because `myisamchk` does not change the table in describe mode, there is no risk of destroying data.

- `myisamchk -dv tbl_name`

  Adding `-v` runs `myisamchk` in verbose mode so that it produces more information about the table. Adding `-v` a second time produces even more information.

- `myisamchk -eis tbl_name`

  Shows only the most important information from a table. This operation is slow because it must read the entire table.

- `myisamchk -eiv tbl_name`

  This is like `-eis`, but tells you what is being done.

The `tbl_name` argument can be either the name of a `MyISAM` table or the name of its index file, as described in Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”. Multiple `tbl_name` arguments can be given.

Suppose that a table named `person` has the following structure. (The `MAX_ROWS` table option is included so that in the example output from `myisamchk` shown later, some values are smaller and fit the output format more easily.)

```
CREATE TABLE person
(
  id         INT NOT NULL AUTO_INCREMENT,
  last_name  VARCHAR(20) NOT NULL,
  first_name VARCHAR(20) NOT NULL,
  birth      DATE,
  death      DATE,
  PRIMARY KEY (id),
  INDEX (last_name, first_name),
  INDEX (birth)
) MAX_ROWS = 1000000;
```

Suppose also that the table has these data and index file sizes:

```
-rw-rw----  1 mysql  mysql  9347072 Aug 19 11:47 person.MYD
-rw-rw----  1 mysql  mysql  6066176 Aug 19 11:47 person.MYI
```

Example of `myisamchk -dvv` output:

```
MyISAM file:         person
Record format:       Packed
Character set:       latin1_swedish_ci (8)
File-version:        1
Creation time:       2009-08-19 16:47:41
Recover time:        2009-08-19 16:47:56
```

```
Status:              checked,analyzed,optimized keys
Auto increment key:              1  Last value:                306688
Data records:               306688  Deleted blocks:                 0
Datafile parts:             306688  Deleted data:                   0
Datafile pointer (bytes):        4  Keyfile pointer (bytes):        3
Datafile length:           9347072  Keyfile length:           6066176
Max datafile length:    4294967294  Max keyfile length:   17179868159
Recordlength:                   54

table description:
Key Start Len Index   Type                 Rec/key         Root  Blocksize
1   2     4   unique  long                       1        99328       1024
2   6     20  multip. varchar prefix           512      3563520       1024
    27    20          varchar                  512
3   48    3   multip. uint24 NULL           306688      6065152       1024

Field Start Length Nullpos Nullbit Type
1     1     1
2     2     4                      no zeros
3     6     21                     varchar
4     27    21                     varchar
5     48    3      1       1       no zeros
6     51    3      1       2       no zeros
```

Explanations for the types of information `myisamchk` produces are given here. “Keyfile” refers to the index file. “Record” and “row” are synonymous, as are “field” and “column.”

The initial part of the table description contains these values:

- `MyISAM file`

  Name of the `MyISAM` (index) file.

- `Record format`

  The format used to store table rows. The preceding examples use `Fixed length`. Other possible values are `Compressed` and `Packed`. (`Packed` corresponds to what `SHOW TABLE STATUS` reports as `Dynamic`.)

- `Chararacter set`

  The table default character set.

- `File-version`

  Version of `MyISAM` format. Currently always 1.

- `Creation time`

  When the data file was created.

- `Recover time`

  When the index/data file was last reconstructed.

- `Status`

  Table status flags. Possible values are `crashed`, `open`, `changed`, `analyzed`, `optimized keys`, and `sorted index pages`.

- `Auto increment key`, `Last value`

  The key number associated the table's `AUTO_INCREMENT` column, and the most recently generated value for this column. These fields do not appear if there is no such column.

- `Data records`

  The number of rows in the table.

- `Deleted blocks`

  How many deleted blocks still have reserved space. You can optimize your table to minimize this space. See Section 6.6.4, “`MyISAM` Table Optimization”.

- `Datafile parts`

  For dynamic-row format, this indicates how many data blocks there are. For an optimized table without fragmented rows, this is the same as `Data records`.

- `Deleted data`

  How many bytes of unreclaimed deleted data there are. You can optimize your table to minimize this space. See Section 6.6.4, “`MyISAM` Table Optimization”.

- `Datafile pointer`

  The size of the data file pointer, in bytes. It is usually 2, 3, 4, or 5 bytes. Most tables manage with 2 bytes, but this cannot be controlled from MySQL yet. For fixed tables, this is a row address. For dynamic tables, this is a byte address.

- `Keyfile pointer`

  The size of the index file pointer, in bytes. It is usually 1, 2, or 3 bytes. Most tables manage with 2 bytes, but this is calculated automatically by MySQL. It is always a block address.

- `Max datafile length`

  How long the table data file can become, in bytes.

- `Max keyfile length`

  How long the table index file can become, in bytes.

- `Recordlength`

  How much space each row takes, in bytes.

The `table description` part of the output includes a list of all keys in the table. For each key, `myisamchk` displays some low-level information:

- `Key`

  This key's number. This value is shown only for the first column of the key. If this value is missing, the line corresponds to the second or later column of a multiple-column key. For the table shown in the example, there are two `table description` lines for the second index. This indicates that it is a multiple-part index with two parts.

- `Start`

  Where in the row this portion of the index starts.

- `Len`

  How long this portion of the index is. For packed numbers, this should always be the full length of the column. For strings, it may be shorter than the full length of the indexed column, because you can index a prefix of a string column. The total length of a multiple-part key is the sum of the `Len` values for all key parts.

- `Index`

  Whether a key value can exist multiple times in the index. Possible values are `unique` or `multip.` (multiple).

- `Type`

  What data type this portion of the index has. This is a `MyISAM` data type with the possible values `packed`, `stripped`, or `empty`.

- `Root`

  Address of the root index block.

- `Blocksize`

  The size of each index block. By default this is 1024, but the value may be changed at compile time when MySQL is built from source.

- `Rec/key`

  This is a statistical value used by the optimizer. It tells how many rows there are per value for this index. A unique index always has a value of 1. This may be updated after a table is loaded (or greatly changed) with `myisamchk -a`. If this is not updated at all, a default value of 30 is given.

The last part of the output provides information about each column:

- `Field`

  The column number.

- `Start`

  The byte position of the column within table rows.

- `Length`

  The length of the column in bytes.

- `Nullpos`, `Nullbit`

  For columns that can be `NULL`, `MyISAM` stores `NULL` values as a flag in a byte. Depending on how many nullable columns there are, there can be one or more bytes used for this purpose. The `Nullpos` and `Nullbit` values, if nonempty, indicate which byte and bit contains that flag indicating whether the column is `NULL`.

  The position and number of bytes used to store `NULL` flags is shown in the line for field 1. This is why there are six `Field` lines for the `person` table even though it has only five columns.

- `Type`

  The data type. The value may contain any of the following descriptors:

  - `constant`

    All rows have the same value.

  - `no endspace`

    Do not store endspace.

  - `no endspace, not_always`

    Do not store endspace and do not do endspace compression for all values.

  - `no endspace, no empty`

    Do not store endspace. Do not store empty values.

  - `table-lookup`

    The column was converted to an `ENUM`.

  - `zerofill(N)`

    The most significant *`N`* bytes in the value are always 0 and are not stored.

  - `no zeros`

    Do not store zeros.

  - `always zero`

    Zero values are stored using one bit.

- `Huff tree`

  The number of the Huffman tree associated with the column.

- `Bits`

  The number of bits used in the Huffman tree.

The `Huff tree` and `Bits` fields are displayed if the table has been compressed with `myisampack`. See Section 4.6.5, “`myisampack` — Generate Compressed, Read-Only MyISAM Tables”, for an example of this information.

Example of `myisamchk -eiv` output:

```
Checking MyISAM file: person
Data records:  306688   Deleted blocks:       0
- check file-size
- check record delete-chain
No recordlinks
- check key delete-chain
block_size 1024:
- check index reference
- check data record references index: 1
Key:  1:  Keyblocks used:  98%  Packed:    0%  Max levels:  3
- check data record references index: 2
Key:  2:  Keyblocks used:  99%  Packed:   97%  Max levels:  3
- check data record references index: 3
Key:  3:  Keyblocks used:  98%  Packed:  -14%  Max levels:  3
Total:    Keyblocks used:  98%  Packed:   89%

- check records and index references
*** LOTS OF ROW NUMBERS DELETED ***

Records:            306688  M.recordlength:       25  Packed:            83%
Recordspace used:       97% Empty space:           2% Blocks/Record:   1.00
Record blocks:      306688  Delete blocks:         0
Record data:       7934464  Deleted data:          0
Lost space:         256512  Linkdata:        1156096

User time 43.08, System time 1.68
Maximum resident set size 0, Integral resident set size 0
Non-physical pagefaults 0, Physical pagefaults 0, Swaps 0
Blocks in 0 out 7, Messages in 0 out 0, Signals 0
Voluntary context switches 0, Involuntary context switches 0
Maximum memory usage: 1046926 bytes (1023k)
```

`myisamchk -eiv` output includes the following information:

- `Data records`

  The number of rows in the table.

- `Deleted blocks`

  How many deleted blocks still have reserved space. You can optimize your table to minimize this space. See Section 6.6.4, “`MyISAM` Table Optimization”.

- `Key`

  The key number.

- `Keyblocks used`

  What percentage of the keyblocks are used. When a table has just been reorganized with `myisamchk`, the values are very high (very near theoretical maximum).

- `Packed`

  MySQL tries to pack key values that have a common suffix. This can only be used for indexes on `CHAR` and `VARCHAR` columns. For long indexed strings that have similar leftmost parts, this can significantly reduce the space used. In the preceding example, the second key is 40 bytes long and a 97% reduction in space is achieved.

- `Max levels`

  How deep the B-tree for this key is. Large tables with long key values get high values.

- `Records`

  How many rows are in the table.

- `M.recordlength`

  The average row length. This is the exact row length for tables with fixed-length rows, because all rows have the same length.

- `Packed`

  MySQL strips spaces from the end of strings. The `Packed` value indicates the percentage of savings achieved by doing this.

- `Recordspace used`

  What percentage of the data file is used.

- `Empty space`

  What percentage of the data file is unused.

- `Blocks/Record`

  Average number of blocks per row (that is, how many links a fragmented row is composed of). This is always 1.0 for fixed-format tables. This value should stay as close to 1.0 as possible. If it gets too large, you can reorganize the table. See Section 6.6.4, "`MyISAM` Table Optimization".

- `Recordblocks`

  How many blocks (links) are used. For fixed-format tables, this is the same as the number of rows.

- `Deleteblocks`

  How many blocks (links) are deleted.

- `Recorddata`

  How many bytes in the data file are used.

- `Deleted data`

  How many bytes in the data file are deleted (unused).

- `Lost space`

  If a row is updated to a shorter length, some space is lost. This is the sum of all such losses, in bytes.

- `Linkdata`

  When the dynamic table format is used, row fragments are linked with pointers (4 to 7 bytes each). `Linkdata` is the sum of the amount of storage used by all such pointers.

4.6.3.6. `myisamchk` Memory Usage

Memory allocation is important when you run `myisamchk`. `myisamchk` uses no more memory than its memory-related variables are set to. If you are going to use `myisamchk` on very large tables, you should first decide how much memory you want it to use. The default is to use only about 3MB to perform repairs. By using larger values, you can get `myisamchk` to operate faster. For example, if you have more than 512MB RAM available, you could use options such as these (in addition to any other options you might specify):

```
shell> myisamchk --sort_buffer_size=256M \
           --key_buffer_size=512M \
           --read_buffer_size=64M \
           --write_buffer_size=64M ...
```

Using `--sort_buffer_size=16M` is probably enough for most cases.

Be aware that `myisamchk` uses temporary files in `TMPDIR`. If `TMPDIR` points to a memory file system, out of memory errors can easily occur. If this happens, run `myisamchk` with the `--tmpdir=path` option to specify a directory located on a file system that has more space.

When performing repair operations, `myisamchk` also needs a lot of disk space:

- Twice the size of the data file (the original file and a copy). This space is not needed if you do a repair with `--quick`; in this case, only the index file is re-created. *This space must be available on the same file system as the original data file*, as the copy is created in the same directory as the original.

- Space for the new index file that replaces the old one. The old index file is truncated at the start of the repair operation, so you usually ignore this space. This space must be available on the same file system as the original data file.

- When using `--recover` or `--sort-recover` (but not when using `--safe-recover`), you need space on disk for sorting. This space is allocated in the temporary directory (specified by `TMPDIR` or `--tmpdir=path`). The following formula yields the amount of space required:

```
(largest_key + row_pointer_length) * number_of_rows * 2
```

You can check the length of the keys and the *`row_pointer_length`* with `myisamchk -dv tbl_name` (see Section 4.6.3.5, “Obtaining Table Information with `myisamchk`”). The *`row_pointer_length`* and *`number_of_rows`* values are the `Datafile pointer` and `Data records` values in the table description. To determine the *`largest_key`* value, check the `Key` lines in the table description. The `Len` column indicates the number of bytes for each key part. For a multiple-column index, the key size is the sum of the `Len` values for all key parts.

If you have a problem with disk space during repair, you can try `--safe-recover` instead of `--recover`.

4.6.4. `myisamlog` — Display MyISAM Log File Contents

`myisamlog` processes the contents of a `MyISAM` log file.

Invoke `myisamlog` like this:

```
shell> myisamlog [options] [log_file [tbl_name] ...]
shell> isamlog [options] [log_file [tbl_name] ...]
```

The default operation is update (`-u`). If a recovery is done (`-r`), all writes and possibly updates and deletes are done and errors are only counted. The default log file name is `myisam.log` for `myisamlog` and `isam.log` for `isamlog` if no *`log_file`* argument is given. If tables are named on the command line, only those tables are updated.

`myisamlog` supports the following options:

- `-?`, `-I`

  Display a help message and exit.

- `-c N`

  Execute only *`N`* commands.

- `-f N`

  Specify the maximum number of open files.

- `-i`

  Display extra information before exiting.

- `-o offset`

  Specify the starting offset.

- `-p N`

  Remove *`N`* components from path.

- `-r`

  Perform a recovery operation.

- `-R record_pos_file record_pos`

  Specify record position file and record position.

- `-u`

  Perform an update operation.

- `-v`

  Verbose mode. Print more output about what the program does. This option can be given multiple times to produce more and more output.

- `-w write_file`

Specify the write file.

- `-V`

  Display version information.

4.6.5. `myisampack` — Generate Compressed, Read-Only MyISAM Tables

The `myisampack` utility compresses `MyISAM` tables. `myisampack` works by compressing each column in the table separately. Usually, `myisampack` packs the data file 40% to 70%.

When the table is used later, the server reads into memory the information needed to decompress columns. This results in much better performance when accessing individual rows, because you only have to uncompress exactly one row.

MySQL uses `mmap()` when possible to perform memory mapping on compressed tables. If `mmap()` does not work, MySQL falls back to normal read/write file operations.

Please note the following:

- If the `mysqld` server was invoked with external locking disabled, it is not a good idea to invoke `myisampack` if the table might be updated by the server during the packing process. It is safest to compress tables with the server stopped.
- After packing a table, it becomes read only. This is generally intended (such as when accessing packed tables on a CD).

Invoke `myisampack` like this:

```
shell> myisampack [options] file_name ...
```

Each file name argument should be the name of an index (`.MYI`) file. If you are not in the database directory, you should specify the path name to the file. It is permissible to omit the `.MYI` extension.

After you compress a table with `myisampack`, you should use `myisamchk -rq` to rebuild its indexes. Section 4.6.3, "`myisamchk` — MyISAM Table-Maintenance Utility".

`myisampack` supports the following options. It also reads option files and supports the options for processing them described at Section 4.2.3.3.1, "Command-Line Options that Affect Option-File Handling".

- `--help`, `-?`

  Display a help message and exit.

- `--backup`, `-b`

  Make a backup of each table's data file using the name `*tbl_name*.OLD`.

- `--character-sets-dir=*path*`

  The directory where character sets are installed. See Section 9.5, "Character Set Configuration".

- `--debug[=*debug_options*]`, `-# [*debug_options*]`

  Write a debugging log. A typical `*debug_options*` string is `'d:t:o,*file_name*'`. The default is `'d:t:o'`.

- `--force`, `-f`

  Produce a packed table even if it becomes larger than the original or if the intermediate file from an earlier invocation of `myisampack` exists. (`myisampack` creates an intermediate file named `*tbl_name*.TMD` in the database directory while it compresses the table. If you kill `myisampack`, the `.TMD` file might not be deleted.) Normally, `myisampack` exits with an error if it finds that `*tbl_name*.TMD` exists. With `--force`, `myisampack` packs the table anyway.

- `--join=*big_tbl_name*`, `-j *big_tbl_name*`

  Join all tables named on the command line into a single packed table `*big_tbl_name*`. All tables that are to be combined *must* have identical structure (same column names and types, same indexes, and so forth).

  `*big_tbl_name*` must not exist prior to the join operation. All source tables named on the command line to be merged into *`big_tbl_name`* must exist. The source tables are read for the join operation but not modified. The join operation does not create a `.frm` file for *`big_tbl_name`*, so after the join operation finishes, copy the `.frm` file from one of the source tables and name it *`big_tbl_name`*`.frm`.

- `--silent`, `-s`

  Silent mode. Write output only when errors occur.

- `--test`, `-t`

  Do not actually pack the table, just test packing it.

- `--tmpdir=`*`path`*, `-T` *`path`*

  Use the named directory as the location where `myisampack` creates temporary files.

- `--verbose`, `-v`

  Verbose mode. Write information about the progress of the packing operation and its result.

- `--version`, `-V`

  Display version information and exit.

- `--wait`, `-w`

  Wait and retry if the table is in use. If the `mysqld` server was invoked with external locking disabled, it is not a good idea to invoke `myisampack` if the table might be updated by the server during the packing process.

The following sequence of commands illustrates a typical table compression session:

```
shell> ls -l station.*
-rw-rw-r--   1 monty    my         994128 Apr 17 19:00 station.MYD
-rw-rw-r--   1 monty    my          53248 Apr 17 19:00 station.MYI
-rw-rw-r--   1 monty    my           5767 Apr 17 19:00 station.frm

shell> myisamchk -dvv station

MyISAM file:     station
Isam-version:  2
Creation time: 1996-03-13 10:08:58
Recover time:  1997-02-02  3:06:43
Data records:              1192  Deleted blocks:              0
Datafile parts:            1192  Deleted data:                0
Datafile pointer (bytes):     2  Keyfile pointer (bytes):     2
Max datafile length:   54657023  Max keyfile length:   33554431
Recordlength:               834
Record format: Fixed length

table description:
Key Start Len Index   Type                 Root  Blocksize    Rec/key
1   2     4   unique  unsigned long        1024       1024          1
2   32    30  multip. text                10240       1024          1

Field Start Length Type
1     1     1
2     2     4
3     6     4
4     10    1
5     11    20
6     31    1
7     32    30
8     62    35
9     97    35
10    132   35
11    167   4
12    171   16
13    187   35
14    222   4
15    226   16
16    242   20
17    262   20
18    282   20
19    302   30
20    332   4
21    336   4
22    340   1
23    341   8
24    349   8
25    357   8
26    365   2
27    367   2
28    369   4
29    373   4
30    377   1
```

```
31    378   2
32    380   8
33    388   4
34    392   4
35    396   4
36    400   4
37    404   1
38    405   4
39    409   4
40    413   4
41    417   4
42    421   4
43    425   4
44    429   20
45    449   30
46    479   1
47    480   1
48    481   79
49    560   79
50    639   79
51    718   79
52    797   8
53    805   1
54    806   1
55    807   20
56    827   4
57    831   4

shell> myisampack station.MYI
Compressing station.MYI: (1192 records)
- Calculating statistics

normal:     20  empty-space:   16  empty-zero:     12  empty-fill:  11
pre-space:   0  end-space:     12  table-lookups:   5  zero:         7
Original trees:  57  After join: 17
- Compressing file
87.14%
Remember to run myisamchk -rq on compressed tables

shell> ls -l station.*
-rw-rw-r--   1 monty    my         127874 Apr 17 19:00 station.MYD
-rw-rw-r--   1 monty    my          55296 Apr 17 19:04 station.MYI
-rw-rw-r--   1 monty    my           5767 Apr 17 19:00 station.frm

shell> myisamchk -dvv station

MyISAM file:     station
Isam-version:  2
Creation time: 1996-03-13 10:08:58
Recover time:  1997-04-17 19:04:26
Data records:               1192  Deleted blocks:              0
Datafile parts:             1192  Deleted data:                0
Datafile pointer (bytes):      3  Keyfile pointer (bytes):     1
Max datafile length:    16777215  Max keyfile length:     131071
Recordlength:                834
Record format: Compressed

table description:
Key Start Len Index   Type                 Root  Blocksize    Rec/key
1   2     4   unique  unsigned long       10240       1024          1
2   32    30  multip. text                54272       1024          1

Field Start Length Type                         Huff tree  Bits
1     1     1      constant                             1     0
2     2     4      zerofill(1)                          2     9
3     6     4      no zeros, zerofill(1)                2     9
4     10    1                                           3     9
5     11    20     table-lookup                         4     0
6     31    1                                           3     9
7     32    30     no endspace, not_always              5     9
8     62    35     no endspace, not_always, no empty    6     9
9     97    35     no empty                             7     9
10    132   35     no endspace, not_always, no empty    6     9
11    167   4      zerofill(1)                          2     9
12    171   16     no endspace, not_always, no empty    5     9
13    187   35     no endspace, not_always, no empty    6     9
14    222   4      zerofill(1)                          2     9
15    226   16     no endspace, not_always, no empty    5     9
16    242   20     no endspace, not_always              8     9
17    262   20     no endspace, no empty                8     9
18    282   20     no endspace, no empty                5     9
19    302   30     no endspace, no empty                6     9
20    332   4      always zero                          2     9
21    336   4      always zero                          2     9
22    340   1                                           3     9
23    341   8      table-lookup                         9     0
24    349   8      table-lookup                        10     0
25    357   8      always zero                          2     9
26    365   2                                           2     9
27    367   2      no zeros, zerofill(1)                2     9
28    369   4      no zeros, zerofill(1)                2     9
29    373   4      table-lookup                        11     0
30    377   1                                           3     9
31    378   2      no zeros, zerofill(1)                2     9
32    380   8      no zeros                             2     9
33    388   4      always zero                          2     9
34    392   4      table-lookup                        12     0
35    396   4      no zeros, zerofill(1)               13     9
```

```
36    400   4      no zeros, zerofill(1)             2     9
37    404   1                                        2     9
38    405   4      no zeros                          2     9
39    409   4      always zero                       2     9
40    413   4      no zeros                          2     9
41    417   4      always zero                       2     9
42    421   4      no zeros                          2     9
43    425   4      always zero                       2     9
44    429   20     no empty                          3     9
45    449   30     no empty                          3     9
46    479   1                                       14     4
47    480   1                                       14     4
48    481   79     no endspace, no empty            15     9
49    560   79     no empty                          2     9
50    639   79     no empty                          2     9
51    718   79     no endspace                      16     9
52    797   8      no empty                          2     9
53    805   1                                       17     1
54    806   1                                        3     9
55    807   20     no empty                          3     9
56    827   4      no zeros, zerofill(2)             2     9
57    831   4      no zeros, zerofill(1)             2     9
```

`myisampack` displays the following kinds of information:

- `normal`

  The number of columns for which no extra packing is used.

- `empty-space`

  The number of columns containing values that are only spaces. These occupy one bit.

- `empty-zero`

  The number of columns containing values that are only binary zeros. These occupy one bit.

- `empty-fill`

  The number of integer columns that do not occupy the full byte range of their type. These are changed to a smaller type. For example, a `BIGINT` column (eight bytes) can be stored as a `TINYINT` column (one byte) if all its values are in the range from `-128` to `127`.

- `pre-space`

  The number of decimal columns that are stored with leading spaces. In this case, each value contains a count for the number of leading spaces.

- `end-space`

  The number of columns that have a lot of trailing spaces. In this case, each value contains a count for the number of trailing spaces.

- `table-lookup`

  The column had only a small number of different values, which were converted to an `ENUM` before Huffman compression.

- `zero`

  The number of columns for which all values are zero.

- `Original trees`

  The initial number of Huffman trees.

- `After join`

  The number of distinct Huffman trees left after joining trees to save some header space.

After a table has been compressed, the `Field` lines displayed by `myisamchk -dvv` include additional information about each column:

- `Type`

  The data type. The value may contain any of the following descriptors:

  - `constant`

    All rows have the same value.

  - `no endspace`

    Do not store endspace.

  - `no endspace, not_always`

    Do not store endspace and do not do endspace compression for all values.

  - `no endspace, no empty`

    Do not store endspace. Do not store empty values.

  - `table-lookup`

    The column was converted to an `ENUM`.

  - `zerofill(N)`

    The most significant *`N`* bytes in the value are always 0 and are not stored.

  - `no zeros`

    Do not store zeros.

  - `always zero`

    Zero values are stored using one bit.

- `Huff tree`

  The number of the Huffman tree associated with the column.

- `Bits`

  The number of bits used in the Huffman tree.

After you run `myisampack`, you must run `myisamchk` to re-create any indexes. At this time, you can also sort the index blocks and create statistics needed for the MySQL optimizer to work more efficiently:

```
shell> myisamchk -rq --sort-index --analyze tbl_name.MYI
```

After you have installed the packed table into the MySQL database directory, you should execute `mysqladmin flush-tables` to force `mysqld` to start using the new table.

To unpack a packed table, use the `--unpack` option to `myisamchk`.

4.6.6. `mysqlaccess` — Client for Checking Access Privileges

`mysqlaccess` is a diagnostic tool that Yves Carlier has provided for the MySQL distribution. It checks the access privileges for a host name, user name, and database combination. Note that `mysqlaccess` checks access using only the `user`, `db`, and `host` tables. It does not check table, column, or routine privileges specified in the `tables_priv`, `columns_priv`, or `procs_priv` tables.

Invoke `mysqlaccess` like this:

```
shell> mysqlaccess [host_name [user_name [db_name]]] [options]
```

`mysqlaccess` supports the following options.

Table 4.10. `mysqlaccess` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--brief	brief	Generate reports in single-line tabular format			

Format	Option File	Description	Introduction	Deprecated	Removed
--commit	commit	Copy the new access privileges from the temporary tables to the original grant tables			
--copy	copy	Reload the temporary grant tables from original ones			
--db=db_name	db	Specify the database name			
--debug=#	debug	Specify the debug level			
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--howto	howto	Display some examples that show how to use mysqlaccess			
--old_server	old_server	Assume that the server is an old MySQL server (prior to MySQL 3.21)			
--password[=password]	password	The password to use when connecting to the server			
--plan	plan	Display suggestions and ideas for future releases			
--preview	preview	Show the privilege differences after making changes to the temporary grant tables			
--relnotes	relnotes	Display the release notes			
--rhost=host_name	rhost	Connect to the MySQL server on the given host			
--rollback	rollback	Undo the most recent changes to the temporary grant tables.			
--spassword[=password]	spassword	The password to use when connecting to the server as the superuser			
--superuser=user_name	superuser	Specify the user name for connecting as the superuser			
--table	table	Generate reports in table format			
--user=user_name,	user	The MySQL user name to use when connecting			
--version		Display version information and exit			

- `--help`, `-?`

  Display a help message and exit.

- `--brief`, `-b`

  Generate reports in single-line tabular format.

- `--commit`

  Copy the new access privileges from the temporary tables to the original grant tables. The grant tables must be flushed for the new privileges to take effect. (For example, execute a `mysqladmin reload` command.)

- `--copy`

  Reload the temporary grant tables from original ones.

- `--db=db_name`, `-d db_name`

  Specify the database name.

- `--debug=N`

  Specify the debug level. `N` can be an integer from 0 to 3.

- `--host=host_name`, `-h host_name`

  The host name to use in the access privileges.

- `--howto`

  Display some examples that show how to use `mysqlaccess`.

- `--old_server`

  Assume that the server is an old MySQL server (before MySQL 3.21) that does not yet know how to handle full `WHERE` clauses.

- `--password[=password]`, `-p[password]`

  The password to use when connecting to the server. If you omit the *`password`* value following the `--password` or `-p` option on the command line, `mysqlaccess` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”.

- `--plan`

  Display suggestions and ideas for future releases.

- `--preview`

  Show the privilege differences after making changes to the temporary grant tables.

- `--relnotes`

  Display the release notes.

- `--rhost=host_name`, `-H host_name`

  Connect to the MySQL server on the given host.

- `--rollback`

  Undo the most recent changes to the temporary grant tables.

- `--spassword[=password]`, `-P[password]`

  The password to use when connecting to the server as the superuser. If you omit the *`password`* value following the `--spassword` or `-p` option on the command line, `mysqlaccess` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”.

- `--superuser=user_name`, `-U user_name`

  Specify the user name for connecting as the superuser.

- `--table`, `-t`

  Generate reports in table format.

- `--user=user_name`, `-u user_name`

  The user name to use in the access privileges.

- `--version`, `-v`

  Display version information and exit.

If your MySQL distribution is installed in some nonstandard location, you must change the location where `mysqlaccess` expects to find the `mysql` client. Edit the `mysqlaccess` script at approximately line 18. Search for a line that looks like this:

```
$MYSQL     = '/usr/local/bin/mysql';    # path to mysql executable
```

Change the path to reflect the location where `mysql` actually is stored on your system. If you do not do this, a `Broken pipe` error will occur when you run `mysqlaccess`.

4.6.7. `mysqlbinlog` — Utility for Processing Binary Log Files

The server's binary log consists of files containing “events” that describe modifications to database contents. The server writes these files in binary format. To display their contents in text format, use the `mysqlbinlog` utility. You can also use `mysqlbinlog` to display the contents of relay log files written by a slave server in a replication setup because relay logs have the same format as binary logs. The binary log and relay log are discussed further in Section 5.2.4, “The Binary Log”, and Section 15.2.2, “Replication Relay and Status Logs”.

Invoke `mysqlbinlog` like this:

```
shell> mysqlbinlog [options] log_file ...
```

For example, to display the contents of the binary log file named `binlog.000003`, use this command:

```
shell> mysqlbinlog binlog.0000003
```

The output includes events contained in `binlog.000003`. For statement-based logging, event information includes the SQL statement, the ID of the server on which it was executed, the timestamp when the statement was executed, how much time it took, and so forth. For row-based logging, the event indicates a row change rather than an SQL statement. See Section 15.1.2, “Replication Formats”, for information about logging modes.

Events are preceded by header comments that provide additional information. For example:

```
# at 141
#100309  9:28:36 server id 123  end_log_pos 245
  Query thread_id=3350  exec_time=11  error_code=0
```

In the first line, the number following `at` indicates the starting position of the event in the binary log file.

The second line starts with a date and time indicating when the statement started on the server where the event originated. For replication, this timestamp is propagated to slave servers. `server id` is the `server_id` value of the server where the event originated. `end_log_pos` indicates where the next event starts (that is, it is the end position of the current event + 1). `thread_id` indicates which thread executed the event. `exec_time` is the time spent executing the event, on a master server. On a slave, it is the difference of the end execution time on the slave minus the beginning execution time on the master. The difference serves as an indicator of how much replication lags behind the master. `error_code` indicates the result from executing the event. Zero means that no error occurred.

The output from `mysqlbinlog` can be re-executed (for example, by using it as input to `mysql`) to redo the statements in the log. This is useful for recovery operations after a server crash. For other usage examples, see the discussion later in this section and in Section 6.5, “Point-in-Time (Incremental) Recovery Using the Binary Log”.

Normally, you use `mysqlbinlog` to read binary log files directly and apply them to the local MySQL server. It is also possible to read binary logs from a remote server by using the `--read-from-remote-server` option. To read remote binary logs, the connection parameter options can be given to indicate how to connect to the server. These options are `--host`, `--password`, `--port`, `--protocol`, `--socket`, and `--user`; they are ignored except when you also use the `--read-from-remote-server` option.

`mysqlbinlog` supports the following options, which can be specified on the command line or in the `[mysqlbinlog]` and `[client]` groups of an option file. `mysqlbinlog` also supports the options for processing option files described at Section 4.2.3.3.1, “Command-Line Options that Affect Option-File Handling”.

Table 4.11. `mysqlbinlog` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--base64-output[=value]	base64-output	Print binary log entries using base-64 encoding			
--character-sets-dir=path	character-sets-dir	The directory where character sets are installed			
--database=db_name	database	List entries for just this database			
-	debug	Write a debugging log			

Format	Option File	Description	Introduction	Deprecated	Removed
-debug[=debug_options]					
--debug-check	debug-check	Print debugging information when the program exits			
--debug-info	debug-info	Print debugging information, memory and CPU statistics when the program exits			
--default-auth=plugin	default-auth=plugin	The authentication plugin to use	5.5.10		
--disable-log-bin	disable-log-bin	Disable binary logging			
--force-read	force-read	If mysqlbinlog reads a binary log event that it does not recognize, it prints a warning			
--help		Display help message and exit			
--hexdump	hexdump	Display a hex dump of the log in comments			
--host=host_name	host	Connect to the MySQL server on the given host			
--local-load=path	local-load	Prepare local temporary files for LOAD DATA INFILE in the specified directory			
--offset=#	offset	Skip the first N entries in the log			
--password[=password]	password	The password to use when connecting to the server			
--plugin-dir=path	plugin-dir=path	The directory where plugins are located	5.5.10		
--port=port_num	port	The TCP/IP port number to use for the connection			
--protocol=type	protocol	The connection protocol to use			
--read-from-remote-server	read-from-remote-server	Read the binary log from a MySQL server rather than reading a local log file			
--result-file=name	result-file	Direct output to the given file			
--server-id=id	server-id	Extract only those events created by the server having the given server ID			
--set-charset=charset_name	set-charset	Add a SET NAMES charset_name statement to the output			
--short-form	short-form	Display only the statements contained in the log			
--socket=path	socket	For connections to localhost			
--start-datetime=datetime	start-datetime	Start reading the binary log at the first event having a timestamp equal to or later than the datetime argument			
--start-position=#	start-position	Start reading the binary log at the first event having a position equal to or greater than the argument			
--stop-datetime=datetime	stop-datetime	Stop reading the binary log at the first event having a timestamp equal to or greater than the datetime argument			
--stop-position=#	stop-position	Stop reading the binary log at the first event having a position equal to or greater than the argument			
--to-last-log	to-last-log	Do not stop at the end of the requested binary log from a MySQL server, but rather continue printing until the end of the last binary log			
--user=user_name,	user	The MySQL user name to use when connecting to the server			

Format	Option File	Description	Introduction	Deprecated	Removed
--verbose		Reconstruct row events as SQL statements			
--version		Display version information and exit			

- `--help`, `-?`

  Display a help message and exit.

- `--base64-output[=value]`

  This option determines when events should be displayed encoded as base-64 strings using `BINLOG` statements. The option has these permissible values (not case sensitive):

  - `AUTO` ("automatic") or `UNSPEC` ("unspecified") displays `BINLOG` statements automatically when necessary (that is, for format description events and row events). If no `--base64-output` option is given, the effect is the same as `--base64-output=AUTO`.

    > **Note**
    >
    > Automatic `BINLOG` display is the only safe behavior if you intend to use the output of `mysqlbinlog` to re-execute binary log file contents. The other option values are intended only for debugging or testing purposes because they may produce output that does not include all events in executable form.

  - `ALWAYS` displays `BINLOG` statements whenever possible. If the `--base64-output` option is given without a value, the effect is the same as `--base64-output=ALWAYS`.

    > **Note**
    >
    > Changes to replication in MySQL 5.6 make output generated by this option unusable, so `ALWAYS` is deprecated as of MySQL 5.5.8 and will be an invalid value in MySQL 5.6

  - `NEVER` causes `BINLOG` statements not to be displayed. `mysqlbinlog` exits with an error if a row event is found that must be displayed using `BINLOG`.

  - `DECODE-ROWS` specifies to `mysqlbinlog` that you intend for row events to be decoded and displayed as commented SQL statements by also specifying the `--verbose` option. Like `NEVER`, `DECODE-ROWS` suppresses display of `BINLOG` statements, but unlike `NEVER`, it does not exit with an error if a row event is found.

  For examples that show the effect of `--base64-output` and `--verbose` on row event output, see Section 4.6.7.2, "`mysqlbinlog` Row Event Display".

- `--bind-address=ip_address`

  On a computer having multiple network interfaces, this option can be used to select which interface is employed when connecting to the MySQL server.

  This option is supported beginning with MySQL 5.5.8.

- `--character-sets-dir=path`

  The directory where character sets are installed. See Section 9.5, "Character Set Configuration".

- `--database=db_name`, `-d db_name`

  This option causes `mysqlbinlog` to output entries from the binary log (local log only) that occur while *`db_name`* is been selected as the default database by `USE`.

  The `--database` option for `mysqlbinlog` is similar to the `--binlog-do-db` option for `mysqld`, but can be used to specify only one database. If `--database` is given multiple times, only the last instance is used.

  The effects of this option depend on whether the statement-based or row-based logging format is in use, in the same way that the effects of `--binlog-do-db` depend on whether statement-based or row-based logging is in use.

  Statement-based logging. The `--database` option works as follows:

  - While *`db_name`* is the default database, statements are output whether they modify tables in *`db_name`* or a different database.

- Unless *`db_name`* is selected as the default database, statements are not output, even if they modify tables in *`db_name`*.
- There is an exception for `CREATE DATABASE`, `ALTER DATABASE`, and `DROP DATABASE`. The database being *created, altered, or dropped* is considered to be the default database when determining whether to output the statement.

Suppose that the binary log was created by executing these statements using statement-based-logging:

```
INSERT INTO test.t1 (i) VALUES(100);
INSERT INTO db2.t2 (j)  VALUES(200);
USE test;
INSERT INTO test.t1 (i) VALUES(101);
INSERT INTO t1 (i)      VALUES(102);
INSERT INTO db2.t2 (j)  VALUES(201);
USE db2;
INSERT INTO test.t1 (i) VALUES(103);
INSERT INTO db2.t2 (j)  VALUES(202);
INSERT INTO t2 (j)      VALUES(203);
```

`mysqlbinlog --database=test` does not output the first two `INSERT` statements because there is no default database. It outputs the three `INSERT` statements following `USE test`, but not the three `INSERT` statements following `USE db2`.

`mysqlbinlog --database=db2` does not output the first two `INSERT` statements because there is no default database. It does not output the three `INSERT` statements following `USE test`, but does output the three `INSERT` statements following `USE db2`.

Row-based logging. `mysqlbinlog` outputs only entries that change tables belonging to *`db_name`*. The default database has no effect on this. Suppose that the binary log just described was created using row-based logging rather than statement-based logging. `mysqlbinlog --database=test` outputs only those entries that modify `t1` in the test database, regardless of whether `USE` was issued or what the default database is.

If a server is running with `binlog_format` set to `MIXED` and you want it to be possible to use `mysqlbinlog` with the `--database` option, you must ensure that tables that are modified are in the database selected by `USE`. (In particular, no cross-database updates should be used.)

- `--debug[=`*`debug_options`*`]`, `-# [`*`debug_options`*`]`

  Write a debugging log. A typical *`debug_options`* string is `'d:t:o,`*`file_name`*`'`. The default is `'d:t:o,/tmp/mysqlbinlog.trace'`.

- `--debug-check`

  Print some debugging information when the program exits.

- `--debug-info`

  Print debugging information and memory and CPU usage statistics when the program exits.

- `--default-auth=`*`plugin`*

  The client-side authentication plugin to use. See Section 5.5.6, “Pluggable Authentication”.

  This option was added in MySQL 5.5.10.

- `--disable-log-bin`, `-D`

  Disable binary logging. This is useful for avoiding an endless loop if you use the `--to-last-log` option and are sending the output to the same MySQL server. This option also is useful when restoring after a crash to avoid duplication of the statements you have logged.

  This option requires that you have the `SUPER` privilege. It causes `mysqlbinlog` to include a `SET sql_log_bin = 0` statement in its output to disable binary logging of the remaining output. The `SET` statement is ineffective unless you have the `SUPER` privilege.

- `--force-read`, `-f`

  With this option, if `mysqlbinlog` reads a binary log event that it does not recognize, it prints a warning, ignores the event, and continues. Without this option, `mysqlbinlog` stops if it reads such an event.

- `--hexdump`, `-H`

  Display a hex dump of the log in comments, as described in Section 4.6.7.1, “`mysqlbinlog` Hex Dump Format”. The hex output can be helpful for replication debugging.

- `--host=host_name`, `-h host_name`

  Get the binary log from the MySQL server on the given host.

- `--local-load=path`, `-l path`

  Prepare local temporary files for `LOAD DATA INFILE` in the specified directory.

  > **Important**
  >
  > These temporary files are not automatically removed by `mysqlbinlog` or any other MySQL program.

- `--offset=N`, `-o N`

  Skip the first `N` entries in the log.

- `--password[=password]`, `-p[password]`

  The password to use when connecting to the server. If you use the short option form (`-p`), you *cannot* have a space between the option and the password. If you omit the `password` value following the `--password` or `-p` option on the command line, `mysqlbinlog` prompts for one.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, "End-User Guidelines for Password Security". You can use an option file to avoid giving the password on the command line.

- `--plugin-dir=path`

  The directory in which to look for plugins. It may be necessary to specify this option if the `--default-auth` option is used to specify an authentication plugin but `mysqlbinlog` does not find it. See Section 5.5.6, "Pluggable Authentication".

  This option was added in MySQL 5.5.10.

- `--port=port_num`, `-P port_num`

  The TCP/IP port number to use for connecting to a remote server.

- `--position=N`

  Deprecated. Use `--start-position` instead. `--position` was removed in MySQL 5.5.3.

- `--protocol={TCP|SOCKET|PIPE|MEMORY}`

  The connection protocol to use for connecting to the server. It is useful when the other connection parameters normally would cause a protocol to be used other than the one you want. For details on the permissible values, see Section 4.2.2, "Connecting to the MySQL Server".

- `--read-from-remote-server`, `-R`

  Read the binary log from a MySQL server rather than reading a local log file. Any connection parameter options are ignored unless this option is given as well. These options are `--host`, `--password`, `--port`, `--protocol`, `--socket`, and `--user`.

  This option requires that the remote server be running. It works only for binary log files on the remote server, not relay log files.

- `--result-file=name`, `-r name`

  Direct output to the given file.

- `--server-id=id`

  Display only those events created by the server having the given server ID.

- `--set-charset=charset_name`

  Add a `SET NAMES charset_name` statement to the output to specify the character set to be used for processing log files.

- `--short-form`, `-s`

  Display only the statements contained in the log, without any extra information or row-based events. This is for testing only, and should not be used in production systems.

- `--socket=path`, `-S path`

  For connections to `localhost`, the Unix socket file to use, or, on Windows, the name of the named pipe to use.

- `--start-datetime=datetime`

  Start reading the binary log at the first event having a timestamp equal to or later than the *`datetime`* argument. The *`datetime`* value is relative to the local time zone on the machine where you run `mysqlbinlog`. The value should be in a format accepted for the `DATETIME` or `TIMESTAMP` data types. For example:

  ```
  shell> mysqlbinlog --start-datetime="2005-12-25 11:25:56" binlog.000003
  ```

  This option is useful for point-in-time recovery. See Section 6.3, “Example Backup and Recovery Strategy”.

- `--start-position=N`, `-j N`

  Start reading the binary log at the first event having a position equal to or greater than *`N`*. This option applies to the first log file named on the command line.

  This option is useful for point-in-time recovery. See Section 6.3, “Example Backup and Recovery Strategy”.

- `--stop-datetime=datetime`

  Stop reading the binary log at the first event having a timestamp equal to or later than the *`datetime`* argument. This option is useful for point-in-time recovery. See the description of the `--start-datetime` option for information about the *`datetime`* value.

  This option is useful for point-in-time recovery. See Section 6.3, “Example Backup and Recovery Strategy”.

- `--stop-position=N`

  Stop reading the binary log at the first event having a position equal to or greater than *`N`*. This option applies to the last log file named on the command line.

  This option is useful for point-in-time recovery. See Section 6.3, “Example Backup and Recovery Strategy”.

- `--to-last-log`, `-t`

  Do not stop at the end of the requested binary log from a MySQL server, but rather continue printing until the end of the last binary log. If you send the output to the same MySQL server, this may lead to an endless loop. This option requires `--read-from-remote-server`.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to a remote server.

- `--verbose`, `-v`

  Reconstruct row events and display them as commented SQL statements. If this option is given twice, the output includes comments to indicate column data types and some metadata.

  For examples that show the effect of `--base64-output` and `--verbose` on row event output, see Section 4.6.7.2, “`mysqlbinlog` Row Event Display”.

- `--version`, `-V`

  Display version information and exit.

You can also set the following variable by using `--var_name=value` syntax:

- `open_files_limit`

  Specify the number of open file descriptors to reserve.

You can pipe the output of `mysqlbinlog` into the `mysql` client to execute the events contained in the binary log. This technique is used to recover from a crash when you have an old backup (see Section 6.5, “Point-in-Time (Incremental) Recovery Using the Binary Log”). For example:

```
shell> mysqlbinlog binlog.000001 | mysql -u root -p
```

Or:

```
shell> mysqlbinlog binlog.[0-9]* | mysql -u root -p
```

You can also redirect the output of `mysqlbinlog` to a text file instead, if you need to modify the statement log first (for example, to remove statements that you do not want to execute for some reason). After editing the file, execute the statements that it contains by using it as input to the `mysql` program:

```
shell> mysqlbinlog binlog.000001 > tmpfile
shell> ... edit tmpfile ...
shell> mysql -u root -p < tmpfile
```

When `mysqlbinlog` is invoked with the `--start-position` option, it displays only those events with an offset in the binary log greater than or equal to a given position (the given position must match the start of one event). It also has options to stop and start when it sees an event with a given date and time. This enables you to perform point-in-time recovery using the `--stop-datetime` option (to be able to say, for example, “roll forward my databases to how they were today at 10:30 a.m.”).

If you have more than one binary log to execute on the MySQL server, the safe method is to process them all using a single connection to the server. Here is an example that demonstrates what may be *unsafe*:

```
shell> mysqlbinlog binlog.000001 | mysql -u root -p # DANGER!!
shell> mysqlbinlog binlog.000002 | mysql -u root -p # DANGER!!
```

Processing binary logs this way using multiple connections to the server causes problems if the first log file contains a `CREATE TEMPORARY TABLE` statement and the second log contains a statement that uses the temporary table. When the first `mysql` process terminates, the server drops the temporary table. When the second `mysql` process attempts to use the table, the server reports “unknown table.”

To avoid problems like this, use a *single* `mysql` process to execute the contents of all binary logs that you want to process. Here is one way to do so:

```
shell> mysqlbinlog binlog.000001 binlog.000002 | mysql -u root -p
```

Another approach is to write all the logs to a single file and then process the file:

```
shell> mysqlbinlog binlog.000001 >  /tmp/statements.sql
shell> mysqlbinlog binlog.000002 >> /tmp/statements.sql
shell> mysql -u root -p -e "source /tmp/statements.sql"
```

`mysqlbinlog` can produce output that reproduces a `LOAD DATA INFILE` operation without the original data file. `mysqlbinlog` copies the data to a temporary file and writes a `LOAD DATA LOCAL INFILE` statement that refers to the file. The default location of the directory where these files are written is system-specific. To specify a directory explicitly, use the `--local-load` option.

Because `mysqlbinlog` converts `LOAD DATA INFILE` statements to `LOAD DATA LOCAL INFILE` statements (that is, it adds `LOCAL`), both the client and the server that you use to process the statements must be configured with the `LOCAL` capability enabled. See Section 5.3.5, “Security Issues with `LOAD DATA LOCAL`”.

> **Warning**
>
> The temporary files created for `LOAD DATA LOCAL` statements are *not* automatically deleted because they are needed until you actually execute those statements. You should delete the temporary files yourself after you no longer need the statement log. The files can be found in the temporary file directory and have names like *`original_file_name-#-#`*.

4.6.7.1. `mysqlbinlog` Hex Dump Format

The `--hexdump` option causes `mysqlbinlog` to produce a hex dump of the binary log contents:

```
shell> mysqlbinlog --hexdump master-bin.000001
```

The hex output consists of comment lines beginning with `#`, so the output might look like this for the preceding command:

```
/*!40019 SET @@session.max_insert_delayed_threads=0*/;
/*!50003 SET @OLD_COMPLETION_TYPE=@@COMPLETION_TYPE,COMPLETION_TYPE=0*/;
# at 4
#051024 17:24:13 server id 1  end_log_pos 98
# Position  Timestamp   Type   Master ID        Size      Master Pos    Flags
# 00000004 9d fc 5c 43   0f   01 00 00 00   5e 00 00 00   62 00 00 00   00 00
# 00000017 04 00 35 2e 30 2e 31 35  2d 64 65 62 75 67 2d 6c |..5.0.15.debug.l|
# 00000027 6f 67 00 00 00 00 00 00  00 00 00 00 00 00 00 00 |og..............|
# 00000037 00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 |................|
# 00000047 00 00 00 00 9d fc 5c 43  13 38 0d 00 08 00 12 00 |.......C.8......|
# 00000057 04 04 04 04 12 00 00 4b  00 04 1a                |.......K...|
#       Start: binlog v 4, server v 5.0.15-debug-log created 051024 17:24:13
#       at startup
ROLLBACK;
```

Hex dump output currently contains the elements in the following list. This format is subject to change. (For more information about binary log format, see http://forge.mysql.com/wiki/MySQL_Internals_Binary_Log.)

- `Position`: The byte position within the log file.
- `Timestamp`: The event timestamp. In the example shown, `'9d fc 5c 43'` is the representation of `'051024 17:24:13'` in hexadecimal.
- `Type`: The event type code. In the example shown, `'0f'` indicates a `FORMAT_DESCRIPTION_EVENT`. The following table lists the possible type codes.

Type	**Name**	**Meaning**
`00`	`UNKNOWN_EVENT`	This event should never be present in the log.
`01`	`START_EVENT_V3`	This indicates the start of a log file written by MySQL 4 or earlier.
`02`	`QUERY_EVENT`	The most common type of events. These contain statements executed on the master.
`03`	`STOP_EVENT`	Indicates that master has stopped.
`04`	`ROTATE_EVENT`	Written when the master switches to a new log file.
`05`	`INTVAR_EVENT`	Used for `AUTO_INCREMENT` values or when the `LAST_INSERT_ID()` function is used in the statement.
`06`	`LOAD_EVENT`	Used for `LOAD DATA INFILE` in MySQL 3.23.
`07`	`SLAVE_EVENT`	Reserved for future use.
`08`	`CREATE_FILE_EVENT`	Used for `LOAD DATA INFILE` statements. This indicates the start of execution of such a statement. A temporary file is created on the slave. Used in MySQL 4 only.
`09`	`APPEND_BLOCK_EVENT`	Contains data for use in a `LOAD DATA INFILE` statement. The data is stored in the temporary file on the slave.
`0a`	`EXEC_LOAD_EVENT`	Used for `LOAD DATA INFILE` statements. The contents of the temporary file is stored in the table on the slave. Used in MySQL 4 only.
`0b`	`DELETE_FILE_EVENT`	Rollback of a `LOAD DATA INFILE` statement. The temporary file should be deleted on the slave.
`0c`	`NEW_LOAD_EVENT`	Used for `LOAD DATA INFILE` in MySQL 4 and earlier.
`0d`	`RAND_EVENT`	Used to send information about random values if the `RAND()` function is used in the statement.
`0e`	`USER_VAR_EVENT`	Used to replicate user variables.
`0f`	`FORMAT_DESCRIPTION_EVENT`	This indicates the start of a log file written by MySQL 5 or later.
`10`	`XID_EVENT`	Event indicating commit of an XA transaction.
`11`	`BEGIN_LOAD_QUERY_EVENT`	Used for `LOAD DATA INFILE` statements in MySQL 5 and later.
`12`	`EXECUTE_LOAD_QUERY_EVENT`	Used for `LOAD DATA INFILE` statements in MySQL 5 and later.
`13`	`TABLE_MAP_EVENT`	Information about a table definition. Used in MySQL 5.1.5 and later.
`14`	`PRE_GA_WRITE_ROWS_EVENT`	Row data for a single table that should be created. Used in MySQL 5.1.5 to 5.1.17.
`15`	`PRE_GA_UPDATE_ROWS_EVENT`	Row data for a single table that needs to be updated. Used in MySQL 5.1.5 to 5.1.17.
`16`	`PRE_GA_DELETE_ROWS_EVENT`	Row data for a single table that should be deleted. Used in MySQL 5.1.5 to 5.1.17.
`17`	`WRITE_ROWS_EVENT`	Row data for a single table that should be created. Used in MySQL 5.1.18 and later.
`18`	`UPDATE_ROWS_EVENT`	Row data for a single table that needs to be updated. Used in MySQL 5.1.18 and later.
`19`	`DELETE_ROWS_EVENT`	Row data for a single table that should be deleted. Used in MySQL 5.1.18

Type	Name	Meaning
		and later.
`1a`	`INCIDENT_EVENT`	Something out of the ordinary happened. Added in MySQL 5.1.18.

- `Master ID`: The server ID of the master that created the event.
- `Size`: The size in bytes of the event.
- `Master Pos`: The position of the next event in the original master log file.
- `Flags`: 16 flags. Currently, the following flags are used. The others are reserved for future use.

Flag	Name	Meaning
`01`	`LOG_EVENT_BINLOG_IN_USE_F`	Log file correctly closed. (Used only in `FORMAT_DESCRIPTION_EVENT`.) If this flag is set (if the flags are, for example, `'01 00'`) in a `FORMAT_DESCRIPTION_EVENT`, the log file has not been properly closed. Most probably this is because of a master crash (for example, due to power failure).
`02`		Reserved for future use.
`04`	`LOG_EVENT_THREAD_SPECIFIC_F`	Set if the event is dependent on the connection it was executed in (for example, `'04 00'`), for example, if the event uses temporary tables.
`08`	`LOG_EVENT_SUPPRESS_USE_F`	Set in some circumstances when the event is not dependent on the default database.

4.6.7.2. `mysqlbinlog` Row Event Display

The following examples illustrate how `mysqlbinlog` displays row events that specify data modifications. These correspond to events with the `WRITE_ROWS_EVENT`, `UPDATE_ROWS_EVENT`, and `DELETE_ROWS_EVENT` type codes. The `--base64-output=DECODE-ROWS` and `--verbose` options may be used to affect row event output.

Suppose that the server is using row-based binary logging and that you execute the following sequence of statements:

```
CREATE TABLE t
(
  id   INT NOT NULL,
  name VARCHAR(20) NOT NULL,
  date DATE NULL
) ENGINE = InnoDB;

START TRANSACTION;
INSERT INTO t VALUES(1, 'apple', NULL);
UPDATE t SET name = 'pear', date = '2009-01-01' WHERE id = 1;
DELETE FROM t WHERE id = 1;
COMMIT;
```

By default, `mysqlbinlog` displays row events encoded as base-64 strings using `BINLOG` statements. Omitting extraneous lines, the output for the row events produced by the preceding statement sequence looks like this:

```
shell> mysqlbinlog log_file
...
# at 218
#080828 15:03:08 server id 1  end_log_pos 258         Write_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAANoAAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBcBAAAAKAAAAAIBAAAQABEAAAAAAAAAEAA//8AQAAAAVhcHBsZQ==
'/*!*/;
...
# at 302
#080828 15:03:08 server id 1  end_log_pos 356         Update_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAAC4BAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBgBAAAANgAAAGQBAAAQABEAAAAAAAAAEAA////AEAAAAFYXBwbGX4AQAAAARwZWFyIbIP
'/*!*/;
...
# at 400
#080828 15:03:08 server id 1  end_log_pos 442         Delete_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAAJABAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBkBAAAAKgAAALoBAAAQABEAAAAAAAAAEAA//4AQAAAARwZWFyIbIP
```

```
'/*!*/;
```

To see the row events as comments in the form of “pseudo-SQL” statements, run `mysqlbinlog` with the `--verbose` or `-v` option. The output will contain lines beginning with `###`:

```
shell> mysqlbinlog -v log_file
...
# at 218
#080828 15:03:08 server id 1  end_log_pos 258         Write_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAANoAAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBcBAAAAKAAAAAIBAAAQABEAAAAAAAEAA//8AQAAAAVhcHBsZQ==
'/*!*/;
### INSERT INTO test.t
### SET
###   @1=1
###   @2='apple'
###   @3=NULL
...
# at 302
#080828 15:03:08 server id 1  end_log_pos 356         Update_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAAC4BAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBgBAAAANgAAAGQBAAAQABEAAAAAAAEAA////AEAAAAFYXBwbGX4AQAAAARwZWFyIbIP
'/*!*/;
### UPDATE test.t
### WHERE
###   @1=1
###   @2='apple'
###   @3=NULL
### SET
###   @1=1
###   @2='pear'
###   @3='2009:01:01'
...
# at 400
#080828 15:03:08 server id 1  end_log_pos 442         Delete_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAAJABAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBkBAAAAKgAAALoBAAAQABEAAAAAAAEAA//4AQAAAARwZWFyIbIP
'/*!*/;
### DELETE FROM test.t
### WHERE
###   @1=1
###   @2='pear'
###   @3='2009:01:01'
```

Specify `--verbose` or `-v` twice to also display data types and some metadata for each column. The output will contain an additional comment following each column change:

```
shell> mysqlbinlog -vv log_file
...
# at 218
#080828 15:03:08 server id 1  end_log_pos 258         Write_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAANoAAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBcBAAAAKAAAAAIBAAAQABEAAAAAAAEAA//8AQAAAAVhcHBsZQ==
'/*!*/;
### INSERT INTO test.t
### SET
###   @1=1 /* INT meta=0 nullable=0 is_null=0 */
###   @2='apple' /* VARSTRING(20) meta=20 nullable=0 is_null=0 */
###   @3=NULL /* VARSTRING(20) meta=0 nullable=1 is_null=1 */
...
# at 302
#080828 15:03:08 server id 1  end_log_pos 356         Update_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAAC4BAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBgBAAAANgAAAGQBAAAQABEAAAAAAAEAA////AEAAAAFYXBwbGX4AQAAAARwZWFyIbIP
'/*!*/;
### UPDATE test.t
### WHERE
###   @1=1 /* INT meta=0 nullable=0 is_null=0 */
###   @2='apple' /* VARSTRING(20) meta=20 nullable=0 is_null=0 */
###   @3=NULL /* VARSTRING(20) meta=0 nullable=1 is_null=1 */
### SET
###   @1=1 /* INT meta=0 nullable=0 is_null=0 */
###   @2='pear' /* VARSTRING(20) meta=20 nullable=0 is_null=0 */
###   @3='2009:01:01' /* DATE meta=0 nullable=1 is_null=0 */
...
# at 400
#080828 15:03:08 server id 1  end_log_pos 442         Delete_rows: table id 17 flags: STMT_END_F

BINLOG '
fAS3SBMBAAAALAAAAJABAAAAABEAAAAAAAAABHRlc3QAAXQAAwMPCgIUAAQ=
fAS3SBkBAAAAKgAAALoBAAAQABEAAAAAAAEAA//4AQAAAARwZWFyIbIP
'/*!*/;
### DELETE FROM test.t
### WHERE
###   @1=1 /* INT meta=0 nullable=0 is_null=0 */
###   @2='pear' /* VARSTRING(20) meta=20 nullable=0 is_null=0 */
###   @3='2009:01:01' /* DATE meta=0 nullable=1 is_null=0 */
```

You can tell `mysqlbinlog` to suppress the `BINLOG` statements for row events by using the `--base64-output=DECODE-ROWS` option. This is similar to `--base64-output=NEVER` but does not exit with an error if a row event is found. The combination of `--base64-output=DECODE-ROWS` and `--verbose` provides a convenient way to see row events only as SQL statements:

```
shell> mysqlbinlog -v --base64-output=DECODE-ROWS log_file
...
# at 218
#080828 15:03:08 server id 1  end_log_pos 258         Write_rows: table id 17 flags: STMT_END_F
### INSERT INTO test.t
### SET
###   @1=1
###   @2='apple'
###   @3=NULL
...
# at 302
#080828 15:03:08 server id 1  end_log_pos 356         Update_rows: table id 17 flags: STMT_END_F
### UPDATE test.t
### WHERE
###   @1=1
###   @2='apple'
###   @3=NULL
### SET
###   @1=1
###   @2='pear'
###   @3='2009:01:01'
...
# at 400
#080828 15:03:08 server id 1  end_log_pos 442         Delete_rows: table id 17 flags: STMT_END_F
### DELETE FROM test.t
### WHERE
###   @1=1
###   @2='pear'
###   @3='2009:01:01'
```

> **Note**
>
> You should not suppress `BINLOG` statements if you intend to re-execute `mysqlbinlog` output.

The SQL statements produced by `--verbose` for row events are much more readable than the corresponding `BINLOG` statements. However, they do not correspond exactly to the original SQL statements that generated the events. The following limitations apply:

- The original column names are lost and replaced by `@N`, where `N` is a column number.
- Character set information is not available in the binary log, which affects string column display:
  - There is no distinction made between corresponding binary and nonbinary string types (`BINARY` and `CHAR`, `VARBINARY` and `VARCHAR`, `BLOB` and `TEXT`). The output uses a data type of `STRING` for fixed-length strings and `VARSTRING` for variable-length strings.
  - For multi-byte character sets, the maximum number of bytes per character is not present in the binary log, so the length for string types is displayed in bytes rather than in characters. For example, `STRING(4)` will be used as the data type for values from either of these column types:

    ```
    CHAR(4) CHARACTER SET latin1
    CHAR(2) CHARACTER SET ucs2
    ```
  - Due to the storage format for events of type `UPDATE_ROWS_EVENT`, `UPDATE` statements are displayed with the `WHERE` clause preceding the `SET` clause.

Proper interpretation of row events requires the information from the format description event at the beginning of the binary log. Because `mysqlbinlog` does not know in advance whether the rest of the log contains row events, by default it displays the format description event using a `BINLOG` statement in the initial part of the output.

If the binary log is known not to contain any events requiring a `BINLOG` statement (that is, no row events), the `--base64-output=NEVER` option can be used to prevent this header from being written.

4.6.8. `mysqldumpslow` — Summarize Slow Query Log Files

The MySQL slow query log contains information about queries that take a long time to execute (see Section 5.2.5, “The Slow

Query Log”). `mysqldumpslow` parses MySQL slow query log files and prints a summary of their contents.

Normally, `mysqldumpslow` groups queries that are similar except for the particular values of number and string data values. It “abstracts” these values to `N` and `'S'` when displaying summary output. The `-a` and `-n` options can be used to modify value abstracting behavior.

Invoke `mysqldumpslow` like this:

```
shell> mysqldumpslow [options] [log_file ...]
```

`mysqldumpslow` supports the following options.

Table 4.12. `mysqldumpslow` Options

Format	Option File	Description	Introduction	Deprecated	Removed
-a		Do not abstract all numbers to N and strings to S			
-n num		Abstract numbers with at least the specified digits			
--debug	debug	Write debugging information			
-g pattern		Only consider statements that match the pattern			
--help		Display help message and exit			
-h name		Host name of the server in the log file name			
-i name		Name of the server instance			
-l		Do not subtract lock time from total time			
-r		Reverse the sort order			
-s value		How to sort output			
-t num		Display only first num queries			
--verbose	verbose	Verbose mode			

- `--help`

  Display a help message and exit.

- `-a`

  Do not abstract all numbers to `N` and strings to `'S'`.

- `--debug`, `-d`

  Run in debug mode.

- `-g pattern`

  Consider only queries that match the (`grep`-style) pattern.

- `-h host_name`

  Host name of MySQL server for `*-slow.log` file name. The value can contain a wildcard. The default is `*` (match all).

- `-i name`

  Name of server instance (if using `mysql.server` startup script).

- `-l`

  Do not subtract lock time from total time.

- `-n N`

  Abstract numbers with at least `N` digits within names.

- `-r`

  Reverse the sort order.

- `-s sort_type`

  How to sort the output. The value of `sort_type` should be chosen from the following list:

  - `t`, `at`: Sort by query time or average query time
  - `l`, `al`: Sort by lock time or average lock time
  - `r`, `ar`: Sort by rows sent or average rows sent
  - `c`: Sort by count

  By default, `mysqldumpslow` sorts by average query time (equivalent to `-s at`).

- `-t N`

  Display only the first `N` queries in the output.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does.

Example of usage:

```
shell> mysqldumpslow

Reading mysql slow query log from /usr/local/mysql/data/mysqld51-apple-slow.log
Count: 1  Time=4.32s (4s)  Lock=0.00s (0s)  Rows=0.0 (0), root[root]@localhost
 insert into t2 select * from t1

Count: 3  Time=2.53s (7s)  Lock=0.00s (0s)  Rows=0.0 (0), root[root]@localhost
 insert into t2 select * from t1 limit N

Count: 3  Time=2.13s (6s)  Lock=0.00s (0s)  Rows=0.0 (0), root[root]@localhost
 insert into t1 select * from t1
```

4.6.9. `mysqlhotcopy` — A Database Backup Program

`mysqlhotcopy` is a Perl script that was originally written and contributed by Tim Bunce. It uses `FLUSH TABLES`, `LOCK TABLES`, and `cp` or `scp` to make a database backup. It is a fast way to make a backup of the database or single tables, but it can be run only on the same machine where the database directories are located. `mysqlhotcopy` works only for backing up `MyISAM` and `ARCHIVE` tables. It runs on Unix.

To use `mysqlhotcopy`, you must have read access to the files for the tables that you are backing up, the `SELECT` privilege for those tables, the `RELOAD` privilege (to be able to execute `FLUSH TABLES`), and the `LOCK TABLES` privilege (to be able to lock the tables).

```
shell> mysqlhotcopy db_name [/path/to/new_directory]
```

```
shell> mysqlhotcopy db_name_1 ... db_name_n /path/to/new_directory
```

Back up tables in the given database that match a regular expression:

```
shell> mysqlhotcopy db_name./regex/
```

The regular expression for the table name can be negated by prefixing it with a tilde ("`~`"):

```
shell> mysqlhotcopy db_name./~regex/
```

`mysqlhotcopy` supports the following options, which can be specified on the command line or in the `[mysqlhotcopy]` and `[client]` groups of an option file. For information about option files, see Section 4.2.3.3, "Using Option Files".

Table 4.13. `mysqlhotcopy` Options

Format	Option File	Description	Introduction	Deprecated	Removed
--addtodest	addtodest	Do not rename target directory (if it exists); merely add files to it			
--allowold	allowold	Do not abort if a target exists; rename it by adding			

Format	Option File	Description	Introduction	Deprecated	Removed
		an _old suffix			
--checkpoint=db_name.tbl_name	checkpoint	Insert checkpoint entries			
--chroot=path	chroot	Base directory of the chroot jail in which mysqld operates			
--debug	debug	Write a debugging log			
--dryrun	dryrun	Report actions without performing them			
--flushlog	flushlog	Flush logs after all tables are locked			
--help		Display help message and exit			
--host=host_name	host	Connect to the MySQL server on the given host			
--keepold	keepold	Do not delete previous (renamed) target when done			
--noindices	noindices	Do not include full index files in the backup			
--old_server	old_server	Connect to server that does not support FLUSH TABLES tbl_list WITH READ LOCK	5.5.3		
--password[=password]	password	The password to use when connecting to the server			
--port=port_num	port	The TCP/IP port number to use for the connection			
--quiet	quiet	Be silent except for errors			
--regexp	regexp	Copy all databases with names that match the given regular expression			
--resetmaster	resetmaster	Reset the binary log after locking all the tables			
--resetslave	resetslave	Reset the master.info file after locking all the tables			
--socket=path	socket	For connections to localhost			
--tmpdir=path	tmpdir	The temporary directory			
--user=user_name,	user	The MySQL user name to use when connecting to the server			

- `--help`, `-?`

  Display a help message and exit.

- `--addtodest`

  Do not rename target directory (if it exists); merely add files to it.

- `--allowold`

  Do not abort if a target exists; rename it by adding an `_old` suffix.

- `--checkpoint=db_name.tbl_name`

  Insert checkpoint entries into the specified database `db_name` and table `tbl_name`.

- `--chroot=path`

  Base directory of the `chroot` jail in which `mysqld` operates. The `path` value should match that of the `--chroot` option given to `mysqld`.

- `--debug`

  Enable debug output.

- `--dryrun`, `-n`

Report actions without performing them.

- `--flushlog`

  Flush logs after all tables are locked.

- `--host=*host_name*`, `-h *host_name*`

  The host name of the local host to use for making a TCP/IP connection to the local server. By default, the connection is made to `localhost` using a Unix socket file.

- `--keepold`

  Do not delete previous (renamed) target when done.

- `--method=*command*`

  The method for copying files (`cp` or `scp`). The default is `cp`.

- `--noindices`

  Do not include full index files for `MyISAM` tables in the backup. This makes the backup smaller and faster. The indexes for reloaded tables can be reconstructed later with `myisamchk -rq`.

- `--password=*password*`, `-p*password*`

  The password to use when connecting to the server. The password value is not optional for this option, unlike for other MySQL programs.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”. You can use an option file to avoid giving the password on the command line.

- `--port=*port_num*`, `-P *port_num*`

  The TCP/IP port number to use when connecting to the local server.

- `--old_server`

  As of MySQL 5.5.3, `mysqlhotcopy` uses `FLUSH TABLES *tbl_list* WITH READ LOCK` to flush and lock tables. Use the `--old_server` option if the server is older than 5.5.3, which is when that statement was introduced. This option was added in MySQL 5.5.3.

- `--quiet`, `-q`

  Be silent except for errors.

- `--record_log_pos=*db_name*.*tbl_name*`

  Record master and slave status in the specified database `*db_name*` and table `*tbl_name*`.

- `--regexp=*expr*`

  Copy all databases with names that match the given regular expression.

- `--resetmaster`

  Reset the binary log after locking all the tables.

- `--resetslave`

  Reset the `master.info` file after locking all the tables.

- `--socket=*path*`, `-S *path*`

  The Unix socket file to use for connections to `localhost`.

- `--suffix=*str*`

  The suffix to use for names of copied databases.

- `--tmpdir=*path*`

The temporary directory. The default is `/tmp`.

- `--user=user_name`, `-u user_name`

  The MySQL user name to use when connecting to the server.

Use `perldoc` for additional `mysqlhotcopy` documentation, including information about the structure of the tables needed for the `--checkpoint` and `--record_log_pos` options:

```
shell> perldoc mysqlhotcopy
```

4.6.10. `mysql_convert_table_format` — Convert Tables to Use a Given Storage Engine

`mysql_convert_table_format` converts the tables in a database to use a particular storage engine (`MyISAM` by default). `mysql_convert_table_format` is written in Perl and requires that the `DBI` and `DBD::mysql` Perl modules be installed (see Section 2.13, “Perl Installation Notes”).

Invoke `mysql_convert_table_format` like this:

```
shell> mysql_convert_table_format [options]db_name
```

The *`db_name`* argument indicates the database containing the tables to be converted.

`mysql_convert_table_format` supports the options described in the following list.

- `--help`

  Display a help message and exit.

- `--force`

  Continue even if errors occur.

- `--host=host_name`

  Connect to the MySQL server on the given host.

- `--password=password`

  The password to use when connecting to the server. Note that the password value is not optional for this option, unlike for other MySQL programs.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”. You can use an option file to avoid giving the password on the command line.

- `--port=port_num`

  The TCP/IP port number to use for the connection.

- `--socket=path`

  For connections to `localhost`, the Unix socket file to use.

- `--type=engine_name`

  Specify the storage engine that the tables should be converted to use. The default is `MyISAM` if this option is not given.

- `--user=user_name`

  The MySQL user name to use when connecting to the server.

- `--verbose`

  Verbose mode. Print more information about what the program does.

- `--version`

Display version information and exit.

4.6.11. `mysql_find_rows` — Extract SQL Statements from Files

`mysql_find_rows` reads files containing SQL statements and extracts statements that match a given regular expression or that contain `USE db_name` or `SET` statements. The utility was written for use with update log files (as used prior to MySQL 5.0) and as such expects statements to be terminated with semicolon (`;`) characters. It may be useful with other files that contain SQL statements as long as statements are terminated with semicolons.

Invoke `mysql_find_rows` like this:

```
shell> mysql_find_rows [options] [file_name ...]
```

Each *`file_name`* argument should be the name of file containing SQL statements. If no file names are given, `mysql_find_rows` reads the standard input.

Examples:

```
mysql_find_rows --regexp=problem_table --rows=20 < update.log
mysql_find_rows --regexp=problem_table  update-log.1 update-log.2
```

`mysql_find_rows` supports the following options:

- `--help`, `--Information`

  Display a help message and exit.

- `--regexp=pattern`

  Display queries that match the pattern.

- `--rows=N`

  Quit after displaying *`N`* queries.

- `--skip-use-db`

  Do not include `USE db_name` statements in the output.

- `--start_row=N`

  Start output from this row.

4.6.12. `mysql_fix_extensions` — Normalize Table File Name Extensions

`mysql_fix_extensions` converts the extensions for `MyISAM` (or `ISAM`) table files to their canonical forms. It looks for files with extensions matching any lettercase variant of `.frm`, `.myd`, `.myi`, `.isd`, and `.ism` and renames them to have extensions of `.frm`, `.MYD`, `.MYI`, `.ISD`, and `.ISM`, respectively. This can be useful after transferring the files from a system with case-insensitive file names (such as Windows) to a system with case-sensitive file names.

Invoke `mysql_fix_extensions` like this, where *`data_dir`* is the path name to the MySQL data directory.

```
shell> mysql_fix_extensions data_dir
```

4.6.13. `mysql_setpermission` — Interactively Set Permissions in Grant Tables

`mysql_setpermission` is a Perl script that was originally written and contributed by Luuk de Boer. It interactively sets permissions in the MySQL grant tables. `mysql_setpermission` is written in Perl and requires that the `DBI` and `DBD::mysql` Perl modules be installed (see Section 2.13, “Perl Installation Notes”).

Invoke `mysql_setpermission` like this:

```
shell> mysql_setpermission [options]
```

`options` should be either `--help` to display the help message, or options that indicate how to connect to the MySQL server. The account used when you connect determines which permissions you have when attempting to modify existing permissions in the grant tables.

`mysql_setpermissions` also reads options from the `[client]` and `[perl]` groups in the `.my.cnf` file in your home directory, if the file exists.

`mysql_setpermission` supports the following options:

- `--help`

  Display a help message and exit.

- `--host=`*`host_name`*

  Connect to the MySQL server on the given host.

- `--password=`*`password`*

  The password to use when connecting to the server. Note that the password value is not optional for this option, unlike for other MySQL programs.

  Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, "End-User Guidelines for Password Security". You can use an option file to avoid giving the password on the command line.

- `--port=`*`port_num`*

  The TCP/IP port number to use for the connection.

- `--socket=`*`path`*

  For connections to `localhost`, the Unix socket file to use.

- `--user=`*`user_name`*

  The MySQL user name to use when connecting to the server.

4.6.14. `mysql_waitpid` — Kill Process and Wait for Its Termination

`mysql_waitpid` signals a process to terminate and waits for the process to exit. It uses the `kill()` system call and Unix signals, so it runs on Unix and Unix-like systems.

Invoke `mysql_waitpid` like this:

```
shell> mysql_waitpid [options] pid wait_time
```

`mysql_waitpid` sends signal 0 to the process identified by *`pid`* and waits up to *`wait_time`* seconds for the process to terminate. *`pid`* and *`wait_time`* must be positive integers.

If process termination occurs within the wait time or the process does not exist, `mysql_waitpid` returns 0. Otherwise, it returns 1.

If the `kill()` system call cannot handle signal 0, `mysql_waitpid()` uses signal 1 instead.

`mysql_waitpid` supports the following options:

- `--help`, `-?`, `-I`

  Display a help message and exit.

- `--verbose`, `-v`

  Verbose mode. Display a warning if signal 0 could not be used and signal 1 is used instead.

- `--version`, `-V`

  Display version information and exit.

4.6.15. `mysql_zap` — Kill Processes That Match a Pattern

`mysql_zap` kills processes that match a pattern. It uses the `ps` command and Unix signals, so it runs on Unix and Unix-like systems.

Invoke `mysql_zap` like this:

```
shell> mysql_zap [-signal] [-?Ift] pattern
```

A process matches if its output line from the `ps` command contains the pattern. By default, `mysql_zap` asks for confirmation for each process. Respond `y` to kill the process, or `q` to exit `mysql_zap`. For any other response, `mysql_zap` does not attempt to kill the process.

If the `-signal` option is given, it specifies the name or number of the signal to send to each process. Otherwise, `mysql_zap` tries first with `TERM` (signal 15) and then with `KILL` (signal 9).

`mysql_zap` supports the following additional options:

- `--help`, `-?`, `-I`

  Display a help message and exit.

- `-f`

  Force mode. `mysql_zap` attempts to kill each process without confirmation.

- `-t`

  Test mode. Display information about each process but do not kill it.

4.7. MySQL Program Development Utilities

This section describes some utilities that you may find useful when developing MySQL programs.

In shell scripts, you can use the `my_print_defaults` program to parse option files and see what options would be used by a given program. The following example shows the output that `my_print_defaults` might produce when asked to show the options found in the `[client]` and `[mysql]` groups:

```
shell> my_print_defaults client mysql
--port=3306
--socket=/tmp/mysql.sock
--no-auto-rehash
```

Note for developers: Option file handling is implemented in the C client library simply by processing all options in the appropriate group or groups before any command-line arguments. This works well for programs that use the last instance of an option that is specified multiple times. If you have a C or C++ program that handles multiply specified options this way but that doesn't read option files, you need add only two lines to give it that capability. Check the source code of any of the standard MySQL clients to see how to do this.

Several other language interfaces to MySQL are based on the C client library, and some of them provide a way to access option file contents. These include Perl and Python. For details, see the documentation for your preferred interface.

4.7.1. `msql2mysql` — Convert mSQL Programs for Use with MySQL

Initially, the MySQL C API was developed to be very similar to that for the mSQL database system. Because of this, mSQL programs often can be converted relatively easily for use with MySQL by changing the names of the C API functions.

The `msql2mysql` utility performs the conversion of mSQL C API function calls to their MySQL equivalents. `msql2mysql` converts the input file in place, so make a copy of the original before converting it. For example, use `msql2mysql` like this:

```
shell> cp client-prog.c client-prog.c.orig
shell> msql2mysql client-prog.c
client-prog.c converted
```

Then examine `client-prog.c` and make any post-conversion revisions that may be necessary.

`msql2mysql` uses the `replace` utility to make the function name substitutions. See Section 4.8.2, “`replace` — A String-Replacement Utility”.

4.7.2. `mysql_config` — Get Compile Options for Compiling Clients

`mysql_config` provides you with useful information for compiling your MySQL client and connecting it to MySQL.

`mysql_config` supports the following options.

- `--cflags`

  Compiler flags to find include files and critical compiler flags and defines used when compiling the `libmysqlclient` library. The options returned are tied to the specific compiler that was used when the library was created and might clash with the settings for your own compiler. Use `--include` for more portable options that contain only include paths.

- `--include`

  Compiler options to find MySQL include files.

- `--libmysqld-libs`, `--embedded`

  Libraries and options required to link with the MySQL embedded server.

- `--libs`

  Libraries and options required to link with the MySQL client library.

- `--libs_r`

  Libraries and options required to link with the thread-safe MySQL client library.

- `--plugindir`

  The default plugin directory path name, defined when configuring MySQL.

- `--port`

  The default TCP/IP port number, defined when configuring MySQL.

- `--socket`

  The default Unix socket file, defined when configuring MySQL.

- `--version`

  Version number for the MySQL distribution.

If you invoke `mysql_config` with no options, it displays a list of all options that it supports, and their values:

```
shell> mysql_config
Usage: /usr/local/mysql/bin/mysql_config [options]
Options:
  --cflags         [-I/usr/local/mysql/include/mysql -mcpu=pentiumpro]
  --include        [-I/usr/local/mysql/include/mysql]
  --libs           [-L/usr/local/mysql/lib/mysql -lmysqlclient -lz
                    -lcrypt -lnsl -lm -L/usr/lib -lssl -lcrypto]
  --libs_r         [-L/usr/local/mysql/lib/mysql -lmysqlclient_r
                    -lpthread -lz -lcrypt -lnsl -lm -lpthread]
  --socket         [/tmp/mysql.sock]
  --port           [3306]
  --version        [4.0.16]
  --libmysqld-libs [-L/usr/local/mysql/lib/mysql -lmysqld -lpthread -lz
                    -lcrypt -lnsl -lm -lpthread -lrt]
```

You can use `mysql_config` within a command line to include the value that it displays for a particular option. For example, to compile a MySQL client program, use `mysql_config` as follows:

```
shell> CFG=/usr/local/mysql/bin/mysql_config
shell> sh -c "gcc -o progname `$CFG --include` progname.c `$CFG --libs`"
```

When you use `mysql_config` this way, be sure to invoke it within backtick (“`”) characters. That tells the shell to execute it and substitute its output into the surrounding command.

4.7.3. `my_print_defaults` — Display Options from Option Files

`my_print_defaults` displays the options that are present in option groups of option files. The output indicates what options will be used by programs that read the specified option groups. For example, the `mysqlcheck` program reads the `[mysqlcheck]` and `[client]` option groups. To see what options are present in those groups in the standard option files, invoke `my_print_defaults` like this:

```
shell> my_print_defaults mysqlcheck client
--user=myusername
--password=secret
--host=localhost
```

The output consists of options, one per line, in the form that they would be specified on the command line.

`my_print_defaults` supports the following options.

- `--help`, `-?`

  Display a help message and exit.

- `--config-file=file_name`, `--defaults-file=file_name`, `-c file_name`

  Read only the given option file.

- `--debug=debug_options`, `-# debug_options`

  Write a debugging log. A typical `debug_options` string is `'d:t:o,file_name'`. The default is `'d:t:o,/tmp/my_print_defaults.trace'`.

- `--defaults-extra-file=file_name`, `--extra-file=file_name`, `-e file_name`

  Read this option file after the global option file but (on Unix) before the user option file.

- `--defaults-group-suffix=suffix`, `-g suffix`

  In addition to the groups named on the command line, read groups that have the given suffix.

- `--no-defaults`, `-n`

  Return an empty string.

- `--verbose`, `-v`

  Verbose mode. Print more information about what the program does.

- `--version`, `-V`

  Display version information and exit.

4.7.4. `resolve_stack_dump` — Resolve Numeric Stack Trace Dump to Symbols

`resolve_stack_dump` resolves a numeric stack dump to symbols.

Invoke `resolve_stack_dump` like this:

```
shell> resolve_stack_dump [options] symbols_file [numeric_dump_file]
```

The symbols file should include the output from the `nm --numeric-sort mysqld` command. The numeric dump file should contain a numeric stack track from `mysqld`. If no numeric dump file is named on the command line, the stack trace is read from the standard input.

`resolve_stack_dump` supports the following options.

- `--help`, `-h`

  Display a help message and exit.

- `--numeric-dump-file=file_name`, `-n file_name`

Read the stack trace from the given file.

- `--symbols-file=file_name`, `-s file_name`

  Use the given symbols file.

- `--version`, `-V`

  Display version information and exit.

4.8. Miscellaneous Programs

4.8.1. `perror` — Explain Error Codes

For most system errors, MySQL displays, in addition to an internal text message, the system error code in one of the following styles:

```
message ... (errno: #)
message ... (Errcode: #)
```

You can find out what the error code means by examining the documentation for your system or by using the `perror` utility.

`perror` prints a description for a system error code or for a storage engine (table handler) error code.

Invoke `perror` like this:

```
shell> perror [options] errorcode ...
```

Example:

```
shell> perror 13 64
OS error code  13:  Permission denied
OS error code  64:  Machine is not on the network
```

To obtain the error message for a MySQL Cluster error code, invoke `perror` with the `--ndb` option:

```
shell> perror --ndb errorcode
```

Note that the meaning of system error messages may be dependent on your operating system. A given error code may mean different things on different operating systems.

`perror` supports the following options.

- `--help`, `--info`, `-I`, `-?`

  Display a help message and exit.

- `--ndb`

  Print the error message for a MySQL Cluster error code.

- `--silent`, `-s`

  Silent mode. Print only the error message.

- `--verbose`, `-v`

  Verbose mode. Print error code and message. This is the default behavior.

- `--version`, `-V`

  Display version information and exit.

4.8.2. `replace` — A String-Replacement Utility

The `replace` utility program changes strings in place in files or on the standard input.

Invoke `replace` in one of the following ways:

```
shell> replace from to [from to] ... -- file_name [file_name] ...
shell> replace from to [from to] ... < file_name
```

`from` represents a string to look for and *`to`* represents its replacement. There can be one or more pairs of strings.

Use the `--` option to indicate where the string-replacement list ends and the file names begin. In this case, any file named on the command line is modified in place, so you may want to make a copy of the original before converting it. *`replace`* prints a message indicating which of the input files it actually modifies.

If the `--` option is not given, `replace` reads the standard input and writes to the standard output.

`replace` uses a finite state machine to match longer strings first. It can be used to swap strings. For example, the following command swaps `a` and `b` in the given files, `file1` and `file2`:

```
shell> replace a b b a -- file1 file2 ...
```

The `replace` program is used by `msql2mysql`. See Section 4.7.1, “`msql2mysql` — Convert mSQL Programs for Use with MySQL”.

`replace` supports the following options.

- `-?`, `-I`

  Display a help message and exit.

- *`-#debug_options`*

  Enable debugging.

- `-s`

  Silent mode. Print less information what the program does.

- `-v`

  Verbose mode. Print more information about what the program does.

- `-V`

  Display version information and exit.

4.8.3. `resolveip` — Resolve Host name to IP Address or Vice Versa

The `resolveip` utility resolves host names to IP addresses and vice versa.

Invoke `resolveip` like this:

```
shell> resolveip [options] {host_name|ip-addr} ...
```

`resolveip` supports the following options.

- `--help`, `--info`, `-?`, `-I`

  Display a help message and exit.

- `--silent`, `-s`

  Silent mode. Produce less output.

- `--version`, `-V`

  Display version information and exit.

Chapter 5. MySQL Server Administration

MySQL Server (`mysqld`) is the main program that does most of the work in a MySQL installation. This section provides an overview of MySQL Server and covers topics that deal with administering a MySQL installation:

- Server configuration
- The server log files
- Security issues and user-account management
- Management of multiple servers on a single machine

5.1. The MySQL Server

`mysqld` is the MySQL server. The following discussion covers these MySQL server configuration topics:

- Startup options that the server supports
- Server system variables
- Server status variables
- How to set the server SQL mode
- The server shutdown process

> **Note**
>
> Not all storage engines are supported by all MySQL server binaries and configurations. To find out how to determine which storage engines your MySQL server installation supports, see Section 12.4.5.17, "`SHOW ENGINES` Syntax".

5.1.1. Server Option and Variable Reference

The following table provides a list of all the command line options, server and status variables applicable within `mysqld`.

The table lists command-line options (Cmd-line), options valid in configuration files (Option file), server system variables (System Var), and status variables (Status var) in one unified list, with notification of where each option/variable is valid. If a server option set on the command line or in an option file differs from the name of the corresponding server system or status variable, the variable name is noted immediately below the corresponding option. For status variables, the scope of the variable is shown (Scope) as either global, session, or both. Please see the corresponding sections for details on setting and using the options and variables. Where appropriate, a direct link to further information on the item as available.

Table 5.1. Option/Variable Summary

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
abort-slave-event-count	Yes	Yes				
Aborted_clients				Yes	Global	No
Aborted_connects				Yes	Global	No
allow-suspicious-udfs	Yes	Yes				
ansi	Yes	Yes				
auto_increment_increment	Yes	Yes	Yes		Both	Yes
auto_increment_offset	Yes	Yes	Yes		Both	Yes
autocommit	Yes	Yes	Yes		Both	Yes
automatic_sp_privileges			Yes		Global	Yes
back_log	Yes	Yes	Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
basedir	Yes	Yes	Yes		Global	No
big-tables	Yes	Yes			Both	Yes
- *Variable*: big_tables			Yes		Both	Yes
bind-address	Yes	Yes	Yes		Global	No
Binlog_cache_disk_use				Yes	Global	No
binlog_cache_size	Yes	Yes	Yes		Global	Yes
Binlog_cache_use				Yes	Global	No
binlog_direct_non_transactional_updates	Yes	Yes	Yes		Both	Yes
binlog-do-db	Yes	Yes				
binlog-format	Yes	Yes			Both	Yes
- *Variable*: binlog_format			Yes		Both	Yes
binlog-ignore-db	Yes	Yes				
binlog-row-event-max-size	Yes	Yes				
Binlog_stmt_cache_disk_use				Yes	Global	No
binlog_stmt_cache_size	Yes	Yes	Yes		Global	Yes
Binlog_stmt_cache_use				Yes	Global	No
bootstrap	Yes	Yes				
bulk_insert_buffer_size	Yes	Yes	Yes		Both	Yes
Bytes_received				Yes	Both	No
Bytes_sent				Yes	Both	No
character_set_client			Yes		Both	Yes
character-set-client-handshake	Yes	Yes				
character_set_connection			Yes		Both	Yes
character_set_database[a]			Yes		Both	Yes
character-set-filesystem	Yes	Yes			Both	Yes
- *Variable*: character_set_filesystem			Yes		Both	Yes
character_set_results			Yes		Both	Yes
character-set-server	Yes	Yes			Both	Yes
- *Variable*: character_set_server			Yes		Both	Yes
character_set_system			Yes		Global	No
character-sets-dir	Yes	Yes			Global	No
- *Variable*: character_sets_dir			Yes		Global	No
chroot	Yes	Yes				
collation_connection			Yes		Both	Yes
collation_database[b]			Yes		Both	Yes
collation-server	Yes	Yes			Both	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
- *Variable*: collation_server			Yes		Both	Yes
Com_admin_commands				Yes	Both	No
Com_alter_db				Yes	Both	No
Com_alter_db_upgrade				Yes	Both	No
Com_alter_event				Yes	Both	No
Com_alter_function				Yes	Both	No
Com_alter_procedure				Yes	Both	No
Com_alter_server				Yes	Both	No
Com_alter_table				Yes	Both	No
Com_alter_tablespace				Yes	Both	No
Com_analyze				Yes	Both	No
Com_assign_to_keycache				Yes	Both	No
Com_backup_table				Yes	Both	No
Com_begin				Yes	Both	No
Com_binlog				Yes	Both	No
Com_call_procedure				Yes	Both	No
Com_change_db				Yes	Both	No
Com_change_master				Yes	Both	No
Com_check				Yes	Both	No
Com_checksum				Yes	Both	No
Com_commit				Yes	Both	No
Com_create_db				Yes	Both	No
Com_create_event				Yes	Both	No
Com_create_function				Yes	Both	No
Com_create_index				Yes	Both	No
Com_create_procedure				Yes	Both	No
Com_create_server				Yes	Both	No
Com_create_table				Yes	Both	No
Com_create_trigger				Yes	Both	No
Com_create_udf				Yes	Both	No
Com_create_user				Yes	Both	No
Com_create_view				Yes	Both	No
Com_dealloc_sql				Yes	Both	No
Com_delete				Yes	Both	No
Com_delete_multi				Yes	Both	No
Com_do				Yes	Both	No
Com_drop_db				Yes	Both	No
Com_drop_event				Yes	Both	No
Com_drop_function				Yes	Both	No
Com_drop_index				Yes	Both	No
Com_drop_procedure				Yes	Both	No
Com_drop_server				Yes	Both	No
Com_drop_table				Yes	Both	No
Com_drop_trigger				Yes	Both	No
Com_drop_user				Yes	Both	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
Com_drop_view				Yes	Both	No
Com_empty_query				Yes	Both	No
Com_execute_sql				Yes	Both	No
Com_flush				Yes	Both	No
Com_grant				Yes	Both	No
Com_ha_close				Yes	Both	No
Com_ha_open				Yes	Both	No
Com_ha_read				Yes	Both	No
Com_help				Yes	Both	No
Com_insert				Yes	Both	No
Com_insert_select				Yes	Both	No
Com_install_plugin				Yes	Both	No
Com_kill				Yes	Both	No
Com_load				Yes	Both	No
Com_lock_tables				Yes	Both	No
Com_optimize				Yes	Both	No
Com_preload_keys				Yes	Both	No
Com_prepare_sql				Yes	Both	No
Com_purge				Yes	Both	No
Com_purge_before_date				Yes	Both	No
Com_release_savepoint				Yes	Both	No
Com_rename_table				Yes	Both	No
Com_rename_user				Yes	Both	No
Com_repair				Yes	Both	No
Com_replace				Yes	Both	No
Com_replace_select				Yes	Both	No
Com_reset				Yes	Both	No
Com_resignal				Yes	Both	No
Com_restore_table				Yes	Both	No
Com_revoke				Yes	Both	No
Com_revoke_all				Yes	Both	No
Com_rollback				Yes	Both	No
Com_rollback_to_savepoint				Yes	Both	No
Com_savepoint				Yes	Both	No
Com_select				Yes	Both	No
Com_set_option				Yes	Both	No
Com_show_authors				Yes	Both	No
Com_show_binlog_events				Yes	Both	No
Com_show_binlogs				Yes	Both	No
Com_show_charsets				Yes	Both	No
Com_show_collations				Yes	Both	No
Com_show_contributors				Yes	Both	No
Com_show_create_db				Yes	Both	No
Com_show_create_event				Yes	Both	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
Com_show_create_func				Yes	Both	No
Com_show_create_proc				Yes	Both	No
Com_show_create_table				Yes	Both	No
Com_show_create_trigger				Yes	Both	No
Com_show_databases				Yes	Both	No
Com_show_engine_logs				Yes	Both	No
Com_show_engine_mutex				Yes	Both	No
Com_show_engine_status				Yes	Both	No
Com_show_errors				Yes	Both	No
Com_show_events				Yes	Both	No
Com_show_fields				Yes	Both	No
Com_show_function_code				Yes	Both	No
Com_show_function_status				Yes	Both	No
Com_show_grants				Yes	Both	No
Com_show_keys				Yes	Both	No
Com_show_logs				Yes	Both	No
Com_show_master_status				Yes	Both	No
Com_show_new_master				Yes	Both	No
Com_show_open_tables				Yes	Both	No
Com_show_plugins				Yes	Both	No
Com_show_privileges				Yes	Both	No
Com_show_procedure_code				Yes	Both	No
Com_show_procedure_status				Yes	Both	No
Com_show_processlist				Yes	Both	No
Com_show_profile				Yes	Both	No
Com_show_profiles				Yes	Both	No
Com_show_relaylog_events				Yes	Both	No
Com_show_slave_hosts				Yes	Both	No
Com_show_slave_status				Yes	Both	No
Com_show_status				Yes	Both	No
Com_show_storage_engines				Yes	Both	No
Com_show_table_status				Yes	Both	No
Com_show_tables				Yes	Both	No
Com_show_triggers				Yes	Both	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
Com_show_variables				Yes	Both	No
Com_show_warnings				Yes	Both	No
Com_signal				Yes	Both	No
Com_slave_start				Yes	Both	No
Com_slave_stop				Yes	Both	No
Com_stmt_close				Yes	Both	No
Com_stmt_execute				Yes	Both	No
Com_stmt_fetch				Yes	Both	No
Com_stmt_prepare				Yes	Both	No
Com_stmt_reprepare				Yes	Both	No
Com_stmt_reset				Yes	Both	No
Com_stmt_send_long_data				Yes	Both	No
Com_truncate				Yes	Both	No
Com_uninstall_plugin				Yes	Both	No
Com_unlock_tables				Yes	Both	No
Com_update				Yes	Both	No
Com_update_multi				Yes	Both	No
Com_xa_commit				Yes	Both	No
Com_xa_end				Yes	Both	No
Com_xa_prepare				Yes	Both	No
Com_xa_recover				Yes	Both	No
Com_xa_rollback				Yes	Both	No
Com_xa_start				Yes	Both	No
completion_type	Yes	Yes	Yes		Both	Yes
Compression				Yes	Session	No
concurrent_insert	Yes	Yes	Yes		Global	Yes
connect_timeout	Yes	Yes	Yes		Global	Yes
Connections				Yes	Global	No
console	Yes	Yes				
core-file	Yes	Yes				
Created_tmp_disk_tables				Yes	Both	No
Created_tmp_files				Yes	Global	No
Created_tmp_tables				Yes	Both	No
datadir	Yes	Yes	Yes		Global	No
date_format			Yes		Global	No
datetime_format			Yes		Global	No
debug	Yes	Yes	Yes		Both	Yes
debug_sync			Yes		Session	Yes
debug-sync-timeout	Yes	Yes				
default-storage-engine	Yes	Yes			Both	Yes
- *Variable*: default_storage_engine			Yes		Both	Yes
default-time-zone	Yes	Yes				
default_week_format	Yes	Yes	Yes		Both	Yes
defaults-extra-file	Yes					
defaults-file	Yes					
defaults-group-suffix	Yes					

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
delay-key-write	Yes	Yes			Global	Yes
- *Variable*: delay_key_write			Yes		Global	Yes
Delayed_errors				Yes	Global	No
delayed_insert_limit	Yes	Yes	Yes		Global	Yes
Delayed_insert_threads				Yes	Global	No
delayed_insert_timeout	Yes	Yes	Yes		Global	Yes
delayed_queue_size	Yes	Yes	Yes		Global	Yes
Delayed_writes				Yes	Global	No
des-key-file	Yes	Yes				
disconnect-slave-event-count	Yes	Yes				
div_precision_increment	Yes	Yes	Yes		Both	Yes
enable-locking	Yes	Yes				
enable-named-pipe	Yes	Yes				
- *Variable*: named_pipe						
enable-pstack	Yes	Yes				
engine-condition-pushdown	Yes	Yes			Both	Yes
- *Variable*: engine_condition_pushdown			Yes		Both	Yes
error_count			Yes		Session	No
event-scheduler	Yes	Yes			Global	Yes
- *Variable*: event_scheduler			Yes		Global	Yes
exit-info	Yes	Yes				
expire_logs_days	Yes	Yes	Yes		Global	Yes
external-locking	Yes	Yes				
- *Variable*: skip_external_locking						
external_user			Yes		Session	No
federated	Yes	Yes				
flush	Yes	Yes	Yes		Global	Yes
Flush_commands				Yes	Global	No
flush_time	Yes	Yes	Yes		Global	Yes
foreign_key_checks			Yes		Both	Yes
ft_boolean_syntax	Yes	Yes	Yes		Global	Yes
ft_max_word_len	Yes	Yes	Yes		Global	No
ft_min_word_len	Yes	Yes	Yes		Global	No
ft_query_expansion_limit	Yes	Yes	Yes		Global	No
ft_stopword_file	Yes	Yes	Yes		Global	No
gdb	Yes	Yes				
general-log	Yes	Yes			Global	Yes
- *Variable*: general_log			Yes		Global	Yes
general_log_file	Yes	Yes	Yes		Global	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
group_concat_max_len	Yes	Yes	Yes		Both	Yes
Handler_commit				Yes	Both	No
Handler_delete				Yes	Both	No
Handler_discover				Yes	Both	No
Handler_prepare				Yes	Both	No
Handler_read_first				Yes	Both	No
Handler_read_key				Yes	Both	No
Handler_read_last				Yes	Both	No
Handler_read_next				Yes	Both	No
Handler_read_prev				Yes	Both	No
Handler_read_rnd				Yes	Both	No
Handler_read_rnd_next				Yes	Both	No
Handler_rollback				Yes	Both	No
Handler_savepoint				Yes	Both	No
Handler_savepoint_rollback				Yes	Both	No
Handler_update				Yes	Both	No
Handler_write				Yes	Both	No
have_compress			Yes		Global	No
have_crypt			Yes		Global	No
have_csv			Yes		Global	No
have_dynamic_loading			Yes		Global	No
have_geometry			Yes		Global	No
have_innodb			Yes		Global	No
have_ndbcluster			Yes		Global	No
have_openssl			Yes		Global	No
have_partitioning			Yes		Global	No
have_profiling			Yes		Global	No
have_query_cache			Yes		Global	No
have_rtree_keys			Yes		Global	No
have_ssl			Yes		Global	No
have_symlink			Yes		Global	No
help	Yes	Yes				
hostname			Yes		Global	No
identity			Yes		Session	Yes
ignore-builtin-innodb	Yes	Yes			Global	No
- *Variable*: ignore_builtin_innodb			Yes		Global	No
init_connect	Yes	Yes	Yes		Global	Yes
init-file	Yes	Yes			Global	No
- *Variable*: init_file			Yes		Global	No
init-rpl-role	Yes	Yes				
init_slave	Yes	Yes	Yes		Global	Yes
innodb	Yes	Yes				
innodb_adaptive_flushi	Yes	Yes	Yes		Global	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
ng						
innodb_adaptive_hash_index	Yes	Yes	Yes		Global	Yes
innodb_additional_mem_pool_size	Yes	Yes	Yes		Global	No
innodb_autoextend_increment	Yes	Yes	Yes		Global	Yes
innodb_autoinc_lock_mode	Yes	Yes	Yes		Global	No
innodb_buffer_pool_instances	Yes	Yes	Yes		Global	No
Innodb_buffer_pool_pages_data				Yes	Global	No
Innodb_buffer_pool_pages_dirty				Yes	Global	No
Innodb_buffer_pool_pages_flushed				Yes	Global	No
Innodb_buffer_pool_pages_free				Yes	Global	No
Innodb_buffer_pool_pages_latched				Yes	Global	No
Innodb_buffer_pool_pages_misc				Yes	Global	No
Innodb_buffer_pool_pages_total				Yes	Global	No
Innodb_buffer_pool_read_ahead				Yes	Global	No
Innodb_buffer_pool_read_ahead_evicted				Yes	Global	No
Innodb_buffer_pool_read_requests				Yes	Global	No
Innodb_buffer_pool_reads				Yes	Global	No
innodb_buffer_pool_size	Yes	Yes	Yes		Global	No
Innodb_buffer_pool_wait_free				Yes	Global	No
Innodb_buffer_pool_write_requests				Yes	Global	No
innodb_change_bufferin	Yes	Yes	Yes		Global	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
g						
innodb_checksums	Yes	Yes	Yes		Global	No
innodb_commit_concurrency	Yes	Yes	Yes		Global	Yes
innodb_concurrency_tickets	Yes	Yes	Yes		Global	Yes
innodb_data_file_path	Yes	Yes	Yes		Global	No
Innodb_data_fsyncs				Yes	Global	No
innodb_data_home_dir	Yes	Yes	Yes		Global	No
Innodb_data_pending_fsyncs				Yes	Global	No
Innodb_data_pending_reads				Yes	Global	No
Innodb_data_pending_writes				Yes	Global	No
Innodb_data_read				Yes	Global	No
Innodb_data_reads				Yes	Global	No
Innodb_data_writes				Yes	Global	No
Innodb_data_written				Yes	Global	No
Innodb_dblwr_pages_written				Yes	Global	No
Innodb_dblwr_writes				Yes	Global	No
innodb_doublewrite	Yes	Yes	Yes		Global	No
innodb_fast_shutdown	Yes	Yes	Yes		Global	Yes
innodb_file_format	Yes	Yes	Yes		Global	Yes
innodb_file_format_check	Yes	Yes	Yes		Global	No
innodb_file_format_max	Yes	Yes	Yes		Global	Yes
innodb_file_per_table	Yes	Yes	Yes		Global	Yes
innodb_flush_log_at_trx_commit	Yes	Yes	Yes		Global	Yes
innodb_flush_method	Yes	Yes	Yes		Global	No
innodb_force_recovery	Yes	Yes	Yes		Global	No
Innodb_have_atomic_builtins				Yes	Global	No
innodb_io_capacity	Yes	Yes	Yes		Global	Yes
innodb_large_prefix	Yes	Yes	Yes		Global	Yes
innodb_lock_wait_timeout	Yes	Yes	Yes		Both	Yes
innodb_locks_unsafe_for_binlog	Yes	Yes	Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
innodb_log_buffer_size	Yes	Yes	Yes		Global	No
innodb_log_file_size	Yes	Yes	Yes		Global	No
innodb_log_files_in_group	Yes	Yes	Yes		Global	No
innodb_log_group_home_dir	Yes	Yes	Yes		Global	No
Innodb_log_waits				Yes	Global	No
Innodb_log_write_requests				Yes	Global	No
Innodb_log_writes				Yes	Global	No
innodb_max_dirty_pages_pct	Yes	Yes	Yes		Global	Yes
innodb_max_purge_lag	Yes	Yes	Yes		Global	Yes
innodb_mirrored_log_groups	Yes	Yes	Yes		Global	No
innodb_old_blocks_pct	Yes	Yes	Yes		Global	Yes
innodb_old_blocks_time	Yes	Yes	Yes		Global	Yes
innodb_open_files	Yes	Yes	Yes		Global	No
Innodb_os_log_fsyncs				Yes	Global	No
Innodb_os_log_pending_fsyncs				Yes	Global	No
Innodb_os_log_pending_writes				Yes	Global	No
Innodb_os_log_written				Yes	Global	No
Innodb_page_size				Yes	Global	No
Innodb_pages_created				Yes	Global	No
Innodb_pages_read				Yes	Global	No
Innodb_pages_written				Yes	Global	No
innodb_purge_batch_size	Yes	Yes	Yes		Global	No
innodb_purge_threads	Yes	Yes	Yes		Global	No
innodb_read_ahead_threshold	Yes	Yes	Yes		Global	Yes
innodb_read_io_threads	Yes	Yes	Yes		Global	No
innodb_replication_delay	Yes	Yes	Yes		Global	Yes
innodb_rollback_on_timeout	Yes	Yes	Yes		Global	No
in-	Yes	Yes	Yes		Global	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
nodb_rollback_segments						
Innodb_row_lock_current_waits				Yes	Global	No
Innodb_row_lock_time				Yes	Global	No
Innodb_row_lock_time_avg				Yes	Global	No
Innodb_row_lock_time_max				Yes	Global	No
Innodb_row_lock_waits				Yes	Global	No
Innodb_rows_deleted				Yes	Global	No
Innodb_rows_inserted				Yes	Global	No
Innodb_rows_read				Yes	Global	No
Innodb_rows_updated				Yes	Global	No
innodb_spin_wait_delay	Yes	Yes	Yes		Global	Yes
innodb_stats_method	Yes	Yes	Yes		Both	Yes
innodb_stats_on_metadata	Yes	Yes	Yes		Global	Yes
innodb_stats_sample_pages	Yes	Yes	Yes		Global	Yes
innodb-status-file	Yes	Yes				
innodb_strict_mode	Yes	Yes	Yes		Both	Yes
innodb_support_xa	Yes	Yes	Yes		Both	Yes
innodb_sync_spin_loops	Yes	Yes	Yes		Global	Yes
innodb_table_locks	Yes	Yes	Yes		Both	Yes
innodb_thread_concurrency	Yes	Yes	Yes		Global	Yes
innodb_thread_sleep_delay	Yes	Yes	Yes		Global	Yes
Innodb_truncated_status_writes				Yes	Global	No
innodb_use_native_aio	Yes	Yes	Yes		Global	No
innodb_use_sys_malloc	Yes	Yes	Yes		Global	No
innodb_version			Yes		Global	No
innodb_write_io_threads	Yes	Yes	Yes		Global	No
insert_id			Yes		Session	Yes
install	Yes					
install-manual	Yes					
interactive_timeout	Yes	Yes	Yes		Both	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
join_buffer_size	Yes	Yes	Yes		Both	Yes
keep_files_on_create	Yes	Yes	Yes		Both	Yes
Key_blocks_not_flushed				Yes	Global	No
Key_blocks_unused				Yes	Global	No
Key_blocks_used				Yes	Global	No
key_buffer_size	Yes	Yes	Yes		Global	Yes
key_cache_age_threshold	Yes	Yes	Yes		Global	Yes
key_cache_block_size	Yes	Yes	Yes		Global	Yes
key_cache_division_limit	Yes	Yes	Yes		Global	Yes
Key_read_requests				Yes	Global	No
Key_reads				Yes	Global	No
Key_write_requests				Yes	Global	No
Key_writes				Yes	Global	No
language	Yes	Yes	Yes		Global	No
large_files_support			Yes		Global	No
large_page_size			Yes		Global	No
large-pages	Yes	Yes			Global	No
- *Variable*: large_pages			Yes		Global	No
last_insert_id			Yes		Session	Yes
Last_query_cost				Yes	Session	No
lc-messages	Yes	Yes			Both	Yes
- *Variable*: lc_messages			Yes		Both	Yes
lc-messages-dir	Yes	Yes			Global	No
- *Variable*: lc_messages_dir			Yes		Global	No
lc_time_names			Yes		Both	Yes
license			Yes		Global	No
local_infile			Yes		Global	Yes
local-infile	Yes	Yes				
- *Variable*: local_infile						
lock_wait_timeout	Yes	Yes	Yes		Both	Yes
locked_in_memory			Yes		Global	No
log	Yes	Yes	Yes		Global	Yes
log_bin			Yes		Global	No
log-bin	Yes	Yes	Yes		Global	No
log-bin-index	Yes	Yes				
log-bin-trust-function-creators	Yes	Yes			Global	Yes
- *Variable*: log_bin_trust_function_creators			Yes		Global	Yes
log-bin-trust-routine-creators	Yes	Yes			Global	Yes
- *Variable*:			Yes		Global	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
log_bin_trust_routine_creators						
log-error	Yes	Yes			Global	No
- *Variable*: log_error			Yes		Global	No
log-isam	Yes	Yes				
log-output	Yes	Yes			Global	Yes
- *Variable*: log_output			Yes		Global	Yes
log-queries-not-using-indexes	Yes	Yes			Global	Yes
- *Variable*: log_queries_not_using_indexes			Yes		Global	Yes
log-short-format	Yes	Yes				
log-slave-updates	Yes	Yes			Global	No
- *Variable*: log_slave_updates			Yes		Global	No
log-slow-admin-statements	Yes	Yes				
log-slow-queries	Yes	Yes			Global	Yes
- *Variable*: log_slow_queries			Yes		Global	Yes
log-slow-slave-statements	Yes	Yes				
log-tc	Yes	Yes				
log-tc-size	Yes	Yes				
log-warnings	Yes	Yes			Both	Yes
- *Variable*: log_warnings			Yes		Both	Yes
long_query_time	Yes	Yes	Yes		Both	Yes
low-priority-updates	Yes	Yes			Both	Yes
- *Variable*: low_priority_updates			Yes		Both	Yes
lower_case_file_system	Yes	Yes	Yes		Global	No
lower_case_table_names	Yes	Yes	Yes		Global	No
master-connect-retry	Yes	Yes				
master-host	Yes	Yes				
master-info-file	Yes	Yes				
master-password	Yes	Yes				
master-port	Yes	Yes				
master-retry-count	Yes	Yes				
master-ssl	Yes	Yes				
master-ssl-ca	Yes	Yes				
master-ssl-capath	Yes	Yes				
master-ssl-cert	Yes	Yes				
master-ssl-cipher	Yes	Yes				
master-ssl-key	Yes	Yes				
master-user	Yes	Yes				
max_allowed_packet	Yes	Yes	Yes		Global	Yes
max_binlog_cache_si	Yes	Yes	Yes		Global	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
ze						
max-bin-log-dump-events	Yes	Yes				
max_binlog_size	Yes	Yes	Yes		Global	Yes
max_binlog_stmt_cache_size	Yes	Yes	Yes		Global	Yes
max_connect_errors	Yes	Yes	Yes		Global	Yes
max_connections	Yes	Yes	Yes		Global	Yes
max_delayed_threads	Yes	Yes	Yes		Both	Yes
max_error_count	Yes	Yes	Yes		Both	Yes
max_heap_table_size	Yes	Yes	Yes		Both	Yes
max_insert_delayed_threads			Yes		Both	Yes
max_join_size	Yes	Yes	Yes		Both	Yes
max_length_for_sort_data	Yes	Yes	Yes		Both	Yes
max_long_data_size	Yes	Yes	Yes		Global	No
max_prepared_stmt_count	Yes	Yes	Yes		Global	Yes
max_relay_log_size	Yes	Yes	Yes		Global	Yes
max_seeks_for_key	Yes	Yes	Yes		Both	Yes
max_sort_length	Yes	Yes	Yes		Both	Yes
max_sp_recursion_depth	Yes	Yes	Yes		Both	Yes
max_tmp_tables	Yes	Yes	Yes		Both	Yes
Max_used_connections				Yes	Global	No
max_user_connections	Yes	Yes	Yes		Both	Yes
max_write_lock_count	Yes	Yes	Yes		Global	Yes
memlock	Yes	Yes	Yes		Global	No
min-examined-row-limit	Yes	Yes	Yes		Both	Yes
myisam-block-size	Yes	Yes				
myisam_data_pointer_size	Yes	Yes	Yes		Global	Yes
myisam_max_sort_file_size	Yes	Yes	Yes		Global	Yes
myisam_mmap_size	Yes	Yes	Yes		Global	No
myisam-recover	Yes	Yes				
- *Variable*: myisam_recover_options						
myisam-recover-options	Yes	Yes				
- *Variable*: myisam_recover_options						
myisam_recover_options			Yes		Global	No
myisam_repair_threads	Yes	Yes	Yes		Both	Yes
myisam_sort_buffer_size	Yes	Yes	Yes		Both	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
myisam_stats_method	Yes	Yes	Yes		Both	Yes
myisam_use_mmap	Yes	Yes	Yes		Global	Yes
named_pipe			Yes		Global	No
ndb_autoincrement_prefetch_sz	Yes	Yes	Yes		Both	Yes
Ndb_conflict_fn_max				Yes	Global	No
Ndb_conflict_fn_old				Yes	Global	No
Ndb_number_of_data_nodes				Yes	Global	No
net_buffer_length	Yes	Yes	Yes		Both	Yes
net_read_timeout	Yes	Yes	Yes		Both	Yes
net_retry_count	Yes	Yes	Yes		Both	Yes
net_write_timeout	Yes	Yes	Yes		Both	Yes
new	Yes	Yes	Yes		Both	Yes
no-defaults	Yes					
Not_flushed_delayed_rows				Yes	Global	No
old	Yes	Yes	Yes		Global	No
old-alter-table	Yes	Yes			Both	Yes
- *Variable*: old_alter_table			Yes		Both	Yes
old-passwords	Yes	Yes			Both	Yes
- *Variable*: old_passwords			Yes		Both	Yes
old-style-user-limits	Yes	Yes				
one-thread	Yes	Yes				
Open_files				Yes	Global	No
open-files-limit	Yes	Yes			Global	No
- *Variable*: open_files_limit			Yes		Global	No
Open_streams				Yes	Global	No
Open_table_definitions				Yes	Global	No
Open_tables				Yes	Both	No
Opened_files				Yes	Global	No
Opened_table_definitions				Yes	Both	No
Opened_tables				Yes	Both	No
optimizer_prune_level	Yes	Yes	Yes		Both	Yes
optimizer_search_depth	Yes	Yes	Yes		Both	Yes
optimizer_switch	Yes	Yes	Yes		Both	Yes
partition	Yes	Yes			Global	No
- *Variable*: have_partitioning			Yes		Global	No
performance_schema	Yes	Yes	Yes		Global	No
Performance_schema_cond_classes_lost				Yes	Global	No
Performance_schema_cond_instances_lost				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
performance_schema_events_waits_history_long_size	Yes	Yes	Yes		Global	No
performance_schema_events_waits_history_size	Yes	Yes	Yes		Global	No
Performance_schema_file_classes_lost				Yes	Global	No
Performance_schema_file_handles_lost				Yes	Global	No
Performance_schema_file_instances_lost				Yes	Global	No
Performance_schema_locker_lost				Yes	Global	No
performance_schema_max_cond_classes	Yes	Yes	Yes		Global	No
performance_schema_max_cond_instances	Yes	Yes	Yes		Global	No
performance_schema_max_file_classes	Yes	Yes	Yes		Global	No
performance_schema_max_file_handles	Yes	Yes	Yes		Global	No
performance_schema_max_file_instances	Yes	Yes	Yes		Global	No
performance_schema_max_mutex_classes	Yes	Yes	Yes		Global	No
performance_schema_max_mutex_instances	Yes	Yes	Yes		Global	No
performance_schema_max_rwlock_classes	Yes	Yes	Yes		Global	No
performance_schema_max_rwlock_instances	Yes	Yes	Yes		Global	No
performance_schema_max_table_handles	Yes	Yes	Yes		Global	No
performance_schema_max_table_instances	Yes	Yes	Yes		Global	No
performance_schema_max_thread_classes	Yes	Yes	Yes		Global	No
performance_schema_max_thread_instances	Yes	Yes	Yes		Global	No
Performance_schema_mutex_				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
classes_lost						
Performance_schema_mutex_instances_lost				Yes	Global	No
Performance_schema_rwlock_classes_lost				Yes	Global	No
Performance_schema_rwlock_instances_lost				Yes	Global	No
Performance_schema_table_handles_lost				Yes	Global	No
Performance_schema_table_instances_lost				Yes	Global	No
Performance_schema_thread_classes_lost				Yes	Global	No
Performance_schema_thread_instances_lost				Yes	Global	No
pid-file	Yes	Yes			Global	No
- *Variable*: pid_file			Yes		Global	No
plugin	Yes	Yes				
plugin_dir	Yes	Yes	Yes		Global	No
plugin-load	Yes	Yes				
port	Yes	Yes	Yes		Global	No
port-open-timeout	Yes	Yes				
preload_buffer_size	Yes	Yes	Yes		Both	Yes
Prepared_stmt_count				Yes	Global	No
print-defaults	Yes					
profiling			Yes		Both	Yes
profiling_history_size			Yes		Both	Yes
protocol_version			Yes		Global	No
proxy_user			Yes		Session	No
pseudo_thread_id			Yes		Session	Yes
Qcache_free_blocks				Yes	Global	No
Qcache_free_memory				Yes	Global	No
Qcache_hits				Yes	Global	No
Qcache_inserts				Yes	Global	No
Qcache_lowmem_prunes				Yes	Global	No
Qcache_not_cached				Yes	Global	No
Qcache_queries_in_cache				Yes	Global	No
Qcache_total_blocks				Yes	Global	No
Queries				Yes	Both	No
query_alloc_block_size	Yes	Yes	Yes		Both	Yes
query_cache_limit	Yes	Yes	Yes		Global	Yes
query_cache_min_res_unit	Yes	Yes	Yes		Global	Yes

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
query_cache_size	Yes	Yes	Yes		Global	Yes
query_cache_type	Yes	Yes	Yes		Both	Yes
query_cache_wlock_invalidate	Yes	Yes	Yes		Both	Yes
query_prealloc_size	Yes	Yes	Yes		Both	Yes
Questions				Yes	Both	No
rand_seed1			Yes		Session	Yes
rand_seed2			Yes		Session	Yes
range_alloc_block_size	Yes	Yes	Yes		Both	Yes
read_buffer_size	Yes	Yes	Yes		Both	Yes
read_only	Yes	Yes	Yes		Global	Yes
read_rnd_buffer_size	Yes	Yes	Yes		Both	Yes
relay-log	Yes	Yes				
relay-log-index	Yes	Yes			Both	No
- *Variable*: relay_log_index			Yes		Both	No
relay_log_index	Yes	Yes	Yes		Global	No
relay-log-info-file	Yes	Yes				
- *Variable*: relay_log_info_file						
relay_log_info_file	Yes	Yes	Yes		Global	No
relay_log_purge	Yes	Yes	Yes		Global	Yes
relay_log_recovery	Yes	Yes	Yes		Global	Yes
relay_log_space_limit	Yes	Yes	Yes		Global	No
remove	Yes					
replicate-do-db	Yes	Yes				
replicate-do-table	Yes	Yes				
replicate-ignore-db	Yes	Yes				
replicate-ignore-table	Yes	Yes				
replicate-rewrite-db	Yes	Yes				
replicate-same-server-id	Yes	Yes				
replicate-wild-do-table	Yes	Yes				
replicate-wild-ignore-table	Yes	Yes				
report-host	Yes	Yes			Global	No
- *Variable*: report_host			Yes		Global	No
report-password	Yes	Yes			Global	No
- *Variable*: report_password			Yes		Global	No
report-port	Yes	Yes			Global	No
- *Variable*: report_port			Yes		Global	No
report-user	Yes	Yes			Global	No
- *Variable*: report_user			Yes		Global	No
rpl_recovery_rank			Yes		Global	Yes
Rpl_semi_sync_master_clients				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
rpl_semi_sync_master_enabled			Yes		Global	Yes
Rpl_semi_sync_master_net_avg_wait_time				Yes	Global	No
Rpl_semi_sync_master_net_wait_time				Yes	Global	No
Rpl_semi_sync_master_net_waits				Yes	Global	No
Rpl_semi_sync_master_no_times				Yes	Global	No
Rpl_semi_sync_master_no_tx				Yes	Global	No
Rpl_semi_sync_master_status				Yes	Global	No
Rpl_semi_sync_master_timefunc_failures				Yes	Global	No
rpl_semi_sync_master_timeout			Yes		Global	Yes
rpl_semi_sync_master_trace_level			Yes		Global	Yes
Rpl_semi_sync_master_tx_avg_wait_time				Yes	Global	No
Rpl_semi_sync_master_tx_wait_time				Yes	Global	No
Rpl_semi_sync_master_tx_waits				Yes	Global	No
rpl_semi_sync_master_wait_no_slave			Yes		Global	Yes
Rpl_semi_sync_master_wait_pos_backtraverse				Yes	Global	No
Rpl_semi_sync_master_wait_sessions				Yes	Global	No
Rpl_semi_sync_master_yes_tx				Yes	Global	No
rpl_semi_sync_slave_enabled			Yes		Global	Yes
Rpl_semi_sync_slave_status				Yes	Global	No
rpl_semi_sync_slave_trace_level			Yes		Global	Yes
Rpl_status				Yes	Global	No
safe-mode	Yes	Yes				
safe-show-database	Yes	Yes	Yes		Global	Yes
safe-user-create	Yes	Yes				
safemalloc-mem-limit	Yes	Yes				
secure-auth	Yes	Yes			Global	Yes
- *Variable*: secure_auth			Yes		Global	Yes
secure-file-priv	Yes	Yes			Global	No
- *Variable*: secure_file_priv			Yes		Global	No
Select_full_join				Yes	Both	No
Select_full_range_join				Yes	Both	No
Select_range				Yes	Both	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
Select_range_check				Yes	Both	No
Select_scan				Yes	Both	No
server-id	Yes	Yes			Global	Yes
- *Variable*: server_id			Yes		Global	Yes
shared_memory			Yes		Global	No
shared_memory_base_name			Yes		Global	No
show-slave-auth-info	Yes	Yes				
skip-character-set-client-handshake	Yes	Yes				
skip-concurrent-insert	Yes	Yes				
- *Variable*: concurrent_insert						
skip-event-scheduler	Yes	Yes				
skip-external-locking	Yes	Yes			Global	No
- *Variable*: skip_external_locking			Yes		Global	No
skip-grant-tables	Yes	Yes				
skip-host-cache	Yes	Yes				
skip-locking	Yes	Yes				
skip-log-warnings	Yes					
skip-name-resolve	Yes	Yes			Global	No
- *Variable*: skip_name_resolve			Yes		Global	No
skip-networking	Yes	Yes			Global	No
- *Variable*: skip_networking			Yes		Global	No
skip-new	Yes	Yes				
skip-partition	Yes	Yes				
skip-safemalloc	Yes	Yes				
skip-show-database	Yes	Yes			Global	No
- *Variable*: skip_show_database			Yes		Global	No
skip-slave-start	Yes	Yes				
skip-ssl	Yes	Yes				
skip-stack-trace	Yes	Yes				
skip-symbolic-links	Yes					
skip-symlink	Yes	Yes				
skip-thread-priority	Yes	Yes				
slave_compressed_protocol	Yes	Yes	Yes		Global	Yes
slave_exec_mode			Yes		Global	Yes
Slave_heartbeat_period				Yes	Global	No
slave-load-tmpdir	Yes	Yes			Global	No
- *Variable*: slave_load_tmpdir			Yes		Global	No
slave-net-timeout	Yes	Yes			Global	Yes
- *Variable*: slave_net_timeout			Yes		Global	Yes
Slave_open_temp_tab				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
les						
Slave_received_heartbeats				Yes	Global	No
Slave_retried_transactions				Yes	Global	No
Slave_running				Yes	Global	No
slave-skip-errors	Yes	Yes			Global	No
- *Variable*: slave_skip_errors			Yes		Global	No
slave_transaction_retries	Yes	Yes	Yes		Global	Yes
slave_type_conversions	Yes	Yes	Yes		Global	No
Slow_launch_threads				Yes	Both	No
slow_launch_time	Yes	Yes	Yes		Global	Yes
Slow_queries				Yes	Both	No
slow-query-log	Yes	Yes			Global	Yes
- *Variable*: slow_query_log			Yes		Global	Yes
slow_query_log_file	Yes	Yes	Yes		Global	Yes
socket	Yes	Yes	Yes		Global	No
sort_buffer_size	Yes	Yes	Yes		Both	Yes
Sort_merge_passes				Yes	Both	No
Sort_range				Yes	Both	No
Sort_rows				Yes	Both	No
Sort_scan				Yes	Both	No
sporadic-bin-log-dump-fail	Yes	Yes				
sql_auto_is_null			Yes		Both	Yes
sql_big_selects			Yes		Both	Yes
sql_big_tables			Yes		Session	Yes
sql_buffer_result			Yes		Session	Yes
sql_log_bin			Yes		Both	Yes
sql_log_off			Yes		Both	Yes
sql_log_update			Yes		Session	Yes
sql_low_priority_updates			Yes		Both	Yes
sql_max_join_size			Yes		Both	Yes
sql-mode	Yes	Yes			Both	Yes
- *Variable*: sql_mode			Yes		Both	Yes
sql_notes			Yes		Both	Yes
sql_quote_show_create			Yes		Both	Yes
sql_safe_updates			Yes		Both	Yes
sql_select_limit			Yes		Both	Yes
sql_slave_skip_counter			Yes		Global	Yes
sql_warnings			Yes		Both	Yes
ssl	Yes	Yes				
Ssl_accept_renegotiates				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
Ssl_accepts				Yes	Global	No
ssl-ca	Yes	Yes			Global	No
- *Variable*: ssl_ca			Yes		Global	No
Ssl_callback_cache_hits				Yes	Global	No
ssl-capath	Yes	Yes			Global	No
- *Variable*: ssl_capath			Yes		Global	No
ssl-cert	Yes	Yes			Global	No
- *Variable*: ssl_cert			Yes		Global	No
ssl-cipher	Yes	Yes			Global	No
- *Variable*: ssl_cipher			Yes		Global	No
Ssl_cipher				Yes	Both	No
Ssl_cipher_list				Yes	Both	No
Ssl_client_connects				Yes	Global	No
Ssl_connect_renegotiates				Yes	Global	No
Ssl_ctx_verify_depth				Yes	Global	No
Ssl_ctx_verify_mode				Yes	Global	No
Ssl_default_timeout				Yes	Both	No
Ssl_finished_accepts				Yes	Global	No
Ssl_finished_connects				Yes	Global	No
ssl-key	Yes	Yes			Global	No
- *Variable*: ssl_key			Yes		Global	No
Ssl_session_cache_hits				Yes	Global	No
Ssl_session_cache_misses				Yes	Global	No
Ssl_session_cache_mode				Yes	Global	No
Ssl_session_cache_overflows				Yes	Global	No
Ssl_session_cache_size				Yes	Global	No
Ssl_session_cache_timeouts				Yes	Global	No
Ssl_sessions_reused				Yes	Both	No
Ssl_used_session_cache_entries				Yes	Global	No
Ssl_verify_depth				Yes	Both	No
Ssl_verify_mode				Yes	Both	No
ssl-verify-server-cert	Yes	Yes				
Ssl_version				Yes	Both	No
standalone	Yes	Yes				
storage_engine			Yes		Both	Yes
symbolic-links	Yes	Yes				
sync_binlog	Yes	Yes	Yes		Global	Yes
sync_frm	Yes	Yes	Yes		Global	Yes
sync_master_info	Yes	Yes	Yes		Global	Yes
sync_relay_log	Yes	Yes	Yes		Global	Yes
sync_relay_log_info	Yes	Yes	Yes		Global	Yes
sysdate-is-now	Yes	Yes				

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
system_time_zone			Yes		Global	No
table_definition_cache	Yes	Yes	Yes		Global	Yes
table_lock_wait_timeout	Yes	Yes	Yes		Global	Yes
Table_locks_immediate				Yes	Global	No
Table_locks_waited				Yes	Global	No
table_open_cache	Yes	Yes	Yes		Global	Yes
table_type			Yes		Both	Yes
tc-heuristic-recover	Yes	Yes				
Tc_log_max_pages_used				Yes	Global	No
Tc_log_page_size				Yes	Global	No
Tc_log_page_waits				Yes	Global	No
temp-pool	Yes	Yes				
thread_cache_size	Yes	Yes	Yes		Global	Yes
thread_concurrency	Yes	Yes	Yes		Global	No
thread_handling	Yes	Yes	Yes		Global	No
thread_stack	Yes	Yes	Yes		Global	No
Threads_cached				Yes	Global	No
Threads_connected				Yes	Global	No
Threads_created				Yes	Global	No
Threads_running				Yes	Global	No
time_format			Yes		Global	No
time_zone	Yes	Yes	Yes		Both	Yes
timed_mutexes	Yes	Yes	Yes		Global	Yes
timestamp			Yes		Session	Yes
tmp_table_size	Yes	Yes	Yes		Both	Yes
tmpdir	Yes	Yes	Yes		Global	No
transaction_alloc_block_size	Yes	Yes	Yes		Both	Yes
transaction-isolation	Yes	Yes				
- *Variable*: tx_isolation						
transaction_prealloc_size	Yes	Yes	Yes		Both	Yes
tx_isolation			Yes		Both	Yes
unique_checks			Yes		Both	Yes
updatable_views_with_limit	Yes	Yes	Yes		Both	Yes
Uptime				Yes	Global	No
Uptime_since_flush_status				Yes	Global	No
user	Yes	Yes				
verbose	Yes	Yes				
version			Yes		Global	No
version_comment			Yes		Global	No
version_compile_machin			Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
e						
version_compile_os			Yes		Global	No
wait_timeout	Yes	Yes	Yes		Both	Yes
warning_count			Yes		Session	No

[a] This option is dynamic, but only the server should set this information. You should not set the value of this variable manually.
[b] This option is dynamic, but only the server should set this information. You should not set the value of this variable manually.

5.1.2. Server Command Options

When you start the `mysqld` server, you can specify program options using any of the methods described in Section 4.2.3, "Specifying Program Options". The most common methods are to provide options in an option file or on the command line. However, in most cases it is desirable to make sure that the server uses the same options each time it runs. The best way to ensure this is to list them in an option file. See Section 4.2.3.3, "Using Option Files".

`mysqld` reads options from the `[mysqld]` and `[server]` groups. `mysqld_safe` reads options from the `[mysqld]`, `[server]`, `[mysqld_safe]`, and `[safe_mysqld]` groups. `mysql.server` reads options from the `[mysqld]` and `[mysql.server]` groups.

An embedded MySQL server usually reads options from the `[server]`, `[embedded]`, and `[xxxxx_SERVER]` groups, where *`xxxxx`* is the name of the application into which the server is embedded.

`mysqld` accepts many command options. For a brief summary, execute `mysqld --help`. To see the full list, use `mysqld --verbose --help`.

The following list shows some of the most common server options. Additional options are described in other sections:

- Options that affect security: See Section 5.3.4, "Security-Related `mysqld` Options".
- SSL-related options: See Section 5.5.8.3, "SSL Command Options".
- Binary log control options: See Section 5.2.4, "The Binary Log".
- Replication-related options: See Section 15.1.3, "Replication and Binary Logging Options and Variables".
- Options for loading plugins such as pluggable storage engines: See Section 5.1.7.1, "Installing and Uninstalling Plugins".
- Options specific to particular storage engines: See Section 13.5.1, "`MyISAM` Startup Options", and Section 13.3.4, "`InnoDB` Startup Options and System Variables".

You can also set the values of server system variables by using variable names as options, as described at the end of this section.

Some options control the size of buffers or caches. For a given buffer, the server might need to allocate internal data structures. These structures typically are allocated from the total memory allocated to the buffer, and the amount of space required might be platform dependent. This means that when you assign a value to an option that controls a buffer size, the amount of space actually available might differ from the value assigned. In some cases, the amount might be less than the value assigned. It is also possible that the server will adjust a value upward. For example, if you assign a value of 0 to an option for which the minimal value is 1024, the server will set the value to 1024.

Values for buffer sizes, lengths, and stack sizes are given in bytes unless otherwise specified.

Some options take file name values. Unless otherwise specified, the default file location is the data directory if the value is a relative path name. To specify the location explicitly, use an absolute path name. Suppose that the data directory is `/var/mysql/data`. If a file-valued option is given as a relative path name, it will be located under `/var/mysql/data`. If the value is an absolute path name, its location is as given by the path name.

- `--help`, `-?`

Command-Line Format	`-?`
	`--help`
Option-File Format	`help`

Display a short help message and exit. Use both the `--verbose` and `--help` options to see the full message.

- `--allow-suspicious-udfs`

Command-Line Format	`--allow-suspicious-udfs`	
Option-File Format	`allow-suspicious-udfs`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

This option controls whether user-defined functions that have only an `xxx` symbol for the main function can be loaded. By default, the option is off and only UDFs that have at least one auxiliary symbol can be loaded; this prevents attempts at loading functions from shared object files other than those containing legitimate UDFs. See Section 21.3.2.6, “User-Defined Function Security Precautions”.

- `--ansi`

Command-Line Format	`--ansi`
	`-a`
Option-File Format	`ansi`

Use standard (ANSI) SQL syntax instead of MySQL syntax. For more precise control over the server SQL mode, use the `--sql-mode` option instead. See Section 1.8.3, “Running MySQL in ANSI Mode”, and Section 5.1.6, “Server SQL Modes”.

- `--basedir=`*`path`*, `-b` *`path`*

Command-Line Format	`--basedir=path`	
	`-b`	
Option-File Format	`basedir`	
Option Sets Variable	Yes, `basedir`	
Variable Name	`basedir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The path to the MySQL installation directory. All paths are usually resolved relative to this directory.

- `--big-tables`

Command-Line Format	`--big-tables`	
Option-File Format	`big-tables`	
Option Sets Variable	Yes, `big_tables`	
Variable Name	`big-tables`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`

Enable large result sets by saving all temporary sets in files. This option prevents most “table full” errors, but also slows down queries for which in-memory tables would suffice. Since MySQL 3.23.2, the server is able to handle large result sets automatically by using memory for small temporary tables and switching to disk tables where necessary.

- `--bind-address=`*`IP`*

Command-Line Format	`--bind-address=name`
Option-File Format	`bind-address=name`

Variable Name	`bind-address`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`
	Default	`0.0.0.0`
	Range	`0.0.0.0-255.255.255.255`

The IP address to bind to. Only one address can be selected. If this option is specified multiple times, the last address given is used.

If no address or `0.0.0.0` is specified, the server listens on all interfaces.

- `--binlog-format={ROW|STATEMENT|MIXED}`

Command-Line Format	`--binlog-format=format`	
Option-File Format	`binlog-format=format`	
Option Sets Variable	Yes, `binlog_format`	
Variable Name	`binlog_format`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`STATEMENT`

	Valid Values	`ROW`
		`STATEMENT`
		`MIXED`

Specify whether to use row-based, statement-based, or mixed replication. Statement-based is the default in MySQL 5.5. See Section 15.1.2, “Replication Formats”.

Previous to MySQL 5.5, setting the binary logging format without enabling binary logging prevented the MySQL server from starting. In MySQL 5.5, the server starts in such cases, the `binlog_format` global system variable is set, and a warning is logged instead of an error. (Bug #42928)

- `--bootstrap`

Command-Line Format	`--bootstrap`
Option-File Format	`bootstrap`

This option is used by the `mysql_install_db` script to create the MySQL privilege tables without having to start a full MySQL server.

This option is unavailable if MySQL was configured with the `DISABLE_GRANT_OPTIONS` compiler flag. See Section 2.9.4, “MySQL Source-Configuration Options”.

- `--character-sets-dir=`*`path`*

Command-Line Format	`--character-sets-dir=path`
Option-File Format	`character-sets-dir=path`
Option Sets Variable	Yes, `character_sets_dir`
Variable Name	`character-sets-dir`
Variable Scope	Global

Dynamic Variable	No	
	Permitted Values	
	Type	`directory name`

The directory where character sets are installed. See Section 9.5, “Character Set Configuration”.

- `--character-set-client-handshake`

Command-Line Format	`--character-set-client-handshake`	
Option-File Format	`character-set-client-handshake`	
	Permitted Values	
	Type	`boolean`
	Default	`TRUE`

Do not ignore character set information sent by the client. To ignore client information and use the default server character set, use `--skip-character-set-client-handshake`; this makes MySQL behave like MySQL 4.0.

- `--character-set-filesystem=charset_name`

Command-Line Format	`--character-set-filesystem=name`	
Option-File Format	`character-set-filesystem`	
Option Sets Variable	Yes, `character_set_filesystem`	
Variable Name	`character_set_filesystem`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The file system character set. This option sets the `character_set_filesystem` system variable.

- `--character-set-server=charset_name`, `-C charset_name`

Command-Line Format	`--character-set-server`	
Option-File Format	`character-set-server`	
Option Sets Variable	Yes, `character_set_server`	
Variable Name	`character_set_server`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

Use *`charset_name`* as the default server character set. See Section 9.5, “Character Set Configuration”. If you use this option to specify a nondefault character set, you should also use `--collation-server` to specify the collation.

- `--chroot=path`, `-r path`

Command-Line Format	`--chroot=name`	
	`-r name`	
Option-File Format	`chroot`	
	Permitted Values	
	Type	`file name`

Put the `mysqld` server in a closed environment during startup by using the `chroot()` system call. This is a recommended security measure. Note that use of this option somewhat limits `LOAD DATA INFILE` and `SELECT ... INTO OUTFILE`.

- `--collation-server=collation_name`

Command-Line Format	`--collation-server`	
Option-File Format	`collation-server`	
Option Sets Variable	Yes, `collation_server`	
Variable Name	`collation_server`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

Use *`collation_name`* as the default server collation. See Section 9.5, “Character Set Configuration”.

- `--console`

Command-Line Format	`--console`
Option-File Format	`console`
Platform Specific	windows

(Windows only.) Write error log messages to `stderr` and `stdout` even if `--log-error` is specified. `mysqld` does not close the console window if this option is used.

- `--core-file`

Command-Line Format	`--core-file`	
Option-File Format	`core-file`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Write a core file if `mysqld` dies. The name and location of the core file is system dependent. On Linux, a core file named `core.pid` is written to the current working directory of the process, which for `mysqld` is the data directory. *`pid`* represents the process ID of the server process. On Mac OS X, a core file named `core.pid` is written to the `/cores` directory. On Solaris, use the `coreadm` command to specify where to write the core file and how to name it.

For some systems, to get a core file you must also specify the `--core-file-size` option to `mysqld_safe`. See Section 4.3.2, “`mysqld_safe` — MySQL Server Startup Script”. On some systems, such as Solaris, you do not get a core file if you are also using the `--user` option. There might be additional restrictions or limitations. For example, it might be necessary to execute `ulimit -c unlimited` before starting the server. Consult your system documentation.

- `--datadir=path`, `-h path`

Command-Line Format	`--datadir=path`	
	`-h`	
Option-File Format	`datadir`	
Option Sets Variable	Yes, `datadir`	
Variable Name	`datadir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The path to the data directory.

- `--debug[=debug_options]`, `-# [debug_options]`

Command-Line Format	`--debug[=debug_options]`	
Option-File Format	`debug`	
Variable Name	`debug`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`
	Default	`'d:t:o,/tmp/mysqld.trace'`

If MySQL is configured with `-DWITH_DEBUG=1`, you can use this option to get a trace file of what `mysqld` is doing. A typical *`debug_options`* string is `'d:t:o,file_name'`. The default is `'d:t:i:o,mysqld.trace'`. See MySQL Internals: Porting.

Using `-DWITH_DEBUG=1` to configure MySQL with debugging support enables you to use the `--debug="d,parser_debug"` option when you start the server. This causes the Bison parser that is used to process SQL statements to dump a parser trace to the server's standard error output. Typically, this output is written to the error log.

This option may be given multiple times. Values that begin with `+` or `-` are added to or subtracted from the previous value. For example, `--debug=T --debug=+P` sets the value to `P:T`.

- `--debug-sync-timeout[=N]`

Command-Line Format	`--debug-sync-timeout[=#]`	
Option-File Format	`debug-sync-timeout`	
	Permitted Values	
	Type	`numeric`

Controls whether the Debug Sync facility for testing and debugging is enabled. Use of Debug Sync requires that MySQL be configured with the `-DENABLE_DEBUG_SYNC=1` option (see Section 2.9.4, “MySQL Source-Configuration Options”). If Debug Sync is not compiled in, this option is not available. The option value is a timeout in seconds. The default value is 0, which disables Debug Sync. To enable it, specify a value greater than 0; this value also becomes the default timeout for individual synchronization points. If the option is given without a value, the timeout is set to 300 seconds.

For a description of the Debug Sync facility and how to use synchronization points, see MySQL Internals: Test Synchronization.

- `--default-character-set=charset_name`

Command-Line Format	`--default-character-set=name`	
	`-C name`	
Option-File Format	`default-character-set=name`	
Deprecated	5.0	
	Permitted Values	
	Type	`string`

Use *`charset_name`* as the default character set. This option is deprecated in favor of `--character-set-server`. See Section 9.5, “Character Set Configuration”. `--default-character-set` was removed in MySQL 5.5.3.

- `--default-collation=collation_name`

Command-Line Format	`--default-collation=name`
Option-File Format	`default-collation=name`
Deprecated	4.1.3

	Permitted Values	
	Type	`string`

Use *`collation_name`* as the default collation. This option is deprecated in favor of `--collation-server`. See Section 9.5, "Character Set Configuration". `--default-collation` was removed in MySQL 5.5.3.

- `--default-storage-engine=`*`type`*

Command-Line Format	`--default-storage-engine=name`	
Option-File Format	`default-storage-engine`	
Option Sets Variable	Yes, `default_storage_engine`	
Variable Name	`default-storage-engine`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.4)	
	Type	`enumeration`
	Default	`MyISAM`
	Permitted Values (>= 5.5.5)	
	Type	`enumeration`
	Default	`InnoDB`

Set the default storage engine (table type) for tables. See Chapter 13, *Storage Engines*.

- `--default-time-zone=`*`timezone`*

Command-Line Format	`--default-time-zone=name`	
Option-File Format	`default-time-zone`	
	Permitted Values	
	Type	`string`

Set the default server time zone. This option sets the global `time_zone` system variable. If this option is not given, the default time zone is the same as the system time zone (given by the value of the `system_time_zone` system variable.

- `--delay-key-write[={OFF|ON|ALL}]`

Command-Line Format	`--delay-key-write[=name]`	
Option-File Format	`delay-key-write`	
Option Sets Variable	Yes, `delay_key_write`	
Variable Name	`delay-key-write`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`ON`

	Valid Values	`ON`
		`OFF`
		`ALL`

Specify how to use delayed key writes. Delayed key writing causes key buffers not to be flushed between writes for `MyISAM` tables. `OFF` disables delayed key writes. `ON` enables delayed key writes for those tables that were created with the

`DELAY_KEY_WRITE` option. `ALL` delays key writes for all `MyISAM` tables. See Section 7.11.2, “Tuning Server Parameters”, and Section 13.5.1, “`MyISAM` Startup Options”.

> **Note**
>
> If you set this variable to `ALL`, you should not use `MyISAM` tables from within another program (such as another MySQL server or `myisamchk`) when the tables are in use. Doing so leads to index corruption.

- `--des-key-file=`*`file_name`*

Command-Line Format	`--des-key-file=file_name`
Option-File Format	`des-key-file=file_name`

Read the default DES keys from this file. These keys are used by the `DES_ENCRYPT()` and `DES_DECRYPT()` functions.

- `--enable-named-pipe`

Command-Line Format	`--enable-named-pipe`
Option-File Format	`enable-named-pipe`
Option Sets Variable	Yes, `named_pipe`
Platform Specific	windows

Enable support for named pipes. This option applies only on Windows.

- `--enable-pstack`

Version Removed	5.5.7	
Command-Line Format	`--enable-pstack`	
Option-File Format	`enable-pstack`	
Deprecated	5.1.54	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

This option is nonfunctional before MySQL 5.5.7 and removed in 5.5.7.

- `--engine-condition-pushdown={ON|OFF}`

Version Deprecated	5.5.3	
Command-Line Format	`--engine-condition-pushdown`	
Option-File Format	`engine-condition-pushdown`	
Option Sets Variable	Yes, `engine_condition_pushdown`	
Variable Name	`engine_condition_pushdown`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
Deprecated	5.5.3, by `optimizer_switch`	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

Sets the `engine_condition_pushdown` system variable. For more information, see Section 7.13.3, “Engine Condition Pushdown Optimization”.

- `--event-scheduler[=`*`value`*`]`

Command-Line Format	`--event-scheduler[=value]`

Option-File Format	`event-scheduler`	
Option Sets Variable	Yes, `event_scheduler`	
Variable Name	`event_scheduler`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`OFF`

	Valid Values	`ON`
		`OFF`
		`DISABLED`

Enable or disable, and start or stop, the event scheduler.

For detailed information, see The `--event-scheduler` Option.

- `--exit-info[=flags]`, `-T [flags]`

Command-Line Format	`--exit-info[=flags]`	
	`-T [flags]`	
Option-File Format	`exit-info`	
	Permitted Values	
	Type	`numeric`

This is a bit mask of different flags that you can use for debugging the `mysqld` server. Do not use this option unless you know *exactly* what it does!

- `--external-locking`

Command-Line Format	`--external-locking`	
Option-File Format	`external-locking`	
Option Sets Variable	Yes, `skip_external_locking`	
Disabled by	`skip-external-locking`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Enable external locking (system locking), which is disabled by default as of MySQL 4.0. Note that if you use this option on a system on which `lockd` does not fully work (such as Linux), it is easy for `mysqld` to deadlock.

External locking affects only `MyISAM` table access. For more information, including conditions under which it can and cannot be used, see Section 7.10.5, “External Locking”.

- `--flush`

Command-Line Format	`--flush`
Option-File Format	`flush`
Variable Name	`flush`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Flush (synchronize) all changes to disk after each SQL statement. Normally, MySQL does a write of all changes to disk only after each SQL statement and lets the operating system handle the synchronizing to disk. See Section C.5.4.2, "What to Do If MySQL Keeps Crashing".

- `--gdb`

Command-Line Format	`--gdb`	
Option-File Format	`gdb`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Install an interrupt handler for `SIGINT` (needed to stop `mysqld` with `^C` to set breakpoints) and disable stack tracing and core file handling. See MySQL Internals: Porting.

- `--general-log[={0|1}]`

Command-Line Format	`--general-log`	
Option-File Format	`general-log`	
Option Sets Variable	Yes, `general_log`	
Variable Name	`general_log`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Specify the initial general query log state. With no argument or an argument of 1, the `--general-log` option enables the log. If omitted or given with an argument of 0, the option disables the log.

- `--init-file=`*`file_name`*

Command-Line Format	`--init-file=file_name`	
Option-File Format	`init-file=file_name`	
Option Sets Variable	Yes, `init_file`	
Variable Name	`init_file`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

Read SQL statements from this file at startup. Each statement must be on a single line and should not include comments.

This option is unavailable if MySQL was configured with the `DISABLE_GRANT_OPTIONS` compiler flag. See Section 2.9.4, "MySQL Source-Configuration Options".

- `--innodb-`*`xxx`*

  The `InnoDB` options are listed in Section 13.3.4, "`InnoDB` Startup Options and System Variables".

- `--install [`*`service_name`*`]`

Command-Line Format	`--install [service_name]`

(Windows only) Install the server as a Windows service that starts automatically during Windows startup. The default service name is `MySQL` if no *`service_name`* value is given. For more information, see Section 2.3.5.7, “Starting MySQL as a Windows Service”.

- `--install-manual [`*`service_name`*`]`

Command-Line Format	`--install-manual [service_name]`

(Windows only) Install the server as a Windows service that must be started manually. It does not start automatically during Windows startup. The default service name is `MySQL` if no *`service_name`* value is given. For more information, see Section 2.3.5.7, “Starting MySQL as a Windows Service”.

- `--language=`*`lang_name`*`, -L `*`lang_name`*

Command-Line Format	`--language=name`	
	`-L`	
Option-File Format	`language`	
Option Sets Variable	Yes, `language`	
Variable Name	`language`	
Variable Scope	Global	
Dynamic Variable	No	
Deprecated	5.6.1	
	Permitted Values	
	Type	`directory name`
	Default	`/usr/local/mysql/share/mysql/english/`

The language to use for error messages. *`lang_name`* can be given as the language name or as the full path name to the directory where the language files are installed. See Section 9.2, “Setting the Error Message Language”.

As of MySQL 5.5, `--lc-messages-dir` and `--lc-messages` should be used rather than `--language`, which is deprecated and handled as an alias for `--lc-messages-dir`.

- `--large-pages`

Command-Line Format	`--large-pages`	
Option-File Format	`large-pages`	
Option Sets Variable	Yes, `large_pages`	
Variable Name	`large_pages`	
Variable Scope	Global	
Dynamic Variable	No	
Platform Specific	linux	
	Permitted Values	
	Type (linux)	`boolean`
	Default	`FALSE`

Some hardware/operating system architectures support memory pages greater than the default (usually 4KB). The actual implementation of this support depends on the underlying hardware and operating system. Applications that perform a lot of memory accesses may obtain performance improvements by using large pages due to reduced Translation Lookaside Buffer (TLB) misses.

MySQL 5.5 supports the Linux implementation of large page support (which is called HugeTLB in Linux). See Section 7.11.4.2, “Enabling Large Page Support”. For Solaris support of large pages, see the description of the `-`

`-super-large-pages` option.

`--large-pages` is disabled by default.

- `--lc-messages=locale_name`

Command-Line Format	`--lc-messages=name`	
Option-File Format	`lc-messages`	
Option Sets Variable	Yes, `lc_messages`	
Variable Name	`lc-messages`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The locale to use for error messages. The server converts the argument to a language name and combines it with the value of the `--lc-messages-dir` to produce the location for the error message file. See Section 9.2, "Setting the Error Message Language".

- `--lc-messages-dir=path`

Command-Line Format	`--lc-messages-dir=path`	
Option-File Format	`lc-messages-dir`	
Option Sets Variable	Yes, `lc_messages_dir`	
Variable Name	`lc-messages-dir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`directory name`

The directory where error messages are located. The value is used together with the value of `--lc-messages` to produce the location for the error message file. See Section 9.2, "Setting the Error Message Language".

- `--log[=file_name]`, `-l [file_name]`

Command-Line Format	`--log[=name]`	
	`-l`	
Option-File Format	`log`	
Option Sets Variable	Yes, `log`	
Variable Name	`log`	
Variable Scope	Global	
Dynamic Variable	Yes	
Deprecated	5.1.29, by `general-log`	
	Permitted Values	
	Type	`string`
	Default	`OFF`

This option enables logging to the general query log, which contains entries that record client connections and SQL statements received from clients. The log output destination can be selected with the `--log-output` option. If you omit the file name, MySQL uses `host_name.log` as the file name. See Section 5.2.1, "Selecting General Query and Slow Query Log Output Destinations", and Section 5.2.3, "The General Query Log".

The `--log` option is deprecated and is removed (along with the `log` system variable) in MySQL 5.6. Instead, use the `--general_log` option to enable the general query log and the `--general_log_file=file_name` option to set the general query log file name.

- `--log-error[=file_name]`

Command-Line Format	`--log-error[=name]`	
Option-File Format	`log-error`	
Option Sets Variable	Yes, `log_error`	
Variable Name	`log_error`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

Log errors and startup messages to this file. See Section 5.2.2, “The Error Log”. If you omit the file name, MySQL uses *`host_name`*`.err`. If the file name has no extension, the server adds an extension of `.err`.

- `--log-isam[=file_name]`

Command-Line Format	`--log-isam[=name]`	
Option-File Format	`log-isam`	
	Permitted Values	
	Type	`file name`

Log all `MyISAM` changes to this file (used only when debugging `MyISAM`).

- `--log-long-format`

Command-Line Format	`--log-long-format`
	`-0`
Option-File Format	`log-long-format`
Deprecated	4.1

Log extra information to the binary log and slow query log, if they have been activated. For example, the user name and timestamp are logged for all queries. This option is deprecated, as it now represents the default logging behavior. (See the description for `--log-short-format`.) The `--log-queries-not-using-indexes` option is available for the purpose of logging queries that do not use indexes to the slow query log. `--log-long-format` was removed in MySQL 5.5.3.

- `--log-output[=value,...]`

Command-Line Format	`--log-output[=name]`	
Option-File Format	`log-output`	
Option Sets Variable	Yes, `log_output`	
Variable Name	`log_output`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`set`
	Default	`FILE`

	Valid Values	`TABLE`
		`FILE`
		`NONE`

This option determines the destination for general query log and slow query log output. The option value can be given as one or more of the words `TABLE`, `FILE`, or `NONE`. If the option is given without a value, the default is `FILE`. `TABLE` select logging to the `general_log` and `slow_log` tables in the `mysql` database as a destination. `FILE` selects logging to log files as a destination. `NONE` disables logging. If `NONE` is present in the option value, it takes precedence over any other words that are present. `TABLE` and `FILE` can both be given to select to both log output destinations.

This option selects log output destinations, but does not enable log output. To do that, use the `--general_log` and `--slow_query_log` options. For `FILE` logging, the `--general_log_file` and `-slow_query_log_file` options determine the log file location. For more information, see Section 5.2.1, "Selecting General Query and Slow Query Log Output Destinations".

- `--log-queries-not-using-indexes`

Command-Line Format	`--log-queries-not-using-indexes`	
Option-File Format	`log-queries-not-using-indexes`	
Option Sets Variable	Yes, `log_queries_not_using_indexes`	
Variable Name	`log_queries_not_using_indexes`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`

If you are using this option with the slow query log enabled, queries that are expected to retrieve all rows are logged. See Section 5.2.5, "The Slow Query Log". This option does not necessarily mean that no index is used. For example, a query that uses a full index scan uses an index but would be logged because the index would not limit the number of rows.

- `--log-short-format`

Command-Line Format	`--log-short-format`	
Option-File Format	`log-short-format`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Originally intended to log less information to the binary log and slow query log, if they have been activated. However, this option is not operational.

- `--log-slow-admin-statements`

Command-Line Format	`--log-slow-admin-statements`	
Option-File Format	`log-slow-admin-statements`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Log slow administrative statements such as `OPTIMIZE TABLE`, `ANALYZE TABLE`, and `ALTER TABLE` to the slow query log.

- `--log-slow-queries[=`*`file_name`*`]`

Command-Line Format	`--log-slow-queries[=name]`
Option-File Format	`log-slow-queries`
Option Sets Variable	Yes, `log_slow_queries`
Variable Name	`log_slow_queries`
Variable Scope	Global
Dynamic Variable	Yes
Deprecated	5.1.29, by `slow-query-log`

	Permitted Values	
	Type	`boolean`

This option enables logging to the slow query log, which contains entries for all queries that have taken more than `long_query_time` seconds to execute. See the descriptions of the `--log-long-format` and `--log-short-format` options for details. The log output destination can be selected with the `--log-output` option. If you omit the file name, MySQL uses `*host_name*-slow.log` as the file name. See Section 5.2.1, “Selecting General Query and Slow Query Log Output Destinations”, and Section 5.2.5, “The Slow Query Log”.

The `--log-slow-queries` option is deprecated and is removed (along with the `log_slow_queries` system variable) in MySQL 5.6. Instead, use the `--slow_query_log` option to enable the slow query log and the `--slow_query_log_file=*file_name*` option to set the slow query log file name.

- `--log-tc=*file_name*`

Command-Line Format	`--log-tc=name`	
Option-File Format	`log-tc`	
	Permitted Values	
	Type	`file name`
	Default	`tc.log`

The name of the memory-mapped transaction coordinator log file (for XA transactions that affect multiple storage engines when the binary log is disabled). The default name is `tc.log`. The file is created under the data directory if not given as a full path name. Currently, this option is unused.

- `--log-tc-size=*size*`

Command-Line Format	`--log-tc-size=#`	
Option-File Format	`log-tc-size`	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`24576`
	Max Value	`4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`24576`
	Max Value	`18446744073709547520`

The size in bytes of the memory-mapped transaction coordinator log. The default size is 24KB.

- `--log-warnings[=*level*]`, `-W [*level*]`

Command-Line Format	`--log-warnings[=#]`
	`-W [#]`
Option-File Format	`log-warnings`
Option Sets Variable	Yes, `log_warnings`
Variable Name	`log_warnings`
Variable Scope	Global, Session
Dynamic Variable	Yes

Disabled by	`skip-log-warnings`	
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1`
	Range	`0-18446744073709547520`

Print out warnings such as `Aborted connection...` to the error log. Enabling this option is recommended, for example, if you use replication (you get more information about what is happening, such as messages about network failures and reconnections). This option is enabled (1) by default, and the default *`level`* value if omitted is 1. To disable this option, use `--log-warnings=0`. If the value is greater than 1, aborted connections are written to the error log, and access-denied errors for new connection attempts are written. See Section C.5.2.11, "Communication Errors and Aborted Connections".

If a slave server was started with `--log-warnings` enabled, the slave prints messages to the error log to provide information about its status, such as the binary log and relay log coordinates where it starts its job, when it is switching to another relay log, when it reconnects after a disconnect, and so forth. The server logs messages about statements that are unsafe for statement-based logging only if `--log-warnings` is enabled.

- `--low-priority-updates`

Command-Line Format	`--low-priority-updates`	
Option-File Format	`low-priority-updates`	
Option Sets Variable	Yes, `low_priority_updates`	
Variable Name	`low_priority_updates`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Give table-modifying operations (`INSERT`, `REPLACE`, `DELETE`, `UPDATE`) lower priority than selects. This can also be done using `{INSERT | REPLACE | DELETE | UPDATE} LOW_PRIORITY ...` to lower the priority of only one query, or by `SET LOW_PRIORITY_UPDATES=1` to change the priority in one thread. This affects only storage engines that use only table-level locking (`MyISAM`, `MEMORY`, `MERGE`). See Section 7.10.2, "Table Locking Issues".

- `--min-examined-row-limit=`*`number`*

Command-Line Format	`--min-examined-row-limit=#`	
Option-File Format	`min-examined-row-limit`	
Variable Name	`min_examined_row_limit`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

When this option is set, queries which examine fewer than *`number`* rows are not written to the slow query log. The default is 0.

- `--memlock`

Command-Line Format	`--memlock`	
Option-File Format	`memlock`	
Variable Name	`locked_in_memory`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Lock the `mysqld` process in memory. This option might help if you have a problem where the operating system is causing `mysqld` to swap to disk.

`--memlock` works on systems that support the `mlockall()` system call; this includes Solaris as well as most Linux distributions that use a 2.4 or newer kernel. On Linux systems, you can tell whether or not `mlockall()` (and thus this option) is supported by checking to see whether or not it is defined in the system `mman.h` file, like this:

```
shell> grep mlockall /usr/include/sys/mman.h
```

If `mlockall()` is supported, you should see in the output of the previous command something like the following:

```
extern int mlockall (int __flags) __THROW;
```

Important

Using this option requires that you run the server as `root`, which, for reasons of security, is normally not a good idea. See Section 5.3.6, “How to Run MySQL as a Normal User”.

You must not try to use this option on a system that does not support the `mlockall()` system call; if you do so, `mysqld` will very likely crash as soon as you try to start it.

- `--myisam-block-size=N`

Command-Line Format	`--myisam-block-size=#`	
Option-File Format	`myisam-block-size`	
	Permitted Values	
	Type	`numeric`
	Default	`1024`
	Range	`1024-16384`

The block size to be used for `MyISAM` index pages.

- `--myisam-recover[=option[,option]...]]`

This option is renamed as of MySQL 5.5.3 to `--myisam-recover-options`. See the description of that option for more information.

- `--myisam-recover-options[=option[,option]...]]`

Version Introduced	5.5.3	
Command-Line Format	`--myisam-recover-options[=name]`	
Option-File Format	`myisam-recover-options`	
Option Sets Variable	Yes, `myisam_recover_options`	
	Permitted Values	
	Type	`enumeration`
	Default	`OFF`

	Valid Values	`OFF`
		`DEFAULT`
		`BACKUP`
		`FORCE`
		`QUICK`

Set the `MyISAM` storage engine recovery mode. The option value is any combination of the values of `DEFAULT`, `OFF`, `BACKUP`, `FORCE`, or `QUICK`. If you specify multiple values, separate them by commas. Specifying the option with no argument is the same as specifying `DEFAULT`, and specifying with an explicit value of `""` disables recovery (same as not giving the option). If recovery is enabled, each time `mysqld` opens a `MyISAM` table, it checks whether the table is marked as crashed or was not closed properly. (The last option works only if you are running with external locking disabled.) If this is the case, `mysqld` runs a check on the table. If the table was corrupted, `mysqld` attempts to repair it.

The following options affect how the repair works.

Option	Description
`DEFAULT`	Recovery without backup, forcing, or quick checking.
`OFF`	Recovery without backup, forcing, or quick checking.
`BACKUP`	If the data file was changed during recovery, save a backup of the `tbl_name.MYD` file as `tbl_name-datetime.BAK`.
`FORCE`	Run recovery even if we would lose more than one row from the `.MYD` file.
`QUICK`	Do not check the rows in the table if there are not any delete blocks.

Before the server automatically repairs a table, it writes a note about the repair to the error log. If you want to be able to recover from most problems without user intervention, you should use the options `BACKUP,FORCE`. This forces a repair of a table even if some rows would be deleted, but it keeps the old data file as a backup so that you can later examine what happened.

This option was named `--myisam-recover`, before MySQL 5.5.3. The old option name still works because it is recognized as an unambiguous prefix of the new name, `--myisam-recover-options`. (Option prefix recognition occurs as described in Section 4.2.3, “Specifying Program Options”.)

The option value `OFF` is available as of MySQL 5.5.3.

See Section 13.5.1, “`MyISAM` Startup Options”.

- `--old-alter-table`

Command-Line Format	`--old-alter-table`
Option-File Format	`old-alter-table`
Option Sets Variable	Yes, `old_alter_table`
Variable Name	`old_alter_table`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`boolean`
	Default	`OFF`

When this option is given, the server does not use the optimized method of processing an `ALTER TABLE` operation. It reverts to using a temporary table, copying over the data, and then renaming the temporary table to the original, as used by MySQL 5.0 and earlier. For more information on the operation of `ALTER TABLE`, see Section 12.1.6, "`ALTER TABLE` Syntax".

- `--old-passwords`

Command-Line Format	`--old_passwords`	
Option-File Format	`old-passwords`	
Option Sets Variable	Yes, `old_passwords`	
Variable Name	`old_passwords`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Force the server to generate short (pre-4.1) password hashes for new passwords. This is useful for compatibility when the server must support older client programs. See Section 5.3.2.3, "Password Hashing in MySQL".

- `--old-style-user-limits`

Command-Line Format	`--old-style-user-limits`	
Option-File Format	`old-style-user-limits`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Enable old-style user limits. (Before MySQL 5.0.3, account resource limits were counted separately for each host from which a user connected rather than per account row in the `user` table.) See Section 5.5.4, "Setting Account Resource Limits".

- `--one-thread`

Command-Line Format	`--one-thread`
Option-File Format	`one-thread`

Only use one thread (for debugging under Linux). This option is available only if the server is built with debugging enabled. See MySQL Internals: Porting.

This option is deprecated and is removed in MySQL 5.6. Use `--thread_handling=no-threads` instead.

- `--open-files-limit=`*`count`*

Command-Line Format	`--open-files-limit=#`
Option-File Format	`open-files-limit`
Option Sets Variable	Yes, `open_files_limit`
Variable Name	`open_files_limit`
Variable Scope	Global
Dynamic Variable	No

	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-65535`

Changes the number of file descriptors available to `mysqld`. You should try increasing the value of this option if `mysqld` gives you the error `Too many open files`. `mysqld` uses the option value to reserve descriptors with `setrlimit()`. If the requested number of file descriptors cannot be allocated, `mysqld` writes a warning to the error log.

`mysqld` may attempt to allocate more than the requested number of descriptors (if they are available), using the values of `max_connections` and `table_open_cache` to estimate whether more descriptors will be needed.

- `--partition[=value]`

Command-Line Format	`--partition`	
Option-File Format	`partition`	
Option Sets Variable	Yes, `have_partitioning`	
Variable Name	`partition`	
Variable Scope	Global	
Dynamic Variable	No	
Disabled by	`skip-partition`	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

Enables or disables user-defined partitioning support in the MySQL Server.

- `--pid-file=path`

Command-Line Format	`--pid-file=file_name`	
Option-File Format	`pid-file=file_name`	
Option Sets Variable	Yes, `pid_file`	
Variable Name	`pid_file`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The path name of the process ID file. The server creates the file in the data directory unless an absolute path name is given to specify a different directory. This file is used by other programs such as `mysqld_safe` to determine the server's process ID.

- `--plugin-xxx`

Specifies an option that pertains to a server plugin. For example, many storage engines can be built as plugins, and for such engines, options for them can be specified with a `--plugin` prefix. Thus, the `--innodb_file_per_table` option for `InnoDB` can be specified as `--plugin-innodb_file_per_table`.

For boolean options that can be enabled or disabled, the `--skip` prefix and other alternative formats are supported as well (see Section 4.2.3.2, “Program Option Modifiers”). For example, `--skip-plugin-innodb_file_per_table` disables `innodb_file_per_table`.

The rationale for the `--plugin` prefix is that it enables plugin options to be specified unambiguously if there is a name conflict with a built-in server option. For example, were a plugin writer to name a plugin “sql” and implement a “mode” option, the option name might be `--sql-mode`, which would conflict with the built-in option of the same name. In such cases, references to the conflicting name are resolved in favor of the built-in option. To avoid the ambiguity, users can specify the plugin option as `--plugin-sql-mode`. Use of the `--plugin` prefix for plugin options is recommended to avoid any question of ambiguity.

- `--plugin-load=plugin_list`

Command-Line Format	`--plugin-load=plugin_list`	
Option-File Format	`plugin-load`	
	Permitted Values	
	Type	`string`

This option tells the server to load the named plugins at startup. The option value is a semicolon-separated list of *`name=plugin_library`* pairs. Each *`name`* is the name of the plugin, and *`plugin_library`* is the name of the shared library that contains the plugin code. Each library file must be located in the directory named by the `plugin_dir` system variable. For example, if plugins named `myplug1` and `myplug2` have library files `myplug1.so` and `myplug2.so`, use this option to load them at startup:

```
shell> mysqld --plugin-load=myplug1=myplug1.so;myplug2=myplug2.so
```

All plugins to load must be named in the same `--plugin-load` option. If multiple `--plugin-load` options are given, only the last one is used.

If a plugin library is named without any preceding plugin name, the server loads all plugins in the library.

Each plugin is loaded for a single invocation of `mysqld` only. After a restart, the plugin is not loaded unless `--plugin-load` is used again. This is in contrast to `INSTALL PLUGIN`, which adds an entry to the `mysql.plugins` table to cause the plugin to be loaded for every normal server startup.

Under normal startup, the server determines which plugins to load by reading the `mysql.plugins` system table. If the server is started with the `--skip-grant-tables` option, it does not consult the `mysql.plugins` table and does not load plugins listed there. `--plugin-load` enables plugins to be loaded even when `--skip-grant-tables` is given. `--plugin-load` also enables plugins to be loaded at startup under configurations when plugins cannot be loaded at runtime.

For additional information about plugin loading, see Section 5.1.7.1, “Installing and Uninstalling Plugins”.

- `--port=port_num`, `-P port_num`

Command-Line Format	`--port=#`	
	`-P`	
Option-File Format	`port`	
Option Sets Variable	Yes, `port`	
Variable Name	`port`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`3306`

The port number to use when listening for TCP/IP connections. The port number must be 1024 or higher unless the server is started by the `root` system user.

- `--port-open-timeout=num`

Command-Line Format	`--port-open-timeout=#`	
Option-File Format	`port-open-timeout`	
	Permitted Values	
	Type	`numeric`
	Default	`0`

On some systems, when the server is stopped, the TCP/IP port might not become available immediately. If the server is restarted quickly afterward, its attempt to reopen the port can fail. This option indicates how many seconds the server should wait for the TCP/IP port to become free if it cannot be opened. The default is not to wait.

- `--remove [service_name]`

Command-Line Format	`--remove [service_name]`

(Windows only) Remove a MySQL Windows service. The default service name is `MySQL` if no *`service_name`* value is given. For more information, see Section 2.3.5.7, “Starting MySQL as a Windows Service”.

- `--safe-mode`

Command-Line Format	`--safe-mode`
Option-File Format	`safe-mode`
Deprecated	5.0

Skip some optimization stages.

- `--safe-show-database`

Command-Line Format	`--safe-show-database`	(until 4.1.1)
Option-File Format	`safe-show-database`	
Variable Name	`safe_show_database`	
Variable Scope	Global	
Dynamic Variable	Yes	
Deprecated	4.0.2	
	Permitted Values	
	Type	`boolean`

This option is deprecated and does not do anything because there is a `SHOW DATABASES` privilege that can be used to control access to database names on a per-account basis. See Section 5.4.1, “Privileges Provided by MySQL”. `--safe-show-database` was removed in MySQL 5.5.3.

- `--safe-user-create`

Command-Line Format	`--safe-user-create`	
Option-File Format	`safe-user-create`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

If this option is enabled, a user cannot create new MySQL users by using the `GRANT` statement unless the user has the `INSERT` privilege for the `mysql.user` table or any column in the table. If you want a user to have the ability to create new users that have those privileges that the user has the right to grant, you should grant the user the following privilege:

```
GRANT INSERT(user) ON mysql.user TO 'user_name'@'host_name';
```

This ensures that the user cannot change any privilege columns directly, but has to use the `GRANT` statement to give privileges to other users.

- `--secure-auth`

Command-Line Format	`--secure-auth`
Option-File Format	`secure-auth`
Option Sets Variable	Yes, `secure_auth`

Variable Name	`secure_auth`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Disallow authentication by clients that attempt to use accounts that have old (pre-4.1) passwords.

- `--secure-file-priv=path`

Command-Line Format	`--secure-file-priv=path`	
Option-File Format	`secure-file-priv=path`	
Option Sets Variable	Yes, `secure_file_priv`	
Variable Name	`secure-file-priv`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

This option limits the effect of the `LOAD_FILE()` function and the `LOAD DATA` and `SELECT ... INTO OUTFILE` statements to work only with files in the specified directory.

- `--shared-memory`

  Enable shared-memory connections by local clients. This option is available only on Windows.

- `--shared-memory-base-name=name`

  The name of shared memory to use for shared-memory connections. This option is available only on Windows. The default name is `MYSQL`. The name is case sensitive.

- `--skip-concurrent-insert`

  Turn off the ability to select and insert at the same time on `MyISAM` tables. (This is to be used only if you think you have found a bug in this feature.) See Section 7.10.3, “Concurrent Inserts”.

- `--skip-external-locking`

  Do not use external locking (system locking). This affects only `MyISAM` table access. For more information, including conditions under which it can and cannot be used, see Section 7.10.5, “External Locking”.

  External locking has been disabled by default since MySQL 4.0.

- `--skip-event-scheduler`

Command-Line Format	`--skip-event-scheduler`
	`--disable-event-scheduler`
Option-File Format	`skip-event-scheduler`

Turns the Event Scheduler `OFF`. This is not the same as disabling the Event Scheduler, which requires setting `--event-scheduler=DISABLED`; see The `--event-scheduler` Option, for more information.

- `--skip-grant-tables`

  This option causes the server to start without using the privilege system at all, which gives anyone with access to the server *unrestricted access to all databases*. You can cause a running server to start using the grant tables again by executing `mysqladmin flush-privileges` or `mysqladmin reload` command from a system shell, or by issuing a MySQL `FLUSH PRIVILEGES` statement after connecting to the server. This option also suppresses loading of plugins that were installed with the `INSTALL PLUGIN` statement, user-defined functions (UDFs), and scheduled events. To cause plugins to be loaded anyway, use the `--plugin-load` option.

`--skip-grant-tables` is unavailable if MySQL was configured with the `DISABLE_GRANT_OPTIONS` compiler flag. See Section 2.9.4, "MySQL Source-Configuration Options".

- `--skip-host-cache`

  Do not use the internal host name cache for faster name-to-IP resolution. Instead, query the DNS server every time a client connects. See Section 7.11.5.2, "How MySQL Uses DNS".

- `--skip-innodb`

  Disable the `InnoDB` storage engine. In this case, the server will not start if the default storage engine is set to `InnoDB`. Use `--default-storage-engine` to set the default to some other engine if necessary.

- `--skip-name-resolve`

  Do not resolve host names when checking client connections. Use only IP addresses. If you use this option, all `Host` column values in the grant tables must be IP addresses or `localhost`. See Section 7.11.5.2, "How MySQL Uses DNS".

- `--skip-networking`

  Do not listen for TCP/IP connections at all. All interaction with `mysqld` must be made using named pipes or shared memory (on Windows) or Unix socket files (on Unix). This option is highly recommended for systems where only local clients are permitted. See Section 7.11.5.2, "How MySQL Uses DNS".

- `--skip-partition`

Command-Line Format	`--skip-partition`
	`--disable-partition`
Option-File Format	`skip-partition`

Disables user-defined partitioning. Existing partitioned tables cannot be accessed when the server has been started with this option.

- `--ssl*`

  Options that begin with `--ssl` specify whether to permit clients to connect using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, "SSL Command Options".

- `--standalone`

Command-Line Format	`--standalone`
Option-File Format	`standalone`
Platform Specific	windows

Available on Windows only; instructs the MySQL server not to run as a service.

- `--super-large-pages`

  Standard use of large pages in MySQL attempts to use the largest size supported, up to 4MB. Under Solaris, a "super large pages" feature enables uses of pages up to 256MB. This feature is available for recent SPARC platforms. It can be enabled or disabled by using the `--super-large-pages` or `--skip-super-large-pages` option.

- `--symbolic-links`, `--skip-symbolic-links`

Command-Line Format	`--symbolic-links`
Option-File Format	`symbolic-links`

Enable or disable symbolic link support. This option has different effects on Windows and Unix:

  - On Windows, enabling symbolic links enables you to establish a symbolic link to a database directory by creating a *`db_name`*`.sym` file that contains the path to the real directory. See Section 7.11.3.1.3, "Using Symbolic Links for Databases on Windows".

  - On Unix, enabling symbolic links means that you can link a `MyISAM` index file or data file to another directory with the `INDEX DIRECTORY` or `DATA DIRECTORY` options of the `CREATE TABLE` statement. If you delete or rename the table, the files that its symbolic links point to also are deleted or renamed. See Section 7.11.3.1.2, "Using Symbolic Links for Tables on Unix".

- `--skip-safemalloc`

Version Removed	5.5.6
Command-Line Format	`--skip-safemalloc`
Option-File Format	`skip-safemalloc`

Previously, if MySQL was configured with full debugging support, all MySQL programs check for memory overruns during each memory allocation and memory freeing operation. This checking is very slow, so for the server you can avoid it when you do not need it by using the `--skip-safemalloc` option.

`safemalloc`, along with this option, was removed in MySQL 5.5.6.

- `--skip-show-database`

Command-Line Format	`--skip-show-database`
Option-File Format	`skip-show-database`
Option Sets Variable	Yes, `skip_show_database`
Variable Name	`skip_show_database`
Variable Scope	Global
Dynamic Variable	No

With this option, the `SHOW DATABASES` statement is permitted only to users who have the `SHOW DATABASES` privilege, and the statement displays all database names. Without this option, `SHOW DATABASES` is permitted to all users, but displays each database name only if the user has the `SHOW DATABASES` privilege or some privilege for the database. Note that *any* global privilege is considered a privilege for the database.

- `--skip-stack-trace`

Command-Line Format	`--skip-stack-trace`
Option-File Format	`skip-stack-trace`

Do not write stack traces. This option is useful when you are running `mysqld` under a debugger. On some systems, you also must use this option to get a core file. See MySQL Internals: Porting.

- `--skip-thread-priority`

Command-Line Format	`--skip-thread-priority`
Option-File Format	`skip-thread-priority`
Deprecated	5.1.29

Disable using thread priorities for faster response time. This option is deprecated and is removed in MySQL 5.6.

- `--slow-query-log[={0|1}]`

Command-Line Format	`--slow-query-log`
Option-File Format	`slow-query-log`
Option Sets Variable	Yes, `slow_query_log`
Variable Name	`slow_query_log`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Specify the initial slow query log state. With no argument or an argument of 1, the `--slow-query-log` option enables the log. If omitted or given with an argument of 0, the option disables the log.

- `--socket=*path*`

Command-Line Format	`--socket=name`	
Option-File Format	`socket`	
Option Sets Variable	Yes, `socket`	
Variable Name	`socket`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`
	Default	`/tmp/mysql.sock`

On Unix, this option specifies the Unix socket file to use when listening for local connections. The default value is `/tmp/mysql.sock`. If this option is given, the server creates the file in the data directory unless an absolute path name is given to specify a different directory. On Windows, the option specifies the pipe name to use when listening for local connections that use a named pipe. The default value is `MySQL` (not case sensitive).

- `--sql-mode=*value*[,*value*[,*value*...]]`

Command-Line Format	`--sql-mode=name`
Option-File Format	`sql-mode`
Option Sets Variable	Yes, `sql_mode`
Variable Name	`sql_mode`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`set`
	Default	`''`

	Valid Values	`ALLOW_INVALID_DATES`
		`ANSI_QUOTES`
		`ERROR_FOR_DIVISION_BY_ZERO`
		`HIGH_NOT_PRECEDENCE`
		`IGNORE_SPACE`
		`NO_AUTO_CREATE_USER`
		`NO_AUTO_VALUE_ON_ZERO`
		`NO_BACKSLASH_ESCAPES`
		`NO_DIR_IN_CREATE`
		`NO_ENGINE_SUBSTITUTION`
		`NO_FIELD_OPTIONS`
		`NO_KEY_OPTIONS`
		`NO_TABLE_OPTIONS`
		`NO_UNSIGNED_SUBTRACTION`
		`NO_ZERO_DATE`
		`NO_ZERO_IN_DATE`
		`ONLY_FULL_GROUP_BY`
		`PAD_CHAR_TO_FULL_LENGTH`
		`PIPES_AS_CONCAT`
		`REAL_AS_FLOAT`
		`STRICT_ALL_TABLES`
		`STRICT_TRANS_TABLES`

Set the SQL mode. See Section 5.1.6, “Server SQL Modes”.

- `--sysdate-is-now`

Command-Line Format	`--sysdate-is-now`	
Option-File Format	`sysdate-is-now`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

`SYSDATE()` by default returns the time at which it executes, not the time at which the statement in which it occurs begins executing. This differs from the behavior of `NOW()`. This option causes `SYSDATE()` to be an alias for `NOW()`. For information about the implications for binary logging and replication, see the description for `SYSDATE()` in Section 11.7, “Date and Time Functions” and for `SET TIMESTAMP` in Section 5.1.3, “Server System Variables”.

- `--tc-heuristic-recover={COMMIT|ROLLBACK}`

Command-Line Format	`--tc-heuristic-recover=name`	
Option-File Format	`tc-heuristic-recover`	
	Permitted Values	
	Type	`enumeration`
	Valid Values	`COMMIT` `RECOVER`

The type of decision to use in the heuristic recovery process. Currently, this option is unused.

- `--temp-pool`

Command-Line Format	`--temp-pool`	
Option-File Format	`temp-pool`	
	Permitted Values	
	Type	`boolean`
	Default	`TRUE`

This option causes most temporary files created by the server to use a small set of names, rather than a unique name for each new file. This works around a problem in the Linux kernel dealing with creating many new files with different names. With the old behavior, Linux seems to “leak” memory, because it is being allocated to the directory entry cache rather than to the disk cache. This option is ignored except on Linux.

- `--transaction-isolation=`*`level`*

Command-Line Format	`--transaction-isolation=name`	
Option-File Format	`transaction-isolation`	
Option Sets Variable	Yes, `tx_isolation`	
	Permitted Values	
	Type	`enumeration`

	Valid Values	`READ-UNCOMMITTED`
		`READ-COMMITTED`
		`REPEATABLE-READ`
		`SERIALIZABLE`

Sets the default transaction isolation level. The `level` value can be `READ-UNCOMMITTED`, `READ-COMMITTED`, `REPEATABLE-READ`, or `SERIALIZABLE`. See Section 12.3.6, “`SET TRANSACTION` Syntax”.

The default transaction isolation level can also be set in the running server using `SET TRANSACTION` or by setting the `tx_isolation` system variable.

- `--tmpdir=`*`path`*, `-t` *`path`*

Command-Line Format	`--tmpdir=path`
	`-t`
Option-File Format	`tmpdir`
Option Sets Variable	Yes, `tmpdir`
Variable Name	`tmpdir`
Variable Scope	Global
Dynamic Variable	No

	Permitted Values	
	Type	`file name`

The path of the directory to use for creating temporary files. It might be useful if your default `/tmp` directory resides on a partition that is too small to hold temporary tables. This option accepts several paths that are used in round-robin fashion. Paths should be separated by colon characters ("`:`") on Unix and semicolon characters ("`;`") on Windows. If the MySQL server is acting as a replication slave, you should not set `--tmpdir` to point to a directory on a memory-based file system or to a directory that is cleared when the server host restarts. For more information about the storage location of temporary files, see Section C.5.4.4, "Where MySQL Stores Temporary Files". A replication slave needs some of its temporary files to survive a machine restart so that it can replicate temporary tables or `LOAD DATA INFILE` operations. If files in the temporary file directory are lost when the server restarts, replication fails.

- `--user={user_name|user_id}`, `-u {user_name|user_id}`

Command-Line Format	`--user=name`	
	`-u name`	
Option-File Format	`user`	
	Permitted Values	
	Type	`string`

Run the `mysqld` server as the user having the name *`user_name`* or the numeric user ID *`user_id`*. ("User" in this context refers to a system login account, not a MySQL user listed in the grant tables.)

This option is *mandatory* when starting `mysqld` as `root`. The server changes its user ID during its startup sequence, causing it to run as that particular user rather than as `root`. See Section 5.3.1, "General Security Guidelines".

To avoid a possible security hole where a user adds a `--user=root` option to a `my.cnf` file (thus causing the server to run as `root`), `mysqld` uses only the first `--user` option specified and produces a warning if there are multiple `--user` options. Options in `/etc/my.cnf` and `$MYSQL_HOME/my.cnf` are processed before command-line options, so it is recommended that you put a `--user` option in `/etc/my.cnf` and specify a value other than `root`. The option in `/etc/my.cnf` is found before any other `--user` options, which ensures that the server runs as a user other than `root`, and that a warning results if any other `--user` option is found.

- `--verbose`, `-v`

  Use this option with the `--help` option for detailed help.

- `--version`, `-V`

  Display version information and exit.

You can assign a value to a server system variable by using an option of the form `--var_name=value`. For example, `--key_buffer_size=32M` sets the `key_buffer_size` variable to a value of 32MB.

Note that when you assign a value to a variable, MySQL might automatically correct the value to stay within a given range, or adjust the value to the closest permissible value if only certain values are permitted.

If you want to restrict the maximum value to which a variable can be set at runtime with `SET`, you can define this by using the `--maximum-var_name=value` command-line option.

You can change the values of most system variables for a running server with the `SET` statement. See Section 12.4.4, "SET Syntax".

Section 5.1.3, "Server System Variables", provides a full description for all variables, and additional information for setting them at server startup and runtime. Section 7.11.2, "Tuning Server Parameters", includes information on optimizing the server by tuning system variables.

5.1.3. Server System Variables

The MySQL server maintains many system variables that indicate how it is configured. Each system variable has a default value. System variables can be set at server startup using options on the command line or in an option file. Most of them can be changed dynamically while the server is running by means of the `SET` statement, which enables you to modify operation of the server without having to stop and restart it. You can refer to system variable values in expressions.

There are several ways to see the names and values of system variables:

- To see the values that a server will use based on its compiled-in defaults and any option files that it reads, use this command:

  ```
  mysqld --verbose --help
  ```

- To see the values that a server will use based on its compiled-in defaults, ignoring the settings in any option files, use this command:

  ```
  mysqld --no-defaults --verbose --help
  ```

- To see the current values used by a running server, use the `SHOW VARIABLES` statement.

This section provides a description of each system variable. Variables with no version indicated are present in all MySQL 5.5 releases. For historical information concerning their implementation, please see http://dev.mysql.com/doc/refman/5.0/en/, and http://dev.mysql.com/doc/refman/4.1/en/.

The following table lists all available system variables:

Table 5.2. System Variable Summary

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
auto_increment_increment	Yes	Yes	Yes	Both	Yes
auto_increment_offset	Yes	Yes	Yes	Both	Yes
autocommit	Yes	Yes	Yes	Both	Yes
automatic_sp_privileges			Yes	Global	Yes
back_log	Yes	Yes	Yes	Global	No
basedir	Yes	Yes	Yes	Global	No
big-tables	Yes	Yes			Yes
- *Variable*: big_tables			Yes	Both	Yes
bind-address	Yes	Yes	Yes	Global	No
binlog_cache_size	Yes	Yes	Yes	Global	Yes
binlog_direct_non_transactional_updates	Yes	Yes	Yes	Both	Yes
binlog-format	Yes	Yes			Yes
- *Variable*: binlog_format			Yes	Both	Yes
binlog_stmt_cache_size	Yes	Yes	Yes	Global	Yes
bulk_insert_buffer_size	Yes	Yes	Yes	Both	Yes
character_set_client			Yes	Both	Yes
character_set_connection			Yes	Both	Yes
character_set_database[a]			Yes	Both	Yes
character-set-filesystem	Yes	Yes			Yes
- *Variable*: character_set_filesystem			Yes	Both	Yes
character_set_results			Yes	Both	Yes
character-set-server	Yes	Yes			Yes
- *Variable*: character_set_server			Yes	Both	Yes
character_set_system			Yes	Global	No
character-sets-dir	Yes	Yes			No
- *Variable*: character_sets_dir			Yes	Global	No
collation_connection			Yes	Both	Yes

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
collation_database[b]			Yes	Both	Yes
collation-server	Yes	Yes			Yes
- *Variable*: collation_server			Yes	Both	Yes
completion_type	Yes	Yes	Yes	Both	Yes
concurrent_insert	Yes	Yes	Yes	Global	Yes
connect_timeout	Yes	Yes	Yes	Global	Yes
datadir	Yes	Yes	Yes	Global	No
date_format			Yes	Global	No
datetime_format			Yes	Global	No
debug	Yes	Yes	Yes	Both	Yes
debug_sync			Yes	Session	Yes
default-storage-engine	Yes	Yes			Yes
- *Variable*: default_storage_engine			Yes	Both	Yes
default_week_format	Yes	Yes	Yes	Both	Yes
delay-key-write	Yes	Yes			Yes
- *Variable*: delay_key_write			Yes	Global	Yes
delayed_insert_limit	Yes	Yes	Yes	Global	Yes
delayed_insert_timeout	Yes	Yes	Yes	Global	Yes
delayed_queue_size	Yes	Yes	Yes	Global	Yes
div_precision_increment	Yes	Yes	Yes	Both	Yes
engine-condition-pushdown	Yes	Yes			Yes
- *Variable*: engine_condition_pushdown			Yes	Both	Yes
error_count			Yes	Session	No
event-scheduler	Yes	Yes			Yes
- *Variable*: event_scheduler			Yes	Global	Yes
expire_logs_days	Yes	Yes	Yes	Global	Yes
external_user			Yes	Session	No
flush	Yes	Yes	Yes	Global	Yes
flush_time	Yes	Yes	Yes	Global	Yes
foreign_key_checks			Yes	Both	Yes
ft_boolean_syntax	Yes	Yes	Yes	Global	Yes
ft_max_word_len	Yes	Yes	Yes	Global	No
ft_min_word_len	Yes	Yes	Yes	Global	No
ft_query_expansion_limit	Yes	Yes	Yes	Global	No
ft_stopword_file	Yes	Yes	Yes	Global	No
general-log	Yes	Yes			Yes
- *Variable*: general_log			Yes	Global	Yes
general_log_file	Yes	Yes	Yes	Global	Yes
group_concat_max_len	Yes	Yes	Yes	Both	Yes
have_compress			Yes	Global	No
have_crypt			Yes	Global	No
have_csv			Yes	Global	No
have_dynamic_loading			Yes	Global	No
have_geometry			Yes	Global	No

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
have_innodb			Yes	Global	No
have_ndbcluster			Yes	Global	No
have_openssl			Yes	Global	No
have_partitioning			Yes	Global	No
have_profiling			Yes	Global	No
have_query_cache			Yes	Global	No
have_rtree_keys			Yes	Global	No
have_ssl			Yes	Global	No
have_symlink			Yes	Global	No
hostname			Yes	Global	No
identity			Yes	Session	Yes
ignore-builtin-innodb	Yes	Yes			No
- *Variable*: ignore_builtin_innodb			Yes	Global	No
init_connect	Yes	Yes	Yes	Global	Yes
init-file	Yes	Yes			No
- *Variable*: init_file			Yes	Global	No
init_slave	Yes	Yes	Yes	Global	Yes
innodb_adaptive_flushing	Yes	Yes	Yes	Global	Yes
innodb_adaptive_hash_index	Yes	Yes	Yes	Global	Yes
innodb_additional_mem_pool_size	Yes	Yes	Yes	Global	No
innodb_autoextend_increment	Yes	Yes	Yes	Global	Yes
innodb_autoinc_lock_mode	Yes	Yes	Yes	Global	No
innodb_buffer_pool_instances	Yes	Yes	Yes	Global	No
innodb_buffer_pool_size	Yes	Yes	Yes	Global	No
innodb_change_buffering	Yes	Yes	Yes	Global	Yes
innodb_checksums	Yes	Yes	Yes	Global	No
innodb_commit_concurrency	Yes	Yes	Yes	Global	Yes
innodb_concurrency_tickets	Yes	Yes	Yes	Global	Yes
innodb_data_file_path	Yes	Yes	Yes	Global	No
innodb_data_home_dir	Yes	Yes	Yes	Global	No
innodb_doublewrite	Yes	Yes	Yes	Global	No
innodb_fast_shutdown	Yes	Yes	Yes	Global	Yes
innodb_file_format	Yes	Yes	Yes	Global	Yes
innodb_file_format_check	Yes	Yes	Yes	Global	No
innodb_file_format_max	Yes	Yes	Yes	Global	Yes
innodb_file_per_table	Yes	Yes	Yes	Global	Yes
innodb_flush_log_at_trx_commit	Yes	Yes	Yes	Global	Yes
innodb_flush_method	Yes	Yes	Yes	Global	No

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
innodb_force_recovery	Yes	Yes	Yes	Global	No
innodb_io_capacity	Yes	Yes	Yes	Global	Yes
innodb_large_prefix	Yes	Yes	Yes	Global	Yes
innodb_lock_wait_timeout	Yes	Yes	Yes	Both	Yes
innodb_locks_unsafe_for_binlog	Yes	Yes	Yes	Global	No
innodb_log_buffer_size	Yes	Yes	Yes	Global	No
innodb_log_file_size	Yes	Yes	Yes	Global	No
innodb_log_files_in_group	Yes	Yes	Yes	Global	No
innodb_log_group_home_dir	Yes	Yes	Yes	Global	No
innodb_max_dirty_pages_pct	Yes	Yes	Yes	Global	Yes
innodb_max_purge_lag	Yes	Yes	Yes	Global	Yes
innodb_mirrored_log_groups	Yes	Yes	Yes	Global	No
innodb_old_blocks_pct	Yes	Yes	Yes	Global	Yes
innodb_old_blocks_time	Yes	Yes	Yes	Global	Yes
innodb_open_files	Yes	Yes	Yes	Global	No
innodb_purge_batch_size	Yes	Yes	Yes	Global	No
innodb_purge_threads	Yes	Yes	Yes	Global	No
innodb_read_ahead_threshold	Yes	Yes	Yes	Global	Yes
innodb_read_io_threads	Yes	Yes	Yes	Global	No
innodb_replication_delay	Yes	Yes	Yes	Global	Yes
innodb_rollback_on_timeout	Yes	Yes	Yes	Global	No
innodb_rollback_segments	Yes	Yes	Yes	Global	Yes
innodb_spin_wait_delay	Yes	Yes	Yes	Global	Yes
innodb_stats_method	Yes	Yes	Yes	Both	Yes
innodb_stats_on_metadata	Yes	Yes	Yes	Global	Yes
innodb_stats_sample_pages	Yes	Yes	Yes	Global	Yes
innodb_strict_mode	Yes	Yes	Yes	Both	Yes
innodb_support_xa	Yes	Yes	Yes	Both	Yes
innodb_sync_spin_loops	Yes	Yes	Yes	Global	Yes
innodb_table_locks	Yes	Yes	Yes	Both	Yes
innodb_thread_concurrency	Yes	Yes	Yes	Global	Yes
innodb_thread_sleep_delay	Yes	Yes	Yes	Global	Yes
innodb_use_native_aio	Yes	Yes	Yes	Global	No
innodb_use_sys_malloc	Yes	Yes	Yes	Global	No
innodb_version			Yes	Global	No

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
innodb_write_io_threads	Yes	Yes	Yes	Global	No
insert_id			Yes	Session	Yes
interactive_timeout	Yes	Yes	Yes	Both	Yes
join_buffer_size	Yes	Yes	Yes	Both	Yes
keep_files_on_create	Yes	Yes	Yes	Both	Yes
key_buffer_size	Yes	Yes	Yes	Global	Yes
key_cache_age_threshold	Yes	Yes	Yes	Global	Yes
key_cache_block_size	Yes	Yes	Yes	Global	Yes
key_cache_division_limit	Yes	Yes	Yes	Global	Yes
language	Yes	Yes	Yes	Global	No
large_files_support			Yes	Global	No
large_page_size			Yes	Global	No
large-pages	Yes	Yes			No
- *Variable*: large_pages			Yes	Global	No
last_insert_id			Yes	Session	Yes
lc-messages	Yes	Yes			Yes
- *Variable*: lc_messages			Yes	Both	Yes
lc-messages-dir	Yes	Yes			No
- *Variable*: lc_messages_dir			Yes	Global	No
lc_time_names			Yes	Both	Yes
license			Yes	Global	No
local_infile			Yes	Global	Yes
lock_wait_timeout	Yes	Yes	Yes	Both	Yes
locked_in_memory			Yes	Global	No
log	Yes	Yes	Yes	Global	Yes
log_bin			Yes	Global	No
log-bin	Yes	Yes	Yes	Global	No
log-bin-trust-function-creators	Yes	Yes			Yes
- *Variable*: log_bin_trust_function_creators			Yes	Global	Yes
log-bin-trust-routine-creators	Yes	Yes			Yes
- *Variable*: log_bin_trust_routine_creators			Yes	Global	Yes
log-error	Yes	Yes			No
- *Variable*: log_error			Yes	Global	No
log-output	Yes	Yes			Yes
- *Variable*: log_output			Yes	Global	Yes
log-queries-not-using-indexes	Yes	Yes			Yes
- *Variable*: log_queries_not_using_indexes			Yes	Global	Yes
log-slave-updates	Yes	Yes			No
- *Variable*: log_slave_updates			Yes	Global	No
log-slow-queries	Yes	Yes			Yes

Name	**Cmd-Line**	**Option file**	**System Var**	**Var Scope**	**Dynamic**
- *Variable*: log_slow_queries			Yes	Global	Yes
log-warnings	Yes	Yes			Yes
- *Variable*: log_warnings			Yes	Both	Yes
long_query_time	Yes	Yes	Yes	Both	Yes
low-priority-updates	Yes	Yes			Yes
- *Variable*: low_priority_updates			Yes	Both	Yes
lower_case_file_system	Yes	Yes	Yes	Global	No
lower_case_table_names	Yes	Yes	Yes	Global	No
max_allowed_packet	Yes	Yes	Yes	Global	Yes
max_binlog_cache_size	Yes	Yes	Yes	Global	Yes
max_binlog_size	Yes	Yes	Yes	Global	Yes
max_binlog_stmt_cache_size	Yes	Yes	Yes	Global	Yes
max_connect_errors	Yes	Yes	Yes	Global	Yes
max_connections	Yes	Yes	Yes	Global	Yes
max_delayed_threads	Yes	Yes	Yes	Both	Yes
max_error_count	Yes	Yes	Yes	Both	Yes
max_heap_table_size	Yes	Yes	Yes	Both	Yes
max_insert_delayed_threads			Yes	Both	Yes
max_join_size	Yes	Yes	Yes	Both	Yes
max_length_for_sort_data	Yes	Yes	Yes	Both	Yes
max_long_data_size	Yes	Yes	Yes	Global	No
max_prepared_stmt_count	Yes	Yes	Yes	Global	Yes
max_relay_log_size	Yes	Yes	Yes	Global	Yes
max_seeks_for_key	Yes	Yes	Yes	Both	Yes
max_sort_length	Yes	Yes	Yes	Both	Yes
max_sp_recursion_depth	Yes	Yes	Yes	Both	Yes
max_tmp_tables	Yes	Yes	Yes	Both	Yes
max_user_connections	Yes	Yes	Yes	Both	Yes
max_write_lock_count	Yes	Yes	Yes	Global	Yes
memlock	Yes	Yes	Yes	Global	No
min-examined-row-limit	Yes	Yes	Yes	Both	Yes
myisam_data_pointer_size	Yes	Yes	Yes	Global	Yes
myisam_max_sort_file_size	Yes	Yes	Yes	Global	Yes
myisam_mmap_size	Yes	Yes	Yes	Global	No
myisam_recover_options			Yes	Global	No
myisam_repair_threads	Yes	Yes	Yes	Both	Yes
myisam_sort_buffer_size	Yes	Yes	Yes	Both	Yes
myisam_stats_method	Yes	Yes	Yes	Both	Yes
myisam_use_mmap	Yes	Yes	Yes	Global	Yes
named_pipe			Yes	Global	No
ndb_autoincrement_prefetch_sz	Yes	Yes	Yes	Both	Yes
net_buffer_length	Yes	Yes	Yes	Both	Yes

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
net_read_timeout	Yes	Yes	Yes	Both	Yes
net_retry_count	Yes	Yes	Yes	Both	Yes
net_write_timeout	Yes	Yes	Yes	Both	Yes
new	Yes	Yes	Yes	Both	Yes
old	Yes	Yes	Yes	Global	No
old-alter-table	Yes	Yes			Yes
- *Variable*: old_alter_table			Yes	Both	Yes
old-passwords	Yes	Yes			Yes
- *Variable*: old_passwords			Yes	Both	Yes
open-files-limit	Yes	Yes			No
- *Variable*: open_files_limit			Yes	Global	No
optimizer_prune_level	Yes	Yes	Yes	Both	Yes
optimizer_search_depth	Yes	Yes	Yes	Both	Yes
optimizer_switch	Yes	Yes	Yes	Both	Yes
partition	Yes	Yes			No
- *Variable*: have_partitioning			Yes	Global	No
performance_schema	Yes	Yes	Yes	Global	No
performance_schema_events_waits_history_long_size	Yes	Yes	Yes	Global	No
performance_schema_events_waits_history_size	Yes	Yes	Yes	Global	No
performance_schema_max_cond_classes	Yes	Yes	Yes	Global	No
performance_schema_max_cond_instances	Yes	Yes	Yes	Global	No
performance_schema_max_file_classes	Yes	Yes	Yes	Global	No
performance_schema_max_file_handles	Yes	Yes	Yes	Global	No
performance_schema_max_file_instances	Yes	Yes	Yes	Global	No
performance_schema_max_mutex_classes	Yes	Yes	Yes	Global	No
performance_schema_max_mutex_instances	Yes	Yes	Yes	Global	No
performance_schema_max_rwlock_classes	Yes	Yes	Yes	Global	No
performance_schema_max_rwlock_instances	Yes	Yes	Yes	Global	No
performance_schema_max_table_handles	Yes	Yes	Yes	Global	No
perform-	Yes	Yes	Yes	Global	No

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
ance_schema_max_table_instances					
performance_schema_max_thread_classes	Yes	Yes	Yes	Global	No
performance_schema_max_thread_instances	Yes	Yes	Yes	Global	No
pid-file	Yes	Yes			No
- *Variable*: pid_file			Yes	Global	No
plugin_dir	Yes	Yes	Yes	Global	No
port	Yes	Yes	Yes	Global	No
preload_buffer_size	Yes	Yes	Yes	Both	Yes
profiling			Yes	Both	Yes
profiling_history_size			Yes	Both	Yes
protocol_version			Yes	Global	No
proxy_user			Yes	Session	No
pseudo_thread_id			Yes	Session	Yes
query_alloc_block_size	Yes	Yes	Yes	Both	Yes
query_cache_limit	Yes	Yes	Yes	Global	Yes
query_cache_min_res_unit	Yes	Yes	Yes	Global	Yes
query_cache_size	Yes	Yes	Yes	Global	Yes
query_cache_type	Yes	Yes	Yes	Both	Yes
query_cache_wlock_invalidate	Yes	Yes	Yes	Both	Yes
query_prealloc_size	Yes	Yes	Yes	Both	Yes
rand_seed1			Yes	Session	Yes
rand_seed2			Yes	Session	Yes
range_alloc_block_size	Yes	Yes	Yes	Both	Yes
read_buffer_size	Yes	Yes	Yes	Both	Yes
read_only	Yes	Yes	Yes	Global	Yes
read_rnd_buffer_size	Yes	Yes	Yes	Both	Yes
relay-log-index	Yes	Yes			No
- *Variable*: relay_log_index			Yes	Both	No
relay_log_index	Yes	Yes	Yes	Global	No
relay_log_info_file	Yes	Yes	Yes	Global	No
relay_log_purge	Yes	Yes	Yes	Global	Yes
relay_log_recovery	Yes	Yes	Yes	Global	Yes
relay_log_space_limit	Yes	Yes	Yes	Global	No
report-host	Yes	Yes			No
- *Variable*: report_host			Yes	Global	No
report-password	Yes	Yes			No
- *Variable*: report_password			Yes	Global	No
report-port	Yes	Yes			No
- *Variable*: report_port			Yes	Global	No
report-user	Yes	Yes			No
- *Variable*: report_user			Yes	Global	No
rpl_recovery_rank			Yes	Global	Yes

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
rpl_semi_sync_master_enabled			Yes	Global	Yes
rpl_semi_sync_master_timeout			Yes	Global	Yes
rpl_semi_sync_master_trace_level			Yes	Global	Yes
rpl_semi_sync_master_wait_no_slave			Yes	Global	Yes
rpl_semi_sync_slave_enabled			Yes	Global	Yes
rpl_semi_sync_slave_trace_level			Yes	Global	Yes
safe-show-database	Yes	Yes	Yes	Global	Yes
secure-auth	Yes	Yes			Yes
- *Variable*: secure_auth			Yes	Global	Yes
secure-file-priv	Yes	Yes			No
- *Variable*: secure_file_priv			Yes	Global	No
server-id	Yes	Yes			Yes
- *Variable*: server_id			Yes	Global	Yes
shared_memory			Yes	Global	No
shared_memory_base_name			Yes	Global	No
skip-external-locking	Yes	Yes			No
- *Variable*: skip_external_locking			Yes	Global	No
skip-name-resolve	Yes	Yes			No
- *Variable*: skip_name_resolve			Yes	Global	No
skip-networking	Yes	Yes			No
- *Variable*: skip_networking			Yes	Global	No
skip-show-database	Yes	Yes			No
- *Variable*: skip_show_database			Yes	Global	No
slave_compressed_protocol	Yes	Yes	Yes	Global	Yes
slave_exec_mode			Yes	Global	Yes
slave-load-tmpdir	Yes	Yes			No
- *Variable*: slave_load_tmpdir			Yes	Global	No
slave-net-timeout	Yes	Yes			Yes
- *Variable*: slave_net_timeout			Yes	Global	Yes
slave-skip-errors	Yes	Yes			No
- *Variable*: slave_skip_errors			Yes	Global	No
slave_transaction_retries	Yes	Yes	Yes	Global	Yes
slave_type_conversions	Yes	Yes	Yes	Global	No
slow_launch_time	Yes	Yes	Yes	Global	Yes
slow-query-log	Yes	Yes			Yes
- *Variable*: slow_query_log			Yes	Global	Yes

Name	**Cmd-Line**	**Option file**	**System Var**	**Var Scope**	**Dynamic**
slow_query_log_file	Yes	Yes	Yes	Global	Yes
socket	Yes	Yes	Yes	Global	No
sort_buffer_size	Yes	Yes	Yes	Both	Yes
sql_auto_is_null			Yes	Both	Yes
sql_big_selects			Yes	Both	Yes
sql_big_tables			Yes	Session	Yes
sql_buffer_result			Yes	Session	Yes
sql_log_bin			Yes	Both	Yes
sql_log_off			Yes	Both	Yes
sql_log_update			Yes	Session	Yes
sql_low_priority_updates			Yes	Both	Yes
sql_max_join_size			Yes	Both	Yes
sql-mode	Yes	Yes			Yes
- *Variable*: sql_mode			Yes	Both	Yes
sql_notes			Yes	Both	Yes
sql_quote_show_create			Yes	Both	Yes
sql_safe_updates			Yes	Both	Yes
sql_select_limit			Yes	Both	Yes
sql_slave_skip_counter			Yes	Global	Yes
sql_warnings			Yes	Both	Yes
ssl-ca	Yes	Yes			No
- *Variable*: ssl_ca			Yes	Global	No
ssl-capath	Yes	Yes			No
- *Variable*: ssl_capath			Yes	Global	No
ssl-cert	Yes	Yes			No
- *Variable*: ssl_cert			Yes	Global	No
ssl-cipher	Yes	Yes			No
- *Variable*: ssl_cipher			Yes	Global	No
ssl-key	Yes	Yes			No
- *Variable*: ssl_key			Yes	Global	No
storage_engine			Yes	Both	Yes
sync_binlog	Yes	Yes	Yes	Global	Yes
sync_frm	Yes	Yes	Yes	Global	Yes
sync_master_info	Yes	Yes	Yes	Global	Yes
sync_relay_log	Yes	Yes	Yes	Global	Yes
sync_relay_log_info	Yes	Yes	Yes	Global	Yes
system_time_zone			Yes	Global	No
table_definition_cache	Yes	Yes	Yes	Global	Yes
table_lock_wait_timeout	Yes	Yes	Yes	Global	Yes
table_open_cache	Yes	Yes	Yes	Global	Yes
table_type			Yes	Both	Yes
thread_cache_size	Yes	Yes	Yes	Global	Yes
thread_concurrency	Yes	Yes	Yes	Global	No
thread_handling	Yes	Yes	Yes	Global	No
thread_stack	Yes	Yes	Yes	Global	No
time_format			Yes	Global	No
time_zone	Yes	Yes	Yes	Both	Yes
timed_mutexes	Yes	Yes	Yes	Global	Yes

Name	Cmd-Line	Option file	System Var	Var Scope	Dynamic
timestamp			Yes	Session	Yes
tmp_table_size	Yes	Yes	Yes	Both	Yes
tmpdir	Yes	Yes	Yes	Global	No
transaction_alloc_block_size	Yes	Yes	Yes	Both	Yes
transaction_prealloc_size	Yes	Yes	Yes	Both	Yes
tx_isolation			Yes	Both	Yes
unique_checks			Yes	Both	Yes
updatable_views_with_limit	Yes	Yes	Yes	Both	Yes
version			Yes	Global	No
version_comment			Yes	Global	No
version_compile_machine			Yes	Global	No
version_compile_os			Yes	Global	No
wait_timeout	Yes	Yes	Yes	Both	Yes
warning_count			Yes	Session	No

[a] This option is dynamic, but only the server should set this information. You should not set the value of this variable manually.
[b] This option is dynamic, but only the server should set this information. You should not set the value of this variable manually.

For additional system variable information, see these sections:

- Section 5.1.4, “Using System Variables”, discusses the syntax for setting and displaying system variable values.
- Section 5.1.4.2, “Dynamic System Variables”, lists the variables that can be set at runtime.
- Information on tuning system variables can be found in Section 7.11.2, “Tuning Server Parameters”.
- Section 13.3.4, “`InnoDB` Startup Options and System Variables”, lists `InnoDB` system variables.
- MySQL Cluster System Variables, lists system variables which are specific to MySQL Cluster.
- For information on server system variables specific to replication, see Section 15.1.3, “Replication and Binary Logging Options and Variables”.

> **Note**
>
> Some of the following variable descriptions refer to “enabling” or “disabling” a variable. These variables can be enabled with the `SET` statement by setting them to `ON` or `1`, or disabled by setting them to `OFF` or `0`. However, before MySQL 5.5.10, to set such a variable on the command line or in an option file, you must set it to `1` or `0`; setting it to `ON` or `OFF` will not work. For example, on the command line, `--delay_key_write=1` works but `--delay_key_write=ON` does not. As of MySQL 5.5.10, boolean variables can be set at startup to the values `ON`, `TRUE`, `OFF`, and `FALSE` (not case sensitive). See Section 4.2.3.2, “Program Option Modifiers”.

Some system variables control the size of buffers or caches. For a given buffer, the server might need to allocate internal data structures. These structures typically are allocated from the total memory allocated to the buffer, and the amount of space required might be platform dependent. This means that when you assign a value to a system variable that controls a buffer size, the amount of space actually available might differ from the value assigned. In some cases, the amount might be less than the value assigned. It is also possible that the server will adjust a value upward. For example, if you assign a value of 0 to a variable for which the minimal value is 1024, the server will set the value to 1024.

Values for buffer sizes, lengths, and stack sizes are given in bytes unless otherwise specified.

Some system variables take file name values. Unless otherwise specified, the default file location is the data directory if the value is a relative path name. To specify the location explicitly, use an absolute path name. Suppose that the data directory is `/var/mysql/data`. If a file-valued variable is given as a relative path name, it will be located under `/var/mysql/data`. If the value is an absolute path name, its location is as given by the path name.

- `autocommit`

Command-Line Format	`--autocommit[=#]`

Option-File Format	`autocommit`	
Option Sets Variable	Yes, `autocommit`	
Variable Name	`autocommit`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`

The autocommit mode. If set to 1, all changes to a table take effect immediately. If set to 0, you must use `COMMIT` to accept a transaction or `ROLLBACK` to cancel it. If `autocommit` is 0 and you change it to 1, MySQL performs an automatic `COMMIT` of any open transaction. Another way to begin a transaction is to use a `START TRANSACTION` or `BEGIN` statement. See Section 12.3.1, “`START TRANSACTION`, `COMMIT`, and `ROLLBACK` Syntax”.

By default, client connections begin with `autocommit` set to 1. To cause clients to begin with a default of 0, set the global `autocommit` value by starting the server with the `--autocommit=0` option. To set the variable using an option file, include these lines:

```
[mysqld]
autocommit=0
```

Before MySQL 5.5.8, the global `autocommit` value cannot be set at startup. As a workaround, set the `init_connect` system variable:

```
SET GLOBAL init_connect='SET autocommit=0';
```

The `init_connect` variable can also be set on the command line or in an option file. To set the variable as just shown using an option file, include these lines:

```
[mysqld]
init_connect='SET autocommit=0'
```

The content of `init_connect` is not executed for users that have the `SUPER` privilege (unlike the effect of setting the global `autocommit` value at startup).

- `automatic_sp_privileges`

Variable Name	`automatic_sp_privileges`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`TRUE`

When this variable has a value of 1 (the default), the server automatically grants the `EXECUTE` and `ALTER ROUTINE` privileges to the creator of a stored routine, if the user cannot already execute and alter or drop the routine. (The `ALTER ROUTINE` privilege is required to drop the routine.) The server also automatically drops those privileges from the creator when the routine is dropped. If `automatic_sp_privileges` is 0, the server does not automatically add or drop these privileges.

The creator of a routine is the account used to execute the `CREATE` statement for it. This might not be the same as the account named as the `DEFINER` in the routine definition.

See also Section 17.2.2, “Stored Routines and MySQL Privileges”.

- `back_log`

Command-Line Format	`--back_log=#`
Option-File Format	`back_log`
Option Sets Variable	Yes, `back_log`
Variable Name	`back_log`

Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`50`
	Range	`1-65535`

The number of outstanding connection requests MySQL can have. This comes into play when the main MySQL thread gets very many connection requests in a very short time. It then takes some time (although very little) for the main thread to check the connection and start a new thread. The `back_log` value indicates how many requests can be stacked during this short time before MySQL momentarily stops answering new requests. You need to increase this only if you expect a large number of connections in a short period of time.

In other words, this value is the size of the listen queue for incoming TCP/IP connections. Your operating system has its own limit on the size of this queue. The manual page for the Unix `listen()` system call should have more details. Check your OS documentation for the maximum value for this variable. `back_log` cannot be set higher than your operating system limit.

- `basedir`

Command-Line Format	`--basedir=path`	
	`-b`	
Option-File Format	`basedir`	
Option Sets Variable	Yes, `basedir`	
Variable Name	`basedir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The MySQL installation base directory. This variable can be set with the `--basedir` option. Relative path names for other variables usually are resolved relative to the base directory.

- `big_tables`

If set to 1, all temporary tables are stored on disk rather than in memory. This is a little slower, but the error `The table` *`tbl_name`* `is full` does not occur for `SELECT` operations that require a large temporary table. The default value for a new connection is 0 (use in-memory temporary tables). Normally, you should never need to set this variable, because in-memory tables are automatically converted to disk-based tables as required.

> **Note**
>
> This variable was formerly named `sql_big_tables`.

- `bulk_insert_buffer_size`

Command-Line Format	`--bulk_insert_buffer_size=#`
Option-File Format	`bulk_insert_buffer_size`
Option Sets Variable	Yes, `bulk_insert_buffer_size`
Variable Name	`bulk_insert_buffer_size`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`8388608`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`8388608`
	Range	`0-18446744073709547520`

`MyISAM` uses a special tree-like cache to make bulk inserts faster for `INSERT ... SELECT`, `INSERT ... VALUES (...), (...), ...`, and `LOAD DATA INFILE` when adding data to nonempty tables. This variable limits the size of the cache tree in bytes per thread. Setting it to 0 disables this optimization. The default value is 8MB.

- `character_set_client`

Variable Name	`character_set_client`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The character set for statements that arrive from the client. The session value of this variable is set using the character set requested by the client when the client connects to the server. (Many clients support a `--default-character-set` option to enable this character set to be specified explicitly. See also Section 9.1.4, "Connection Character Sets and Collations".) The global value of the variable is used to set the session value in cases when the client-requested value is unknown or not available, or the server is configured to ignore client requests:

- The client is from a version of MySQL older than MySQL 4.1, and thus does not request a character set.
- The client requests a character set not known to the server. For example, a Japanese-enabled client requests `sjis` when connecting to a server not configured with `sjis` support.
- `mysqld` was started with the `--skip-character-set-client-handshake` option, which causes it to ignore client character set configuration. This reproduces MySQL 4.0 behavior and is useful should you wish to upgrade the server without upgrading all the clients.

`ucs2`, `utf16`, and `utf32` cannot be used as a client character set, which means that they also do not work for `SET NAMES` or `SET CHARACTER SET`.

- `character_set_connection`

Variable Name	`character_set_connection`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The character set used for literals that do not have a character set introducer and for number-to-string conversion.

- `character_set_database`

Variable Name	`character_set_database`
Variable Scope	Global, Session

Dynamic Variable	Yes	
Footnote	This option is dynamic, but only the server should set this information. You should not set the value of this variable manually.	
	Permitted Values	
	Type	`string`

The character set used by the default database. The server sets this variable whenever the default database changes. If there is no default database, the variable has the same value as `character_set_server`.

- `character_set_filesystem`

Command-Line Format	`--character-set-filesystem=name`	
Option-File Format	`character-set-filesystem`	
Option Sets Variable	Yes, `character_set_filesystem`	
Variable Name	`character_set_filesystem`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The file system character set. This variable is used to interpret string literals that refer to file names, such as in the `LOAD DATA INFILE` and `SELECT ... INTO OUTFILE` statements and the `LOAD_FILE()` function. Such file names are converted from `character_set_client` to `character_set_filesystem` before the file opening attempt occurs. The default value is `binary`, which means that no conversion occurs. For systems on which multi-byte file names are permitted, a different value may be more appropriate. For example, if the system represents file names using UTF-8, set `character_set_filesystem` to `'utf8'`.

- `character_set_results`

Variable Name	`character_set_results`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The character set used for returning query results such as result sets or error messages to the client.

- `character_set_server`

Command-Line Format	`--character-set-server`	
Option-File Format	`character-set-server`	
Option Sets Variable	Yes, `character_set_server`	
Variable Name	`character_set_server`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The server's default character set.

- `character_set_system`

Variable Name	`character_set_system`
Variable Scope	Global

Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The character set used by the server for storing identifiers. The value is always `utf8`.

- `character_sets_dir`

Command-Line Format	`--character-sets-dir=path`	
Option-File Format	`character-sets-dir=path`	
Option Sets Variable	Yes, `character_sets_dir`	
Variable Name	`character-sets-dir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`directory name`

The directory where character sets are installed.

- `collation_connection`

Variable Name	`collation_connection`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The collation of the connection character set.

- `collation_database`

Variable Name	`collation_database`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
Footnote	This option is dynamic, but only the server should set this information. You should not set the value of this variable manually.	
	Permitted Values	
	Type	`string`

The collation used by the default database. The server sets this variable whenever the default database changes. If there is no default database, the variable has the same value as `collation_server`.

- `collation_server`

Command-Line Format	`--collation-server`	
Option-File Format	`collation-server`	
Option Sets Variable	Yes, `collation_server`	
Variable Name	`collation_server`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The server's default collation.

- `completion_type`

Command-Line Format	`--completion_type=#`	
Option-File Format	`completion_type`	
Option Sets Variable	Yes, `completion_type`	
Variable Name	`completion_type`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.2)	
	Type	`numeric`
	Default	`0`

	Valid Values	`0`
		`1`
		`2`

	Permitted Values (>= 5.5.3)	
	Type	`enumeration`
	Default	`NO_CHAIN`

	Valid Values	`NO_CHAIN`
		`CHAIN`
		`RELEASE`
		`0`
		`1`
		`2`

The transaction completion type. This variable can take the values shown in the following table. As of MySQL 5.5.3, the variable can be assigned using either the name values or corresponding integer values. Before 5.5.3, only the integer values can be used.

Value	**Description**
`NO_CHAIN` (or 0)	`COMMIT` and `ROLLBACK` are unaffected. This is the default value.
`CHAIN` (or 1)	`COMMIT` and `ROLLBACK` are equivalent to `COMMIT AND CHAIN` and `ROLLBACK AND CHAIN`, respectively. (A new transaction starts immediately with the same isolation level as the just-terminated transaction.)
`RELEASE` (or 2)	`COMMIT` and `ROLLBACK` are equivalent to `COMMIT RELEASE` and `ROLLBACK RELEASE`, respectively. (The server disconnects after terminating the transaction.)

`completion_type` affects transactions that begin with `START TRANSACTION` or `BEGIN` and end with `COMMIT` or `ROLLBACK`. It does not apply to implicit commits resulting from execution of the statements listed in Section 12.3.3, “Statements That Cause an Implicit Commit”. It also does not apply for `XA COMMIT`, `XA ROLLBACK`, or when `autocommit=1`.

- `concurrent_insert`

Command-Line Format	`--concurrent_insert[=#]`
Option-File Format	`concurrent_insert`
Option Sets Variable	Yes, `concurrent_insert`
Variable Name	`concurrent_insert`

Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.2)	
	Type	`numeric`
	Default	`1`

	Valid Values	`0`
		`1`
		`2`

	Permitted Values (>= 5.5.3)	
	Type	`enumeration`
	Default	`AUTO`

	Valid Values	`NEVER`
		`AUTO`
		`ALWAYS`
		`0`
		`1`
		`2`

If `AUTO` (the default), MySQL permits `INSERT` and `SELECT` statements to run concurrently for `MyISAM` tables that have no free blocks in the middle of the data file. If you start `mysqld` with `--skip-new`, this variable is set to `NEVER`.

This variable can take the values shown in the following table. As of MySQL 5.5.3, the variable can be assigned using either the name values or corresponding integer values. Before 5.5.3, only the integer values can be used.

Value	**Description**
`NEVER` (or 0)	Disables concurrent inserts
`AUTO` (or 1)	(Default) Enables concurrent insert for `MyISAM` tables that do not have holes
`ALWAYS` (or 2)	Enables concurrent inserts for all `MyISAM` tables, even those that have holes. For a table with a hole, new rows are inserted at the end of the table if it is in use by another thread. Otherwise, MySQL acquires a normal write lock and inserts the row into the hole.

See also Section 7.10.3, “Concurrent Inserts”.

- `connect_timeout`

Command-Line Format	`--connect_timeout=#`	
Option-File Format	`connect_timeout`	
Option Sets Variable	Yes, `connect_timeout`	
Variable Name	`connect_timeout`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`10`

The number of seconds that the `mysqld` server waits for a connect packet before responding with `Bad handshake`. The default value is 10 seconds.

Increasing the `connect_timeout` value might help if clients frequently encounter errors of the form `Lost connection to MySQL server at 'XXX', system error: errno`.

- `datadir`

Command-Line Format	`--datadir=path`	
	`-h`	
Option-File Format	`datadir`	
Option Sets Variable	Yes, `datadir`	
Variable Name	`datadir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The MySQL data directory. This variable can be set with the `--datadir` option.

- `date_format`

This variable is unused.

- `datetime_format`

This variable is unused.

- `debug`

Command-Line Format	`--debug[=debug_options]`	
Option-File Format	`debug`	
Variable Name	`debug`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`
	Default	`'d:t:o,/tmp/mysqld.trace'`

This variable indicates the current debugging settings. It is available only for servers built with debugging support. The initial value comes from the value of instances of the `--debug` option given at server startup. The global and session values may be set at runtime; the `SUPER` privilege is required, even for the session value.

Assigning a value that begins with `+` or `-` cause the value to added to or subtracted from the current value:

```
mysql> SET debug = 'T';
mysql> SELECT @@debug;
+---------+
| @@debug |
+---------+
| T       |
+---------+

mysql> SET debug = '+P';
mysql> SELECT @@debug;
+---------+
| @@debug |
+---------+
| P:T     |
+---------+

mysql> SET debug = '-P';
mysql> SELECT @@debug;
+---------+
| @@debug |
+---------+
| T       |
+---------+
```

- `debug_sync`

Variable Name	`debug_sync`	
Variable Scope	Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

This variable is the user interface to the Debug Sync facility. Use of Debug Sync requires that MySQL be configured with the `-DENABLE_DEBUG_SYNC=1` option (see Section 2.9.4, “MySQL Source-Configuration Options”). If Debug Sync is not compiled in, this system variable is not available.

The global variable value is read only and indicates whether the facility is enabled. By default, Debug Sync is disabled and the value of `debug_sync` is `OFF`. If the server is started with `--debug-sync-timeout=N`, where `N` is a timeout value greater than 0, Debug Sync is enabled and the value of `debug_sync` is `ON - current signal` followed by the signal name. Also, `N` becomes the default timeout for individual synchronization points.

The session value can be read by any user and will have the same value as the global variable. The session value can be set by users that have the `SUPER` privilege to control synchronization points.

For a description of the Debug Sync facility and how to use synchronization points, see MySQL Internals: Test Synchronization.

- `default_storage_engine`

Command-Line Format	`--default-storage-engine=name`	
Option-File Format	`default-storage-engine`	
Option Sets Variable	Yes, `default_storage_engine`	
Variable Name	`default-storage-engine`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.4)	
	Type	`enumeration`
	Default	`MyISAM`
	Permitted Values (>= 5.5.5)	
	Type	`enumeration`
	Default	`InnoDB`

The default storage engine. To set the storage engine at server startup, use the `--default-storage-engine` option. See Section 5.1.2, “Server Command Options”.

This variable was added in MySQL 5.5.3 to be used in preference to `storage_engine`, which is now deprecated.

- `default_week_format`

Command-Line Format	`--default_week_format=#`	
Option-File Format	`default_week_format`	
Option Sets Variable	Yes, `default_week_format`	
Variable Name	`default_week_format`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-7`

The default mode value to use for the `WEEK()` function. See Section 11.7, “Date and Time Functions”.

- `delay_key_write`

Command-Line Format	`--delay-key-write[=name]`	
Option-File Format	`delay-key-write`	
Option Sets Variable	Yes, `delay_key_write`	
Variable Name	`delay-key-write`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`ON`

	Valid Values	`ON`
		`OFF`
		`ALL`

This option applies only to `MyISAM` tables. It can have one of the following values to affect handling of the `DELAY_KEY_WRITE` table option that can be used in `CREATE TABLE` statements.

Option	Description
`OFF`	`DELAY_KEY_WRITE` is ignored.
`ON`	MySQL honors any `DELAY_KEY_WRITE` option specified in `CREATE TABLE` statements. This is the default value.
`ALL`	All new opened tables are treated as if they were created with the `DELAY_KEY_WRITE` option enabled.

If `DELAY_KEY_WRITE` is enabled for a table, the key buffer is not flushed for the table on every index update, but only when the table is closed. This speeds up writes on keys a lot, but if you use this feature, you should add automatic checking of all `MyISAM` tables by starting the server with the `--myisam-recover-options` option (for example, `--myisam-recover-options=BACKUP,FORCE`). See Section 5.1.2, “Server Command Options”, and Section 13.5.1, “`MyISAM` Startup Options”.

> **Warning**
>
> If you enable external locking with `--external-locking`, there is no protection against index corruption for tables that use delayed key writes.

- `delayed_insert_limit`

Command-Line Format	`--delayed_insert_limit=#`	
Option-File Format	`delayed_insert_limit`	
Option Sets Variable	Yes, `delayed_insert_limit`	
Variable Name	`delayed_insert_limit`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`100`
	Range	`1-4294967295`

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`100`
	Range	`1-18446744073709547520`

After inserting `delayed_insert_limit` delayed rows, the `INSERT DELAYED` handler thread checks whether there are any `SELECT` statements pending. If so, it permits them to execute before continuing to insert delayed rows.

- `delayed_insert_timeout`

Command-Line Format	`--delayed_insert_timeout=#`	
Option-File Format	`delayed_insert_timeout`	
Option Sets Variable	Yes, `delayed_insert_timeout`	
Variable Name	`delayed_insert_timeout`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`300`

How many seconds an `INSERT DELAYED` handler thread should wait for `INSERT` statements before terminating.

- `delayed_queue_size`

Command-Line Format	`--delayed_queue_size=#`	
Option-File Format	`delayed_queue_size`	
Option Sets Variable	Yes, `delayed_queue_size`	
Variable Name	`delayed_queue_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`1000`
	Range	`1-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1000`
	Range	`1-18446744073709547520`

This is a per-table limit on the number of rows to queue when handling `INSERT DELAYED` statements. If the queue becomes full, any client that issues an `INSERT DELAYED` statement waits until there is room in the queue again.

- `div_precision_increment`

Command-Line Format	`--div_precision_increment=#`
Option-File Format	`div_precision_increment`

Option Sets Variable	Yes, `div_precision_increment`	
Variable Name	`div_precision_increment`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`4`
	Range	`0-30`

This variable indicates the number of digits by which to increase the scale of the result of division operations performed with the `/` operator. The default value is 4. The minimum and maximum values are 0 and 30, respectively. The following example illustrates the effect of increasing the default value.

```
mysql> SELECT 1/7;
+--------+
| 1/7    |
+--------+
| 0.1429 |
+--------+
mysql> SET div_precision_increment = 12;
mysql> SELECT 1/7;
+----------------+
| 1/7            |
+----------------+
| 0.142857142857 |
+----------------+
```

- `engine_condition_pushdown`

Version Deprecated	5.5.3	
Command-Line Format	`--engine-condition-pushdown`	
Option-File Format	`engine-condition-pushdown`	
Option Sets Variable	Yes, `engine_condition_pushdown`	
Variable Name	`engine_condition_pushdown`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
Deprecated	5.5.3, by `optimizer_switch`	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

The engine condition pushdown optimization enables processing for certain comparisons to be “pushed down” to the storage engine level for more efficient execution. For more information, see Section 7.13.3, “Engine Condition Pushdown Optimization”.

Engine condition pushdown is used only by the `NDBCLUSTER` storage engine. Enabling this optimization on a MySQL Server acting as a MySQL Cluster SQL node causes `WHERE` conditions on unindexed columns to be evaluated on the cluster's data nodes and only the rows that match to be sent back to the SQL node that issued the query. This greatly reduces the amount of cluster data that must be sent over the network, increasing the efficiency with which results are returned.

The `engine_condition_pushdown` variable controls whether engine condition pushdown is enabled. By default, this variable is `ON` (1). Setting it to `OFF` (0) disables pushdown.

This variable is deprecated as of MySQL 5.5.3 and is removed in MySQL 5.6. Use the `engine_condition_pushdown` flag of the `optimizer_switch` variable instead. See Section 7.8.4.2, “Controlling Switchable Optimizations”.

- `error_count`

  The number of errors that resulted from the last statement that generated messages. This variable is read only. See Section 12.4.5.18, “`SHOW ERRORS` Syntax”.

- `event_scheduler`

Command-Line Format	`--event-scheduler[=value]`	
Option-File Format	`event-scheduler`	
Option Sets Variable	Yes, `event_scheduler`	
Variable Name	`event_scheduler`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`OFF`

	Valid Values	`ON`
		`OFF`
		`DISABLED`

This variable indicates the status of the Event Scheduler; possible values are `ON`, `OFF`, and `DISABLED`, with the default being `OFF`. This variable and its effects on the Event Scheduler's operation are discussed in greater detail in the Overview section of the Events chapter.

- `expire_logs_days`

Command-Line Format	`--expire_logs_days=#`	
Option-File Format	`expire_logs_days`	
Option Sets Variable	Yes, `expire_logs_days`	
Variable Name	`expire_logs_days`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-99`

The number of days for automatic binary log file removal. The default is 0, which means "no automatic removal." Possible removals happen at startup and when the binary log is flushed. Log flushing occurs as indicated in Section 5.2, "MySQL Server Logs".

To remove binary log files manually, use the `PURGE BINARY LOGS` statement. See Section 12.5.1.1, "`PURGE BINARY LOGS` Syntax".

- `external_user`

Version Introduced	5.5.7	
Variable Name	`external_user`	
Variable Scope	Session	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The extern user name used during the authentication process. With native (built-in) MySQL authentication, this variable is `NULL`. See Section 5.5.7, "Proxy Users".

This variable was added in MySQL 5.5.7.

- `flush`

Command-Line Format	`--flush`	
Option-File Format	`flush`	
Variable Name	`flush`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

If `ON`, the server flushes (synchronizes) all changes to disk after each SQL statement. Normally, MySQL does a write of all changes to disk only after each SQL statement and lets the operating system handle the synchronizing to disk. See Section C.5.4.2, "What to Do If MySQL Keeps Crashing". This variable is set to `ON` if you start `mysqld` with the `--flush` option.

- `flush_time`

Command-Line Format	`--flush_time=#`	
Option-File Format	`flush_time`	
Option Sets Variable	Yes, `flush_time`	
Variable Name	`flush_time`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Min Value	`0`
	Permitted Values	
	Type (windows)	`numeric`
	Default	`1800`
	Min Value	`0`

If this is set to a nonzero value, all tables are closed every `flush_time` seconds to free up resources and synchronize unflushed data to disk. This option is best used only on Windows 9x or Me, or on systems with minimal resources.

- `foreign_key_checks`

If set to 1 (the default), foreign key constraints for `InnoDB` tables are checked. If set to 0, they are ignored. Disabling foreign key checking can be useful for reloading `InnoDB` tables in an order different from that required by their parent/child relationships. See Section 13.3.5.4, "`FOREIGN KEY` Constraints".

Setting `foreign_key_checks` to 0 also affects data definition statements: `DROP SCHEMA` drops a schema even if it contains tables that have foreign keys that are referred to by tables outside the schema, and `DROP TABLE` drops tables that have foreign keys that are referred to by other tables.

> **Note**
>
> Setting `foreign_key_checks` to 1 does not trigger a scan of the existing table data. Therefore, rows added to the table while `foreign_key_checks = 0` will not be verified for consistency.

- `ft_boolean_syntax`

Command-Line Format	`--ft_boolean_syntax=name`
Option-File Format	`ft_boolean_syntax`
Variable Name	`ft_boolean_syntax`

Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`
	Default	`+-><()~*:""&`

The list of operators supported by boolean full-text searches performed using `IN BOOLEAN MODE`. See Section 11.9.2, “Boolean Full-Text Searches”.

The default variable value is `'+ -><()~*:""&|'`. The rules for changing the value are as follows:

- Operator function is determined by position within the string.
- The replacement value must be 14 characters.
- Each character must be an ASCII nonalphanumeric character.
- Either the first or second character must be a space.
- No duplicates are permitted except the phrase quoting operators in positions 11 and 12. These two characters are not required to be the same, but they are the only two that may be.
- Positions 10, 13, and 14 (which by default are set to “`:`”, “`&`”, and “`|`”) are reserved for future extensions.

- `ft_max_word_len`

Command-Line Format	`--ft_max_word_len=#`	
Option-File Format	`ft_max_word_len`	
Option Sets Variable	Yes, `ft_max_word_len`	
Variable Name	`ft_max_word_len`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Min Value	`10`

The maximum length of the word to be included in a `FULLTEXT` index.

> **Note**
>
> `FULLTEXT` indexes must be rebuilt after changing this variable. Use `REPAIR TABLE tbl_name QUICK`.

- `ft_min_word_len`

Command-Line Format	`--ft_min_word_len=#`	
Option-File Format	`ft_min_word_len`	
Option Sets Variable	Yes, `ft_min_word_len`	
Variable Name	`ft_min_word_len`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`4`
	Min Value	`1`

The minimum length of the word to be included in a `FULLTEXT` index.

> **Note**
>
> `FULLTEXT` indexes must be rebuilt after changing this variable. Use `REPAIR TABLE tbl_name QUICK`.

- `ft_query_expansion_limit`

Command-Line Format	`--ft_query_expansion_limit=#`	
Option-File Format	`ft_query_expansion_limit`	
Option Sets Variable	Yes, `ft_query_expansion_limit`	
Variable Name	`ft_query_expansion_limit`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`20`
	Range	`0-1000`

The number of top matches to use for full-text searches performed using `WITH QUERY EXPANSION`.

- `ft_stopword_file`

Command-Line Format	`--ft_stopword_file=file_name`	
Option-File Format	`ft_stopword_file=file_name`	
Option Sets Variable	Yes, `ft_stopword_file`	
Variable Name	`ft_stopword_file`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The file from which to read the list of stopwords for full-text searches. The server looks for the file in the data directory unless an absolute path name is given to specify a different directory. All the words from the file are used; comments are *not* honored. By default, a built-in list of stopwords is used (as defined in the `storage/myisam/ft_static.c` file). Setting this variable to the empty string (`''`) disables stopword filtering. See also Section 11.9.4, “Full-Text Stopwords”.

> **Note**
>
> `FULLTEXT` indexes must be rebuilt after changing this variable or the contents of the stopword file. Use `REPAIR TABLE tbl_name QUICK`.

- `general_log`

Command-Line Format	`--general-log`	
Option-File Format	`general-log`	
Option Sets Variable	Yes, `general_log`	
Variable Name	`general_log`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Whether the general query log is enabled. The value can be 0 (or `OFF`) to disable the log or 1 (or `ON`) to enable the log. The default value depends on whether the `--general_log` option is given. The destination for log output is controlled by the `log_output` system variable; if that value is `NONE`, no log entries are written even if the log is enabled.

- `general_log_file`

Command-Line Format	`--general-log-file=file_name`	
Option-File Format	`general_log_file`	
Option Sets Variable	Yes, `general_log_file`	
Variable Name	`general_log_file`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`file name`
	Default	`host_name.log`

The name of the general query log file. The default value is `host_name.log`, but the initial value can be changed with the `--general_log_file` option.

- `group_concat_max_len`

Command-Line Format	`--group_concat_max_len=#`	
Option-File Format	`group_concat_max_len`	
Option Sets Variable	Yes, `group_concat_max_len`	
Variable Name	`group_concat_max_len`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`1024`
	Range	`4-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1024`
	Range	`4-18446744073709547520`

The maximum permitted result length in bytes for the `GROUP_CONCAT()` function. The default is 1024.

- `have_compress`

  `YES` if the `zlib` compression library is available to the server, `NO` if not. If not, the `COMPRESS()` and `UNCOMPRESS()` functions cannot be used.

- `have_crypt`

  `YES` if the `crypt()` system call is available to the server, `NO` if not. If not, the `ENCRYPT()` function cannot be used.

- `have_csv`

  `YES` if `mysqld` supports `CSV` tables, `NO` if not.

  This variable is deprecated and is removed in MySQL 5.6. Use `SHOW ENGINES` instead.

- `have_dynamic_loading`

  `YES` if `mysqld` supports dynamic loading of plugins, `NO` if not.

- `have_geometry`

  `YES` if the server supports spatial data types, `NO` if not.

- `have_innodb`

  `YES` if `mysqld` supports `InnoDB` tables. `DISABLED` if `--skip-innodb` is used.

  This variable is deprecated and is removed in MySQL 5.6. Use `SHOW ENGINES` instead.

- `have_openssl`

  This variable is an alias for `have_ssl`.

- `have_partitioning`

  `YES` if `mysqld` supports partitioning.

- `have_profiling`

  `YES` if statement profiling is enabled, `NO` if not. See Section 12.4.5.31, “`SHOW PROFILE` Syntax”.

- `have_query_cache`

  `YES` if `mysqld` supports the query cache, `NO` if not.

  This variable is deprecated and is removed in MySQL 5.6. Use `SHOW ENGINES` instead.

- `have_rtree_keys`

  `YES` if `RTREE` indexes are available, `NO` if not. (These are used for spatial indexes in `MyISAM` tables.)

- `have_ssl`

  `YES` if `mysqld` supports SSL connections, `NO` if not. `DISABLED` indicates that the server was compiled with SSL support, but but was not started with the appropriate `--ssl-*xxx*` options. See Section 5.5.8.2, “Using SSL Connections”, for more information.

- `have_symlink`

  `YES` if symbolic link support is enabled, `NO` if not. This is required on Unix for support of the `DATA DIRECTORY` and `INDEX DIRECTORY` table options, and on Windows for support of data directory symlinks.

- `hostname`

Variable Name	`hostname`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

  The server sets this variable to the server host name at startup.

- `identity`

  This variable is a synonym for the `last_insert_id` variable. It exists for compatibility with other database systems. You can read its value with `SELECT @@identity`, and set it using `SET identity`.

- `init_connect`

Command-Line Format	`--init-connect=name`
Option-File Format	`init_connect`
Option Sets Variable	Yes, `init_connect`

Variable Name	`init_connect`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

A string to be executed by the server for each client that connects. The string consists of one or more SQL statements, separated by semicolon characters. For example, each client session begins by default with autocommit mode enabled. For older servers (before MySQL 5.5.8), there is no global `autocommit` system variable to specify that autocommit should be disabled by default, but as a workaround `init_connect` can be used to achieve the same effect:

```
SET GLOBAL init_connect='SET autocommit=0';
```

The `init_connect` variable can also be set on the command line or in an option file. To set the variable as just shown using an option file, include these lines:

```
[mysqld]
init_connect='SET autocommit=0'
```

The content of `init_connect` is not executed for users that have the `SUPER` privilege. This is done so that an erroneous value for `init_connect` does not prevent all clients from connecting. For example, the value might contain a statement that has a syntax error, thus causing client connections to fail. Not executing `init_connect` for users that have the `SUPER` privilege enables them to open a connection and fix the `init_connect` value.

- `init_file`

Command-Line Format	`--init-file=file_name`	
Option-File Format	`init-file=file_name`	
Option Sets Variable	Yes, `init_file`	
Variable Name	`init_file`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The name of the file specified with the `--init-file` option when you start the server. This should be a file containing SQL statements that you want the server to execute when it starts. Each statement must be on a single line and should not include comments. No statement terminator such as `;`, `\g`, or `\G` should be given at the end of each statement.

Note that the `--init-file` option is unavailable if MySQL was configured with the `DISABLE_GRANT_OPTIONS` compiler flag. See Section 2.9.4, “MySQL Source-Configuration Options”.

- `innodb_xxx`

`InnoDB` system variables are listed in Section 13.3.4, “`InnoDB` Startup Options and System Variables”.

- `insert_id`

The value to be used by the following `INSERT` or `ALTER TABLE` statement when inserting an `AUTO_INCREMENT` value. This is mainly used with the binary log.

- `interactive_timeout`

Command-Line Format	`--interactive_timeout=#`
Option-File Format	`interactive_timeout`
Option Sets Variable	Yes, `interactive_timeout`
Variable Name	`interactive_timeout`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`28800`
	Min Value	`1`

The number of seconds the server waits for activity on an interactive connection before closing it. An interactive client is defined as a client that uses the `CLIENT_INTERACTIVE` option to `mysql_real_connect()`. See also `wait_timeout`.

- `join_buffer_size`

Command-Line Format	`--join_buffer_size=#`	
Option-File Format	`join_buffer_size`	
Option Sets Variable	Yes, `join_buffer_size`	
Variable Name	`join_buffer_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	

The minimum size of the buffer that is used for plain index scans, range index scans, and joins that do not use indexes and thus perform full table scans. Normally, the best way to get fast joins is to add indexes. Increase the value of `join_buffer_size` to get a faster full join when adding indexes is not possible. One join buffer is allocated for each full join between two tables. For a complex join between several tables for which indexes are not used, multiple join buffers might be necessary. There is no gain from setting the buffer larger than required to hold each matching row, and all joins allocate at least the minimum size, so use caution in setting this variable to a large value globally. It is better to keep the global setting small and change to a larger setting only in sessions that are doing large joins. Memory allocation time can cause substantial performance drops if the global size is larger than needed by most queries that use it.

The maximum permissible setting for `join_buffer_size` is 4GB. Values larger than 4GB are permitted for 64-bit platforms (except 64-bit Windows, for which large values are truncated to 4GB with a warning).

- `keep_files_on_create`

Command-Line Format	`--keep_files_on_create=#`	
Option-File Format	`keep_files_on_create`	
Option Sets Variable	Yes, `keep_files_on_create`	
Variable Name	`keep_files_on_create`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

If a `MyISAM` table is created with no `DATA DIRECTORY` option, the `.MYD` file is created in the database directory. By default, if `MyISAM` finds an existing `.MYD` file in this case, it overwrites it. The same applies to `.MYI` files for tables created with no `INDEX DIRECTORY` option. To suppress this behavior, set the `keep_files_on_create` variable to `ON` (1), in which case `MyISAM` will not overwrite existing files and returns an error instead. The default value is `OFF` (0).

If a `MyISAM` table is created with a `DATA DIRECTORY` or `INDEX DIRECTORY` option and an existing `.MYD` or `.MYI` file is found, MyISAM always returns an error. It will not overwrite a file in the specified directory.

- `key_buffer_size`

Command-Line Format	`--key_buffer_size=#`
Option-File Format	`key_buffer_size`
Option Sets Variable	Yes, `key_buffer_size`
Variable Name	`key_buffer_size`

Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`8388608`
	Range	`8-4294967295`

Index blocks for `MyISAM` tables are buffered and are shared by all threads. `key_buffer_size` is the size of the buffer used for index blocks. The key buffer is also known as the key cache.

The maximum permissible setting for `key_buffer_size` is 4GB on 32-bit platforms. Values larger than 4GB are permitted for 64-bit platforms. The effective maximum size might be less, depending on your available physical RAM and per-process RAM limits imposed by your operating system or hardware platform. The value of this variable indicates the amount of memory requested. Internally, the server allocates as much memory as possible up to this amount, but the actual allocation might be less.

You can increase the value to get better index handling for all reads and multiple writes; on a system whose primary function is to run MySQL using the `MyISAM` storage engine, 25% of the machine's total memory is an acceptable value for this variable. However, you should be aware that, if you make the value too large (for example, more than 50% of the machine's total memory), your system might start to page and become extremely slow. This is because MySQL relies on the operating system to perform file system caching for data reads, so you must leave some room for the file system cache. You should also consider the memory requirements of any other storage engines that you may be using in addition to `MyISAM`.

For even more speed when writing many rows at the same time, use `LOCK TABLES`. See Section 7.2.2.1, “Speed of `INSERT` Statements”.

You can check the performance of the key buffer by issuing a `SHOW STATUS` statement and examining the `Key_read_requests`, `Key_reads`, `Key_write_requests`, and `Key_writes` status variables. (See Section 12.4.5, “`SHOW` Syntax”.) The `Key_reads/Key_read_requests` ratio should normally be less than 0.01. The `Key_writes/Key_write_requests` ratio is usually near 1 if you are using mostly updates and deletes, but might be much smaller if you tend to do updates that affect many rows at the same time or if you are using the `DELAY_KEY_WRITE` table option.

The fraction of the key buffer in use can be determined using `key_buffer_size` in conjunction with the `Key_blocks_unused` status variable and the buffer block size, which is available from the `key_cache_block_size` system variable:

```
1 - ((Key_blocks_unused * key_cache_block_size) / key_buffer_size)
```

This value is an approximation because some space in the key buffer is allocated internally for administrative structures. Factors that influence the amount of overhead for these structures include block size and pointer size. As block size increases, the percentage of the key buffer lost to overhead tends to decrease. Larger blocks results in a smaller number of read operations (because more keys are obtained per read), but conversely an increase in reads of keys that are not examined (if not all keys in a block are relevant to a query).

It is possible to create multiple `MyISAM` key caches. The size limit of 4GB applies to each cache individually, not as a group. See Section 7.9.2, “The `MyISAM` Key Cache”.

- `key_cache_age_threshold`

Command-Line Format	`--key_cache_age_threshold=#`
Option-File Format	`key_cache_age_threshold`
Option Sets Variable	Yes, `key_cache_age_threshold`
Variable Name	`key_cache_age_threshold`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`300`
	Range	`100-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`300`
	Range	`100-18446744073709547520`

This value controls the demotion of buffers from the hot sublist of a key cache to the warm sublist. Lower values cause demotion to happen more quickly. The minimum value is 100. The default value is 300. See Section 7.9.2, “The `MyISAM` Key Cache”.

- `key_cache_block_size`

Command-Line Format	`--key_cache_block_size=#`	
Option-File Format	`key_cache_block_size`	
Option Sets Variable	Yes, `key_cache_block_size`	
Variable Name	`key_cache_block_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1024`
	Range	`512-16384`

The size in bytes of blocks in the key cache. The default value is 1024. See Section 7.9.2, “The `MyISAM` Key Cache”.

- `key_cache_division_limit`

Command-Line Format	`--key_cache_division_limit=#`	
Option-File Format	`key_cache_division_limit`	
Option Sets Variable	Yes, `key_cache_division_limit`	
Variable Name	`key_cache_division_limit`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`100`
	Range	`1-100`

The division point between the hot and warm sublists of the key cache buffer list. The value is the percentage of the buffer list to use for the warm sublist. Permissible values range from 1 to 100. The default value is 100. See Section 7.9.2, “The `MyISAM` Key Cache”.

- `language`

Command-Line Format	`--language=name`
	`-L`

Option-File Format	`language`	
Option Sets Variable	Yes, `language`	
Variable Name	`language`	
Variable Scope	Global	
Dynamic Variable	No	
Deprecated	5.6.1	
	Permitted Values	
	Type	`directory name`
	Default	`/usr/local/mysql/share/mysql/english/`

The directory where error messages are located. See Section 9.2, “Setting the Error Message Language”.

`language` is removed as of MySQL 5.5.0. Similar information is available from the `lc_messages_dir` and `lc_messages` variables.

- `large_files_support`

Variable Name	`large_files_support`
Variable Scope	Global
Dynamic Variable	No

Whether `mysqld` was compiled with options for large file support.

- `large_pages`

Command-Line Format	`--large-pages`	
Option-File Format	`large-pages`	
Option Sets Variable	Yes, `large_pages`	
Variable Name	`large_pages`	
Variable Scope	Global	
Dynamic Variable	No	
Platform Specific	linux	
	Permitted Values	
	Type (linux)	`boolean`
	Default	`FALSE`

Whether large page support is enabled (via the `--large-pages` option). See Section 7.11.4.2, “Enabling Large Page Support”.

- `large_page_size`

Variable Name	`large_page_size`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type (linux)	`numeric`
	Default	`0`

If large page support is enabled, this shows the size of memory pages. Currently, large memory pages are supported only on Linux; on other platforms, the value of this variable is always 0. See Section 7.11.4.2, “Enabling Large Page Support”.

- `last_insert_id`

  The value to be returned from `LAST_INSERT_ID()`. This is stored in the binary log when you use `LAST_INSERT_ID()` in a statement that updates a table. Setting this variable does not update the value returned by the `mysql_insert_id()` C API function.

- `lc_messages`

Command-Line Format	`--lc-messages=name`	
Option-File Format	`lc-messages`	
Option Sets Variable	Yes, `lc_messages`	
Variable Name	`lc-messages`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

  The locale to use for error messages. The server converts the value to a language name and combines it with the value of the `lc_messages_dir` to produce the location for the error message file. See Section 9.2, “Setting the Error Message Language”.

- `lc_messages_dir`

Command-Line Format	`--lc-messages-dir=path`	
Option-File Format	`lc-messages-dir`	
Option Sets Variable	Yes, `lc_messages_dir`	
Variable Name	`lc-messages-dir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`directory name`

  The directory where error messages are located. The value is used together with the value of `lc_messages` to produce the location for the error message file. See Section 9.2, “Setting the Error Message Language”.

- `lc_time_names`

Variable Name	`lc_time_names`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

  This variable specifies the locale that controls the language used to display day and month names and abbreviations. This variable affects the output from the `DATE_FORMAT()`, `DAYNAME()` and `MONTHNAME()` functions. Locale names are POSIX-style values such as `'ja_JP'` or `'pt_BR'`. The default value is `'en_US'` regardless of your system's locale setting. For further information, see Section 9.7, “MySQL Server Locale Support”.

- `license`

Variable Name	`license`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`
	Default	`GPL`

The type of license the server has.

- `local_infile`

Variable Name	`local_infile`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`

Whether `LOCAL` is supported for `LOAD DATA INFILE` statements. See Section 5.3.5, “Security Issues with `LOAD DATA LOCAL`”.

- `lock_wait_timeout`

Version Introduced	5.5.3	
Command-Line Format	`--lock_wait_timeout=#`	
Option-File Format	`lock_wait_timeout`	
Option Sets Variable	Yes, `lock_wait_timeout`	
Variable Name	`lock_wait_timeout`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`31536000`
	Range	`1-31536000`

This variable specifies the timeout in seconds for attempts to acquire metadata locks. The permissible values range from 1 to 3153600 (1 year). The default is 3153600.

This timeout applies to all statements that use metadata locks. These include DML and DDL operations on tables, views, stored procedures, and stored functions, as well as `LOCK TABLES`, `FLUSH TABLES WITH READ LOCK`, and `HANDLER` statements.

The timeout value applies separately for each metadata lock attempt. A given statement can require more than one lock, so it is possible for the statement to block for longer than the `lock_wait_timeout` value before reporting a timeout error. When lock timeout occurs, `ER_LOCK_WAIT_TIMEOUT` is reported.

`lock_wait_timeout` does not apply to delayed inserts, which always execute with a timeout of 1 year. This is done to avoid unnecessary timeouts because a session that issues a delayed insert receives no notification of delayed insert timeouts.

This variable was added in MySQL 5.5.3.

- `locked_in_memory`

Variable Name	`locked_in_memory`
Variable Scope	Global
Dynamic Variable	No

Whether `mysqld` was locked in memory with `--memlock`.

- `log`

  Whether logging of all statements to the general query log is enabled. See Section 5.2.3, “The General Query Log”.

  This variable is deprecated and is removed in MySQL 5.6. Use `general_log` instead.

- `log_bin`

Variable Name	`log_bin`
Variable Scope	Global
Dynamic Variable	No

Whether the binary log is enabled. If the `--log-bin` option is used, then the value of this variable is `ON`; otherwise it is `OFF`. This variable reports only on the status of binary logging (enabled or disabled); it does not actually report the value to which `--log-bin` is set.

See Section 5.2.4, "The Binary Log".

- `log_bin_trust_function_creators`

Command-Line Format	`--log-bin-trust-function-creators`	
Option-File Format	`log-bin-trust-function-creators`	
Option Sets Variable	Yes, `log_bin_trust_function_creators`	
Variable Name	`log_bin_trust_function_creators`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

This variable applies when binary logging is enabled. It controls whether stored function creators can be trusted not to create stored functions that will cause unsafe events to be written to the binary log. If set to 0 (the default), users are not permitted to create or alter stored functions unless they have the `SUPER` privilege in addition to the `CREATE ROUTINE` or `ALTER ROUTINE` privilege. A setting of 0 also enforces the restriction that a function must be declared with the `DETERMINISTIC` characteristic, or with the `READS SQL DATA` or `NO SQL` characteristic. If the variable is set to 1, MySQL does not enforce these restrictions on stored function creation. This variable also applies to trigger creation. See Section 17.7, "Binary Logging of Stored Programs".

- `log_error`

Command-Line Format	`--log-error[=name]`	
Option-File Format	`log-error`	
Option Sets Variable	Yes, `log_error`	
Variable Name	`log_error`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The location of the error log.

- `log_output`

Command-Line Format	`--log-output[=name]`
Option-File Format	`log-output`
Option Sets Variable	Yes, `log_output`
Variable Name	`log_output`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`set`
	Default	`FILE`

	Valid Values	`TABLE`
		`FILE`
		`NONE`

The destination for general query log and slow query log output. The value can be a comma-separated list of one or more of the words `TABLE` (log to tables), `FILE` (log to files), or `NONE` (do not log to tables or files). The default value is `TABLE`. `NONE`, if present, takes precedence over any other specifiers. If the value is `NONE` log entries are not written even if the logs are enabled. If the logs are not enabled, no logging occurs even if the value of `log_output` is not `NONE`. For more information, see Section 5.2.1, "Selecting General Query and Slow Query Log Output Destinations".

- `log_queries_not_using_indexes`

Command-Line Format	`--log-queries-not-using-indexes`	
Option-File Format	`log-queries-not-using-indexes`	
Option Sets Variable	Yes, `log_queries_not_using_indexes`	
Variable Name	`log_queries_not_using_indexes`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`

Whether queries that do not use indexes are logged to the slow query log. See Section 5.2.5, "The Slow Query Log".

- `log_slave_updates`

Whether updates received by a slave server from a master server should be logged to the slave's own binary log. Binary logging must be enabled on the slave for this variable to have any effect. See Section 15.1.3, "Replication and Binary Logging Options and Variables".

- `log_slow_queries`

Command-Line Format	`--log-slow-queries[=name]`	
Option-File Format	`log-slow-queries`	
Option Sets Variable	Yes, `log_slow_queries`	
Variable Name	`log_slow_queries`	
Variable Scope	Global	
Dynamic Variable	Yes	
Deprecated	5.1.29, by `slow-query-log`	
	Permitted Values	
	Type	`boolean`

Whether slow queries should be logged. "Slow" is determined by the value of the `long_query_time` variable. See Section 5.2.5, "The Slow Query Log".

This variable is deprecated and is removed in MySQL 5.6. Use `slow_query_log` instead.

- `log_warnings`

Command-Line Format	`--log-warnings[=#]`
	`-W [#]`
Option-File Format	`log-warnings`

Option Sets Variable	Yes, `log_warnings`	
Variable Name	`log_warnings`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
Disabled by	`skip-log-warnings`	
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1`
	Range	`0-18446744073709547520`

Whether to produce additional warning messages to the error log. It is enabled (1) by default and can be disabled by setting it to 0. Aborted connections and access-denied errors for new connection attempts are logged if the value is greater than 1. The server logs messages about statements that are unsafe for statement-based logging only if the value is greater than 0.

- `long_query_time`

Command-Line Format	`--long_query_time=#`	
Option-File Format	`long_query_time`	
Option Sets Variable	Yes, `long_query_time`	
Variable Name	`long_query_time`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`10`
	Min Value	`0`

If a query takes longer than this many seconds, the server increments the `Slow_queries` status variable. If the slow query log is enabled, the query is logged to the slow query log file. This value is measured in real time, not CPU time, so a query that is under the threshold on a lightly loaded system might be above the threshold on a heavily loaded one. The minimum value is 0, and a resolution of microseconds is supported when logging to a file. However, the microseconds part is ignored and only integer values are written when logging to tables. The default value is 10. See Section 5.2.5, “The Slow Query Log”.

- `low_priority_updates`

Command-Line Format	`--low-priority-updates`	
Option-File Format	`low-priority-updates`	
Option Sets Variable	Yes, `low_priority_updates`	
Variable Name	`low_priority_updates`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

If set to `1`, all `INSERT`, `UPDATE`, `DELETE`, and `LOCK TABLE WRITE` statements wait until there is no pending `SELECT` or `LOCK TABLE READ` on the affected table. This affects only storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`). This variable previously was named `sql_low_priority_updates`.

- `lower_case_file_system`

Command-Line Format	`--lower_case_file_system[=#]`	
Option-File Format	`lower_case_file_system`	
Option Sets Variable	Yes, `lower_case_file_system`	
Variable Name	`lower_case_file_system`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`

This variable describes the case sensitivity of file names on the file system where the data directory is located. `OFF` means file names are case sensitive, `ON` means they are not case sensitive. This variable is read only because it reflects a file system attribute and setting it would have no effect on the file system.

- `lower_case_table_names`

Command-Line Format	`--lower_case_table_names[=#]`	
Option-File Format	`lower_case_table_names`	
Option Sets Variable	Yes, `lower_case_table_names`	
Variable Name	`lower_case_table_names`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-2`

If set to 0, table names are stored as specified and comparisons are case sensitive. If set to 1, table names are stored in lowercase on disk and comparisons are not case sensitive. If set to 2, table names are stored as given but compared in lowercase. This option also applies to database names and table aliases. For additional information, see Section 8.2.2, “Identifier Case Sensitivity”.

You should *not* set this variable to 0 if you are running MySQL on a system that has case-insensitive file names (such as Windows or Mac OS X). If you set this variable to 0 on such a system and access `MyISAM` tablenames using different lettercases, index corruption may result. On Windows the default value is 1. On Mac OS X, the default value is 2.

If you are using `InnoDB` tables, you should set this variable to 1 on all platforms to force names to be converted to lowercase.

The setting of this variable has no effect on replication filtering options. This is a known issue which is fixed in MySQL 5.6. See Section 15.2.3, “How Servers Evaluate Replication Filtering Rules”, for more information.

You should not use different settings for `lower_case_table_names` on replication masters and slaves. In particular, you should not do this when the slave uses a case-sensitive file system, as this can cause replication to fail. This is a known issue which is fixed in MySQL 5.6. For more information, see Section 15.4.1.33, “Replication and Variables”.

- `max_allowed_packet`

Command-Line Format	`--max_allowed_packet=#`
Option-File Format	`max_allowed_packet`
Option Sets Variable	Yes, `max_allowed_packet`
Variable Name	`max_allowed_packet`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`1048576`
	Range	`1024-1073741824`

The maximum size of one packet or any generated/intermediate string.

The packet message buffer is initialized to `net_buffer_length` bytes, but can grow up to `max_allowed_packet` bytes when needed. This value by default is small, to catch large (possibly incorrect) packets.

You must increase this value if you are using large `BLOB` columns or long strings. It should be as big as the largest `BLOB` you want to use. The protocol limit for `max_allowed_packet` is 1GB. The value should be a multiple of 1024; nonmultiples are rounded down to the nearest multiple.

When you change the message buffer size by changing the value of the `max_allowed_packet` variable, you should also change the buffer size on the client side if your client program permits it. On the client side, `max_allowed_packet` has a default of 1GB. Some programs such as `mysql` and `mysqldump` enable you to change the client-side value by setting `max_allowed_packet` on the command line or in an option file.

The session value of this variable is read only.

- `max_connect_errors`

Command-Line Format	`--max_connect_errors=#`	
Option-File Format	`max_connect_errors`	
Option Sets Variable	Yes, `max_connect_errors`	
Variable Name	`max_connect_errors`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`10`
	Range	`1-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`10`
	Range	`1-18446744073709547520`

If there are more than this number of interrupted connections from a host, that host is blocked from further connections. You can unblock blocked hosts with the `FLUSH HOSTS` statement. If a connection is established successfully within fewer than `max_connect_errors` attempts after a previous connection was interrupted, the error count for the host is cleared to zero. However, once a host is blocked, the `FLUSH HOSTS` statement is the only way to unblock it.

- `max_connections`

Command-Line Format	`--max_connections=#`
Option-File Format	`max_connections`
Option Sets Variable	Yes, `max_connections`
Variable Name	`max_connections`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`151`
	Range	`1-100000`

The maximum permitted number of simultaneous client connections. By default, this is 151. See Section C.5.2.7, “`Too many connections`”, for more information.

Increasing this value increases the number of file descriptors that `mysqld` requires. See Section 7.4.3.1, “How MySQL Opens and Closes Tables”, for comments on file descriptor limits.

- `max_delayed_threads`

Command-Line Format	`--max_delayed_threads=#`	
Option-File Format	`max_delayed_threads`	
Option Sets Variable	Yes, `max_delayed_threads`	
Variable Name	`max_delayed_threads`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`20`
	Range	`0-16384`

Do not start more than this number of threads to handle `INSERT DELAYED` statements. If you try to insert data into a new table after all `INSERT DELAYED` threads are in use, the row is inserted as if the `DELAYED` attribute was not specified. If you set this to 0, MySQL never creates a thread to handle `DELAYED` rows; in effect, this disables `DELAYED` entirely.

For the `SESSION` value of this variable, the only valid values are 0 or the `GLOBAL` value.

- `max_error_count`

Command-Line Format	`--max_error_count=#`	
Option-File Format	`max_error_count`	
Option Sets Variable	Yes, `max_error_count`	
Variable Name	`max_error_count`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`64`
	Range	`0-65535`

The maximum number of error, warning, and note messages to be stored for display by the `SHOW ERRORS` and `SHOW WARNINGS` statements.

- `max_heap_table_size`

Command-Line Format	`--max_heap_table_size=#`
Option-File Format	`max_heap_table_size`
Option Sets Variable	Yes, `max_heap_table_size`
Variable Name	`max_heap_table_size`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`16777216`
	Range	`16384-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`16777216`
	Range	`16384-18446744073709547520`

This variable sets the maximum size to which user-created `MEMORY` tables are permitted to grow. The value of the variable is used to calculate `MEMORY` table `MAX_ROWS` values. Setting this variable has no effect on any existing `MEMORY` table, unless the table is re-created with a statement such as `CREATE TABLE` or altered with `ALTER TABLE` or `TRUNCATE TABLE`. A server restart also sets the maximum size of existing `MEMORY` tables to the global `max_heap_table_size` value.

This variable is also used in conjunction with `tmp_table_size` to limit the size of internal in-memory tables. See Section 7.4.3.3, "How MySQL Uses Internal Temporary Tables".

- `max_insert_delayed_threads`

Variable Name	`max_insert_delayed_threads`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`

This variable is a synonym for `max_delayed_threads`.

- `max_join_size`

Command-Line Format	`--max_join_size=#`	
Option-File Format	`max_join_size`	
Option Sets Variable	Yes, `max_join_size`	
Variable Name	`max_join_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (>= 5.5.0)	
	Type	`numeric`
	Default	`18446744073709551615`
	Range	`1-18446744073709551615`

Do not permit `SELECT` statements that probably need to examine more than `max_join_size` rows (for single-table statements) or row combinations (for multiple-table statements) or that are likely to do more than `max_join_size` disk seeks. By setting this value, you can catch `SELECT` statements where keys are not used properly and that would probably take a long time. Set it if your users tend to perform joins that lack a `WHERE` clause, that take a long time, or that return millions of rows.

Setting this variable to a value other than `DEFAULT` resets the value of `sql_big_selects` to `0`. If you set the `sql_big_selects` value again, the `max_join_size` variable is ignored.

If a query result is in the query cache, no result size check is performed, because the result has previously been computed and it does not burden the server to send it to the client.

This variable previously was named `sql_max_join_size`.

- `max_length_for_sort_data`

Command-Line Format	`--max_length_for_sort_data=#`	
Option-File Format	`max_length_for_sort_data`	
Option Sets Variable	Yes, `max_length_for_sort_data`	
Variable Name	`max_length_for_sort_data`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1024`
	Range	`4-8388608`

The cutoff on the size of index values that determines which `filesort` algorithm to use. See Section 7.13.9, "`ORDER BY` Optimization".

- `max_long_data_size`

Version Introduced	5.5.11	
Version Deprecated	5.5.11	
Command-Line Format	`--max_long_data_size=#`	
Option-File Format	`max_long_data_size`	
Option Sets Variable	Yes, `max_long_data_size`	
Variable Name	`max_long_data_size`	
Variable Scope	Global	
Dynamic Variable	No	
Deprecated	5.5.11	
	Permitted Values	
	Type	`numeric`
	Default	`1048576`
	Range	`1024-4294967295`

The maximum size of parameter values that can be sent with the `mysql_stmt_send_long_data()` C API function. If not set at server startup, the default is the value of the `max_allowed_packet` system variable. This variable is deprecated. In MySQL 5.6, it is removed and the maximum parameter size is controlled by `max_allowed_packet`.

- `max_prepared_stmt_count`

Command-Line Format	`--max_prepared_stmt_count=#`	
Option-File Format	`max_prepared_stmt_count`	
Option Sets Variable	Yes, `max_prepared_stmt_count`	
Variable Name	`max_prepared_stmt_count`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`16382`
	Range	`0-1048576`

This variable limits the total number of prepared statements in the server. It can be used in environments where there is the potential for denial-of-service attacks based on running the server out of memory by preparing huge numbers of statements. If the value is set lower than the current number of prepared statements, existing statements are not affected and can be used, but no new statements can be prepared until the current number drops below the limit. The default value is 16,382. The permissible range of values is from 0 to 1 million. Setting the value to 0 disables prepared statements.

- `max_relay_log_size`

Command-Line Format	`--max_relay_log_size=#`	
Option-File Format	`max_relay_log_size`	
Option Sets Variable	Yes, `max_relay_log_size`	
Variable Name	`max_relay_log_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-1073741824`

If a write by a replication slave to its relay log causes the current log file size to exceed the value of this variable, the slave rotates the relay logs (closes the current file and opens the next one). If `max_relay_log_size` is 0, the server uses `max_binlog_size` for both the binary log and the relay log. If `max_relay_log_size` is greater than 0, it constrains the size of the relay log, which enables you to have different sizes for the two logs. You must set `max_relay_log_size` to between 4096 bytes and 1GB (inclusive), or to 0. The default value is 0. See Section 15.2.1, “Replication Implementation Details”.

- `max_seeks_for_key`

Command-Line Format	`--max_seeks_for_key=#`	
Option-File Format	`max_seeks_for_key`	
Option Sets Variable	Yes, `max_seeks_for_key`	
Variable Name	`max_seeks_for_key`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`4294967295`
	Range	`1-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`18446744073709547520`
	Range	`1-18446744073709547520`

Limit the assumed maximum number of seeks when looking up rows based on a key. The MySQL optimizer assumes that no more than this number of key seeks are required when searching for matching rows in a table by scanning an index, regardless of the actual cardinality of the index (see Section 12.4.5.23, “`SHOW INDEX` Syntax”). By setting this to a low value (say, 100), you can force MySQL to prefer indexes instead of table scans.

- `max_sort_length`

Command-Line Format	`--max_sort_length=#`
Option-File Format	`max_sort_length`

Option Sets Variable	Yes, `max_sort_length`	
Variable Name	`max_sort_length`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1024`
	Range	`4-8388608`

The number of bytes to use when sorting `BLOB` or `TEXT` values. Only the first `max_sort_length` bytes of each value are used; the rest are ignored.

- `max_sp_recursion_depth`

Command-Line Format	`--max_sp_recursion_depth[=#]`	
Option-File Format	`max_sp_recursion_depth`	
Option Sets Variable	Yes, `max_sp_recursion_depth`	
Variable Name	`max_sp_recursion_depth`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Max Value	`255`

The number of times that any given stored procedure may be called recursively. The default value for this option is 0, which completely disables recursion in stored procedures. The maximum value is 255.

Stored procedure recursion increases the demand on thread stack space. If you increase the value of `max_sp_recursion_depth`, it may be necessary to increase thread stack size by increasing the value of `thread_stack` at server startup.

- `max_tmp_tables`

Command-Line Format	`--max_tmp_tables=#`	
Option-File Format	`max_tmp_tables`	
Option Sets Variable	Yes, `max_tmp_tables`	
Variable Name	`max_tmp_tables`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`32`
	Range	`1-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`32`
	Range	`1-18446744073709547520`

The maximum number of temporary tables a client can keep open at the same time. (This variable does not yet do anything.)

- `max_user_connections`

Command-Line Format	`--max_user_connections=#`	
Option-File Format	`max_user_connections`	
Option Sets Variable	Yes, `max_user_connections`	
Variable Name	`max_user_connections`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`

The maximum number of simultaneous connections permitted to any given MySQL user account. A value of 0 (the default) means "no limit."

This variable has a global value that can be set at server startup or runtime. It also has a read-only session value that indicates the effective simultaneous-connection limit that applies to the account associated with the current session. The session value is initialized as follows:

- If the user account has a nonzero `MAX_USER_CONNECTIONS` resource limit, the session `max_user_connections` value is set to that limit.
- Otherwise, the session `max_user_connections` value is set to the global value.

Account resource limits are specified using the `GRANT` statement. See Section 5.5.4, "Setting Account Resource Limits", and Section 12.4.1.3, "`GRANT` Syntax".

- `max_write_lock_count`

Command-Line Format	`--max_write_lock_count=#`	
Option-File Format	`max_write_lock_count`	
Option Sets Variable	Yes, `max_write_lock_count`	
Variable Name	`max_write_lock_count`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`4294967295`
	Range	`1-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`18446744073709547520`
	Range	`1-18446744073709547520`

After this many write locks, permit some pending read lock requests to be processed in between.

- `min_examined_row_limit`

Command-Line Format	`--min-examined-row-limit=#`

Option-File Format	`min-examined-row-limit`	
Variable Name	`min_examined_row_limit`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

Queries that examine fewer than this number of rows are not logged to the slow query log.

- `myisam_data_pointer_size`

Command-Line Format	`--myisam_data_pointer_size=#`	
Option-File Format	`myisam_data_pointer_size`	
Option Sets Variable	Yes, `myisam_data_pointer_size`	
Variable Name	`myisam_data_pointer_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`6`
	Range	`2-7`

The default pointer size in bytes, to be used by `CREATE TABLE` for `MyISAM` tables when no `MAX_ROWS` option is specified. This variable cannot be less than 2 or larger than 7. The default value is 6. See Section C.5.2.12, “`The table is full`”.

- `myisam_max_sort_file_size`

Command-Line Format	`--myisam_max_sort_file_size=#`	
Option-File Format	`myisam_max_sort_file_size`	
Option Sets Variable	Yes, `myisam_max_sort_file_size`	
Variable Name	`myisam_max_sort_file_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`2147483648`

The maximum size of the temporary file that MySQL is permitted to use while re-creating a `MyISAM` index (during `REPAIR TABLE`, `ALTER TABLE`, or `LOAD DATA INFILE`). If the file size would be larger than this value, the index is created using the key cache instead, which is slower. The value is given in bytes.

The default value is 2GB. If `MyISAM` index files exceed this size and disk space is available, increasing the value may help performance. The space must be available in the file system containing the directory where the original index file is located.

- `myisam_mmap_size`

<table>
<tr><td>Version Introduced</td><td>5.5.1</td></tr>
<tr><td>Command-Line Format</td><td><code>--myisam_mmap_size=#</code></td></tr>
<tr><td>Option-File Format</td><td><code>myisam_mmap_size</code></td></tr>
<tr><td>Option Sets Variable</td><td>Yes, <code>myisam_mmap_size</code></td></tr>
<tr><td>Variable Name</td><td><code>myisam_mmap_size</code></td></tr>
<tr><td>Variable Scope</td><td>Global</td></tr>
<tr><td>Dynamic Variable</td><td>No</td></tr>
<tr><td></td><td><table>
<tr><th colspan="2">Permitted Values</th></tr>
<tr><td>Platform Bit Size</td><td><code>32</code></td></tr>
<tr><td>Type</td><td><code>numeric</code></td></tr>
<tr><td>Default</td><td><code>4294967295</code></td></tr>
<tr><td>Range</td><td><code>7-4294967295</code></td></tr>
</table></td></tr>
<tr><td></td><td><table>
<tr><th colspan="2">Permitted Values</th></tr>
<tr><td>Platform Bit Size</td><td><code>64</code></td></tr>
<tr><td>Type</td><td><code>numeric</code></td></tr>
<tr><td>Default</td><td><code>18446744073709547520</code></td></tr>
<tr><td>Range</td><td><code>7-18446744073709547520</code></td></tr>
</table></td></tr>
</table>

The maximum amount of memory to use for memory mapping compressed `MyISAM` files. If many compressed `MyISAM` tables are used, the value can be decreased to reduce the likelihood of memory-swapping problems. This variable was added in MySQL 5.5.1.

- `myisam_recover_options`

Variable Name	`myisam_recover_options`
Variable Scope	Global
Dynamic Variable	No

The value of the `--myisam-recover-options` option. See Section 5.1.2, “Server Command Options”.

- `myisam_repair_threads`

<table>
<tr><td>Command-Line Format</td><td><code>--myisam_repair_threads=#</code></td></tr>
<tr><td>Option-File Format</td><td><code>myisam_repair_threads</code></td></tr>
<tr><td>Option Sets Variable</td><td>Yes, <code>myisam_repair_threads</code></td></tr>
<tr><td>Variable Name</td><td><code>myisam_repair_threads</code></td></tr>
<tr><td>Variable Scope</td><td>Global, Session</td></tr>
<tr><td>Dynamic Variable</td><td>Yes</td></tr>
<tr><td></td><td><table>
<tr><th colspan="2">Permitted Values</th></tr>
<tr><td>Platform Bit Size</td><td><code>32</code></td></tr>
<tr><td>Type</td><td><code>numeric</code></td></tr>
<tr><td>Default</td><td><code>1</code></td></tr>
<tr><td>Range</td><td><code>1-4294967295</code></td></tr>
</table></td></tr>
</table>

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1`
	Range	`1-18446744073709547520`

If this value is greater than 1, `MyISAM` table indexes are created in parallel (each index in its own thread) during the `Repair by sorting` process. The default value is 1.

> **Note**
>
> Multi-threaded repair is still *beta-quality* code.

- `myisam_sort_buffer_size`

Command-Line Format	`--myisam_sort_buffer_size=#`	
Option-File Format	`myisam_sort_buffer_size`	
Option Sets Variable	Yes, `myisam_sort_buffer_size`	
Variable Name	`myisam_sort_buffer_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`8388608`
	Range	`4-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`8388608`
	Range	`4-18446744073709547520`

The size of the buffer that is allocated when sorting `MyISAM` indexes during a `REPAIR TABLE` or when creating indexes with `CREATE INDEX` or `ALTER TABLE`.

The maximum permissible setting for `myisam_sort_buffer_size` is 4GB. Values larger than 4GB are permitted for 64-bit platforms (except 64-bit Windows, for which large values are truncated to 4GB with a warning).

- `myisam_stats_method`

Command-Line Format	`--myisam_stats_method=name`
Option-File Format	`myisam_stats_method`
Option Sets Variable	Yes, `myisam_stats_method`
Variable Name	`myisam_stats_method`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`enumeration`

	Valid Values	`nulls_equal`
		`nulls_unequal`
		`nulls_ignored`

How the server treats `NULL` values when collecting statistics about the distribution of index values for `MyISAM` tables. This variable has three possible values, `nulls_equal`, `nulls_unequal`, and `nulls_ignored`. For `nulls_equal`, all `NULL` index values are considered equal and form a single value group that has a size equal to the number of `NULL` values. For `nulls_unequal`, `NULL` values are considered unequal, and each `NULL` forms a distinct value group of size 1. For `nulls_ignored`, `NULL` values are ignored.

The method that is used for generating table statistics influences how the optimizer chooses indexes for query execution, as described in Section 7.3.7, “`InnoDB` and `MyISAM` Index Statistics Collection”.

- `myisam_use_mmap`

Command-Line Format	`--myisam_use_mmap`	
Option-File Format	`myisam_use_mmap`	
Option Sets Variable	Yes, `myisam_use_mmap`	
Variable Name	`myisam_use_mmap`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Use memory mapping for reading and writing `MyISAM` tables.

- `named_pipe`

Variable Name	`named_pipe`	
Variable Scope	Global	
Dynamic Variable	No	
Platform Specific	windows	
	Permitted Values	
	Type (windows)	`boolean`
	Default	`OFF`

(Windows only.) Indicates whether the server supports connections over named pipes.

- `net_buffer_length`

Command-Line Format	`--net_buffer_length=#`
Option-File Format	`net_buffer_length`
Option Sets Variable	Yes, `net_buffer_length`
Variable Name	`net_buffer_length`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`16384`
	Range	`1024-1048576`

Each client thread is associated with a connection buffer and result buffer. Both begin with a size given by `net_buffer_length` but are dynamically enlarged up to `max_allowed_packet` bytes as needed. The result buffer shrinks to `net_buffer_length` after each SQL statement.

This variable should not normally be changed, but if you have very little memory, you can set it to the expected length of statements sent by clients. If statements exceed this length, the connection buffer is automatically enlarged. The maximum value to which `net_buffer_length` can be set is 1MB.

The session value of this variable is read only.

- `net_read_timeout`

Command-Line Format	`--net_read_timeout=#`	
Option-File Format	`net_read_timeout`	
Option Sets Variable	Yes, `net_read_timeout`	
Variable Name	`net_read_timeout`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`30`
	Min Value	`1`

The number of seconds to wait for more data from a connection before aborting the read. When the server is reading from the client, `net_read_timeout` is the timeout value controlling when to abort. When the server is writing to the client, `net_write_timeout` is the timeout value controlling when to abort. See also `slave_net_timeout`.

- `net_retry_count`

Command-Line Format	`--net_retry_count=#`	
Option-File Format	`net_retry_count`	
Option Sets Variable	Yes, `net_retry_count`	
Variable Name	`net_retry_count`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`10`
	Range	`1-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`10`
	Range	`1-18446744073709547520`

If a read or write on a communication port is interrupted, retry this many times before giving up. This value should be set quite high on FreeBSD because internal interrupts are sent to all threads.

- `net_write_timeout`

<table>
<tr><td>Command-Line Format</td><td colspan="2"><code>--net_write_timeout=#</code></td></tr>
<tr><td>Option-File Format</td><td colspan="2"><code>net_write_timeout</code></td></tr>
<tr><td>Option Sets Variable</td><td colspan="2">Yes, <code>net_write_timeout</code></td></tr>
<tr><td>Variable Name</td><td colspan="2"><code>net_write_timeout</code></td></tr>
<tr><td>Variable Scope</td><td colspan="2">Global, Session</td></tr>
<tr><td>Dynamic Variable</td><td colspan="2">Yes</td></tr>
<tr><td rowspan="4"></td><td colspan="2">Permitted Values</td></tr>
<tr><td>Type</td><td><code>numeric</code></td></tr>
<tr><td>Default</td><td><code>60</code></td></tr>
<tr><td>Min Value</td><td><code>1</code></td></tr>
</table>

The number of seconds to wait for a block to be written to a connection before aborting the write. See also `net_read_timeout`.

- `new`

<table>
<tr><td>Command-Line Format</td><td colspan="2"><code>--new</code></td></tr>
<tr><td></td><td colspan="2"><code>-n</code></td></tr>
<tr><td>Option-File Format</td><td colspan="2"><code>new</code></td></tr>
<tr><td>Option Sets Variable</td><td colspan="2">Yes, <code>new</code></td></tr>
<tr><td>Variable Name</td><td colspan="2"><code>new</code></td></tr>
<tr><td>Variable Scope</td><td colspan="2">Global, Session</td></tr>
<tr><td>Dynamic Variable</td><td colspan="2">Yes</td></tr>
<tr><td>Disabled by</td><td colspan="2"><code>skip-new</code></td></tr>
<tr><td rowspan="3"></td><td colspan="2">Permitted Values</td></tr>
<tr><td>Type</td><td><code>boolean</code></td></tr>
<tr><td>Default</td><td><code>FALSE</code></td></tr>
</table>

This variable was used in MySQL 4.0 to turn on some 4.1 behaviors, and is retained for backward compatibility. In MySQL 5.5, its value is always `OFF`.

- `old`

Command-Line Format	`--old`
Option-File Format	`old`
Variable Name	`old`
Variable Scope	Global
Dynamic Variable	No

`old` is a compatibility variable. It is disabled by default, but can be enabled at startup to revert the server to behaviors present in older versions.

Currently, when `old` is enabled, it changes the default scope of index hints to that used prior to MySQL 5.1.17. That is, index hints with no `FOR` clause apply only to how indexes are used for row retrieval and not to resolution of `ORDER BY` or `GROUP BY` clauses. (See Section 12.2.9.2, “Index Hint Syntax”.) Take care about enabling this in a replication setup. With statement-based binary logging, having different modes for the master and slaves might lead to replication errors.

- `old_alter_table`

Command-Line Format	`--old-alter-table`	
Option-File Format	`old-alter-table`	
Option Sets Variable	Yes, `old_alter_table`	
Variable Name	`old_alter_table`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

When this variable is enabled, the server does not use the optimized method of processing an `ALTER TABLE` operation. It reverts to using a temporary table, copying over the data, and then renaming the temporary table to the original, as used by MySQL 5.0 and earlier. For more information on the operation of `ALTER TABLE`, see Section 12.1.6, “`ALTER TABLE` Syntax”.

- `old_passwords`

Command-Line Format	`--old_passwords`	
Option-File Format	`old-passwords`	
Option Sets Variable	Yes, `old_passwords`	
Variable Name	`old_passwords`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Whether the server should use pre-4.1-style passwords for MySQL user accounts. See Section C.5.2.4, “`Client does not support authentication protocol`”.

- `one_shot`

  This is not a variable, but it can be used when setting some variables. It is described in Section 12.4.4, “`SET` Syntax”.

- `open_files_limit`

Command-Line Format	`--open-files-limit=#`	
Option-File Format	`open-files-limit`	
Option Sets Variable	Yes, `open_files_limit`	
Variable Name	`open_files_limit`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-65535`

The number of files that the operating system permits `mysqld` to open. This is the real value permitted by the system and might be different from the value you gave using the `--open-files-limit` option to `mysqld` or `mysqld_safe`. The value is 0 on systems where MySQL cannot change the number of open files.

- `optimizer_prune_level`

Command-Line Format	`--optimizer_prune_level[=#]`

Option-File Format	`optimizer_prune_level`	
Option Sets Variable	Yes, `optimizer_prune_level`	
Variable Name	`optimizer_prune_level`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`1`

Controls the heuristics applied during query optimization to prune less-promising partial plans from the optimizer search space. A value of 0 disables heuristics so that the optimizer performs an exhaustive search. A value of 1 causes the optimizer to prune plans based on the number of rows retrieved by intermediate plans.

- `optimizer_search_depth`

Command-Line Format	`--optimizer_search_depth[=#]`	
Option-File Format	`optimizer_search_depth`	
Option Sets Variable	Yes, `optimizer_search_depth`	
Variable Name	`optimizer_search_depth`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.99)	
	Type	`numeric`
	Default	`62`
	Range	`0-63`

The maximum depth of search performed by the query optimizer. Values larger than the number of relations in a query result in better query plans, but take longer to generate an execution plan for a query. Values smaller than the number of relations in a query return an execution plan quicker, but the resulting plan may be far from being optimal. If set to 0, the system automatically picks a reasonable value. If set to 63, the optimizer switches to the algorithm used in MySQL 5.0.0 (and previous versions) for performing searches. The value of 63 is deprecated and will be treated as invalid in a future MySQL release.

- `optimizer_switch`

Command-Line Format	`--optimizer_switch=value`	
Option-File Format	`optimizer_switch`	
	`optimizer_switch`	
	`optimizer_switch`	
Option Sets Variable	Yes, `optimizer_switch`	
Variable Name	`optimizer_switch`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.2)	
	Type	`set`

	Valid Values	`index_merge={on|off}`
		`index_merge_intersection={on|off}`
		`index_merge_sort_union={on|off}`
		`index_merge_union={on|off}`

	Permitted Values (>= 5.5.3)	
	Type	`set`

	Valid Values	`engine_condition_pushdown={on|off}`
		`index_merge={on|off}`
		`index_merge_intersection={on|off}`
		`index_merge_sort_union={on|off}`
		`index_merge_union={on|off}`

The `optimizer_switch` system variable enables control over optimizer behavior. The value of this variable is a set of flags, each of which has a value of `on` or `off` to indicate whether the corresponding optimizer behavior is enabled or disabled. This variable has global and session values and can be changed at runtime. The global default can be set at server startup.

To see the current set of optimizer flags, select the variable value:

```
mysql> SELECT @@optimizer_switch\G
*************************** 1. row ***************************
@@optimizer_switch: index_merge=on,index_merge_union=on,
                    index_merge_sort_union=on,
                    index_merge_intersection=on,
                    engine_condition_pushdown=on
```

For more information about the syntax of this variable and the optimizer behaviors that it controls, see Section 7.8.4.2, “Controlling Switchable Optimizations”.

- `performance_schema_xxx`

  Performance Schema system variables are listed in Section 19.8, “Performance Schema System Variables”.

- `pid_file`

Command-Line Format	`--pid-file=file_name`	
Option-File Format	`pid-file=file_name`	
Option Sets Variable	Yes, `pid_file`	
Variable Name	`pid_file`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The path name of the process ID (PID) file. This variable can be set with the `--pid-file` option.

- `plugin_dir`

Command-Line Format	`--plugin_dir=path`	
Option-File Format	`plugin_dir`	
Option Sets Variable	Yes, `plugin_dir`	
Variable Name	`plugin_dir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values (>= 5.5.0, <= 5.5.4)	
	Type (other)	`directory name`
	Default	`BASEDIR/lib/mysql/plugin`

	Permitted Values (>= 5.5.0, <= 5.5.4)	
	Type (windows)	`directory name`
	Default	`BASEDIR/lib/plugin`
	Permitted Values (>= 5.5.5)	
	Type	`directory name`
	Default	`BASEDIR/lib/plugin`

The path name of the plugin directory.

If the plugin directory is writable by the server, it may be possible for a user to write executable code to a file in the directory using `SELECT ... INTO DUMPFILE`. This can be prevented by making `plugin_dir` read only to the server or by setting `--secure-file-priv` to a directory where `SELECT` writes can be made safely.

- `port`

Command-Line Format	`--port=#`	
	`-P`	
Option-File Format	`port`	
Option Sets Variable	Yes, `port`	
Variable Name	`port`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`3306`

The number of the port on which the server listens for TCP/IP connections. This variable can be set with the `--port` option.

- `preload_buffer_size`

Command-Line Format	`--preload_buffer_size=#`	
Option-File Format	`preload_buffer_size`	
Option Sets Variable	Yes, `preload_buffer_size`	
Variable Name	`preload_buffer_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`32768`
	Range	`1024-1073741824`

The size of the buffer that is allocated when preloading indexes.

- `profiling`

If set to 0 (the default), statement profiling is disabled. If set to 1, statement profiling is enabled and the `SHOW PROFILES` and `SHOW PROFILE` statements provide access to profiling information. See Section 12.4.5.32, “`SHOW PROFILES` Syntax”.

- `profiling_history_size`

The number of statements for which to maintain profiling information if `profiling` is enabled. The default value is 15. The maximum value is 100. Setting the value to 0 effectively disables profiling. See Section 12.4.5.32, “`SHOW PROFILES` Syntax”.

- `protocol_version`

Variable Name	`protocol_version`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`

  The version of the client/server protocol used by the MySQL server.

- `proxy_user`

Version Introduced	5.5.7	
Variable Name	`proxy_user`	
Variable Scope	Session	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

  If the current client is a proxy for another user, this variable is the proxy user account name. Otherwise, this variable is `NULL`. See Section 5.5.7, “Proxy Users”.

  This variable was added in MySQL 5.5.7.

- `pseudo_thread_id`

Variable Name	`pseudo_thread_id`	
Variable Scope	Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`

  This variable is for internal server use.

- `query_alloc_block_size`

Command-Line Format	`--query_alloc_block_size=#`	
Option-File Format	`query_alloc_block_size`	
Option Sets Variable	Yes, `query_alloc_block_size`	
Variable Name	`query_alloc_block_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`8192`
	Range	`1024-4294967295`
	Block Size	`1024`

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`8192`
	Range	`1024-18446744073709547520`
	Block Size	`1024`

The allocation size of memory blocks that are allocated for objects created during statement parsing and execution. If you have problems with memory fragmentation, it might help to increase this parameter.

- `query_cache_limit`

Command-Line Format	`--query_cache_limit=#`	
Option-File Format	`query_cache_limit`	
Option Sets Variable	Yes, `query_cache_limit`	
Variable Name	`query_cache_limit`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`1048576`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1048576`
	Range	`0-18446744073709547520`

Do not cache results that are larger than this number of bytes. The default value is 1MB.

- `query_cache_min_res_unit`

Command-Line Format	`--query_cache_min_res_unit=#`	
Option-File Format	`query_cache_min_res_unit`	
Option Sets Variable	Yes, `query_cache_min_res_unit`	
Variable Name	`query_cache_min_res_unit`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`4096`
	Range	`512-4294967295`

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`4096`
	Range	`512-18446744073709547520`

The minimum size (in bytes) for blocks allocated by the query cache. The default value is 4096 (4KB). Tuning information for this variable is given in Section 7.9.3.3, “Query Cache Configuration”.

- `query_cache_size`

Command-Line Format	`--query_cache_size=#`	
Option-File Format	`query_cache_size`	
Option Sets Variable	Yes, `query_cache_size`	
Variable Name	`query_cache_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

The amount of memory allocated for caching query results. The default value is 0, which disables the query cache. To reduce overhead significantly, you should also start the server with `query_cache_type=0` if you will not be using the query cache. The permissible values are multiples of 1024; other values are rounded down to the nearest multiple. Note that `query_cache_size` bytes of memory are allocated even if `query_cache_type` is set to 0. See Section 7.9.3.3, “Query Cache Configuration”, for more information.

The query cache needs a minimum size of about 40KB to allocate its structures. (The exact size depends on system architecture.) If you set the value of `query_cache_size` too small, a warning will occur, as described in Section 7.9.3.3, “Query Cache Configuration”.

- `query_cache_type`

Command-Line Format	`--query_cache_type=#`
Option-File Format	`query_cache_type`
Option Sets Variable	Yes, `query_cache_type`
Variable Name	`query_cache_type`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`enumeration`
	Default	`1`

	Valid Values	`0`
		`1`
		`2`

Set the query cache type. Setting the `GLOBAL` value sets the type for all clients that connect thereafter. Individual clients can set the `SESSION` value to affect their own use of the query cache. Possible values are shown in the following table.

Option	Description
`0` or `OFF`	Do not cache results in or retrieve results from the query cache. Note that this does not deallocate the query cache buffer. To do that, you should set `query_cache_size` to 0.
`1` or `ON`	Cache all cacheable query results except for those that begin with `SELECT SQL_NO_CACHE`.
`2` or `DEMAND`	Cache results only for cacheable queries that begin with `SELECT SQL_CACHE`.

This variable defaults to `ON`.

If the server is started with `query_cache_type` set to 0, it does not acquire the query cache mutex at all, which means that the query cache cannot be enabled at runtime and there is reduced overhead in query execution.

- `query_cache_wlock_invalidate`

Command-Line Format	`--query_cache_wlock_invalidate`	
Option-File Format	`query_cache_wlock_invalidate`	
Option Sets Variable	Yes, `query_cache_wlock_invalidate`	
Variable Name	`query_cache_wlock_invalidate`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Normally, when one client acquires a `WRITE` lock on a `MyISAM` table, other clients are not blocked from issuing statements that read from the table if the query results are present in the query cache. Setting this variable to 1 causes acquisition of a `WRITE` lock for a table to invalidate any queries in the query cache that refer to the table. This forces other clients that attempt to access the table to wait while the lock is in effect.

- `query_prealloc_size`

Command-Line Format	`--query_prealloc_size=#`
Option-File Format	`query_prealloc_size`
Option Sets Variable	Yes, `query_prealloc_size`
Variable Name	`query_prealloc_size`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`8192`
	Range	`8192-4294967295`
	Block Size	`1024`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`8192`
	Range	`8192-18446744073709547520`
	Block Size	`1024`

The size of the persistent buffer used for statement parsing and execution. This buffer is not freed between statements. If you are running complex queries, a larger `query_prealloc_size` value might be helpful in improving performance, because it can reduce the need for the server to perform memory allocation during query execution operations.

- `rand_seed1`

  The `rand_seed1` and `rand_seed2` variables exist as session variables only, and can be set but not read. The variables—but not their values—are shown in the output of `SHOW VARIABLES`.

  The purpose of these variables is to support replication of the `RAND()` function. For statements that invoke `RAND()`, the master passes two values to the slave, where they are used to seed the random number generator. The slave uses these values to set the session variables `rand_seed1` and `rand_seed2` so that `RAND()` on the slave generates the same value as on the master.

- `rand_seed2`

  See the description for `rand_seed1`.

- `range_alloc_block_size`

Command-Line Format	`--range_alloc_block_size=#`	
Option-File Format	`range_alloc_block_size`	
Option Sets Variable	Yes, `range_alloc_block_size`	
Variable Name	`range_alloc_block_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`4096`
	Range	`4096-4294967295`
	Block Size	`1024`

The size of blocks that are allocated when doing range optimization.

- `read_buffer_size`

Command-Line Format	`--read_buffer_size=#`

Option-File Format	`read_buffer_size`	
Option Sets Variable	Yes, `read_buffer_size`	
Variable Name	`read_buffer_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`131072`
	Range	`8200-2147479552`

Each thread that does a sequential scan allocates a buffer of this size (in bytes) for each table it scans. If you do many sequential scans, you might want to increase this value, which defaults to 131072. The value of this variable should be a multiple of 4KB. If it is set to a value that is not a multiple of 4KB, its value will be rounded down to the nearest multiple of 4KB.

The maximum permissible setting for `read_buffer_size` is 2GB.

`read_buffer_size` and `read_rnd_buffer_size` are not specific to any storage engine and apply in a general manner for optimization. See Section 7.11.4.1, "How MySQL Uses Memory", for example.

- `read_only`

Command-Line Format	`--read-only`	
Option-File Format	`read_only`	
Option Sets Variable	Yes, `read_only`	
Variable Name	`read_only`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`

This variable is off by default. When it is enabled, the server permits no updates except from users that have the `SUPER` privilege or (on a slave server) from updates performed by slave threads. In replication setups, it can be useful to enable `read_only` on slave servers to ensure that slaves accept updates only from the master server and not from clients.

`read_only` does not apply to `TEMPORARY` tables, nor does it prevent the server from inserting rows into the log tables (see Section 5.2.1, "Selecting General Query and Slow Query Log Output Destinations"). This variable does not prevent the use of `ANALYZE TABLE` or `OPTIMIZE TABLE` statements because its purpose is to prevent changes to table structure or contents. Analysis and optimization do not qualify as such changes. This means, for example, that consistency checks on read-only slaves can be performed with `mysqlcheck --all-databases --analyze`.

`read_only` exists only as a `GLOBAL` variable, so changes to its value require the `SUPER` privilege. Changes to `read_only` on a master server are not replicated to slave servers. The value can be set on a slave server independent of the setting on the master.

> ### Important
>
> In MySQL 5.5, enabling `read_only` prevents the use of the `SET PASSWORD` statement by any user not having the `SUPER` privilege. This is not necessarily the case for all MySQL release series. When replicating from one MySQL release series to another (for example, from a MySQL 5.0 master to a MySQL 5.1 or later slave), you should check the documentation for the versions running on both master and slave to determine whether the behavior of `read_only` in this regard is or is not the same, and, if it is different, whether this has an impact on your applications.

The following conditions apply:

- If you attempt to enable `read_only` while you have any explicit locks (acquired with `LOCK TABLES`) or have a pending transaction, an error occurs.
- If you attempt to enable `read_only` while other clients hold explicit table locks or have pending transactions, the attempt

blocks until the locks are released and the transactions end. While the attempt to enable `read_only` is pending, requests by other clients for table locks or to begin transactions also block until `read_only` has been set.

- `read_only` can be enabled while you hold a global read lock (acquired with `FLUSH TABLES WITH READ LOCK`) because that does not involve table locks.

As of MySQL 5.5.3, attempts to set `read_only` block for active transactions that hold metadata locks until those transactions end.

- `read_rnd_buffer_size`

Command-Line Format	`--read_rnd_buffer_size=#`	
Option-File Format	`read_rnd_buffer_size`	
Option Sets Variable	Yes, `read_rnd_buffer_size`	
Variable Name	`read_rnd_buffer_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`262144`
	Range	`8200-4294967295`

When reading rows in sorted order following a key-sorting operation, the rows are read through this buffer to avoid disk seeks. See Section 7.13.9, "`ORDER BY` Optimization". Setting the variable to a large value can improve `ORDER BY` performance by a lot. However, this is a buffer allocated for each client, so you should not set the global variable to a large value. Instead, change the session variable only from within those clients that need to run large queries.

The maximum permissible setting for `read_rnd_buffer_size` is 2GB.

`read_buffer_size` and `read_rnd_buffer_size` are not specific to any storage engine and apply in a general manner for optimization. See Section 7.11.4.1, "How MySQL Uses Memory", for example.

- `relay_log_purge`

Command-Line Format	`--relay_log_purge`	
Option-File Format	`relay_log_purge`	
Option Sets Variable	Yes, `relay_log_purge`	
Variable Name	`relay_log_purge`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`TRUE`

Disables or enables automatic purging of relay log files as soon as they are not needed any more. The default value is 1 (`ON`).

- `relay_log_space_limit`

Command-Line Format	`--relay_log_space_limit=#`
Option-File Format	`relay_log_space_limit`
Option Sets Variable	Yes, `relay_log_space_limit`
Variable Name	`relay_log_space_limit`
Variable Scope	Global
Dynamic Variable	No

	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

The maximum amount of space to use for all relay logs.

- `report_host`

Command-Line Format	`--report-host=host_name`	
Option-File Format	`report-host`	
Option Sets Variable	Yes, `report_host`	
Variable Name	`report-host`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The value of the `--report-host` option.

- `report_password`

Command-Line Format	`--report-password=name`	
Option-File Format	`report-password`	
Option Sets Variable	Yes, `report_password`	
Variable Name	`report-password`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The value of the `--report-password` option. Not the same as the password used for the MySQL replication user account.

- `report_port`

Command-Line Format	`--report-port=#`
Option-File Format	`report-port`
Option Sets Variable	Yes, `report_port`
Variable Name	`report-port`
Variable Scope	Global
Dynamic Variable	No

	Permitted Values	
	Type	`numeric`
	Default	`3306`

The value of the `--report-port` option.

- `report_user`

Command-Line Format	`--report-user=name`	
Option-File Format	`report-user`	
Option Sets Variable	Yes, `report_user`	
Variable Name	`report-user`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The value of the `--report-user` option. Not the same as the name for the MySQL replication user account.

- `rpl_semi_sync_master_enabled`

Variable Name	`rpl_semi_sync_master_enabled`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Controls whether semisynchronous replication is enabled on the master. To enable or disable the plugin, set this variable to `ON` or `OFF` (or 1 or 0), respectively. The default is `OFF`.

This variable is available only if the master-side semisynchronous replication plugin is installed.

- `rpl_semi_sync_master_timeout`

Variable Name	`rpl_semi_sync_master_timeout`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values (>= 5.5.0)	
	Type	`numeric`
	Default	`10000`

A value in milliseconds that controls how long the master waits on a commit for acknowledgment from a slave before timing out and reverting to asynchronous replication. The default value is 10000 (10 seconds).

This variable is available only if the master-side semisynchronous replication plugin is installed.

- `rpl_semi_sync_master_trace_level`

Variable Name	`rpl_semi_sync_master_trace_level`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`32`

The semisynchronous replication debug trace level on the master. Currently, four levels are defined:

- 1 = general level (for example, time function failures)
- 16 = detail level (more verbose information)
- 32 = net wait level (more information about network waits)
- 64 = function level (information about function entry and exit)

This variable is available only if the master-side semisynchronous replication plugin is installed.

- `rpl_semi_sync_master_wait_no_slave`

Variable Name	`rpl_semi_sync_master_wait_no_slave`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

With semisynchronous replication, for each transaction, the master waits until timeout for acknowledgment of receipt from some semisynchronous slave. If no response occurs during this period, the master reverts to normal replication. This variable controls whether the master waits for the timeout to expire before reverting to normal replication even if the slave count drops to zero during the timeout period.

If the value is `ON` (the default), it is permissible for the slave count to drop to zero during the timeout period (for example, if slaves disconnect). The master still waits for the timeout, so as long as some slave reconnects and acknowledges the transaction within the timeout interval, semisynchronous replication continues.

If the value is `OFF`, the master reverts to normal replication if the slave count drops to zero during the timeout period.

This variable is available only if the master-side semisynchronous replication plugin is installed.

- `rpl_semi_sync_slave_enabled`

Variable Name	`rpl_semi_sync_slave_enabled`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Controls whether semisynchronous replication is enabled on the slave. To enable or disable the plugin, set this variable to `ON` or `OFF` (or 1 or 0), respectively. The default is `OFF`.

This variable is available only if the slave-side semisynchronous replication plugin is installed.

- `rpl_semi_sync_slave_trace_level`

Variable Name	`rpl_semi_sync_slave_trace_level`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`32`

The semisynchronous replication debug trace level on the slave. See `rpl_semi_sync_master_trace_level` for the permissible values.

This variable is available only if the slave-side semisynchronous replication plugin is installed.

- `secure_auth`

Command-Line Format	`--secure-auth`	
Option-File Format	`secure-auth`	
Option Sets Variable	Yes, `secure_auth`	
Variable Name	`secure_auth`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

If the MySQL server has been started with the `--secure-auth` option, it blocks connections from all accounts that have passwords stored in the old (pre-4.1) format. In that case, the value of this variable is `ON`, otherwise it is `OFF`.

You should enable this option if you want to prevent all use of passwords employing the old format (and hence insecure communication over the network).

Server startup fails with an error if this option is enabled and the privilege tables are in pre-4.1 format. See Section C.5.2.4, “`Client does not support authentication protocol`”.

- `secure_file_priv`

Command-Line Format	`--secure-file-priv=path`	
Option-File Format	`secure-file-priv=path`	
Option Sets Variable	Yes, `secure_file_priv`	
Variable Name	`secure-file-priv`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

By default, this variable is empty. If set to the name of a directory, it limits the effect of the `LOAD_FILE()` function and the `LOAD DATA` and `SELECT ... INTO OUTFILE` statements to work only with files in that directory.

- `server_id`

Command-Line Format	`--server-id=#`
Option-File Format	`server-id`
Option Sets Variable	Yes, `server_id`
Variable Name	`server_id`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`

The server ID, used in replication to give each master and slave a unique identity. This variable is set by the `--server-id` option. For each server participating in replication, you should pick a positive integer in the range from 1 to $2^{32} - 1$ to act as that server's ID.

- `shared_memory`

Variable Name	`shared_memory`
Variable Scope	Global
Dynamic Variable	No
Platform Specific	windows

(Windows only.) Whether the server permits shared-memory connections.

- `shared_memory_base_name`

Variable Name	`shared_memory_base_name`
Variable Scope	Global
Dynamic Variable	No
Platform Specific	windows

(Windows only.) The name of shared memory to use for shared-memory connections. This is useful when running multiple MySQL instances on a single physical machine. The default name is `MYSQL`. The name is case sensitive.

- `skip_external_locking`

  This is `OFF` if `mysqld` uses external locking, `ON` if external locking is disabled. This affects only `MyISAM` table access.

- `skip_name_resolve`

  This variable is set from the value of the `--skip-name-resolve` option. If it is `ON`, `mysqld` resolves host names when checking client connections. If `OFF`, `mysqld` uses only IP numbers and all `Host` column values in the grant tables must be IP addresses or `localhost`. See Section 7.11.5.2, “How MySQL Uses DNS”.

  This variable was added in MySQL 5.5.5.

- `skip_networking`

  This is `ON` if the server permits only local (non-TCP/IP) connections. On Unix, local connections use a Unix socket file. On Windows, local connections use a named pipe or shared memory. This variable can be set to `ON` with the `--skip-networking` option.

- `skip_show_database`

  This prevents people from using the `SHOW DATABASES` statement if they do not have the `SHOW DATABASES` privilege. This can improve security if you have concerns about users being able to see databases belonging to other users. Its effect depends on the `SHOW DATABASES` privilege: If the variable value is `ON`, the `SHOW DATABASES` statement is permitted only to users who have the `SHOW DATABASES` privilege, and the statement displays all database names. If the value is `OFF`, `SHOW DATABASES` is permitted to all users, but displays the names of only those databases for which the user has the `SHOW DATABASES` or other privilege.

- `slow_launch_time`

Command-Line Format	`--slow_launch_time=#`
Option-File Format	`slow_launch_time`
Option Sets Variable	Yes, `slow_launch_time`

Variable Name	`slow_launch_time`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`2`

If creating a thread takes longer than this many seconds, the server increments the `Slow_launch_threads` status variable.

- `slow_query_log`

Command-Line Format	`--slow-query-log`	
Option-File Format	`slow-query-log`	
Option Sets Variable	Yes, `slow_query_log`	
Variable Name	`slow_query_log`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Whether the slow query log is enabled. The value can be 0 (or `OFF`) to disable the log or 1 (or `ON`) to enable the log. The default value depends on whether the `--slow_query_log` option is given. The destination for log output is controlled by the `log_output` system variable; if that value is `NONE`, no log entries are written even if the log is enabled.

- `slow_query_log_file`

Command-Line Format	`--slow-query-log-file=file_name`	
Option-File Format	`slow_query_log_file`	
Option Sets Variable	Yes, `slow_query_log_file`	
Variable Name	`slow_query_log_file`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`file name`

The name of the slow query log file. The default value is *`host_name`*`-slow.log`, but the initial value can be changed with the `--slow_query_log_file` option.

- `socket`

Command-Line Format	`--socket=name`	
Option-File Format	`socket`	
Option Sets Variable	Yes, `socket`	
Variable Name	`socket`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`
	Default	`/tmp/mysql.sock`

On Unix platforms, this variable is the name of the socket file that is used for local client connections. The default is `/tmp/mysql.sock`. (For some distribution formats, the directory might be different, such as `/var/lib/mysql` for RPMs.)

On Windows, this variable is the name of the named pipe that is used for local client connections. The default value is `MySQL` (not case sensitive).

- `sort_buffer_size`

Command-Line Format	`--sort_buffer_size=#`	
Option-File Format	`sort_buffer_size`	
Option Sets Variable	Yes, `sort_buffer_size`	
Variable Name	`sort_buffer_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`2097144`
	Max Value	`4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`2097144`
	Max Value	`18446744073709547520`

Each session that needs to do a sort allocates a buffer of this size. `sort_buffer_size` is not specific to any storage engine and applies in a general manner for optimization. See Section 7.13.9, “`ORDER BY` Optimization”, for example.

If you see many `Sort_merge_passes` per second in `SHOW GLOBAL STATUS` output, you can consider increasing the `sort_buffer_size` value to speed up `ORDER BY` or `GROUP BY` operations that cannot be improved with query optimization or improved indexing. The entire buffer is allocated even if it is not all needed, so setting it larger than required globally will slow down most queries that sort. It is best to increase it as a session setting, and only for the sessions that need a larger size. On Linux, there are thresholds of 256KB and 2MB where larger values may significantly slow down memory allocation, so you should consider staying below one of those values. Experiment to find the best value for your workload. See Section C.5.4.4, “Where MySQL Stores Temporary Files”.

The maximum permissible setting for `sort_buffer_size` is 4GB. Values larger than 4GB are permitted for 64-bit platforms (except 64-bit Windows, for which large values are truncated to 4GB with a warning).

- `sql_auto_is_null`

Variable Name	`sql_auto_is_null`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.2)	
	Type	`boolean`
	Default	`1`
	Permitted Values (>= 5.5.3)	
	Type	`boolean`
	Default	`0`

If this variable is set to 1, then after a statement that successfully inserts an automatically generated `AUTO_INCREMENT` value, you can find that value by issuing a statement of the following form:

```
SELECT * FROM tbl_name WHERE auto_col IS NULL
```

If the statement returns a row, the value returned is the same as if you invoked the `LAST_INSERT_ID()` function. For details, including the return value after a multiple-row insert, see Section 11.14, “Information Functions”. If no `AUTO_INCREMENT` value was successfully inserted, the `SELECT` statement returns no row.

The behavior of retrieving an `AUTO_INCREMENT` value by using an `IS NULL` comparison is used by some ODBC programs, such as Access. See Section 20.1.7.1.1, “Obtaining Auto-Increment Values”. This behavior can be disabled by setting `sql_auto_is_null` to 0.

The default value of `sql_auto_is_null` is 0 as of MySQL 5.5.3, and 1 for earlier versions.

- `sql_big_selects`

Variable Name	`sql_big_selects`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`1`

If set to 0, MySQL aborts `SELECT` statements that are likely to take a very long time to execute (that is, statements for which the optimizer estimates that the number of examined rows exceeds the value of `max_join_size`). This is useful when an inadvisable `WHERE` statement has been issued. The default value for a new connection is 1, which permits all `SELECT` statements.

If you set the `max_join_size` system variable to a value other than `DEFAULT`, `sql_big_selects` is set to 0.

- `sql_buffer_result`

Variable Name	`sql_buffer_result`	
Variable Scope	Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`0`

If set to 1, `sql_buffer_result` forces results from `SELECT` statements to be put into temporary tables. This helps MySQL free the table locks early and can be beneficial in cases where it takes a long time to send results to the client. The default value is 0.

- `sql_log_bin`

Variable Name	`sql_log_bin`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`

If set to 0, no logging is done to the binary log for the client. The client must have the `SUPER` privilege to set this option. The default value is 1.

Beginning with MySQL 5.5.5, it is no longer possible to set `@@session.sql_log_bin` within a transaction or subquery. (Bug #53437)

- `sql_log_off`

Variable Name	`sql_log_off`

Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`0`

If set to 1, no logging is done to the general query log for this client. The client must have the `SUPER` privilege to set this option. The default value is 0.

- `sql_log_update`

Version Removed	5.5.3	
Variable Name	`sql_log_update`	
Variable Scope	Session	
Dynamic Variable	Yes	
Deprecated	5.0, by `sql_log_bin`	
	Permitted Values	
	Type	`boolean`

This variable is deprecated, and is mapped to `sql_log_bin`. It was removed in MySQL 5.5.3.

- `sql_mode`

Command-Line Format	`--sql-mode=name`
Option-File Format	`sql-mode`
Option Sets Variable	Yes, `sql_mode`
Variable Name	`sql_mode`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`set`
	Default	`''`

	Valid Values	`ALLOW_INVALID_DATES`
		`ANSI_QUOTES`
		`ERROR_FOR_DIVISION_BY_ZERO`
		`HIGH_NOT_PRECEDENCE`
		`IGNORE_SPACE`
		`NO_AUTO_CREATE_USER`
		`NO_AUTO_VALUE_ON_ZERO`
		`NO_BACKSLASH_ESCAPES`
		`NO_DIR_IN_CREATE`
		`NO_ENGINE_SUBSTITUTION`
		`NO_FIELD_OPTIONS`
		`NO_KEY_OPTIONS`
		`NO_TABLE_OPTIONS`
		`NO_UNSIGNED_SUBTRACTION`
		`NO_ZERO_DATE`
		`NO_ZERO_IN_DATE`
		`ONLY_FULL_GROUP_BY`
		`PAD_CHAR_TO_FULL_LENGTH`
		`PIPES_AS_CONCAT`
		`REAL_AS_FLOAT`
		`STRICT_ALL_TABLES`
		`STRICT_TRANS_TABLES`

The current server SQL mode, which can be set dynamically. See Section 5.1.6, "Server SQL Modes".

- `sql_notes`

  If set to 1 (the default), warnings of `Note` level are recorded. If set to 0, `Note` warnings are suppressed. `mysqldump` includes output to set this variable to 0 so that reloading the dump file does not produce warnings for events that do not affect the integrity of the reload operation.

- `sql_quote_show_create`

  If set to 1 (the default), the server quotes identifiers for `SHOW CREATE TABLE` and `SHOW CREATE DATABASE` statements. If set to 0, quoting is disabled. This option is enabled by default so that replication works for identifiers that require quoting. See Section 12.4.5.12, "`SHOW CREATE TABLE` Syntax", and Section 12.4.5.8, "`SHOW CREATE DATABASE` Syntax".

- `sql_safe_updates`

  If set to 1, MySQL aborts `UPDATE` or `DELETE` statements that do not use a key in the `WHERE` clause or a `LIMIT` clause. This makes it possible to catch `UPDATE` or `DELETE` statements where keys are not used properly and that would probably change or delete a large number of rows. The default value is 0.

- `sql_select_limit`

Variable Name	`sql_select_limit`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`

The maximum number of rows to return from `SELECT` statements. The default value for a new connection is the maximum number of rows that the server permits per table. Typical default values are $(2^{32})–1$ or $(2^{64})–1$. If you have changed the limit, the default value can be restored by assigning a value of `DEFAULT`.

If a `SELECT` has a `LIMIT` clause, the `LIMIT` takes precedence over the value of `sql_select_limit`.

`sql_select_limit` does not apply to `SELECT` statements executed within stored routines. It also does not apply to `SELECT` statements that do not produce a result set to be returned to the client. These include `SELECT` statements in subqueries, `CREATE TABLE ... SELECT`, and `INSERT INTO ... SELECT`.

- `sql_warnings`

  This variable controls whether single-row `INSERT` statements produce an information string if warnings occur. The default is 0. Set the value to 1 to produce an information string.

- `ssl_ca`

Command-Line Format	`--ssl-ca=name`	
Option-File Format	`ssl-ca`	
Option Sets Variable	Yes, `ssl_ca`	
Variable Name	`ssl_ca`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The path to a file with a list of trusted SSL CAs.

- `ssl_capath`

Command-Line Format	`--ssl-capath=name`	
Option-File Format	`ssl-capath`	
Option Sets Variable	Yes, `ssl_capath`	
Variable Name	`ssl_capath`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The path to a directory that contains trusted SSL CA certificates in PEM format.

- `ssl_cert`

Command-Line Format	`--ssl-cert=name`
Option-File Format	`ssl-cert`
Option Sets Variable	Yes, `ssl_cert`
Variable Name	`ssl_cert`
Variable Scope	Global

Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The name of the SSL certificate file to use for establishing a secure connection.

- `ssl_cipher`

Command-Line Format	`--ssl-cipher=name`	
Option-File Format	`ssl-cipher`	
Option Sets Variable	Yes, `ssl_cipher`	
Variable Name	`ssl_cipher`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

A list of permissible ciphers to use for SSL encryption.

- `ssl_key`

Command-Line Format	`--ssl-key=name`	
Option-File Format	`ssl-key`	
Option Sets Variable	Yes, `ssl_key`	
Variable Name	`ssl_key`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The name of the SSL key file to use for establishing a secure connection.

- `storage_engine`

Variable Name	`storage_engine`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values (>= 5.5.3, <= 5.5.4)	
	Type	`enumeration`
	Default	`MyISAM`
	Permitted Values (>= 5.5.5)	
	Type	`enumeration`
	Default	`InnoDB`

The default storage engine (table type). To set the storage engine at server startup, use the `--default-storage-engine` option. See Section 5.1.2, “Server Command Options”.

This variable is deprecated as of MySQL 5.5.3. Use `default_storage_engine` instead.

- `sync_frm`

Command-Line Format	`--sync-frm`
Option-File Format	`sync_frm`

Option Sets Variable	Yes, `sync_frm`	
Variable Name	`sync_frm`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`TRUE`

If this variable is set to 1, when any nontemporary table is created its `.frm` file is synchronized to disk (using `fdatasync()`). This is slower but safer in case of a crash. The default is 1.

- `system_time_zone`

Variable Name	`system_time_zone`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The server system time zone. When the server begins executing, it inherits a time zone setting from the machine defaults, possibly modified by the environment of the account used for running the server or the startup script. The value is used to set `system_time_zone`. Typically the time zone is specified by the `TZ` environment variable. It also can be specified using the `--timezone` option of the `mysqld_safe` script.

The `system_time_zone` variable differs from `time_zone`. Although they might have the same value, the latter variable is used to initialize the time zone for each client that connects. See Section 9.6, “MySQL Server Time Zone Support”.

- `table_definition_cache`

Command-Line Format	`--table_definition_cache=#`	
Option-File Format	`table_definition_cache`	
Option Sets Variable	Yes, `table_definition_cache`	
Variable Name	`table_definition_cache`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`400`
	Range	`400-524288`

The number of table definitions that can be stored in the definition cache. If you use a large number of tables, you can create a large table definition cache to speed up opening of tables. The table definition cache takes less space and does not use file descriptors, unlike the normal table cache. The minimum and default values are both 400.

- `table_lock_wait_timeout`

Version Removed	5.5.3
Command-Line Format	`--table_lock_wait_timeout=#`
Option-File Format	`table_lock_wait_timeout`
Option Sets Variable	Yes, `table_lock_wait_timeout`
Variable Name	`table_lock_wait_timeout`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`50`
	Range	`1-1073741824`

This variable is unused. It was removed in 5.5.3.

- `table_open_cache`

Command-Line Format	`--table-open-cache=#`	
Option-File Format	`table_open_cache`	
Variable Name	`table_open_cache`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`400`
	Range	`400-524288`

The number of open tables for all threads. Increasing this value increases the number of file descriptors that `mysqld` requires. You can check whether you need to increase the table cache by checking the `Opened_tables` status variable. See Section 5.1.5, “Server Status Variables”. If the value of `Opened_tables` is large and you do not use `FLUSH TABLES` often (which just forces all tables to be closed and reopened), then you should increase the value of the `table_open_cache` variable. For more information about the table cache, see Section 7.4.3.1, “How MySQL Opens and Closes Tables”.

- `table_type`

  This variable was removed in MySQL 5.5.3. Use `storage_engine` instead.

- `thread_cache_size`

Command-Line Format	`--thread_cache_size=#`	
Option-File Format	`thread_cache_size`	
Option Sets Variable	Yes, `thread_cache_size`	
Variable Name	`thread_cache_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-16384`

How many threads the server should cache for reuse. When a client disconnects, the client's threads are put in the cache if there are fewer than `thread_cache_size` threads there. Requests for threads are satisfied by reusing threads taken from the cache if possible, and only when the cache is empty is a new thread created. This variable can be increased to improve performance if you have a lot of new connections. Normally, this does not provide a notable performance improvement if you have a good thread implementation. However, if your server sees hundreds of connections per second you should normally set `thread_cache_size` high enough so that most new connections use cached threads. By examining the difference between the `Connections` and `Threads_created` status variables, you can see how efficient the thread cache is. For details, see Section 5.1.5, “Server Status Variables”.

- `thread_concurrency`

Command-Line Format	`--thread_concurrency=#`
Option-File Format	`thread_concurrency`

Option Sets Variable	Yes, `thread_concurrency`	
Variable Name	`thread_concurrency`	
Variable Scope	Global	
Dynamic Variable	No	
Deprecated	5.6.1	
	Permitted Values	
	Type	`numeric`
	Default	`10`
	Range	`1-512`

This variable is specific to Solaris systems, for which `mysqld` invokes the `thr_setconcurrency()` with the variable value. This function enables applications to give the threads system a hint about the desired number of threads that should be run at the same time.

- `thread_handling`

Command-Line Format	`--thread_handling=name`	
Option-File Format	`thread_handling`	
Option Sets Variable	Yes, `thread_handling`	
Variable Name	`thread_handling`	
Variable Scope	Global	
Dynamic Variable	No	

The thread-handling model used by the server for connection threads. The permissible values are `no-threads` (the server uses a single thread) and `one-thread-per-connection` (the server uses one thread to handle each client connection). `no-threads` is useful for debugging under Linux; see MySQL Internals: Porting.

- `thread_stack`

Command-Line Format	`--thread_stack=#`	
Option-File Format	`thread_stack`	
Option Sets Variable	Yes, `thread_stack`	
Variable Name	`thread_stack`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`196608`
	Range	`131072-4294967295`
	Block Size	`1024`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`262144`
	Range	`131072-18446744073709547520`
	Block Size	`1024`

The stack size for each thread. Many of the limits detected by the `crash-me` test are dependent on this value. See Section 7.12.2, “The MySQL Benchmark Suite”. The default of 192KB (256KB for 64-bit systems) is large enough for normal operation. If the thread stack size is too small, it limits the complexity of the SQL statements that the server can handle, the recursion depth of stored procedures, and other memory-consuming actions.

- `time_format`

  This variable is unused.

- `time_zone`

Command-Line Format	`--default_time_zone=string`	
Option-File Format	`default_time_zone`	
Variable Name	`time_zone`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

The current time zone. This variable is used to initialize the time zone for each client that connects. By default, the initial value of this is `'SYSTEM'` (which means, “use the value of `system_time_zone`”). The value can be specified explicitly at server startup with the `--default-time-zone` option. See Section 9.6, “MySQL Server Time Zone Support”.

- `timed_mutexes`

Command-Line Format	`--timed_mutexes`	
Option-File Format	`timed_mutexes`	
Option Sets Variable	Yes, `timed_mutexes`	
Variable Name	`timed_mutexes`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

This variable controls whether `InnoDB` mutexes are timed. If this variable is set to 0 or `OFF` (the default), mutex timing is disabled. If the variable is set to 1 or `ON`, mutex timing is enabled. With timing enabled, the `os_wait_times` value in the output from `SHOW ENGINE INNODB MUTEX` indicates the amount of time (in ms) spent in operating system waits. Otherwise, the value is 0.

- `timestamp = {`*`timestamp_value`*` | DEFAULT}`

  Set the time for this client. This is used to get the original timestamp if you use the binary log to restore rows. *`timestamp_value`* should be a Unix epoch timestamp, not a MySQL timestamp.

  `SET timestamp` affects the value returned by `NOW()` but not by `SYSDATE()`. This means that timestamp settings in the binary log have no effect on invocations of `SYSDATE()`. The server can be started with the `--sysdate-is-now` option to cause `SYSDATE()` to be an alias for `NOW()`, in which case `SET timestamp` affects both functions.

- `tmp_table_size`

Command-Line Format	`--tmp_table_size=#`
Option-File Format	`tmp_table_size`
Option Sets Variable	Yes, `tmp_table_size`
Variable Name	`tmp_table_size`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`system dependent`
	Range	`1024-4294967295`

The maximum size of internal in-memory temporary tables. (The actual limit is determined as the minimum of `tmp_table_size` and `max_heap_table_size`.) If an in-memory temporary table exceeds the limit, MySQL automatically converts it to an on-disk `MyISAM` table. Increase the value of `tmp_table_size` (and `max_heap_table_size` if necessary) if you do many advanced `GROUP BY` queries and you have lots of memory. This variable does not apply to user-created `MEMORY` tables.

You can compare the number of internal on-disk temporary tables created to the total number of internal temporary tables created by comparing the values of the `Created_tmp_disk_tables` and `Created_tmp_tables` variables.

See also Section 7.4.3.3, “How MySQL Uses Internal Temporary Tables”.

- `tmpdir`

Command-Line Format	`--tmpdir=path`	
	`-t`	
Option-File Format	`tmpdir`	
Option Sets Variable	Yes, `tmpdir`	
Variable Name	`tmpdir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The directory used for temporary files and temporary tables. This variable can be set to a list of several paths that are used in round-robin fashion. Paths should be separated by colon characters (“`:`”) on Unix and semicolon characters (“`;`”) on Windows.

The multiple-directory feature can be used to spread the load between several physical disks. If the MySQL server is acting as a replication slave, you should not set `tmpdir` to point to a directory on a memory-based file system or to a directory that is cleared when the server host restarts. A replication slave needs some of its temporary files to survive a machine restart so that it can replicate temporary tables or `LOAD DATA INFILE` operations. If files in the temporary file directory are lost when the server restarts, replication fails. You can set the slave's temporary directory using the `slave_load_tmpdir` variable. In that case, the slave will not use the general `tmpdir` value and you can set `tmpdir` to a nonpermanent location.

- `transaction_alloc_block_size`

Command-Line Format	`--transaction_alloc_block_size=#`	
Option-File Format	`transaction_alloc_block_size`	
Option Sets Variable	Yes, `transaction_alloc_block_size`	
Variable Name	`transaction_alloc_block_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`8192`
	Range	`1024-4294967295`
	Block Size	`1024`

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`8192`
	Range	`1024-18446744073709547520`
	Block Size	`1024`

The amount in bytes by which to increase a per-transaction memory pool which needs memory. See the description of `transaction_prealloc_size`.

- `transaction_prealloc_size`

Command-Line Format	`--transaction_prealloc_size=#`	
Option-File Format	`transaction_prealloc_size`	
Option Sets Variable	Yes, `transaction_prealloc_size`	
Variable Name	`transaction_prealloc_size`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`4096`
	Range	`1024-4294967295`
	Block Size	`1024`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`4096`
	Range	`1024-18446744073709547520`
	Block Size	`1024`

There is a per-transaction memory pool from which various transaction-related allocations take memory. The initial size of the pool in bytes is `transaction_prealloc_size`. For every allocation that cannot be satisfied from the pool because it has insufficient memory available, the pool is increased by `transaction_alloc_block_size` bytes. When the transaction ends, the pool is truncated to `transaction_prealloc_size` bytes.

By making `transaction_prealloc_size` sufficiently large to contain all statements within a single transaction, you can avoid many `malloc()` calls.

- `tx_isolation`

Variable Name	`tx_isolation`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`enumeration`
	Default	`REPEATABLE-READ`

	Valid Values	`READ-UNCOMMITTED`
		`READ-COMMITTED`
		`REPEATABLE-READ`
		`SERIALIZABLE`

The default transaction isolation level. Defaults to `REPEATABLE-READ`.

This variable is set by the `SET TRANSACTION ISOLATION LEVEL` statement. See Section 12.3.6, "`SET TRANSACTION` Syntax". If you set `tx_isolation` directly to an isolation level name that contains a space, the name should be enclosed within quotation marks, with the space replaced by a dash. For example:

```
SET tx_isolation = 'READ-COMMITTED';
```

Any unique prefix of a valid value may be used to set the value of this variable.

The default transactional isolation level can also be set at startup using the `--transaction-isolation` server option.

- `unique_checks`

Variable Name	`unique_checks`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`1`

If set to 1 (the default), uniqueness checks for secondary indexes in `InnoDB` tables are performed. If set to 0, storage engines are permitted to assume that duplicate keys are not present in input data. If you know for certain that your data does not contain uniqueness violations, you can set this to 0 to speed up large table imports to `InnoDB`.

Note that setting this variable to 0 does not *require* storage engines to ignore duplicate keys. An engine is still permitted to check for them and issue duplicate-key errors if it detects them.

- `updatable_views_with_limit`

Command-Line Format	`--updatable_views_with_limit=#`	
Option-File Format	`updatable_views_with_limit`	
Option Sets Variable	Yes, `updatable_views_with_limit`	
Variable Name	`updatable_views_with_limit`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`1`

This variable controls whether updates to a view can be made when the view does not contain all columns of the primary key defined in the underlying table, if the update statement contains a `LIMIT` clause. (Such updates often are generated by GUI tools.) An update is an `UPDATE` or `DELETE` statement. Primary key here means a `PRIMARY KEY`, or a `UNIQUE` index in which no column can contain `NULL`.

The variable can have two values:

  - `1` or `YES`: Issue a warning only (not an error message). This is the default value.
  - `0` or `NO`: Prohibit the update.

- `version`

  The version number for the server. The value might also include a suffix indicating server build or configuration information. `-log` indicates that one or more of the general log, slow query log, or binary log are enabled. `-debug` indicates that the server was built with debugging support enabled.

- `version_comment`

Variable Name	`version_comment`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

  The `CMake` configuration program has a `WITH_COMMENT` option that permits a comment to be specified when building MySQL. This variable contains the value of that comment. See Section 2.9.4, “MySQL Source-Configuration Options”.

- `version_compile_machine`

Variable Name	`version_compile_machine`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

  The type of machine or architecture on which MySQL was built.

- `version_compile_os`

Variable Name	`version_compile_os`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

  The type of operating system on which MySQL was built.

- `wait_timeout`

Command-Line Format	`--wait_timeout=#`	
Option-File Format	`wait_timeout`	
Option Sets Variable	Yes, `wait_timeout`	
Variable Name	`wait_timeout`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`28800`
	Range	`1-31536000`

	Permitted Values	
	Type (windows)	`numeric`
	Default	`28800`
	Range	`1-2147483`

The number of seconds the server waits for activity on a noninteractive connection before closing it. This timeout applies only to TCP/IP and Unix socket file connections, not to connections made using named pipes, or shared memory.

On thread startup, the session `wait_timeout` value is initialized from the global `wait_timeout` value or from the global `interactive_timeout` value, depending on the type of client (as defined by the `CLIENT_INTERACTIVE` connect option to `mysql_real_connect()`). See also `interactive_timeout`.

- `warning_count`

  The number of errors, warnings, and notes that resulted from the last statement that generated messages. This variable is read only. See Section 12.4.5.41, “`SHOW WARNINGS` Syntax”.

5.1.4. Using System Variables

The MySQL server maintains many system variables that indicate how it is configured. Section 5.1.3, “Server System Variables”, describes the meaning of these variables. Each system variable has a default value. System variables can be set at server startup using options on the command line or in an option file. Most of them can be changed dynamically while the server is running by means of the `SET` statement, which enables you to modify operation of the server without having to stop and restart it. You can refer to system variable values in expressions.

The server maintains two kinds of system variables. Global variables affect the overall operation of the server. Session variables affect its operation for individual client connections. A given system variable can have both a global and a session value. Global and session system variables are related as follows:

- When the server starts, it initializes all global variables to their default values. These defaults can be changed by options specified on the command line or in an option file. (See Section 4.2.3, “Specifying Program Options”.)
- The server also maintains a set of session variables for each client that connects. The client's session variables are initialized at connect time using the current values of the corresponding global variables. For example, the client's SQL mode is controlled by the session `sql_mode` value, which is initialized when the client connects to the value of the global `sql_mode` value.

System variable values can be set globally at server startup by using options on the command line or in an option file. When you use a startup option to set a variable that takes a numeric value, the value can be given with a suffix of `K`, `M`, or `G` (either uppercase or lowercase) to indicate a multiplier of 1024, 1024^2 or 1024^3; that is, units of kilobytes, megabytes, or gigabytes, respectively. Thus, the following command starts the server with a query cache size of 16 megabytes and a maximum packet size of one gigabyte:

```
mysqld --query_cache_size=16M --max_allowed_packet=1G
```

Within an option file, those variables are set like this:

```
[mysqld]
query_cache_size=16M
max_allowed_packet=1G
```

The lettercase of suffix letters does not matter; `16M` and `16m` are equivalent, as are `1G` and `1g`.

If you want to restrict the maximum value to which a system variable can be set at runtime with the `SET` statement, you can specify this maximum by using an option of the form `--maximum-var_name=value` at server startup. For example, to prevent the value of `query_cache_size` from being increased to more than 32MB at runtime, use the option `--maximum-query_cache_size=32M`.

Many system variables are dynamic and can be changed while the server runs by using the `SET` statement. For a list, see Section 5.1.4.2, “Dynamic System Variables”. To change a system variable with `SET`, refer to it as *`var_name`*, optionally preceded by a modifier:

- To indicate explicitly that a variable is a global variable, precede its name by `GLOBAL` or `@@global.`. The `SUPER` privilege is required to set global variables.
- To indicate explicitly that a variable is a session variable, precede its name by `SESSION`, `@@session.`, or `@@`. Setting a session variable requires no special privilege, but a client can change only its own session variables, not those of any other client.
- `LOCAL` and `@@local.` are synonyms for `SESSION` and `@@session.`.
- If no modifier is present, `SET` changes the session variable.

A `SET` statement can contain multiple variable assignments, separated by commas. If you set several system variables, the most recent `GLOBAL` or `SESSION` modifier in the statement is used for following variables that have no modifier specified.

Examples:

```
SET sort_buffer_size=10000;
SET @@local.sort_buffer_size=10000;
SET GLOBAL sort_buffer_size=1000000, SESSION sort_buffer_size=1000000;
SET @@sort_buffer_size=1000000;
SET @@global.sort_buffer_size=1000000, @@local.sort_buffer_size=1000000;
```

The `@@var_name` syntax for system variables is supported for compatibility with some other database systems.

If you change a session system variable, the value remains in effect until your session ends or until you change the variable to a different value. The change is not visible to other clients.

If you change a global system variable, the value is remembered and used for new connections until the server restarts. (To make a global system variable setting permanent, you should set it in an option file.) The change is visible to any client that accesses that global variable. However, the change affects the corresponding session variable only for clients that connect after the change. The global variable change does not affect the session variable for any client that is currently connected (not even that of the client that issues the `SET GLOBAL` statement).

To prevent incorrect usage, MySQL produces an error if you use `SET GLOBAL` with a variable that can only be used with `SET SESSION` or if you do not specify `GLOBAL` (or `@@global.`) when setting a global variable.

To set a `SESSION` variable to the `GLOBAL` value or a `GLOBAL` value to the compiled-in MySQL default value, use the `DEFAULT` keyword. For example, the following two statements are identical in setting the session value of `max_join_size` to the global value:

```
SET max_join_size=DEFAULT;
SET @@session.max_join_size=@@global.max_join_size;
```

Not all system variables can be set to `DEFAULT`. In such cases, use of `DEFAULT` results in an error.

You can refer to the values of specific global or session system variables in expressions by using one of the `@@`-modifiers. For example, you can retrieve values in a `SELECT` statement like this:

```
SELECT @@global.sql_mode, @@session.sql_mode, @@sql_mode;
```

When you refer to a system variable in an expression as `@@var_name` (that is, when you do not specify `@@global.` or `@@session.`), MySQL returns the session value if it exists and the global value otherwise. (This differs from `SET @@var_name = value`, which always refers to the session value.)

> **Note**
>
> Some variables displayed by `SHOW VARIABLES` may not be available using `SELECT @@var_name` syntax; an `Unknown system variable` occurs. As a workaround in such cases, you can use `SHOW VARIABLES LIKE 'var_name'`.

Suffixes for specifying a value multiplier can be used when setting a variable at server startup, but not to set the value with `SET` at runtime. On the other hand, with `SET` you can assign a variable's value using an expression, which is not true when you set a variable at server startup. For example, the first of the following lines is legal at server startup, but the second is not:

```
shell> mysql --max_allowed_packet=16M
shell> mysql --max_allowed_packet=16*1024*1024
```

Conversely, the second of the following lines is legal at runtime, but the first is not:

```
mysql> SET GLOBAL max_allowed_packet=16M;
mysql> SET GLOBAL max_allowed_packet=16*1024*1024;
```

> **Note**
>
> Some system variables can be enabled with the `SET` statement by setting them to `ON` or `1`, or disabled by setting them to `OFF` or `0`. However, to set such a variable on the command line or in an option file, you must set it to `1` or `0`; setting it to `ON` or `OFF` will not work. For example, on the command line, `--delay_key_write=1` works but `--delay_key_write=ON` does not.

To display system variable names and values, use the `SHOW VARIABLES` statement:

```
mysql> SHOW VARIABLES;
+---------------------------------+-----------------------------------+
| Variable_name                   | Value                             |
+---------------------------------+-----------------------------------+
| auto_increment_increment        | 1                                 |
| auto_increment_offset           | 1                                 |
| automatic_sp_privileges         | ON                                |
| back_log                        | 50                                |
| basedir                         | /home/mysql/                      |
| binlog_cache_size               | 32768                             |
| bulk_insert_buffer_size         | 8388608                           |
| character_set_client            | latin1                            |
| character_set_connection        | latin1                            |
| character_set_database          | latin1                            |
| character_set_results           | latin1                            |
| character_set_server            | latin1                            |
| character_set_system            | utf8                              |
| character_sets_dir              | /home/mysql/share/mysql/charsets/ |
| collation_connection            | latin1_swedish_ci                 |
| collation_database              | latin1_swedish_ci                 |
| collation_server                | latin1_swedish_ci                 |
...
| innodb_additional_mem_pool_size | 1048576                           |
| innodb_autoextend_increment     | 8                                 |
| innodb_buffer_pool_size         | 8388608                           |
| innodb_checksums                | ON                                |
| innodb_commit_concurrency       | 0                                 |
| innodb_concurrency_tickets      | 500                               |
| innodb_data_file_path           | ibdata1:10M:autoextend            |
| innodb_data_home_dir            |                                   |
...
| version                         | 5.1.6-alpha-log                   |
| version_comment                 | Source distribution               |
| version_compile_machine         | i686                              |
| version_compile_os              | suse-linux                        |
| wait_timeout                    | 28800                             |
+---------------------------------+-----------------------------------+
```

With a `LIKE` clause, the statement displays only those variables that match the pattern. To obtain a specific variable name, use a `LIKE` clause as shown:

```
SHOW VARIABLES LIKE 'max_join_size';
SHOW SESSION VARIABLES LIKE 'max_join_size';
```

To get a list of variables whose name match a pattern, use the “`%`” wildcard character in a `LIKE` clause:

```
SHOW VARIABLES LIKE '%size%';
SHOW GLOBAL VARIABLES LIKE '%size%';
```

Wildcard characters can be used in any position within the pattern to be matched. Strictly speaking, because “`_`” is a wildcard that matches any single character, you should escape it as “`\_`” to match it literally. In practice, this is rarely necessary.

For `SHOW VARIABLES`, if you specify neither `GLOBAL` nor `SESSION`, MySQL returns `SESSION` values.

The reason for requiring the `GLOBAL` keyword when setting `GLOBAL`-only variables but not when retrieving them is to prevent problems in the future. If we were to remove a `SESSION` variable that has the same name as a `GLOBAL` variable, a client with the `SUPER` privilege might accidentally change the `GLOBAL` variable rather than just the `SESSION` variable for its own connection. If we add a `SESSION` variable with the same name as a `GLOBAL` variable, a client that intends to change the `GLOBAL` variable might find only its own `SESSION` variable changed.

5.1.4.1. Structured System Variables

A structured variable differs from a regular system variable in two respects:

- Its value is a structure with components that specify server parameters considered to be closely related.
- There might be several instances of a given type of structured variable. Each one has a different name and refers to a different resource maintained by the server.

MySQL 5.5 supports one structured variable type, which specifies parameters governing the operation of key caches. A key cache structured variable has these components:

- `key_buffer_size`
- `key_cache_block_size`
- `key_cache_division_limit`
- `key_cache_age_threshold`

This section describes the syntax for referring to structured variables. Key cache variables are used for syntax examples, but specific details about how key caches operate are found elsewhere, in Section 7.9.2, “The `MyISAM` Key Cache”.

To refer to a component of a structured variable instance, you can use a compound name in *`instance_name.component_name`* format. Examples:

```
hot_cache.key_buffer_size
hot_cache.key_cache_block_size
cold_cache.key_cache_block_size
```

For each structured system variable, an instance with the name of `default` is always predefined. If you refer to a component of a structured variable without any instance name, the `default` instance is used. Thus, `default.key_buffer_size` and `key_buffer_size` both refer to the same system variable.

Structured variable instances and components follow these naming rules:

- For a given type of structured variable, each instance must have a name that is unique *within* variables of that type. However, instance names need not be unique *across* structured variable types. For example, each structured variable has an instance named `default`, so `default` is not unique across variable types.
- The names of the components of each structured variable type must be unique across all system variable names. If this were not true (that is, if two different types of structured variables could share component member names), it would not be clear which default structured variable to use for references to member names that are not qualified by an instance name.
- If a structured variable instance name is not legal as an unquoted identifier, refer to it as a quoted identifier using backticks. For example, `hot-cache` is not legal, but `` `hot-cache` `` is.
- `global`, `session`, and `local` are not legal instance names. This avoids a conflict with notation such as `@@global.var_name` for referring to nonstructured system variables.

Currently, the first two rules have no possibility of being violated because the only structured variable type is the one for key caches. These rules will assume greater significance if some other type of structured variable is created in the future.

With one exception, you can refer to structured variable components using compound names in any context where simple variable names can occur. For example, you can assign a value to a structured variable using a command-line option:

```
shell> mysqld --hot_cache.key_buffer_size=64K
```

In an option file, use this syntax:

```
[mysqld]
hot_cache.key_buffer_size=64K
```

If you start the server with this option, it creates a key cache named `hot_cache` with a size of 64KB in addition to the default key cache that has a default size of 8MB.

Suppose that you start the server as follows:

```
shell> mysqld --key_buffer_size=256K \
         --extra_cache.key_buffer_size=128K \
         --extra_cache.key_cache_block_size=2048
```

In this case, the server sets the size of the default key cache to 256KB. (You could also have written `--default.key_buffer_size=256K`.) In addition, the server creates a second key cache named `extra_cache` that has a size of 128KB, with the size of block buffers for caching table index blocks set to 2048 bytes.

The following example starts the server with three different key caches having sizes in a 3:1:1 ratio:

```
shell> mysqld --key_buffer_size=6M \
         --hot_cache.key_buffer_size=2M \
         --cold_cache.key_buffer_size=2M
```

Structured variable values may be set and retrieved at runtime as well. For example, to set a key cache named `hot_cache` to a size of 10MB, use either of these statements:

```
mysql> SET GLOBAL hot_cache.key_buffer_size = 10*1024*1024;
mysql> SET @@global.hot_cache.key_buffer_size = 10*1024*1024;
```

To retrieve the cache size, do this:

```
mysql> SELECT @@global.hot_cache.key_buffer_size;
```

However, the following statement does not work. The variable is not interpreted as a compound name, but as a simple string for a `LIKE` pattern-matching operation:

```
mysql> SHOW GLOBAL VARIABLES LIKE 'hot_cache.key_buffer_size';
```

This is the exception to being able to use structured variable names anywhere a simple variable name may occur.

5.1.4.2. Dynamic System Variables

Many server system variables are dynamic and can be set at runtime using `SET GLOBAL` or `SET SESSION`. You can also obtain their values using `SELECT`. See Section 5.1.4, “Using System Variables”.

The following table shows the full list of all dynamic system variables. The last column indicates for each variable whether `GLOBAL` or `SESSION` (or both) apply. The table also lists session options that can be set with the `SET` statement. Section 5.1.3, “Server System Variables”, discusses these options.

Variables that have a type of “string” take a string value. Variables that have a type of “numeric” take a numeric value. Variables that have a type of “boolean” can be set to 0, 1, `ON` or `OFF`. (If you set them on the command line or in an option file, use the numeric values.) Variables that are marked as “enumeration” normally should be set to one of the available values for the variable, but can also be set to the number that corresponds to the desired enumeration value. For enumerated system variables, the first enumeration value corresponds to 0. This differs from `ENUM` columns, for which the first enumeration value corresponds to 1.

Table 5.3. Dynamic Variable Summary

Variable Name	**Variable Type**	**Variable Scope**
`auto_increment_increment`	numeric	`GLOBAL` | `SESSION`
`auto_increment_offset`	numeric	`GLOBAL` | `SESSION`
`autocommit`	boolean	`GLOBAL` | `SESSION`
`automatic_sp_privileges`	boolean	`GLOBAL`
`big_tables`	boolean	`GLOBAL` | `SESSION`
`binlog_cache_size`	numeric	`GLOBAL`
`binlog_direct_non_transactional_updates`	boolean	`GLOBAL` | `SESSION`
`binlog_format`	enumeration	`GLOBAL` | `SESSION`
`binlog_stmt_cache_size`	numeric	`GLOBAL`
`bulk_insert_buffer_size`	numeric	`GLOBAL` | `SESSION`
`character_set_client`	string	`GLOBAL` | `SESSION`
`character_set_connection`	string	`GLOBAL` | `SESSION`
`character_set_database`	string	`GLOBAL` | `SESSION`
`character_set_filesystem`	string	`GLOBAL` | `SESSION`
`character_set_results`	string	`GLOBAL` | `SESSION`
`character_set_server`	string	`GLOBAL` | `SESSION`
`collation_connection`	string	`GLOBAL` | `SESSION`
`collation_database`	string	`GLOBAL` | `SESSION`
`collation_server`	string	`GLOBAL` | `SESSION`

Variable Name	Variable Type	Variable Scope
`completion_type`	numeric	`GLOBAL` | `SESSION`
`concurrent_insert`	boolean	`GLOBAL`
`connect_timeout`	numeric	`GLOBAL`
`debug`	string	`GLOBAL` | `SESSION`
`debug_sync`	string	`SESSION`
`default_storage_engine`	enumeration	`GLOBAL` | `SESSION`
`default_week_format`	numeric	`GLOBAL` | `SESSION`
`delay_key_write`	enumeration	`GLOBAL`
`delayed_insert_limit`	numeric	`GLOBAL`
`delayed_insert_timeout`	numeric	`GLOBAL`
`delayed_queue_size`	numeric	`GLOBAL`
`div_precision_increment`	numeric	`GLOBAL` | `SESSION`
`engine_condition_pushdown`	boolean	`GLOBAL` | `SESSION`
`event_scheduler`	enumeration	`GLOBAL`
`expire_logs_days`	numeric	`GLOBAL`
`flush`	boolean	`GLOBAL`
`flush_time`	numeric	`GLOBAL`
`foreign_key_checks`	boolean	`GLOBAL` | `SESSION`
`ft_boolean_syntax`	string	`GLOBAL`
`general_log`	boolean	`GLOBAL`
`general_log_file`	filename	`GLOBAL`
`group_concat_max_len`	numeric	`GLOBAL` | `SESSION`
`identity`	numeric	`SESSION`
`init_connect`	string	`GLOBAL`
`init_slave`	string	`GLOBAL`
`innodb_adaptive_flushing`	boolean	`GLOBAL`
`innodb_adaptive_hash_index`	boolean	`GLOBAL`
`innodb_autoextend_increment`	numeric	`GLOBAL`
`innodb_change_buffering`	enumeration	`GLOBAL`
`innodb_commit_concurrency`	numeric	`GLOBAL`
`innodb_concurrency_tickets`	numeric	`GLOBAL`
`innodb_fast_shutdown`	numeric	`GLOBAL`
`innodb_file_format`	string	`GLOBAL`
`innodb_file_format_max`	string	`GLOBAL`
`innodb_file_per_table`	boolean	`GLOBAL`
`innodb_flush_log_at_trx_commit`	numeric	`GLOBAL`
`innodb_io_capacity`	numeric	`GLOBAL`
`innodb_large_prefix`	boolean	`GLOBAL`
`innodb_lock_wait_timeout`	numeric	`GLOBAL` | `SESSION`
`innodb_max_dirty_pages_pct`	numeric	`GLOBAL`
`innodb_max_purge_lag`	numeric	`GLOBAL`
`innodb_old_blocks_pct`	numeric	`GLOBAL`
`innodb_old_blocks_time`	numeric	`GLOBAL`
`innodb_read_ahead_threshold`	numeric	`GLOBAL`
`innodb_replication_delay`	numeric	`GLOBAL`
`innodb_rollback_segments`	numeric	`GLOBAL`
`innodb_spin_wait_delay`	numeric	`GLOBAL`
`innodb_stats_method`	enumeration	`GLOBAL` | `SESSION`

Variable Name	Variable Type	Variable Scope
`innodb_stats_on_metadata`	boolean	`GLOBAL`
`innodb_stats_sample_pages`	numeric	`GLOBAL`
`innodb_strict_mode`	boolean	`GLOBAL` | `SESSION`
`innodb_support_xa`	boolean	`GLOBAL` | `SESSION`
`innodb_sync_spin_loops`	numeric	`GLOBAL`
`innodb_table_locks`	boolean	`GLOBAL` | `SESSION`
`innodb_thread_concurrency`	numeric	`GLOBAL`
`innodb_thread_sleep_delay`	numeric	`GLOBAL`
`insert_id`	numeric	`SESSION`
`interactive_timeout`	numeric	`GLOBAL` | `SESSION`
`join_buffer_size`	numeric	`GLOBAL` | `SESSION`
`keep_files_on_create`	boolean	`GLOBAL` | `SESSION`
`key_buffer_size`	numeric	`GLOBAL`
`key_cache_age_threshold`	numeric	`GLOBAL`
`key_cache_block_size`	numeric	`GLOBAL`
`key_cache_division_limit`	numeric	`GLOBAL`
`last_insert_id`	numeric	`SESSION`
`lc_messages`	string	`GLOBAL` | `SESSION`
`lc_time_names`	string	`GLOBAL` | `SESSION`
`local_infile`	boolean	`GLOBAL`
`lock_wait_timeout`	numeric	`GLOBAL` | `SESSION`
`log`	string	`GLOBAL`
`log_bin_trust_function_creators`	boolean	`GLOBAL`
`log_bin_trust_routine_creators`	boolean	`GLOBAL`
`log_output`	set	`GLOBAL`
`log_queries_not_using_indexes`	boolean	`GLOBAL`
`log_slow_queries`	boolean	`GLOBAL`
`log_warnings`	numeric	`GLOBAL` | `SESSION`
`long_query_time`	numeric	`GLOBAL` | `SESSION`
`low_priority_updates`	boolean	`GLOBAL` | `SESSION`
`max_allowed_packet`	numeric	`GLOBAL`
`max_binlog_cache_size`	numeric	`GLOBAL`
`max_binlog_size`	numeric	`GLOBAL`
`max_binlog_stmt_cache_size`	numeric	`GLOBAL`
`max_connect_errors`	numeric	`GLOBAL`
`max_connections`	numeric	`GLOBAL`
`max_delayed_threads`	numeric	`GLOBAL` | `SESSION`
`max_error_count`	numeric	`GLOBAL` | `SESSION`
`max_heap_table_size`	numeric	`GLOBAL` | `SESSION`
`max_insert_delayed_threads`	numeric	`GLOBAL` | `SESSION`
`max_join_size`	numeric	`GLOBAL` | `SESSION`
`max_length_for_sort_data`	numeric	`GLOBAL` | `SESSION`
`max_prepared_stmt_count`	numeric	`GLOBAL`
`max_relay_log_size`	numeric	`GLOBAL`
`max_seeks_for_key`	numeric	`GLOBAL` | `SESSION`
`max_sort_length`	numeric	`GLOBAL` | `SESSION`
`max_sp_recursion_depth`	numeric	`GLOBAL` | `SESSION`
`max_tmp_tables`	numeric	`GLOBAL` | `SESSION`

Variable Name	**Variable Type**	**Variable Scope**
`max_user_connections`	numeric	`GLOBAL` | `SESSION`
`max_write_lock_count`	numeric	`GLOBAL`
`min_examined_row_limit`	numeric	`GLOBAL` | `SESSION`
`myisam_data_pointer_size`	numeric	`GLOBAL`
`myisam_max_sort_file_size`	numeric	`GLOBAL`
`myisam_repair_threads`	numeric	`GLOBAL` | `SESSION`
`myisam_sort_buffer_size`	numeric	`GLOBAL` | `SESSION`
`myisam_stats_method`	enumeration	`GLOBAL` | `SESSION`
`myisam_use_mmap`	boolean	`GLOBAL`
`ndb_autoincrement_prefetch_sz`	numeric	`GLOBAL` | `SESSION`
`net_buffer_length`	numeric	`GLOBAL` | `SESSION`
`net_read_timeout`	numeric	`GLOBAL` | `SESSION`
`net_retry_count`	numeric	`GLOBAL` | `SESSION`
`net_write_timeout`	numeric	`GLOBAL` | `SESSION`
`new`	boolean	`GLOBAL` | `SESSION`
`old_alter_table`	boolean	`GLOBAL` | `SESSION`
`old_passwords`	boolean	`GLOBAL` | `SESSION`
`optimizer_prune_level`	boolean	`GLOBAL` | `SESSION`
`optimizer_search_depth`	numeric	`GLOBAL` | `SESSION`
`optimizer_switch`	set	`GLOBAL` | `SESSION`
`preload_buffer_size`	numeric	`GLOBAL` | `SESSION`
`profiling`	boolean	`GLOBAL` | `SESSION`
`profiling_history_size`	numeric	`GLOBAL` | `SESSION`
`pseudo_thread_id`	numeric	`SESSION`
`query_alloc_block_size`	numeric	`GLOBAL` | `SESSION`
`query_cache_limit`	numeric	`GLOBAL`
`query_cache_min_res_unit`	numeric	`GLOBAL`
`query_cache_size`	numeric	`GLOBAL`
`query_cache_type`	enumeration	`GLOBAL` | `SESSION`
`query_cache_wlock_invalidate`	boolean	`GLOBAL` | `SESSION`
`query_prealloc_size`	numeric	`GLOBAL` | `SESSION`
`rand_seed1`	numeric	`SESSION`
`rand_seed2`	numeric	`SESSION`
`range_alloc_block_size`	numeric	`GLOBAL` | `SESSION`
`read_buffer_size`	numeric	`GLOBAL` | `SESSION`
`read_only`	numeric	`GLOBAL`
`read_rnd_buffer_size`	numeric	`GLOBAL` | `SESSION`
`relay_log_purge`	boolean	`GLOBAL`
`relay_log_recovery`	boolean	`GLOBAL`
`rpl_recovery_rank`	numeric	`GLOBAL`
`rpl_semi_sync_master_enabled`	boolean	`GLOBAL`
`rpl_semi_sync_master_timeout`	numeric	`GLOBAL`
`rpl_semi_sync_master_trace_level`	numeric	`GLOBAL`
`rpl_semi_sync_master_wait_no_slave`	boolean	`GLOBAL`
`rpl_semi_sync_slave_enabled`	boolean	`GLOBAL`
`rpl_semi_sync_slave_trace_level`	numeric	`GLOBAL`
`safe_show_database`	boolean	`GLOBAL`
`secure_auth`	boolean	`GLOBAL`

Variable Name	Variable Type	Variable Scope
`server_id`	numeric	GLOBAL
`slave_compressed_protocol`	boolean	GLOBAL
`slave_exec_mode`	enumeration	GLOBAL
`slave_net_timeout`	numeric	GLOBAL
`slave_transaction_retries`	numeric	GLOBAL
`slow_launch_time`	numeric	GLOBAL
`slow_query_log`	boolean	GLOBAL
`slow_query_log_file`	filename	GLOBAL
`sort_buffer_size`	numeric	GLOBAL | SESSION
`sql_auto_is_null`	boolean	GLOBAL | SESSION
`sql_big_selects`	boolean	GLOBAL | SESSION
`sql_big_tables`	boolean	SESSION
`sql_buffer_result`	boolean	SESSION
`sql_log_bin`	boolean	GLOBAL | SESSION
`sql_log_off`	boolean	GLOBAL | SESSION
`sql_log_update`	boolean	SESSION
`sql_low_priority_updates`	boolean	GLOBAL | SESSION
`sql_max_join_size`	numeric	GLOBAL | SESSION
`sql_mode`	set	GLOBAL | SESSION
`sql_notes`	boolean	GLOBAL | SESSION
`sql_quote_show_create`	boolean	GLOBAL | SESSION
`sql_safe_updates`	boolean	GLOBAL | SESSION
`sql_select_limit`	numeric	GLOBAL | SESSION
`sql_slave_skip_counter`	numeric	GLOBAL
`sql_warnings`	boolean	GLOBAL | SESSION
`storage_engine`	enumeration	GLOBAL | SESSION
`sync_binlog`	numeric	GLOBAL
`sync_frm`	boolean	GLOBAL
`sync_master_info`	numeric	GLOBAL
`sync_relay_log`	numeric	GLOBAL
`sync_relay_log_info`	numeric	GLOBAL
`table_definition_cache`	numeric	GLOBAL
`table_lock_wait_timeout`	numeric	GLOBAL
`table_open_cache`	numeric	GLOBAL
`table_type`	enumeration	GLOBAL | SESSION
`thread_cache_size`	numeric	GLOBAL
`time_zone`	string	GLOBAL | SESSION
`timed_mutexes`	boolean	GLOBAL
`timestamp`	numeric	SESSION
`tmp_table_size`	numeric	GLOBAL | SESSION
`transaction_alloc_block_size`	numeric	GLOBAL | SESSION
`transaction_prealloc_size`	numeric	GLOBAL | SESSION
`tx_isolation`	enumeration	GLOBAL | SESSION
`unique_checks`	boolean	GLOBAL | SESSION
`updatable_views_with_limit`	boolean	GLOBAL | SESSION
`wait_timeout`	numeric	GLOBAL | SESSION

5.1.5. Server Status Variables

The server maintains many status variables that provide information about its operation. You can view these variables and their values by using the `SHOW [GLOBAL | SESSION] STATUS` statement (see Section 12.4.5.36, “`SHOW STATUS` Syntax”). The optional `GLOBAL` keyword aggregates the values over all connections, and `SESSION` shows the values for the current connection.

```
mysql> SHOW GLOBAL STATUS;
+-----------------------------------+------------+
| Variable_name                     | Value      |
+-----------------------------------+------------+
| Aborted_clients                   | 0          |
| Aborted_connects                  | 0          |
| Bytes_received                    | 155372598  |
| Bytes_sent                        | 1176560426 |
...
| Connections                       | 30023      |
| Created_tmp_disk_tables           | 0          |
| Created_tmp_files                 | 3          |
| Created_tmp_tables                | 2          |
...
| Threads_created                   | 217        |
| Threads_running                   | 88         |
| Uptime                            | 1389872    |
+-----------------------------------+------------+
```

The following table lists all available server status variables:

Table 5.4. Status Variable Summary

Variable Name	Variable Type	Variable Scope
`Aborted_clients`	numeric	`GLOBAL`
`Aborted_connects`	numeric	`GLOBAL`
`Binlog_cache_disk_use`	numeric	`GLOBAL`
`Binlog_cache_use`	numeric	`GLOBAL`
`Binlog_stmt_cache_disk_use`	numeric	`GLOBAL`
`Binlog_stmt_cache_use`	numeric	`GLOBAL`
`Bytes_received`	numeric	`GLOBAL` | `SESSION`
`Bytes_sent`	numeric	`GLOBAL` | `SESSION`
`Com_admin_commands`	numeric	`GLOBAL` | `SESSION`
`Com_alter_db`	numeric	`GLOBAL` | `SESSION`
`Com_alter_db_upgrade`	numeric	`GLOBAL` | `SESSION`
`Com_alter_event`	numeric	`GLOBAL` | `SESSION`
`Com_alter_function`	numeric	`GLOBAL` | `SESSION`
`Com_alter_procedure`	numeric	`GLOBAL` | `SESSION`
`Com_alter_server`	numeric	`GLOBAL` | `SESSION`
`Com_alter_table`	numeric	`GLOBAL` | `SESSION`
`Com_alter_tablespace`	numeric	`GLOBAL` | `SESSION`
`Com_analyze`	numeric	`GLOBAL` | `SESSION`
`Com_assign_to_keycache`	numeric	`GLOBAL` | `SESSION`
`Com_backup_table`	numeric	`GLOBAL` | `SESSION`
`Com_begin`	numeric	`GLOBAL` | `SESSION`
`Com_binlog`	numeric	`GLOBAL` | `SESSION`
`Com_call_procedure`	numeric	`GLOBAL` | `SESSION`
`Com_change_db`	numeric	`GLOBAL` | `SESSION`
`Com_change_master`	numeric	`GLOBAL` | `SESSION`
`Com_check`	numeric	`GLOBAL` | `SESSION`
`Com_checksum`	numeric	`GLOBAL` | `SESSION`
`Com_commit`	numeric	`GLOBAL` | `SESSION`
`Com_create_db`	numeric	`GLOBAL` | `SESSION`
`Com_create_event`	numeric	`GLOBAL` | `SESSION`

Variable Name	Variable Type	Variable Scope
Com_create_function	numeric	GLOBAL | SESSION
Com_create_index	numeric	GLOBAL | SESSION
Com_create_procedure	numeric	GLOBAL | SESSION
Com_create_server	numeric	GLOBAL | SESSION
Com_create_table	numeric	GLOBAL | SESSION
Com_create_trigger	numeric	GLOBAL | SESSION
Com_create_udf	numeric	GLOBAL | SESSION
Com_create_user	numeric	GLOBAL | SESSION
Com_create_view	numeric	GLOBAL | SESSION
Com_dealloc_sql	numeric	GLOBAL | SESSION
Com_delete	numeric	GLOBAL | SESSION
Com_delete_multi	numeric	GLOBAL | SESSION
Com_do	numeric	GLOBAL | SESSION
Com_drop_db	numeric	GLOBAL | SESSION
Com_drop_event	numeric	GLOBAL | SESSION
Com_drop_function	numeric	GLOBAL | SESSION
Com_drop_index	numeric	GLOBAL | SESSION
Com_drop_procedure	numeric	GLOBAL | SESSION
Com_drop_server	numeric	GLOBAL | SESSION
Com_drop_table	numeric	GLOBAL | SESSION
Com_drop_trigger	numeric	GLOBAL | SESSION
Com_drop_user	numeric	GLOBAL | SESSION
Com_drop_view	numeric	GLOBAL | SESSION
Com_empty_query	numeric	GLOBAL | SESSION
Com_execute_sql	numeric	GLOBAL | SESSION
Com_flush	numeric	GLOBAL | SESSION
Com_grant	numeric	GLOBAL | SESSION
Com_ha_close	numeric	GLOBAL | SESSION
Com_ha_open	numeric	GLOBAL | SESSION
Com_ha_read	numeric	GLOBAL | SESSION
Com_help	numeric	GLOBAL | SESSION
Com_insert	numeric	GLOBAL | SESSION
Com_insert_select	numeric	GLOBAL | SESSION
Com_install_plugin	numeric	GLOBAL | SESSION
Com_kill	numeric	GLOBAL | SESSION
Com_load	numeric	GLOBAL | SESSION
Com_lock_tables	numeric	GLOBAL | SESSION
Com_optimize	numeric	GLOBAL | SESSION
Com_preload_keys	numeric	GLOBAL | SESSION
Com_prepare_sql	numeric	GLOBAL | SESSION
Com_purge	numeric	GLOBAL | SESSION
Com_purge_before_date	numeric	GLOBAL | SESSION
Com_release_savepoint	numeric	GLOBAL | SESSION
Com_rename_table	numeric	GLOBAL | SESSION
Com_rename_user	numeric	GLOBAL | SESSION
Com_repair	numeric	GLOBAL | SESSION
Com_replace	numeric	GLOBAL | SESSION
Com_replace_select	numeric	GLOBAL | SESSION

Variable Name	Variable Type	Variable Scope
`Com_reset`	numeric	`GLOBAL` | `SESSION`
`Com_resignal`	numeric	`GLOBAL` | `SESSION`
`Com_restore_table`	numeric	`GLOBAL` | `SESSION`
`Com_revoke`	numeric	`GLOBAL` | `SESSION`
`Com_revoke_all`	numeric	`GLOBAL` | `SESSION`
`Com_rollback`	numeric	`GLOBAL` | `SESSION`
`Com_rollback_to_savepoint`	numeric	`GLOBAL` | `SESSION`
`Com_savepoint`	numeric	`GLOBAL` | `SESSION`
`Com_select`	numeric	`GLOBAL` | `SESSION`
`Com_set_option`	numeric	`GLOBAL` | `SESSION`
`Com_show_authors`	numeric	`GLOBAL` | `SESSION`
`Com_show_binlog_events`	numeric	`GLOBAL` | `SESSION`
`Com_show_binlogs`	numeric	`GLOBAL` | `SESSION`
`Com_show_charsets`	numeric	`GLOBAL` | `SESSION`
`Com_show_collations`	numeric	`GLOBAL` | `SESSION`
`Com_show_contributors`	numeric	`GLOBAL` | `SESSION`
`Com_show_create_db`	numeric	`GLOBAL` | `SESSION`
`Com_show_create_event`	numeric	`GLOBAL` | `SESSION`
`Com_show_create_func`	numeric	`GLOBAL` | `SESSION`
`Com_show_create_proc`	numeric	`GLOBAL` | `SESSION`
`Com_show_create_table`	numeric	`GLOBAL` | `SESSION`
`Com_show_create_trigger`	numeric	`GLOBAL` | `SESSION`
`Com_show_databases`	numeric	`GLOBAL` | `SESSION`
`Com_show_engine_logs`	numeric	`GLOBAL` | `SESSION`
`Com_show_engine_mutex`	numeric	`GLOBAL` | `SESSION`
`Com_show_engine_status`	numeric	`GLOBAL` | `SESSION`
`Com_show_errors`	numeric	`GLOBAL` | `SESSION`
`Com_show_events`	numeric	`GLOBAL` | `SESSION`
`Com_show_fields`	numeric	`GLOBAL` | `SESSION`
`Com_show_function_code`	numeric	`GLOBAL` | `SESSION`
`Com_show_function_status`	numeric	`GLOBAL` | `SESSION`
`Com_show_grants`	numeric	`GLOBAL` | `SESSION`
`Com_show_keys`	numeric	`GLOBAL` | `SESSION`
`Com_show_logs`	numeric	`GLOBAL` | `SESSION`
`Com_show_master_status`	numeric	`GLOBAL` | `SESSION`
`Com_show_new_master`	numeric	`GLOBAL` | `SESSION`
`Com_show_open_tables`	numeric	`GLOBAL` | `SESSION`
`Com_show_plugins`	numeric	`GLOBAL` | `SESSION`
`Com_show_privileges`	numeric	`GLOBAL` | `SESSION`
`Com_show_procedure_code`	numeric	`GLOBAL` | `SESSION`
`Com_show_procedure_status`	numeric	`GLOBAL` | `SESSION`
`Com_show_processlist`	numeric	`GLOBAL` | `SESSION`
`Com_show_profile`	numeric	`GLOBAL` | `SESSION`
`Com_show_profiles`	numeric	`GLOBAL` | `SESSION`
`Com_show_relaylog_events`	numeric	`GLOBAL` | `SESSION`
`Com_show_slave_hosts`	numeric	`GLOBAL` | `SESSION`
`Com_show_slave_status`	numeric	`GLOBAL` | `SESSION`
`Com_show_status`	numeric	`GLOBAL` | `SESSION`

Variable Name	Variable Type	Variable Scope
`Com_show_storage_engines`	numeric	`GLOBAL` | `SESSION`
`Com_show_table_status`	numeric	`GLOBAL` | `SESSION`
`Com_show_tables`	numeric	`GLOBAL` | `SESSION`
`Com_show_triggers`	numeric	`GLOBAL` | `SESSION`
`Com_show_variables`	numeric	`GLOBAL` | `SESSION`
`Com_show_warnings`	numeric	`GLOBAL` | `SESSION`
`Com_signal`	numeric	`GLOBAL` | `SESSION`
`Com_slave_start`	numeric	`GLOBAL` | `SESSION`
`Com_slave_stop`	numeric	`GLOBAL` | `SESSION`
`Com_stmt_close`	numeric	`GLOBAL` | `SESSION`
`Com_stmt_execute`	numeric	`GLOBAL` | `SESSION`
`Com_stmt_fetch`	numeric	`GLOBAL` | `SESSION`
`Com_stmt_prepare`	numeric	`GLOBAL` | `SESSION`
`Com_stmt_reprepare`	numeric	`GLOBAL` | `SESSION`
`Com_stmt_reset`	numeric	`GLOBAL` | `SESSION`
`Com_stmt_send_long_data`	numeric	`GLOBAL` | `SESSION`
`Com_truncate`	numeric	`GLOBAL` | `SESSION`
`Com_uninstall_plugin`	numeric	`GLOBAL` | `SESSION`
`Com_unlock_tables`	numeric	`GLOBAL` | `SESSION`
`Com_update`	numeric	`GLOBAL` | `SESSION`
`Com_update_multi`	numeric	`GLOBAL` | `SESSION`
`Com_xa_commit`	numeric	`GLOBAL` | `SESSION`
`Com_xa_end`	numeric	`GLOBAL` | `SESSION`
`Com_xa_prepare`	numeric	`GLOBAL` | `SESSION`
`Com_xa_recover`	numeric	`GLOBAL` | `SESSION`
`Com_xa_rollback`	numeric	`GLOBAL` | `SESSION`
`Com_xa_start`	numeric	`GLOBAL` | `SESSION`
`Compression`	numeric	`SESSION`
`Connections`	numeric	`GLOBAL`
`Created_tmp_disk_tables`	numeric	`GLOBAL` | `SESSION`
`Created_tmp_files`	numeric	`GLOBAL`
`Created_tmp_tables`	numeric	`GLOBAL` | `SESSION`
`Delayed_errors`	numeric	`GLOBAL`
`Delayed_insert_threads`	numeric	`GLOBAL`
`Delayed_writes`	numeric	`GLOBAL`
`Flush_commands`	numeric	`GLOBAL`
`Handler_commit`	numeric	`GLOBAL` | `SESSION`
`Handler_delete`	numeric	`GLOBAL` | `SESSION`
`Handler_discover`	numeric	`GLOBAL` | `SESSION`
`Handler_prepare`	numeric	`GLOBAL` | `SESSION`
`Handler_read_first`	numeric	`GLOBAL` | `SESSION`
`Handler_read_key`	numeric	`GLOBAL` | `SESSION`
`Handler_read_last`	numeric	`GLOBAL` | `SESSION`
`Handler_read_next`	numeric	`GLOBAL` | `SESSION`
`Handler_read_prev`	numeric	`GLOBAL` | `SESSION`
`Handler_read_rnd`	numeric	`GLOBAL` | `SESSION`
`Handler_read_rnd_next`	numeric	`GLOBAL` | `SESSION`
`Handler_rollback`	numeric	`GLOBAL` | `SESSION`

Variable Name	Variable Type	Variable Scope
`Handler_savepoint`	numeric	`GLOBAL` | `SESSION`
`Handler_savepoint_rollback`	numeric	`GLOBAL` | `SESSION`
`Handler_update`	numeric	`GLOBAL` | `SESSION`
`Handler_write`	numeric	`GLOBAL` | `SESSION`
`Innodb_buffer_pool_pages_data`	numeric	`GLOBAL`
`Innodb_buffer_pool_pages_dirty`	numeric	`GLOBAL`
`Innodb_buffer_pool_pages_flushed`	numeric	`GLOBAL`
`Innodb_buffer_pool_pages_free`	numeric	`GLOBAL`
`Innodb_buffer_pool_pages_latched`	numeric	`GLOBAL`
`Innodb_buffer_pool_pages_misc`	numeric	`GLOBAL`
`Innodb_buffer_pool_pages_total`	numeric	`GLOBAL`
`Innodb_buffer_pool_read_ahead`	numeric	`GLOBAL`
`Innodb_buffer_pool_read_ahead_evicted`	numeric	`GLOBAL`
`Innodb_buffer_pool_read_requests`	numeric	`GLOBAL`
`Innodb_buffer_pool_reads`	numeric	`GLOBAL`
`Innodb_buffer_pool_wait_free`	numeric	`GLOBAL`
`Innodb_buffer_pool_write_requests`	numeric	`GLOBAL`
`Innodb_data_fsyncs`	numeric	`GLOBAL`
`Innodb_data_pending_fsyncs`	numeric	`GLOBAL`
`Innodb_data_pending_reads`	numeric	`GLOBAL`
`Innodb_data_pending_writes`	numeric	`GLOBAL`
`Innodb_data_read`	numeric	`GLOBAL`
`Innodb_data_reads`	numeric	`GLOBAL`
`Innodb_data_writes`	numeric	`GLOBAL`
`Innodb_data_written`	numeric	`GLOBAL`
`Innodb_dblwr_pages_written`	numeric	`GLOBAL`
`Innodb_dblwr_writes`	numeric	`GLOBAL`
`Innodb_have_atomic_builtins`	numeric	`GLOBAL`
`Innodb_log_waits`	numeric	`GLOBAL`
`Innodb_log_write_requests`	numeric	`GLOBAL`
`Innodb_log_writes`	numeric	`GLOBAL`
`Innodb_os_log_fsyncs`	numeric	`GLOBAL`
`Innodb_os_log_pending_fsyncs`	numeric	`GLOBAL`
`Innodb_os_log_pending_writes`	numeric	`GLOBAL`
`Innodb_os_log_written`	numeric	`GLOBAL`
`Innodb_page_size`	numeric	`GLOBAL`
`Innodb_pages_created`	numeric	`GLOBAL`
`Innodb_pages_read`	numeric	`GLOBAL`
`Innodb_pages_written`	numeric	`GLOBAL`
`Innodb_row_lock_current_waits`	numeric	`GLOBAL`
`Innodb_row_lock_time`	numeric	`GLOBAL`
`Innodb_row_lock_time_avg`	numeric	`GLOBAL`
`Innodb_row_lock_time_max`	numeric	`GLOBAL`
`Innodb_row_lock_waits`	numeric	`GLOBAL`
`Innodb_rows_deleted`	numeric	`GLOBAL`
`Innodb_rows_inserted`	numeric	`GLOBAL`
`Innodb_rows_read`	numeric	`GLOBAL`
`Innodb_rows_updated`	numeric	`GLOBAL`

Variable Name	Variable Type	Variable Scope
`Innodb_truncated_status_writes`	numeric	`GLOBAL`
`Key_blocks_not_flushed`	numeric	`GLOBAL`
`Key_blocks_unused`	numeric	`GLOBAL`
`Key_blocks_used`	numeric	`GLOBAL`
`Key_read_requests`	numeric	`GLOBAL`
`Key_reads`	numeric	`GLOBAL`
`Key_write_requests`	numeric	`GLOBAL`
`Key_writes`	numeric	`GLOBAL`
`Last_query_cost`	numeric	`SESSION`
`Max_used_connections`	numeric	`GLOBAL`
`Ndb_conflict_fn_max`	numeric	`GLOBAL`
`Ndb_conflict_fn_old`	numeric	`GLOBAL`
`Ndb_number_of_data_nodes`	numeric	`GLOBAL`
`Not_flushed_delayed_rows`	numeric	`GLOBAL`
`Open_files`	numeric	`GLOBAL`
`Open_streams`	numeric	`GLOBAL`
`Open_table_definitions`	numeric	`GLOBAL`
`Open_tables`	numeric	`GLOBAL` | `SESSION`
`Opened_files`	numeric	`GLOBAL`
`Opened_table_definitions`	numeric	`GLOBAL` | `SESSION`
`Opened_tables`	numeric	`GLOBAL` | `SESSION`
`Performance_schema_cond_classes_lost`	numeric	`GLOBAL`
`Performance_schema_cond_instances_lost`	numeric	`GLOBAL`
`Performance_schema_file_classes_lost`	numeric	`GLOBAL`
`Performance_schema_file_handles_lost`	numeric	`GLOBAL`
`Performance_schema_file_instances_lost`	numeric	`GLOBAL`
`Performance_schema_locker_lost`	numeric	`GLOBAL`
`Performance_schema_mutex_classes_lost`	numeric	`GLOBAL`
`Performance_schema_mutex_instances_lost`	numeric	`GLOBAL`
`Performance_schema_rwlock_classes_lost`	numeric	`GLOBAL`
`Performance_schema_rwlock_instances_lost`	numeric	`GLOBAL`
`Performance_schema_table_handles_lost`	numeric	`GLOBAL`
`Performance_schema_table_instances_lost`	numeric	`GLOBAL`
`Performance_schema_thread_classes_lost`	numeric	`GLOBAL`
`Performance_schema_thread_instances_lost`	numeric	`GLOBAL`
`Prepared_stmt_count`	numeric	`GLOBAL`
`Qcache_free_blocks`	numeric	`GLOBAL`
`Qcache_free_memory`	numeric	`GLOBAL`
`Qcache_hits`	numeric	`GLOBAL`
`Qcache_inserts`	numeric	`GLOBAL`
`Qcache_lowmem_prunes`	numeric	`GLOBAL`
`Qcache_not_cached`	numeric	`GLOBAL`
`Qcache_queries_in_cache`	numeric	`GLOBAL`
`Qcache_total_blocks`	numeric	`GLOBAL`
`Queries`	numeric	`GLOBAL` | `SESSION`
`Questions`	numeric	`GLOBAL` | `SESSION`
`Rpl_semi_sync_master_clients`	numeric	`GLOBAL`
`Rpl_semi_sync_master_net_avg_wait_time`	numeric	`GLOBAL`

Variable Name	Variable Type	Variable Scope
Rpl_semi_sync_master_net_wait_time	numeric	GLOBAL
Rpl_semi_sync_master_net_waits	numeric	GLOBAL
Rpl_semi_sync_master_no_times	numeric	GLOBAL
Rpl_semi_sync_master_no_tx	numeric	GLOBAL
Rpl_semi_sync_master_status	boolean	GLOBAL
Rpl_semi_sync_master_timefunc_failures	numeric	GLOBAL
Rpl_semi_sync_master_tx_avg_wait_time	numeric	GLOBAL
Rpl_semi_sync_master_tx_wait_time	numeric	GLOBAL
Rpl_semi_sync_master_tx_waits	numeric	GLOBAL
Rpl_semi_sync_master_wait_pos_backtraverse	numeric	GLOBAL
Rpl_semi_sync_master_wait_sessions	numeric	GLOBAL
Rpl_semi_sync_master_yes_tx	numeric	GLOBAL
Rpl_semi_sync_slave_status	boolean	GLOBAL
Rpl_status	string	GLOBAL
Select_full_join	numeric	GLOBAL | SESSION
Select_full_range_join	numeric	GLOBAL | SESSION
Select_range	numeric	GLOBAL | SESSION
Select_range_check	numeric	GLOBAL | SESSION
Select_scan	numeric	GLOBAL | SESSION
Slave_heartbeat_period		GLOBAL
Slave_open_temp_tables	numeric	GLOBAL
Slave_received_heartbeats		GLOBAL
Slave_retried_transactions	numeric	GLOBAL
Slave_running	boolean	GLOBAL
Slow_launch_threads	numeric	GLOBAL | SESSION
Slow_queries	numeric	GLOBAL | SESSION
Sort_merge_passes	numeric	GLOBAL | SESSION
Sort_range	numeric	GLOBAL | SESSION
Sort_rows	numeric	GLOBAL | SESSION
Sort_scan	numeric	GLOBAL | SESSION
Ssl_accept_renegotiates	numeric	GLOBAL
Ssl_accepts	numeric	GLOBAL
Ssl_callback_cache_hits	numeric	GLOBAL
Ssl_cipher	string	GLOBAL | SESSION
Ssl_cipher_list	string	GLOBAL | SESSION
Ssl_client_connects	numeric	GLOBAL
Ssl_connect_renegotiates	numeric	GLOBAL
Ssl_ctx_verify_depth	numeric	GLOBAL
Ssl_ctx_verify_mode	numeric	GLOBAL
Ssl_default_timeout	numeric	GLOBAL | SESSION
Ssl_finished_accepts	numeric	GLOBAL
Ssl_finished_connects	numeric	GLOBAL
Ssl_session_cache_hits	numeric	GLOBAL
Ssl_session_cache_misses	numeric	GLOBAL
Ssl_session_cache_mode	string	GLOBAL
Ssl_session_cache_overflows	numeric	GLOBAL
Ssl_session_cache_size	numeric	GLOBAL
Ssl_session_cache_timeouts	numeric	GLOBAL

Variable Name	Variable Type	Variable Scope
`Ssl_sessions_reused`	numeric	`GLOBAL` | `SESSION`
`Ssl_used_session_cache_entries`	numeric	`GLOBAL`
`Ssl_verify_depth`	numeric	`GLOBAL` | `SESSION`
`Ssl_verify_mode`	numeric	`GLOBAL` | `SESSION`
`Ssl_version`	string	`GLOBAL` | `SESSION`
`Table_locks_immediate`	numeric	`GLOBAL`
`Table_locks_waited`	numeric	`GLOBAL`
`Tc_log_max_pages_used`	numeric	`GLOBAL`
`Tc_log_page_size`	numeric	`GLOBAL`
`Tc_log_page_waits`	numeric	`GLOBAL`
`Threads_cached`	numeric	`GLOBAL`
`Threads_connected`	numeric	`GLOBAL`
`Threads_created`	numeric	`GLOBAL`
`Threads_running`	numeric	`GLOBAL`
`Uptime`	numeric	`GLOBAL`
`Uptime_since_flush_status`	numeric	`GLOBAL`

Many status variables are reset to 0 by the `FLUSH STATUS` statement.

The status variables have the following meanings. Variables with no version indicated were already present prior to MySQL 5.5. For information regarding their implementation history, see *MySQL 5.1 Reference Manual*.

- `Aborted_clients`

  The number of connections that were aborted because the client died without closing the connection properly. See Section C.5.2.11, “Communication Errors and Aborted Connections”.

- `Aborted_connects`

  The number of failed attempts to connect to the MySQL server. See Section C.5.2.11, “Communication Errors and Aborted Connections”.

- `Binlog_cache_disk_use`

  The number of transactions that used the binary log cache but that exceeded the value of `binlog_cache_size` and used a temporary file to store changes from the transaction.

  In MySQL versions 5.5.3 through 5.5.8, this variable also included the number of nontransactional statements that caused the binary log transaction cache to be written to disk. Beginning with MySQL 5.5.9, the number of such nontransactional statements is tracked separately in the `Binlog_stmt_cache_disk_use` status variable.

- `Binlog_cache_use`

  The number of transactions that used the binary log cache.

- `Binlog_stmt_cache_disk_use`

  The number of nontransaction statements that used the binary log statement cache but that exceeded the value of `binlog_stmt_cache_size` and used a temporary file to store those statements.

- `Binlog_stmt_cache_use`

  The number of nontransactional statements that used the binary log statement cache.

- `Bytes_received`

  The number of bytes received from all clients.

- `Bytes_sent`

  The number of bytes sent to all clients.

- `Com_xxx`

  The `Com_xxx` statement counter variables indicate the number of times each `xxx` statement has been executed. There is one status variable for each type of statement. For example, `Com_delete` and `Com_insert` count `DELETE` and `INSERT` statements, respectively. However, if a query result is returned from query cache, the server increments the `Qcache_hits` status variable, not `Com_select`. See Section 7.9.3.4, "Query Cache Status and Maintenance".

  All of the `Com_stmt_xxx` variables are increased even if a prepared statement argument is unknown or an error occurred during execution. In other words, their values correspond to the number of requests issued, not to the number of requests successfully completed.

  The `Com_stmt_xxx` status variables are as follows:

  - `Com_stmt_prepare`
  - `Com_stmt_execute`
  - `Com_stmt_fetch`
  - `Com_stmt_send_long_data`
  - `Com_stmt_reset`
  - `Com_stmt_close`

  Those variables stand for prepared statement commands. Their names refer to the `COM_xxx` command set used in the network layer. In other words, their values increase whenever prepared statement API calls such as `mysql_stmt_prepare()`, `mysql_stmt_execute()`, and so forth are executed. However, `Com_stmt_prepare`, `Com_stmt_execute` and `Com_stmt_close` also increase for `PREPARE`, `EXECUTE`, or `DEALLOCATE PREPARE`, respectively. Additionally, the values of the older statement counter variables `Com_prepare_sql`, `Com_execute_sql`, and `Com_dealloc_sql` increase for the `PREPARE`, `EXECUTE`, and `DEALLOCATE PREPARE` statements. `Com_stmt_fetch` stands for the total number of network round-trips issued when fetching from cursors.

  `Com_stmt_reprepare` indicated the number of times statements were automatically reprepared by the server after metadata changes to tables or views referred to by the statement. A reprepare operation increments `Com_stmt_reprepare` is incremented, and also `Com_stmt_prepare`.

- `Compression`

  Whether the client connection uses compression in the client/server protocol.

- `Connections`

  The number of connection attempts (successful or not) to the MySQL server.

- `Created_tmp_disk_tables`

  The number of internal on-disk temporary tables created by the server while executing statements.

  If an internal temporary table is created initially as an in-memory table but becomes too large, MySQL automatically converts it to an on-disk table. The maximum size for in-memory temporary tables is the minimum of the `tmp_table_size` and `max_heap_table_size` values. If `Created_tmp_disk_tables` is large, you may want to increase the `tmp_table_size` or `max_heap_table_size` values. value to lessen the likelihood that internal temporary tables in memory will be converted to on-disk tables.

  You can compare the number of internal on-disk temporary tables created to the total number of internal temporary tables created by comparing the values of the `Created_tmp_disk_tables` and `Created_tmp_tables` variables.

  See also Section 7.4.3.3, "How MySQL Uses Internal Temporary Tables".

- `Created_tmp_files`

  How many temporary files `mysqld` has created.

- `Created_tmp_tables`

  The number of internal temporary tables created by the server while executing statements.

  You can compare the number of internal on-disk temporary tables created to the total number of internal temporary tables created by comparing the values of the `Created_tmp_disk_tables` and `Created_tmp_tables` variables.

See also Section 7.4.3.3, “How MySQL Uses Internal Temporary Tables”.

Each invocation of the `SHOW STATUS` statement uses an internal temporary table and increments the global `Created_tmp_tables` value.

- `Delayed_errors`

  The number of rows written with `INSERT DELAYED` for which some error occurred (probably `duplicate key`).

- `Delayed_insert_threads`

  The number of `INSERT DELAYED` handler threads in use.

- `Delayed_writes`

  The number of `INSERT DELAYED` rows written.

- `Flush_commands`

  The number of executed `FLUSH` statements.

- `Handler_commit`

  The number of internal `COMMIT` statements.

- `Handler_delete`

  The number of times that rows have been deleted from tables.

- `Handler_prepare`

  A counter for the prepare phase of two-phase commit operations.

- `Handler_read_first`

  The number of times the first entry in an index was read. If this value is high, it suggests that the server is doing a lot of full index scans; for example, `SELECT col1 FROM foo`, assuming that `col1` is indexed.

- `Handler_read_key`

  The number of requests to read a row based on a key. If this value is high, it is a good indication that your tables are properly indexed for your queries.

- `Handler_read_last`

  The number of requests to read the last key in an index. With `ORDER BY`, the server will issue a first-key request followed by several next-key requests, whereas with With `ORDER BY DESC`, the server will issue a last-key request followed by several previous-key requests. This variable was added in MySQL 5.5.7.

- `Handler_read_next`

  The number of requests to read the next row in key order. This value is incremented if you are querying an index column with a range constraint or if you are doing an index scan.

- `Handler_read_prev`

  The number of requests to read the previous row in key order. This read method is mainly used to optimize `ORDER BY ... DESC`.

- `Handler_read_rnd`

  The number of requests to read a row based on a fixed position. This value is high if you are doing a lot of queries that require sorting of the result. You probably have a lot of queries that require MySQL to scan entire tables or you have joins that do not use keys properly.

- `Handler_read_rnd_next`

  The number of requests to read the next row in the data file. This value is high if you are doing a lot of table scans. Generally this suggests that your tables are not properly indexed or that your queries are not written to take advantage of the indexes you have.

- `Handler_rollback`

  The number of requests for a storage engine to perform a rollback operation.

- `Handler_savepoint`

  The number of requests for a storage engine to place a savepoint.

- `Handler_savepoint_rollback`

  The number of requests for a storage engine to roll back to a savepoint.

- `Handler_update`

  The number of requests to update a row in a table.

- `Handler_write`

  The number of requests to insert a row in a table.

- `Innodb_buffer_pool_pages_data`

  The number of pages containing data (dirty or clean).

- `Innodb_buffer_pool_pages_dirty`

  The number of pages currently dirty.

- `Innodb_buffer_pool_pages_flushed`

  The number of buffer pool page-flush requests.

- `Innodb_buffer_pool_pages_free`

  The number of free pages.

- `Innodb_buffer_pool_pages_latched`

  The number of latched pages in `InnoDB` buffer pool. These are pages currently being read or written or that cannot be flushed or removed for some other reason. Calculation of this variable is expensive, so it is available only when the `UNIV_DEBUG` system is defined at server build time.

- `Innodb_buffer_pool_pages_misc`

  The number of pages that are busy because they have been allocated for administrative overhead such as row locks or the adaptive hash index. This value can also be calculated as `Innodb_buffer_pool_pages_total` – `Innodb_buffer_pool_pages_free` – `Innodb_buffer_pool_pages_data`.

- `Innodb_buffer_pool_pages_total`

  The total size of the buffer pool, in pages.

- `Innodb_buffer_pool_read_ahead`

  The number of pages read into the `InnoDB` buffer pool by the read-ahead background thread.

- `Innodb_buffer_pool_read_ahead_evicted`

  The number of pages read into the `InnoDB` buffer pool by the read-ahead background thread that were subsequently evicted without having been accessed by queries.

- `Innodb_buffer_pool_read_requests`

  The number of logical read requests `InnoDB` has done.

- `Innodb_buffer_pool_reads`

  The number of logical reads that `InnoDB` could not satisfy from the buffer pool, and had to read directly from the disk.

- `Innodb_buffer_pool_wait_free`

  Normally, writes to the `InnoDB` buffer pool happen in the background. However, if it is necessary to read or create a page and no clean pages are available, it is also necessary to wait for pages to be flushed first. This counter counts instances of these waits. If the buffer pool size has been set properly, this value should be small.

- `Innodb_buffer_pool_write_requests`

  The number writes done to the `InnoDB` buffer pool.

- `Innodb_data_fsyncs`

  The number of `fsync()` operations so far.

- `Innodb_data_pending_fsyncs`

  The current number of pending `fsync()` operations.

- `Innodb_data_pending_reads`

  The current number of pending reads.

- `Innodb_data_pending_writes`

  The current number of pending writes.

- `Innodb_data_read`

  The amount of data read since the server was started.

- `Innodb_data_reads`

  The total number of data reads.

- `Innodb_data_writes`

  The total number of data writes.

- `Innodb_data_written`

  The amount of data written so far, in bytes.

- `Innodb_dblwr_pages_written`

  The number of pages that have been written for doublewrite operations. See Section 13.3.12.1, “`InnoDB` Disk I/O”.

- `Innodb_dblwr_writes`

  The number of doublewrite operations that have been performed. See Section 13.3.12.1, “`InnoDB` Disk I/O”.

- `Innodb_have_atomic_builtins`

  Indicates whether the server was built with atomic instructions.

- `Innodb_log_waits`

  The number of times that the log buffer was too small and a wait was required for it to be flushed before continuing.

- `Innodb_log_write_requests`

  The number of log write requests.

- `Innodb_log_writes`

  The number of physical writes to the log file.

- `Innodb_os_log_fsyncs`

  The number of `fsync()` writes done to the log file.

- `Innodb_os_log_pending_fsyncs`

  The number of pending log file `fsync()` operations.

- `Innodb_os_log_pending_writes`

The number of pending log file writes.

- `Innodb_os_log_written`

  The number of bytes written to the log file.

- `Innodb_page_size`

  The compiled-in `InnoDB` page size (default 16KB). Many values are counted in pages; the page size enables them to be easily converted to bytes.

- `Innodb_pages_created`

  The number of pages created.

- `Innodb_pages_read`

  The number of pages read.

- `Innodb_pages_written`

  The number of pages written.

- `Innodb_row_lock_current_waits`

  The number of row locks currently being waited for.

- `Innodb_row_lock_time`

  The total time spent in acquiring row locks, in milliseconds.

- `Innodb_row_lock_time_avg`

  The average time to acquire a row lock, in milliseconds.

- `Innodb_row_lock_time_max`

  The maximum time to acquire a row lock, in milliseconds.

- `Innodb_row_lock_waits`

  The number of times a row lock had to be waited for.

- `Innodb_rows_deleted`

  The number of rows deleted from `InnoDB` tables.

- `Innodb_rows_inserted`

  The number of rows inserted into `InnoDB` tables.

- `Innodb_rows_read`

  The number of rows read from `InnoDB` tables.

- `Innodb_rows_updated`

  The number of rows updated in `InnoDB` tables.

- `Innodb_truncated_status_writes`

  The number of times output from the `SHOW ENGINE INNODB STATUS` is truncated. Monitoring applications that parse the output from this command can test this value before and after issuing the `SHOW ENGINE` command, to confirm if the output is complete or not.

- `Key_blocks_not_flushed`

  The number of key blocks in the key cache that have changed but have not yet been flushed to disk.

- `Key_blocks_unused`

The number of unused blocks in the key cache. You can use this value to determine how much of the key cache is in use; see the discussion of `key_buffer_size` in Section 5.1.3, “Server System Variables”.

- `Key_blocks_used`

  The number of used blocks in the key cache. This value is a high-water mark that indicates the maximum number of blocks that have ever been in use at one time.

- `Key_read_requests`

  The number of requests to read a key block from the cache.

- `Key_reads`

  The number of physical reads of a key block from disk. If `Key_reads` is large, then your `key_buffer_size` value is probably too small. The cache miss rate can be calculated as `Key_reads`/`Key_read_requests`.

- `Key_write_requests`

  The number of requests to write a key block to the cache.

- `Key_writes`

  The number of physical writes of a key block to disk.

- `Last_query_cost`

  The total cost of the last compiled query as computed by the query optimizer. This is useful for comparing the cost of different query plans for the same query. The default value of 0 means that no query has been compiled yet. The default value is 0. `Last_query_cost` has session scope.

  The `Last_query_cost` value can be computed accurately only for simple “flat” queries, not complex queries such as those with subqueries or `UNION`. For the latter, the value is set to 0.

- `Max_used_connections`

  The maximum number of connections that have been in use simultaneously since the server started.

- `Not_flushed_delayed_rows`

  The number of rows waiting to be written in `INSERT DELAYED` queues.

- `Open_files`

  The number of files that are open. This count includes regular files opened by the server. It does not include other types of files such as sockets or pipes. Also, the count does not include files that storage engines open using their own internal functions rather than asking the server level to do so.

- `Open_streams`

  The number of streams that are open (used mainly for logging).

- `Open_table_definitions`

  The number of cached `.frm` files.

- `Open_tables`

  The number of tables that are open.

- `Opened_files`

  The number of files that have been opened with `my_open()` (a `mysys` library function). Parts of the server that open files without using this function do not increment the count.

- `Opened_table_definitions`

  The number of `.frm` files that have been cached.

- `Opened_tables`

The number of tables that have been opened. If `Opened_tables` is big, your `table_open_cache` value is probably too small.

- `Performance_schema_xxx`

  Performance Schema status variables are listed in Section 19.9, “Performance Schema Status Variables”.

- `Prepared_stmt_count`

  The current number of prepared statements. (The maximum number of statements is given by the `max_prepared_stmt_count` system variable.)

- `Qcache_free_blocks`

  The number of free memory blocks in the query cache.

- `Qcache_free_memory`

  The amount of free memory for the query cache.

- `Qcache_hits`

  The number of query cache hits.

- `Qcache_inserts`

  The number of queries added to the query cache.

- `Qcache_lowmem_prunes`

  The number of queries that were deleted from the query cache because of low memory.

- `Qcache_not_cached`

  The number of noncached queries (not cacheable, or not cached due to the `query_cache_type` setting).

- `Qcache_queries_in_cache`

  The number of queries registered in the query cache.

- `Qcache_total_blocks`

  The total number of blocks in the query cache.

- `Queries`

  The number of statements executed by the server. This variable includes statements executed within stored programs, unlike the `Questions` variable. It does not count `COM_PING` or `COM_STATISTICS` commands.

- `Questions`

  The number of statements executed by the server. This includes only statements sent to the server by clients and not statements executed within stored programs, unlike the `Queries` variable. This variable does not count `COM_PING`, `COM_STATISTICS`, `COM_STMT_PREPARE`, `COM_STMT_CLOSE`, or `COM_STMT_RESET` commands.

- `Rpl_semi_sync_master_clients`

  The number of semisynchronous slaves.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_net_avg_wait_time`

  The average time in microseconds the master waited for a slave reply.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_net_wait_time`

  The total time in microseconds the master waited for slave replies.

This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_net_waits`

  The total number of times the master waited for slave replies.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_no_times`

  The number of times the master turned off semisynchronous replication.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_no_tx`

  The number of commits that were not acknowledged successfully by a slave.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_status`

  Whether semisynchronous replication currently is operational on the master. The value is `ON` if the plugin has been enabled and a commit acknowledgment has occurred. It is `OFF` if the plugin is not enabled or the master has fallen back to asynchronous replication due to commit acknowledgment timeout.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_timefunc_failures`

  The number of times the master failed when calling time functions such as `gettimeofday()`.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_tx_avg_wait_time`

  The average time in microseconds the master waited for each transaction.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_tx_wait_time`

  The total time in microseconds the master waited for transactions.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_tx_waits`

  The total number of times the master waited for transactions.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_wait_pos_backtraverse`

  The total number of times the master waited for an event with binary coordinates lower than events waited for previously. This can occur when the order in which transactions start waiting for a reply is different from the order in which their binary log events are written.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_wait_sessions`

  The number of sessions currently waiting for slave replies.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_master_yes_tx`

  The number of commits that were acknowledged successfully by a slave.

  This variable is available only if the master-side semisynchronous replication plugin is installed.

- `Rpl_semi_sync_slave_status`

  Whether semisynchronous replication currently is operational on the slave. This is `ON` if the plugin has been enabled and the slave I/O thread is running, `OFF` otherwise.

  This variable is available only if the slave-side semisynchronous replication plugin is installed.

- `Rpl_status`

  The status of fail-safe replication (not implemented). This variable is unused and is removed in MySQL 5.6.

- `Select_full_join`

  The number of joins that perform table scans because they do not use indexes. If this value is not 0, you should carefully check the indexes of your tables.

- `Select_full_range_join`

  The number of joins that used a range search on a reference table.

- `Select_range`

  The number of joins that used ranges on the first table. This is normally not a critical issue even if the value is quite large.

- `Select_range_check`

  The number of joins without keys that check for key usage after each row. If this is not 0, you should carefully check the indexes of your tables.

- `Select_scan`

  The number of joins that did a full scan of the first table.

- `Slave_heartbeat_period`

  Shows the replication heartbeat interval (in seconds) on a replication slave.

- `Slave_open_temp_tables`

  The number of temporary tables that the slave SQL thread currently has open. If the value is greater than zero, it is not safe to shut down the slave; see Section 15.4.1.19, “Replication and Temporary Tables”.

- `Slave_received_heartbeats`

  This counter increments with each replication heartbeat received by a replication slave since the last time that the slave was restarted or reset, or a `CHANGE MASTER TO` statement was issued.

- `Slave_retried_transactions`

  The total number of times since startup that the replication slave SQL thread has retried transactions.

- `Slave_running`

  This is `ON` if this server is a replication slave that is connected to a replication master, and both the I/O and SQL threads are running; otherwise, it is `OFF`.

- `Slow_launch_threads`

  The number of threads that have taken more than `slow_launch_time` seconds to create.

- `Slow_queries`

  The number of queries that have taken more than `long_query_time` seconds. See Section 5.2.5, “The Slow Query Log”.

- `Sort_merge_passes`

  The number of merge passes that the sort algorithm has had to do. If this value is large, you should consider increasing the value of the `sort_buffer_size` system variable.

- `Sort_range`

  The number of sorts that were done using ranges.

- `Sort_rows`

  The number of sorted rows.

- `Sort_scan`

  The number of sorts that were done by scanning the table.

- `Ssl_accept_renegotiates`

  The number of negotiates needed to establish the connection.

- `Ssl_accepts`

  The number of accepted SSL connections.

- `Ssl_callback_cache_hits`

  The number of callback cache hits.

- `Ssl_cipher`

  The current SSL cipher (empty for non-SSL connections).

- `Ssl_cipher_list`

  The list of possible SSL ciphers.

- `Ssl_client_connects`

  The number of SSL connection attempts to an SSL-enabled master.

- `Ssl_connect_renegotiates`

  The number of negotiates needed to establish the connection to an SSL-enabled master.

- `Ssl_ctx_verify_depth`

  The SSL context verification depth (how many certificates in the chain are tested).

- `Ssl_ctx_verify_mode`

  The SSL context verification mode.

- `Ssl_default_timeout`

  The default SSL timeout.

- `Ssl_finished_accepts`

  The number of successful SSL connections to the server.

- `Ssl_finished_connects`

  The number of successful slave connections to an SSL-enabled master.

- `Ssl_session_cache_hits`

  The number of SSL session cache hits.

- `Ssl_session_cache_misses`

  The number of SSL session cache misses.

- `Ssl_session_cache_mode`

  The SSL session cache mode.

- `Ssl_session_cache_overflows`

  The number of SSL session cache overflows.

- `Ssl_session_cache_size`

  The SSL session cache size.

- `Ssl_session_cache_timeouts`

  The number of SSL session cache timeouts.

- `Ssl_sessions_reused`

  How many SSL connections were reused from the cache.

- `Ssl_used_session_cache_entries`

  How many SSL session cache entries were used.

- `Ssl_verify_depth`

  The verification depth for replication SSL connections.

- `Ssl_verify_mode`

  The verification mode for replication SSL connections.

- `Ssl_version`

  The SSL version number.

- `Table_locks_immediate`

  The number of times that a request for a table lock could be granted immediately.

- `Table_locks_waited`

  The number of times that a request for a table lock could not be granted immediately and a wait was needed. If this is high and you have performance problems, you should first optimize your queries, and then either split your table or tables or use replication.

- `Tc_log_max_pages_used`

  For the memory-mapped implementation of the log that is used by `mysqld` when it acts as the transaction coordinator for recovery of internal XA transactions, this variable indicates the largest number of pages used for the log since the server started. If the product of `Tc_log_max_pages_used` and `Tc_log_page_size` is always significantly less than the log size, the size is larger than necessary and can be reduced. (The size is set by the `--log-tc-size` option. Currently, this variable is unused: It is unneeded for binary log-based recovery, and the memory-mapped recovery log method is not used unless the number of storage engines capable of two-phase commit is greater than one. (`InnoDB` is the only applicable engine.)

- `Tc_log_page_size`

  The page size used for the memory-mapped implementation of the XA recovery log. The default value is determined using `getpagesize()`. Currently, this variable is unused for the same reasons as described for `Tc_log_max_pages_used`.

- `Tc_log_page_waits`

  For the memory-mapped implementation of the recovery log, this variable increments each time the server was not able to commit a transaction and had to wait for a free page in the log. If this value is large, you might want to increase the log size (with the `--log-tc-size` option). For binary log-based recovery, this variable increments each time the binary log cannot be closed because there are two-phase commits in progress. (The close operation waits until all such transactions are finished.)

- `Threads_cached`

  The number of threads in the thread cache.

- `Threads_connected`

  The number of currently open connections.

- `Threads_created`

  The number of threads created to handle connections. If `Threads_created` is big, you may want to increase the `thread_cache_size` value. The cache miss rate can be calculated as `Threads_created`/`Connections`.

- `Threads_running`

  The number of threads that are not sleeping.

- `Uptime`

  The number of seconds that the server has been up.

- `Uptime_since_flush_status`

  The number of seconds since the most recent `FLUSH STATUS` statement.

5.1.6. Server SQL Modes

The MySQL server can operate in different SQL modes, and can apply these modes differently for different clients. This capability enables each application to tailor the server's operating mode to its own requirements.

For answers to some questions that are often asked about server SQL modes in MySQL, see Section B.3, "MySQL 5.5 FAQ: Server SQL Mode".

Modes define what SQL syntax MySQL should support and what kind of data validation checks it should perform. This makes it easier to use MySQL in different environments and to use MySQL together with other database servers.

You can set the default SQL mode by starting `mysqld` with the `--sql-mode="`*`modes`*`"` option, or by using `sql-mode="`*`modes`*`"` in `my.cnf` (Unix operating systems) or `my.ini` (Windows). *`modes`* is a list of different modes separated by comma ("`,`") characters. The default value is empty (no modes set). The *`modes`* value also can be empty (`--sql-mode=""` on the command line, or `sql-mode=""` in `my.cnf` on Unix systems or in `my.ini` on Windows) if you want to clear it explicitly.

You can change the SQL mode at runtime by using a `SET [GLOBAL|SESSION] sql_mode='`*`modes`*`'` statement to set the `sql_mode` system value. Setting the `GLOBAL` variable requires the `SUPER` privilege and affects the operation of all clients that connect from that time on. Setting the `SESSION` variable affects only the current client. Any client can change its own session `sql_mode` value at any time.

> ### Important
>
> **SQL mode and user-defined partitioning.** Changing the server SQL mode after creating and inserting data into partitioned tables can cause major changes in the behavior of such tables, and could lead to loss or corruption of data. It is strongly recommended that you never change the SQL mode once you have created tables employing user-defined partitioning.
>
> When replicating partitioned tables, differing SQL modes on master and slave can also lead to problems. For best results, you should always use the same server SQL mode on the master and on the slave.
>
> See Section 16.5, "Restrictions and Limitations on Partitioning", for more information.

You can retrieve the current global or session `sql_mode` value with the following statements:

```
SELECT @@GLOBAL.sql_mode;
SELECT @@SESSION.sql_mode;
```

The most important `sql_mode` values are probably these:

- `ANSI`

  This mode changes syntax and behavior to conform more closely to standard SQL.

- `STRICT_TRANS_TABLES`

  If a value could not be inserted as given into a transactional table, abort the statement. For a nontransactional table, abort the statement if the value occurs in a single-row statement or the first row of a multiple-row statement. More detail is given later in this section.

- `TRADITIONAL`

  Make MySQL behave like a "traditional" SQL database system. A simple description of this mode is "give an error instead of a warning" when inserting an incorrect value into a column.

> **Note**
>
> The `INSERT`/`UPDATE` aborts as soon as the error is noticed. This may not be what you want if you are using a non-transactional storage engine, because data changes made prior to the error may not be rolled back, resulting in a “partially done” update.

When this manual refers to “strict mode,” it means a mode where at least one of `STRICT_TRANS_TABLES` or `STRICT_ALL_TABLES` is enabled.

The following list describes all supported modes:

- `ALLOW_INVALID_DATES`

  Do not perform full checking of dates. Check only that the month is in the range from 1 to 12 and the day is in the range from 1 to 31. This is very convenient for Web applications where you obtain year, month, and day in three different fields and you want to store exactly what the user inserted (without date validation). This mode applies to `DATE` and `DATETIME` columns. It does not apply `TIMESTAMP` columns, which always require a valid date.

  The server requires that month and day values be legal, and not merely in the range 1 to 12 and 1 to 31, respectively. With strict mode disabled, invalid dates such as `'2004-04-31'` are converted to `'0000-00-00'` and a warning is generated. With strict mode enabled, invalid dates generate an error. To permit such dates, enable `ALLOW_INVALID_DATES`.

- `ANSI_QUOTES`

  Treat “`"`” as an identifier quote character (like the “`` ` ``” quote character) and not as a string quote character. You can still use “`` ` ``” to quote identifiers with this mode enabled. With `ANSI_QUOTES` enabled, you cannot use double quotation marks to quote literal strings, because it is interpreted as an identifier.

- `ERROR_FOR_DIVISION_BY_ZERO`

  Produce an error in strict mode (otherwise a warning) when a division by zero (or `MOD(X,0)`) occurs during an `INSERT` or `UPDATE`. If this mode is not enabled, MySQL instead returns `NULL` for divisions by zero. For `INSERT IGNORE` or `UPDATE IGNORE`, MySQL generates a warning for divisions by zero, but the result of the operation is `NULL`.

- `HIGH_NOT_PRECEDENCE`

  The precedence of the `NOT` operator is such that expressions such as `NOT a BETWEEN b AND c` are parsed as `NOT (a BETWEEN b AND c)`. In some older versions of MySQL, the expression was parsed as `(NOT a) BETWEEN b AND c`. The old higher-precedence behavior can be obtained by enabling the `HIGH_NOT_PRECEDENCE` SQL mode.

  ```
  mysql> SET sql_mode = '';
  mysql> SELECT NOT 1 BETWEEN -5 AND 5;
          -> 0
  mysql> SET sql_mode = 'HIGH_NOT_PRECEDENCE';
  mysql> SELECT NOT 1 BETWEEN -5 AND 5;
          -> 1
  ```

- `IGNORE_SPACE`

  Permit spaces between a function name and the “`(`” character. This causes built-in function names to be treated as reserved words. As a result, identifiers that are the same as function names must be quoted as described in Section 8.2, “Schema Object Names”. For example, because there is a `COUNT()` function, the use of `count` as a table name in the following statement causes an error:

  ```
  mysql> CREATE TABLE count (i INT);
  ERROR 1064 (42000): You have an error in your SQL syntax
  ```

  The table name should be quoted:

  ```
  mysql> CREATE TABLE `count` (i INT);
  Query OK, 0 rows affected (0.00 sec)
  ```

  The `IGNORE_SPACE` SQL mode applies to built-in functions, not to user-defined functions or stored functions. It is always permissible to have spaces after a UDF or stored function name, regardless of whether `IGNORE_SPACE` is enabled.

  For further discussion of `IGNORE_SPACE`, see Section 8.2.4, “Function Name Parsing and Resolution”.

- `NO_AUTO_CREATE_USER`

Prevent the `GRANT` statement from automatically creating new users if it would otherwise do so, unless a nonempty password also is specified.

This mode has no effect for `GRANT` statements that include an `IDENTIFIED WITH` clause. That is, `GRANT ... IDENTIFIED WITH` creates nonexistent users regardless of the mode setting.

- `NO_AUTO_VALUE_ON_ZERO`

  `NO_AUTO_VALUE_ON_ZERO` affects handling of `AUTO_INCREMENT` columns. Normally, you generate the next sequence number for the column by inserting either `NULL` or `0` into it. `NO_AUTO_VALUE_ON_ZERO` suppresses this behavior for `0` so that only `NULL` generates the next sequence number.

  This mode can be useful if `0` has been stored in a table's `AUTO_INCREMENT` column. (Storing `0` is not a recommended practice, by the way.) For example, if you dump the table with `mysqldump` and then reload it, MySQL normally generates new sequence numbers when it encounters the `0` values, resulting in a table with contents different from the one that was dumped. Enabling `NO_AUTO_VALUE_ON_ZERO` before reloading the dump file solves this problem. `mysqldump` now automatically includes in its output a statement that enables `NO_AUTO_VALUE_ON_ZERO`, to avoid this problem.

- `NO_BACKSLASH_ESCAPES`

  Disable the use of the backslash character (“`\`”) as an escape character within strings. With this mode enabled, backslash becomes an ordinary character like any other.

- `NO_DIR_IN_CREATE`

  When creating a table, ignore all `INDEX DIRECTORY` and `DATA DIRECTORY` directives. This option is useful on slave replication servers.

- `NO_ENGINE_SUBSTITUTION`

  Control automatic substitution of the default storage engine when a statement such as `CREATE TABLE` or `ALTER TABLE` specifies a storage engine that is disabled or not compiled in.

  Because storage engines can be pluggable at runtime, unavailable engines are treated the same way:

  With `NO_ENGINE_SUBSTITUTION` disabled, for `CREATE TABLE` the default engine is used and a warning occurs if the desired engine is unavailable. For `ALTER TABLE`, a warning occurs and the table is not altered.

  With `NO_ENGINE_SUBSTITUTION` enabled, an error occurs and the table is not created or altered if the desired engine is unavailable.

- `NO_FIELD_OPTIONS`

  Do not print MySQL-specific column options in the output of `SHOW CREATE TABLE`. This mode is used by `mysqldump` in portability mode.

- `NO_KEY_OPTIONS`

  Do not print MySQL-specific index options in the output of `SHOW CREATE TABLE`. This mode is used by `mysqldump` in portability mode.

- `NO_TABLE_OPTIONS`

  Do not print MySQL-specific table options (such as `ENGINE`) in the output of `SHOW CREATE TABLE`. This mode is used by `mysqldump` in portability mode.

- `NO_UNSIGNED_SUBTRACTION`

  By default, subtraction between integer operands produces an `UNSIGNED` result if any operand is`UNSIGNED`. When `NO_UNSIGNED_SUBTRACTION` is enabled, the subtraction result is signed, *even if any operand is unsigned*. For example, compare the type of column `c2` in table `t1` with that of column `c2` in table `t2`:

```
mysql> SET sql_mode='';
mysql> CREATE TABLE test (c1 BIGINT UNSIGNED NOT NULL);
mysql> CREATE TABLE t1 SELECT c1 - 1 AS c2 FROM test;
mysql> DESCRIBE t1;
+-------+---------------------+------+-----+---------+-------+
| Field | Type                | Null | Key | Default | Extra |
+-------+---------------------+------+-----+---------+-------+
| c2    | bigint(21) unsigned |      |     | 0       |       |
+-------+---------------------+------+-----+---------+-------+

mysql> SET sql_mode='NO_UNSIGNED_SUBTRACTION';
mysql> CREATE TABLE t2 SELECT c1 - 1 AS c2 FROM test;
mysql> DESCRIBE t2;
+-------+------------+------+-----+---------+-------+
| Field | Type       | Null | Key | Default | Extra |
+-------+------------+------+-----+---------+-------+
| c2    | bigint(21) |      |     | 0       |       |
+-------+------------+------+-----+---------+-------+
```

Note that this means that `BIGINT UNSIGNED` is not 100% usable in all contexts. See Section 11.10, "Cast Functions and Operators".

```
mysql> SET sql_mode = '';
mysql> SELECT CAST(0 AS UNSIGNED) - 1;
+-------------------------+
| CAST(0 AS UNSIGNED) - 1 |
+-------------------------+
|    18446744073709551615 |
+-------------------------+

mysql> SET sql_mode = 'NO_UNSIGNED_SUBTRACTION';
mysql> SELECT CAST(0 AS UNSIGNED) - 1;
+-------------------------+
| CAST(0 AS UNSIGNED) - 1 |
+-------------------------+
|                      -1 |
+-------------------------+
```

- `NO_ZERO_DATE`

  In strict mode, do not permit `'0000-00-00'` as a valid date. You can still insert zero dates with the `IGNORE` option. When not in strict mode, the date is accepted but a warning is generated.

- `NO_ZERO_IN_DATE`

  In strict mode, do not accept dates where the year part is nonzero but the month or day part is 0 (for example, `'0000-00-00'` is legal but `'2010-00-01'` and `'2010-01-00'` are not). If used with the `IGNORE` option, MySQL inserts a `'0000-00-00'` date for any such date. When not in strict mode, the date is accepted but a warning is generated.

- `ONLY_FULL_GROUP_BY`

  Do not permit queries for which the select list refers to nonaggregated columns that are not named in the `GROUP BY` clause. The following query is invalid with this mode enabled because `address` is not named in the `GROUP BY` clause:

  ```
  SELECT name, address, MAX(age) FROM t GROUP BY name;
  ```

  This mode also restricts references to nonaggregated columns in the `HAVING` clause that are not named in the `GROUP BY` clause.

- `PAD_CHAR_TO_FULL_LENGTH`

  By default, trailing spaces are trimmed from `CHAR` column values on retrieval. If `PAD_CHAR_TO_FULL_LENGTH` is enabled, trimming does not occur and retrieved `CHAR` values are padded to their full length. This mode does not apply to `VARCHAR` columns, for which trailing spaces are retained on retrieval.

  ```
  mysql> CREATE TABLE t1 (c1 CHAR(10));
  Query OK, 0 rows affected (0.37 sec)

  mysql> INSERT INTO t1 (c1) VALUES('xy');
  Query OK, 1 row affected (0.01 sec)

  mysql> SET sql_mode = '';
  Query OK, 0 rows affected (0.00 sec)

  mysql> SELECT c1, CHAR_LENGTH(c1) FROM t1;
  +------+-----------------+
  | c1   | CHAR_LENGTH(c1) |
  +------+-----------------+
  | xy   |               2 |
  +------+-----------------+
  1 row in set (0.00 sec)

  mysql> SET sql_mode = 'PAD_CHAR_TO_FULL_LENGTH';
  Query OK, 0 rows affected (0.00 sec)

  mysql> SELECT c1, CHAR_LENGTH(c1) FROM t1;
  +------------+-----------------+
  | c1         | CHAR_LENGTH(c1) |
  +------------+-----------------+
  | xy         |              10 |
  +------------+-----------------+
  1 row in set (0.00 sec)
  ```

- `PIPES_AS_CONCAT`

  Treat `||` as a string concatenation operator (same as `CONCAT()`) rather than as a synonym for `OR`.

- `REAL_AS_FLOAT`

  Treat `REAL` as a synonym for `FLOAT`. By default, MySQL treats `REAL` as a synonym for `DOUBLE`.

- `STRICT_ALL_TABLES`

  Enable strict mode for all storage engines. Invalid data values are rejected. Additional detail follows.

- `STRICT_TRANS_TABLES`

  Enable strict mode for transactional storage engines, and when possible for nontransactional storage engines. Additional details follow.

Strict mode controls how MySQL handles input values that are invalid or missing. A value can be invalid for several reasons. For example, it might have the wrong data type for the column, or it might be out of range. A value is missing when a new row to be inserted does not contain a value for a non-`NULL` column that has no explicit `DEFAULT` clause in its definition. (For a `NULL` column, `NULL` is inserted if the value is missing.)

For transactional tables, an error occurs for invalid or missing values in a statement when either of the `STRICT_ALL_TABLES` or `STRICT_TRANS_TABLES` modes are enabled. The statement is aborted and rolled back.

For nontransactional tables, the behavior is the same for either mode, if the bad value occurs in the first row to be inserted or updated. The statement is aborted and the table remains unchanged. If the statement inserts or modifies multiple rows and the bad value occurs in the second or later row, the result depends on which strict option is enabled:

- For `STRICT_ALL_TABLES`, MySQL returns an error and ignores the rest of the rows. However, in this case, the earlier rows still have been inserted or updated. This means that you might get a partial update, which might not be what you want. To avoid this, it is best to use single-row statements because these can be aborted without changing the table.

- For `STRICT_TRANS_TABLES`, MySQL converts an invalid value to the closest valid value for the column and insert the adjusted value. If a value is missing, MySQL inserts the implicit default value for the column data type. In either case, MySQL generates a warning rather than an error and continues processing the statement. Implicit defaults are described in Section 10.1.4, “Data Type Default Values”.

Strict mode disallows invalid date values such as `'2004-04-31'`. It does not disallow dates with zero month or day parts such as `'2004-04-00'` or “zero” dates. To disallow these as well, enable the `NO_ZERO_IN_DATE` and `NO_ZERO_DATE` SQL modes in addition to strict mode.

If you are not using strict mode (that is, neither `STRICT_TRANS_TABLES` nor `STRICT_ALL_TABLES` is enabled), MySQL inserts adjusted values for invalid or missing values and produces warnings. In strict mode, you can produce this behavior by using `INSERT IGNORE` or `UPDATE IGNORE`. See Section 12.4.5.41, “`SHOW WARNINGS` Syntax”.

Strict mode does not affect whether foreign key constraints are checked. `foreign_key_checks` can be used for that. (See Section 5.1.3, “Server System Variables”.)

The following special modes are provided as shorthand for combinations of mode values from the preceding list.

The descriptions include all mode values that are available in the most recent version of MySQL. For older versions, a combination mode does not include individual mode values that are not available except in newer versions.

- `ANSI`

  Equivalent to `REAL_AS_FLOAT`, `PIPES_AS_CONCAT`, `ANSI_QUOTES`, `IGNORE_SPACE`.

  `ANSI` mode also causes the server to return an error for queries where a set function *`S`* with an outer reference *`S(outer_ref)`* cannot be aggregated in the outer query against which the outer reference has been resolved. This is such a query:

  ```
  SELECT * FROM t1 WHERE t1.a IN (SELECT MAX(t1.b) FROM t2 WHERE ...);
  ```

  Here, `MAX(t1.b)` cannot aggregated in the outer query because it appears in the `WHERE` clause of that query. Standard SQL requires an error in this situation. If `ANSI` mode is not enabled, the server treats *`S(outer_ref)`* in such queries the same way that it would interpret *`S(const)`*.

See Section 1.8.3, “Running MySQL in ANSI Mode”.

- `DB2`

  Equivalent to `PIPES_AS_CONCAT`, `ANSI_QUOTES`, `IGNORE_SPACE`, `NO_KEY_OPTIONS`, `NO_TABLE_OPTIONS`, `NO_FIELD_OPTIONS`.

- `MAXDB`

  Equivalent to `PIPES_AS_CONCAT`, `ANSI_QUOTES`, `IGNORE_SPACE`, `NO_KEY_OPTIONS`, `NO_TABLE_OPTIONS`, `NO_FIELD_OPTIONS`, `NO_AUTO_CREATE_USER`.

- `MSSQL`

  Equivalent to `PIPES_AS_CONCAT`, `ANSI_QUOTES`, `IGNORE_SPACE`, `NO_KEY_OPTIONS`, `NO_TABLE_OPTIONS`, `NO_FIELD_OPTIONS`.

- `MYSQL323`

  Equivalent to `NO_FIELD_OPTIONS`, `HIGH_NOT_PRECEDENCE`.

- `MYSQL40`

  Equivalent to `NO_FIELD_OPTIONS`, `HIGH_NOT_PRECEDENCE`.

- `ORACLE`

  Equivalent to `PIPES_AS_CONCAT`, `ANSI_QUOTES`, `IGNORE_SPACE`, `NO_KEY_OPTIONS`, `NO_TABLE_OPTIONS`, `NO_FIELD_OPTIONS`, `NO_AUTO_CREATE_USER`.

- `POSTGRESQL`

  Equivalent to `PIPES_AS_CONCAT`, `ANSI_QUOTES`, `IGNORE_SPACE`, `NO_KEY_OPTIONS`, `NO_TABLE_OPTIONS`, `NO_FIELD_OPTIONS`.

- `TRADITIONAL`

  Equivalent to `STRICT_TRANS_TABLES`, `STRICT_ALL_TABLES`, `NO_ZERO_IN_DATE`, `NO_ZERO_DATE`, `ERROR_FOR_DIVISION_BY_ZERO`, `NO_AUTO_CREATE_USER`, and `NO_ENGINE_SUBSTITUTION`.

5.1.7. Server Plugins

MySQL supports a plugin API that enables creation of server components. Plugins can be loaded at server startup, or loaded and unloaded at runtime without restarting the server. The components supported by this interface include, but are not limited to, storage engines, full-text parser plugins, partitioning support, and server extensions.

5.1.7.1. Installing and Uninstalling Plugins

Server plugins must be loaded in to the server before they can be used. MySQL enables you to load a plugin at server startup or at runtime. It is also possible to control the activation of loaded plugins at startup, and to unload them at runtime.

- Installing plugins
- Controlling plugin activation
- Uninstalling plugins

Installing Plugins

Server plugins must be known to the server before they can be used. A plugin can be made known several ways, as described here. In the following descriptions, *`plugin_name`* stands for a plugin name such as `innodb` or `csv`.

Built-in plugins:

A plugin that is built in to the server is known by the server automatically. Normally, the server enables the plugin at startup, although this can be changed with the `--`*`plugin_name`* option.

Plugins registered in the `mysql.plugin` table:

The `mysql.plugin` table serves as a registry of plugins. The server normally enables each plugin listed in the table at startup, although whether a given plugin is enabled can be changed with the `--plugin_name` option. If the server is started with the `--skip-grant-tables` option, it does not consult this table and does not load the plugins listed there.

Plugins named with the `--plugin-load` option:

A plugin that is located in a plugin library file can be loaded at server startup with the `--plugin-load` option. Normally, the server enables the plugin at startup, although this can be changed with the `--plugin_name` option.

The option value is a semicolon-separated list of *`name=plugin_library`* pairs. Each *`name`* is the name of the plugin, and *`plugin_library`* is the name of the shared library that contains the plugin code. If a plugin library is named without any preceding plugin name, the server loads all plugins in the library. Each library file must be located in the directory named by the `plugin_dir` system variable.

This option does not register any plugin in the `mysql.plugin` table. For subsequent restarts, the server loads the plugin again only if `--plugin-load` is given again. That is, this option effects a one-time installation that persists only for one server invocation.

`--plugin-load` enables plugins to be loaded even when `--skip-grant-tables` is given (which causes the server to ignore the `mysql.plugin` table). `--plugin-load` also enables plugins to be loaded at startup under configurations when plugins cannot be loaded at runtime.

Plugins installed with the `INSTALL PLUGIN` statement:

A plugin that is located in a plugin library file can be loaded at runtime with the `INSTALL PLUGIN` statement. The statement also registers the plugin in the `mysql.plugin` table to cause the server to load it on subsequent restarts. For this reason, `INSTALL PLUGIN` requires the `INSERT` privilege for the `mysql.plugin` table.

If a plugin is named both using a `--plugin-load` option and in the `mysql.plugin` table, the server starts but writes these messages to the error log:

```
100310 19:15:44 [ERROR] Function 'plugin_name' already exists
100310 19:15:44 [Warning] Couldn't load plugin named 'plugin_name'
with soname 'plugin_object_file'.
```

Example: The `--plugin-load` option installs a plugin at server startup. To install a plugin named `myplugin` in a plugin library file named `somepluglib.so`, use these lines in a `my.cnf` file:

```
[mysqld]
plugin-load=myplugin=somepluglib.so
```

In this case, the plugin is not registered in `mysql.plugin`. Restarting the server without the `--plugin-load` option causes the plugin not to be loaded at startup.

Alternatively, the `INSTALL PLUGIN` statement causes the server to load the plugin code from the library file at runtime:

```
mysql> INSTALL PLUGIN myplugin SONAME 'somepluglib.so';
```

`INSTALL PLUGIN` also causes “permanent” plugin registration: The server lists the plugin in the `mysql.plugin` table to ensure that it is loaded on subsequent server restarts.

Many plugins can be loaded either at server startup or at runtime. However, if a plugin is designed such that it must be loaded and initialized during server startup, use `--plugin-load` rather than `INSTALL PLUGIN`.

While a plugin is loaded, information about it is available at runtime from several sources, such as the `INFORMATION_SCHEMA.PLUGINS` table and the `SHOW PLUGINS` statement. For more information, see Section 5.1.7.2, “Obtaining Server Plugin Information”.

Controlling Plugin Activation

If the server knows about a plugin when it starts (for example, because the plugin is named using a `--plugin-load` option or registered in the `mysql.plugin` table), the server loads and enables the plugin by default. It is possible to control activation for such a plugin using a `--plugin_name[=value]` startup option named after the plugin. In the following descriptions, *`plugin_name`* stands for a plugin name such as `innodb` or `csv`. As with other options, dashes and underscores are interchangeable in option names. For example, `--my_plugin=ON` and `--my-plugin=ON` are equivalent.

- `--plugin_name=OFF`

Tells the server to disable the plugin.

- `--plugin_name[=ON]`

  Tells the server to enable the plugin. (Specifying the option as `--plugin_name` without a value has the same effect.) If the plugin fails to initialize, the server runs with the plugin disabled.

- `--plugin_name=FORCE`

  Tells the server to enable the plugin, but if plugin initialization fails, the server does not start. In other words, this option forces the server to run with the plugin enabled or not at all.

- `--plugin_name=FORCE_PLUS_PERMANENT`

  Like `FORCE`, but in addition prevents the plugin from being unloaded at runtime. If a user attempts to do so with `UNINSTALL PLUGIN`, an error occurs. This value is available as of MySQL 5.5.7.

The values `OFF`, `ON`, `FORCE`, and `FORCE_PLUS_PERMANENT` are not case sensitive.

The activation state for plugins is visible in the `LOAD_OPTION` column of the `INFORMATION_SCHEMA.PLUGINS` table.

Suppose that `CSV`, `BLACKHOLE`, and `ARCHIVE` are built-in pluggable storage engines and that you want the server to load them at startup, subject to these conditions: The server is permitted to run if `CSV` initialization fails, but must require that `BLACKHOLE` initialization succeeds, and `ARCHIVE` should be disabled. To accomplish that, use these lines in an option file:

```
[mysqld]
csv=ON
blackhole=FORCE
archive=OFF
```

The `--enable-plugin_name` option format is supported as a synonym for `--plugin_name=ON`. The `--disable-plugin_name` and `--skip-plugin_name` option formats are supported as synonyms for `--plugin_name=OFF`.

Before MySQL 5.1.36, plugin options are boolean options (see Section 4.2.3.2, “Program Option Modifiers”). That is, any of these options enable the plugin:

```
--plugin_name
--plugin_name=1
--enable-plugin_name
```

And these options disable the plugin:

```
--plugin_name=0
--disable-plugin_name
--skip-plugin_name
```

If you upgrade to MySQL 5.5 from a version older than 5.1.36 and previously used options of the form `--plugin_name=0` or `--plugin_name=1`, the equivalent options are now `--plugin_name=OFF` and `--plugin_name=ON`, respectively. You also have the choice of requiring plugins to start successfully by using `--plugin_name=FORCE` or `--plugin_name=FORCE_PLUS_PERMANENT`.

If a plugin is disabled, either explicitly with `OFF` or implicitly because it was enabled with `ON` but failed to initialize, aspects of server operation that require the plugin will change. For example, if the plugin implements a storage engine, existing tables for the storage engine become inaccessible, and attempts to create new tables for the storage engine result in tables that use the default storage engine unless the `NO_ENGINE_SUBSTITUTION` SQL mode has been enabled to cause an error to occur instead.

Disabling a plugin may require adjustment to other options. For example, if you start the server using `--skip-innodb` to disable `InnoDB`, other `innodb_xxx` options likely will need to be omitted from the startup command. In addition, because `InnoDB` is the default storage engine, it will not start unless you specify another available storage engine with `--default-storage-engine`.

Uninstalling Plugins

A plugin known to the server can be uninstalled to disable it at runtime with the `UNINSTALL PLUGIN` statement. The statement unloads the plugin and removes it from the `mysql.plugin` table if it is registered there. For this reason, `UNINSTALL PLUGIN` statement requires the `DELETE` privilege for the `mysql.plugin` table. With the plugin no longer registered in the table, the server will not load the plugin automatically for subsequent restarts.

`UNINSTALL PLUGIN` can unload plugins regardless of whether they were loaded with `INSTALL PLUGIN` or -

`-plugin-load`.

`UNINSTALL PLUGIN` is subject to these exceptions:

- It cannot unload plugins that are built in to the server. These can be identified as those that have a library name of `NULL` in the output from `INFORMATION_SCHEMA.PLUGINS` or `SHOW PLUGINS`.
- It cannot unload plugins for which the server was started with `--plugin_name=FORCE_PLUS_PERMANENT`, which prevents plugin unloading at runtime. These can be identified from the `LOAD_OPTION` column of the `INFORMATION_SCHEMA.PLUGINS` table.

5.1.7.2. Obtaining Server Plugin Information

There are several ways to determine which plugins are installed in the server:

- The `INFORMATION_SCHEMA.PLUGINS` table contains a row for each loaded plugin. Any that have a `PLUGIN_LIBRARY` value of `NULL` are built in and cannot be unloaded.

```
mysql> SELECT * FROM information_schema.PLUGINS\G
*************************** 1. row ***************************
           PLUGIN_NAME: binlog
        PLUGIN_VERSION: 1.0
         PLUGIN_STATUS: ACTIVE
           PLUGIN_TYPE: STORAGE ENGINE
   PLUGIN_TYPE_VERSION: 50158.0
        PLUGIN_LIBRARY: NULL
PLUGIN_LIBRARY_VERSION: NULL
         PLUGIN_AUTHOR: MySQL AB
    PLUGIN_DESCRIPTION: This is a pseudo storage engine to represent the binlog in a transaction
        PLUGIN_LICENSE: GPL
           LOAD_OPTION: FORCE
...
*************************** 10. row ***************************
           PLUGIN_NAME: InnoDB
        PLUGIN_VERSION: 1.0
         PLUGIN_STATUS: ACTIVE
           PLUGIN_TYPE: STORAGE ENGINE
   PLUGIN_TYPE_VERSION: 50158.0
        PLUGIN_LIBRARY: ha_innodb_plugin.so
PLUGIN_LIBRARY_VERSION: 1.0
         PLUGIN_AUTHOR: Innobase Oy
    PLUGIN_DESCRIPTION: Supports transactions, row-level locking,
                        and foreign keys
        PLUGIN_LICENSE: GPL
           LOAD_OPTION: ON
...
```

- The `SHOW PLUGINS` statement displays a row for each loaded plugin. Any that have a `Library` value of `NULL` are built in and cannot be unloaded.

```
mysql> SHOW PLUGINS\G
*************************** 1. row ***************************
   Name: binlog
 Status: ACTIVE
   Type: STORAGE ENGINE
Library: NULL
License: GPL
...
*************************** 10. row ***************************
   Name: InnoDB
 Status: ACTIVE
   Type: STORAGE ENGINE
Library: ha_innodb_plugin.so
License: GPL
...
```

- The `mysql.plugin` table shows which plugins have been registered with `INSTALL PLUGIN`. The table contains only plugin names and library file names, so it does not provide as much information as the `PLUGINS` table or the `SHOW PLUGINS` statement.

5.1.8. Server-Side Help

MySQL Server supports a `HELP` statement that returns online information from the MySQL Reference manual (see Section 12.8.3, “`HELP` Syntax”). The proper operation of this statement requires that the help tables in the `mysql` database be initialized with help topic information, which is done by processing the contents of the `fill_help_tables.sql` script.

If you install MySQL using a binary or source distribution on Unix, help table setup occurs when you run `mysql_install_db`.

For an RPM distribution on Linux or binary distribution on Windows, help table setup occurs as part of the MySQL installation process.

If you upgrade MySQL using a binary distribution, the help tables are not upgraded automatically, but you can upgrade them manually. Locate the `fill_help_tables.sql` file in the `share` or `share/mysql` directory. Change location into that directory and process the file with the `mysql` client as follows:

```
shell> mysql -u root mysql < fill_help_tables.sql
```

You can also obtain the latest `fill_help_tables.sql` at any time to upgrade your help tables. Download the proper file for your version of MySQL from http://dev.mysql.com/doc/index-other.html. After downloading and uncompressing the file, process it with `mysql` as described previously.

If you are working with Bazaar and a MySQL development source tree, you will need to download the `fill_help_tables.sql` file because the tree contains only a "stub" version.

5.1.9. Server Response to Signals

On Unix, signals can be sent to processes. `mysqld` responds to signals sent to it as follows:

- `SIGTERM` causes the server to shut down.
- `SIGHUP` causes the server to reload the grant tables and flush the logs (like `FLUSH PRIVILEGES` and `FLUSH LOGS`). It also writes a status report to the error log that has this format:

```
Status information:

Current dir: /var/mysql/data/
Running threads: 0  Stack size: 196608
Current locks:

Key caches:
default
Buffer_size:       8388600
Block_size:           1024
Division_limit:        100
Age_limit:             300
blocks used:             0
not flushed:             0
w_requests:              0
writes:                  0
r_requests:              0
reads:                   0

handler status:
read_key:            0
read_next:           0
read_rnd             0
read_first:          1
write:               0
delete               0
update:              0

Table status:
Opened tables:          5
Open tables:            0
Open files:             7
Open streams:           0

Alarm status:
Active alarms:   1
Max used alarms: 2
Next alarm time: 67
```

On some Mac OS X 10.3 versions, `mysqld` ignores `SIGHUP` and `SIGQUIT`.

5.1.10. The Shutdown Process

The server shutdown process takes place as follows:

1. The shutdown process is initiated.

   This can occur initiated several ways. For example, a user with the `SHUTDOWN` privilege can execute a `mysqladmin shutdown` command. `mysqladmin` can be used on any platform supported by MySQL. Other operating system-specific shutdown initiation methods are possible as well: The server shuts down on Unix when it receives a `SIGTERM` signal. A server running as a service on Windows shuts down when the services manager tells it to.

2. The server creates a shutdown thread if necessary.

   Depending on how shutdown was initiated, the server might create a thread to handle the shutdown process. If shutdown was requested by a client, a shutdown thread is created. If shutdown is the result of receiving a `SIGTERM` signal, the signal thread might handle shutdown itself, or it might create a separate thread to do so. If the server tries to create a shutdown thread and cannot (for example, if memory is exhausted), it issues a diagnostic message that appears in the error log:

   ```
   Error: Can't create thread to kill server
   ```

3. The server stops accepting new connections.

   To prevent new activity from being initiated during shutdown, the server stops accepting new client connections by closing the handlers for the network interfaces to which it normally listens for connections: the TCP/IP port, the Unix socket file, the Windows named pipe, and shared memory on Windows.

4. The server terminates current activity.

   For each thread associated with a client connection, the server breaks the connection to the client and marks the thread as killed. Threads die when they notice that they are so marked. Threads for idle connections die quickly. Threads that currently are processing statements check their state periodically and take longer to die. For additional information about thread termination, see Section 12.4.6.4, “`KILL` Syntax”, in particular for the instructions about killed `REPAIR TABLE` or `OPTIMIZE TABLE` operations on `MyISAM` tables.

   For threads that have an open transaction, the transaction is rolled back. Note that if a thread is updating a nontransactional table, an operation such as a multiple-row `UPDATE` or `INSERT` may leave the table partially updated because the operation can terminate before completion.

   If the server is a master replication server, it treats threads associated with currently connected slaves like other client threads. That is, each one is marked as killed and exits when it next checks its state.

   If the server is a slave replication server, it stops the the I/O and SQL threads, if they are active, before marking client threads as killed. The SQL thread is permitted to finish its current statement (to avoid causing replication problems), and then stops. If the SQL thread was in the middle of a transaction at this point, the transaction is rolled back.

   If the slave is updating a non-transactional table when it is forcibly killed, the slave's data may become inconsistent with the master.

5. The server shuts down or closes storage engines.

   At this stage, the server flushes the table cache and closes all open tables.

   Each storage engine performs any actions necessary for tables that it manages. For example, `MyISAM` flushes any pending index writes for a table. `InnoDB` flushes its buffer pool to disk (unless `innodb_fast_shutdown` is 2), writes the current LSN to the tablespace, and terminates its own internal threads.

6. The server exits.

5.2. MySQL Server Logs

MySQL Server has several different logs that can help you find out what activity is taking place.

Log Type	Information Written to Log
Error log	Problems encountered starting, running, or stopping `mysqld`
General query log	Established client connections and statements received from clients
Binary log	All statements that change data (also used for replication)
Relay log	Data changes received from a replication master server
Slow query log	All queries that took more than `long_query_time` seconds to execute or did not use indexes

By default, all log files are created in the data directory. You can force the server to close and reopen the log files (or in some cases switch to a new log file) by flushing the logs. Log flushing occurs when you issue a `FLUSH LOGS` statement or execute a `mysqladmin flush-logs`, `mysqladmin refresh`, `mysqldump --flush-logs`, or `mysqldump --master-data` command. See Section 12.4.6.3, “`FLUSH` Syntax”, Section 4.5.2, “`mysqladmin` — Client for Administering a MySQL Server”, and Section 4.5.4, “`mysqldump` — A Database Backup Program”. In addition, the binary log is flushed when its size reaches the value of the `max_binlog_size` system variable.

The relay log is used only on slave replication servers, to hold data changes from the master server that must also be made on the slave. For discussion of relay log contents and configuration, see Section 15.2.2.1, “The Slave Relay Log”.

The server can write general query and slow query entries to log tables, log files, or both. For details, see Section 5.2.1, “Selecting General Query and Slow Query Log Output Destinations”.

You can also control during runtime the general query and slow query logs. You can enable or disable logging, or change the name of the log file. See Section 5.2.3, “The General Query Log”, and Section 5.2.5, “The Slow Query Log”.

For information about log maintenance operations such as expiration of old log files, see Section 5.2.6, “Server Log Maintenance”.

For information about keeping logs secure, see Section 5.3.2.1, “Administrator Guidelines for Password Security”.

5.2.1. Selecting General Query and Slow Query Log Output Destinations

MySQL Server provides flexible control over the destination of output to the general query log and the slow query log. Possible destinations for log entries are log files or the `general_log` and `slow_log` tables in the `mysql` database. If logging is enabled, either or both destinations can be selected.

Currently, logging to tables incurs significantly more server overhead than logging to files. If you enable the general log or slow query log and require highest performance, you should use file logging, not table logging.

Log control at server startup. The `--log-output` option specifies the destination for log output, if logging is enabled. This option does not in itself enable the logs. Its syntax is `--log-output[=value,...]`:

- If `--log-output` is given with a value, the value should be a comma-separated list of one or more of the words `TABLE` (log to tables), `FILE` (log to files), or `NONE` (do not log to tables or files). `NONE`, if present, takes precedence over any other specifiers.
- If `--log-output` is omitted or given without a value, the default logging destination is `FILE`.

The `general_log` system variable, if given, enables logging to the general query log for the selected log destinations. If specified at server startup, `general_log` takes an optional argument of 1 or 0 to enable or disable the log. To specify a file name other than the default for file logging, set the `general_log_file` variable. Similarly, the `slow_query_log` variable, if given, enables logging to the slow query log for the selected destinations and setting `slow_query_log_file` specifies a file name for file logging. If either log is enabled, the server opens the corresponding log file and writes startup messages to it. However, further logging of queries to the file does not occur unless the `FILE` log destination is selected.

Examples:

- To write general query log entries to the log table and the log file, use `--log-output=TABLE,FILE` to select both log destinations and the `--general_log` option to enable the general query log.
- To write general and slow query log entries only to the log tables, use `--log-output=TABLE` to select tables as the log destination and the `--general_log` and `--slow_query_log` options to enable both logs.
- To write slow query log entries only to the log file, use `--log-output=FILE` to select files as the log destination and the `--slow_query_log` option to enable the slow query log. (In this case, because the default log destination is `FILE`, you could omit the `--log-output` option.)

Log control at runtime. Several system variables are associated with log tables and files and enable runtime control over logging:

- The global `log_output` system variable indicates the current logging destination. It can be modified at runtime to change the destination.
- The global `general_log` and `slow_query_log` variables indicate whether the general query log and slow query log are enabled (`ON`) or disabled (`OFF`). You can set these variables at runtime to control whether the logs are enabled.
- The global `general_log_file` and `slow_query_log_file` variables indicate the names of the general query log and slow query log files. You can set these variables at server startup or at runtime to change the names of the log files.
- The session `sql_log_off` variable can be set to `ON` or `OFF` to disable or enable general query logging for the current connection.

The use of tables for log output offers the following benefits:

- Log entries have a standard format. To display the current structure of the log tables, use these statements:

  ```
  SHOW CREATE TABLE mysql.general_log;
  SHOW CREATE TABLE mysql.slow_log;
  ```

- Log contents are accessible through SQL statements. This enables the use of queries that select only those log entries that satisfy specific criteria. For example, to select log contents associated with a particular client (which can be useful for identifying problematic queries from that client), it is easier to do this using a log table than a log file.
- Logs are accessible remotely through any client that can connect to the server and issue queries (if the client has the appropriate log table privileges). It is not necessary to log in to the server host and directly access the file system.

The log table implementation has the following characteristics:

- In general, the primary purpose of log tables is to provide an interface for users to observe the runtime execution of the server, not to interfere with its runtime execution.
- `CREATE TABLE`, `ALTER TABLE`, and `DROP TABLE` are valid operations on a log table. For `ALTER TABLE` and `DROP TABLE`, the log table cannot be in use and must be disabled, as described later.
- By default, the log tables use the `CSV` storage engine that writes data in comma-separated values format. For users who have access to the `.CSV` files that contain log table data, the files are easy to import into other programs such as spreadsheets that can process CSV input.

  The log tables can be altered to use the `MyISAM` storage engine. You cannot use `ALTER TABLE` to alter a log table that is in use. The log must be disabled first. No engines other than `CSV` or `MyISAM` are legal for the log tables.
- To disable logging so that you can alter (or drop) a log table, you can use the following strategy. The example uses the general query log; the procedure for the slow query log is similar but uses the `slow_log` table and `slow_query_log` system variable.

  ```
  SET @old_log_state = @@global.general_log;
  SET GLOBAL general_log = 'OFF';
  ALTER TABLE mysql.general_log ENGINE = MyISAM;
  SET GLOBAL general_log = @old_log_state;
  ```

- `TRUNCATE TABLE` is a valid operation on a log table. It can be used to expire log entries.
- `RENAME TABLE` is a valid operation on a log table. You can atomically rename a log table (to perform log rotation, for example) using the following strategy:

  ```
  USE mysql;
  CREATE TABLE IF NOT EXISTS general_log2 LIKE general_log;
  RENAME TABLE general_log TO general_log_backup, general_log2 TO general_log;
  ```

- As of MySQL 5.5.7, `CHECK TABLE` is a valid operation on a log table.
- `LOCK TABLES` cannot be used on a log table.
- `INSERT`, `DELETE`, and `UPDATE` cannot be used on a log table. These operations are permitted only internally to the server itself.
- `FLUSH TABLES WITH READ LOCK` and the state of the global `read_only` system variable have no effect on log tables. The server can always write to the log tables.
- Entries written to the log tables are not written to the binary log and thus are not replicated to slave servers.
- To flush the log tables or log files, use `FLUSH TABLES` or `FLUSH LOGS`, respectively.
- Partitioning of log tables is not permitted.

5.2.2. The Error Log

The error log contains information indicating when `mysqld` was started and stopped and also any critical errors that occur while the server is running. If `mysqld` notices a table that needs to be automatically checked or repaired, it writes a message to the error log.

On some operating systems, the error log contains a stack trace if `mysqld` dies. The trace can be used to determine where `mysqld` died. See MySQL Internals: Porting.

You can specify where `mysqld` writes the error log with the `--log-error[=file_name]` option. If the option is given with no `file_name` value, `mysqld` uses the name `host_name.err` by default. The server creates the file in the data directory unless an absolute path name is given to specify a different directory.

If you do not specify `--log-error`, or (on Windows) if you use the `--console` option, errors are written to `stderr`, the standard error output. Usually this is your terminal.

On Windows, error output is always written to the `.err` file if `--console` is not given.

In addition, on Windows, events and error messages are written to the Windows Event Log within the Application log. Entries marked as `Warning` and `Note` are written to the Event Log, but informational messages (such as information statements from individual storage engines) are not copied to the Event Log. The log entries have a source of **MySQL**. You cannot disable writing information to the Windows Event Log.

If you flush the logs using `FLUSH LOGS` or `mysqladmin flush-logs` and `mysqld` is writing the error log to a file (for example, if it was started with the `--log-error` option), the effect is version dependent:

- As of MySQL 5.5.7, the server closes and reopens the log file. To rename the file, you can do so manually before flushing. Then flushing the logs reopens a new file with the original file name. For example, you can rename the file and create a new one using the following commands:

  ```
  shell> mv host_name.err host_name.err-old
  shell> mysqladmin flush-logs
  shell> mv host_name.err-old backup-directory
  ```

  On Windows, use `rename` rather than `mv`.

- Prior to MySQL 5.5.7, the server renames the current log file with the suffix `-old`, then creates a new empty log file. Be aware that a second log-flushing operation thus causes the original error log file to be lost unless you save it under a different name. On Windows, you cannot rename the error log while the server has it open before MySQL 5.5.7. To avoid a restart, flush the logs first to cause the server to rename the original file and create a new one, then save the renamed file. That also works on Unix, or you can use the commands shown earlier.

No error log renaming occurs when the logs are flushed in any case if the server is not writing to a named file.

The `--log-warnings` option or `log_warnings` system variable can be used to control warning logging to the error log. The default value is enabled (1). Warning logging can be disabled using a value of 0. If the value is greater than 1, aborted connections are written to the error log, and access-denied errors for new connection attempts are written. See Section C.5.2.11, “Communication Errors and Aborted Connections”.

If you use `mysqld_safe` to start `mysqld`, `mysqld_safe` arranges for `mysqld` to write error messages to a log file or to `syslog` `mysqld_safe` has three error-logging options, `--syslog`, `--skip-syslog`, and `--log-error`. The default with no logging options or with `--skip-syslog` is to use the default log file. To explicitly specify use of an error log file, specify `--log-error=file_name` to `mysqld_safe`, and `mysqld_safe` will arrange for `mysqld` to write messages to a log file. To use `syslog` instead, specify the `--syslog` option.

If you specify `--log-error` in an option file in a section that `mysqld` reads, `mysqld_safe` also will find and use the option.

If `mysqld_safe` is used to start `mysqld` and `mysqld` dies unexpectedly, `mysqld_safe` notices that it needs to restart `mysqld` and writes a `restarted mysqld` message to the error log.

5.2.3. The General Query Log

The general query log is a general record of what `mysqld` is doing. The server writes information to this log when clients connect or disconnect, and it logs each SQL statement received from clients. The general query log can be very useful when you suspect an error in a client and want to know exactly what the client sent to `mysqld`.

`mysqld` writes statements to the query log in the order that it receives them, which might differ from the order in which they are executed. This logging order contrasts to the binary log, for which statements are written after they are executed but before any locks are released. (Also, the query log contains all statements, whereas the binary log does not contain statements that only select data.)

By default, the general query log is disabled. Use `--general_log[={0|1}]` to specify the initial general query log state explicitly. With no argument or an argument of 1, `--general_log` enables the log. With an argument of 0, this option disables the log. You can use `--general_log_file=file_name` to specify a log file name. You can also use `--log-output` to specify the log destination (as described in Section 5.2.1, “Selecting General Query and Slow Query Log Output Destinations”). The older options to enable the general query log, `--log` and `-l`, are deprecated.

If you specify no name for the general query log file, the default name is `host_name.log`. The server creates the file in the data directory unless an absolute path name is given to specify a different directory.

To control the general query log at runtime, use the global `general_log` and `general_log_file` system variables. Set `general_log` to 0 (or `OFF`) to disable the log or to 1 (or `ON`) to enable it. Set `general_log_file` to specify the name of the log file. If a log file already is open, it is closed and the new file is opened.

When the general query log is enabled, the server writes output to any destinations specified by the `--log-output` option or `log_output` system variable. If you enable the log, the server opens the log file and writes startup messages to it. However, further logging of queries to the file does not occur unless the `FILE` log destination is selected. If the destination is `NONE`, no queries are written even if the general log is enabled. Setting the log file name has no effect on logging if the log destination value does not contain `FILE`.

Server restarts and log flushing do not cause a new general query log file to be generated (although flushing closes and reopens it). You can rename the file and create a new one by using the following commands:

```
shell> mv host_name.log host_name-old.log
shell> mysqladmin flush-logs
shell> mv host_name-old.log backup-directory
```

On Windows, use `rename` rather than `mv`.

You can also rename the general query log file at runtime by disabling the log:

```
SET GLOBAL general_log = 'OFF';
```

With the log disabled, rename the log file externally; for example, from the command line. Then enable the log again:

```
SET GLOBAL general_log = 'ON';
```

This method works on any platform and does not require a server restart.

The session `sql_log_off` variable can be set to `ON` or `OFF` to disable or enable general query logging for the current connection.

The general query log should be protected because logged statements might contain passwords. See Section 5.3.2.1, “Administrator Guidelines for Password Security”.

5.2.4. The Binary Log

The binary log contains “events” that describe database changes such as table creation operations or changes to table data. It also contains events for statements that potentially could have made changes (for example, a `DELETE` which matched no rows), unless row-based logging is used. The binary log also contains information about how long each statement took that updated data. The binary log has two important purposes:

- For replication, the binary log is used on master replication servers as a record of the statements to be sent to slave servers. The master server sends the events contained in its binary log to its slaves, which execute those events to make the same data changes that were made on the master. See Section 15.2, “Replication Implementation”.
- Certain data recovery operations require use of the binary log. After a backup has been restored, the events in the binary log that were recorded after the backup was made are re-executed. These events bring databases up to date from the point of the backup. See Section 6.5, “Point-in-Time (Incremental) Recovery Using the Binary Log”.

Running a server with binary logging enabled makes performance slightly slower. However, the benefits of the binary log in enabling you to set up replication and for restore operations generally outweigh this minor performance decrement.

For information about server options and variables affecting the operation of binary logging, see Section 15.1.3.4, “Binary Log Options and Variables”.

The binary log is not used for statements such as `SELECT` or `SHOW` that do not modify data. If you want to log all statements (for example, to identify a problem query), use the general query log. See Section 5.2.3, “The General Query Log”.

The binary log should be protected because logged statements might contain passwords. See Section 5.3.2.1, “Administrator Guidelines for Password Security”.

The format of the events recorded in the binary log is dependent on the binary logging format. Three format types are supported, row-based logging, statement-based logging and mixed-base logging. The binary logging format used depends on the MySQL version. For more information on logging formats, see Section 5.2.4.1, “Binary Logging Formats”.

For information about the format of the binary log itself, see http://forge.mysql.com/wiki/MySQL_Internals_Binary_Log.

To enable the binary log, start the server with the `--log-bin[=base_name]` option. If no `base_name` value is given, the default name is the value of the `pid-file` option (which by default is the name of host machine) followed by `-bin`. If the basename is given, the server writes the file in the data directory unless the basename is given with a leading absolute path name to specify a different directory. It is recommended that you specify a basename; see Section C.5.8, “Known Issues in MySQL”, for the reason.

If you supply an extension in the log name (for example, `--log-bin=base_name.extension`), the extension is silently removed and ignored.

`mysqld` appends a numeric extension to the binary log basename to generate binary log file names. The number increases each time the server creates a new log file, thus creating an ordered series of files. The server creates a new file in the series each time it starts or flushes the logs. The server also creates a new binary log file automatically after the current log's size reaches `max_binlog_size`. A binary log file may become larger than `max_binlog_size` if you are using large transactions because a transaction is written to the file in one piece, never split between files.

To keep track of which binary log files have been used, `mysqld` also creates a binary log index file that contains the names of all used binary log files. By default, this has the same basename as the binary log file, with the extension `'.index'`. You can change the name of the binary log index file with the `--log-bin-index[=file_name]` option. You should not manually edit this file while `mysqld` is running; doing so would confuse `mysqld`.

The term “binary log file” generally denotes an individual numbered file containing database events. The term “binary log” collectively denotes the set of numbered binary log files plus the index file.

The server evaluates the `--binlog-do-db` and `--binlog-ignore-db` options in the same way as it does the `--replicate-do-db` and `--replicate-ignore-db` options. For information about how this is done, see Section 15.2.3.1, “Evaluation of Database-Level Replication and Binary Logging Options”.

A replication slave server by default does not write to its own binary log any data modifications that are received from the replication master. To log these modifications, start the slave with the `--log-slave-updates` option in addition to the `--log-bin` option (see Section 15.1.3.3, “Replication Slave Options and Variables”). This is done when a slave is also to act as a master to other slaves in chained replication.

You can delete all binary log files with the `RESET MASTER` statement, or a subset of them with `PURGE BINARY LOGS`. See Section 12.4.6.6, “`RESET` Syntax”, and Section 12.5.1.1, “`PURGE BINARY LOGS` Syntax”.

If you are using replication, you should not delete old binary log files on the master until you are sure that no slave still needs to use them. For example, if your slaves never run more than three days behind, once a day you can execute `mysqladmin flush-logs` on the master and then remove any logs that are more than three days old. You can remove the files manually, but it is preferable to use `PURGE BINARY LOGS`, which also safely updates the binary log index file for you (and which can take a date argument). See Section 12.5.1.1, “`PURGE BINARY LOGS` Syntax”.

A client that has the `SUPER` privilege can disable binary logging of its own statements by using a `SET sql_log_bin=0` statement. See Section 5.1.3, “Server System Variables”.

You can display the contents of binary log files with the `mysqlbinlog` utility. This can be useful when you want to reprocess statements in the log for a recovery operation. For example, you can update a MySQL server from the binary log as follows:

```
shell> mysqlbinlog log_file | mysql -h server_name
```

`mysqlbinlog` also can be used to display replication slave relay log file contents because they are written using the same format as binary log files. For more information on the `mysqlbinlog` utility and how to use it, see Section 4.6.7, “`mysqlbinlog` — Utility for Processing Binary Log Files”. For more information about the binary log and recovery operations, see Section 6.5, “Point-in-Time (Incremental) Recovery Using the Binary Log”.

Binary logging is done immediately after a statement completes but before any locks are released or any commit is done. This ensures that the log is logged in execution order.

Updates to nontransactional tables are stored in the binary log immediately after execution.

Within an uncommitted transaction, all updates (`UPDATE`, `DELETE`, or `INSERT`) that change transactional tables such as `InnoDB` tables are cached until a `COMMIT` statement is received by the server. At that point, `mysqld` writes the entire transaction to the binary log before the `COMMIT` is executed.

Modifications to nontransactional tables cannot be rolled back. If a transaction that is rolled back includes modifications to nontransactional tables, the entire transaction is logged with a `ROLLBACK` statement at the end to ensure that the modifications to those tables are replicated.

When a thread that handles the transaction starts, it allocates a buffer of `binlog_cache_size` to buffer statements. If a statement is bigger than this, the thread opens a temporary file to store the transaction. The temporary file is deleted when the thread ends.

The `Binlog_cache_use` status variable shows the number of transactions that used this buffer (and possibly a temporary file) for storing statements. The `Binlog_cache_disk_use` status variable shows how many of those transactions actually had to use a temporary file. These two variables can be used for tuning `binlog_cache_size` to a large enough value that avoids the use of temporary files.

The `max_binlog_cache_size` system variable (default 4GB, which is also the maximum) can be used to restrict the total size used to cache a multiple-statement transaction. If a transaction is larger than this many bytes, it fails and rolls back. The minimum value is 4096.

If you are using the binary log and row based logging, concurrent inserts are converted to normal inserts for `CREATE ... SELECT` or `INSERT ... SELECT` statement. This is done to ensure that you can re-create an exact copy of your tables by applying the log during a backup operation. If you are using statement-based logging, the original statement is written to the log.

The binary log format has some known limitations that can affect recovery from backups. See Section 15.4.1, “Replication Features and Issues”.

Binary logging for stored programs is done as described in Section 17.7, “Binary Logging of Stored Programs”.

Note that the binary log format differs in MySQL 5.5 from previous versions of MySQL, due to enhancements in replication. See Section 15.4.2, “Replication Compatibility Between MySQL Versions”.

Writes to the binary log file and binary log index file are handled in the same way as writes to `MyISAM` tables. See Section C.5.4.3, “How MySQL Handles a Full Disk”.

By default, the binary log is not synchronized to disk at each write. So if the operating system or machine (not only the MySQL server) crashes, there is a chance that the last statements of the binary log are lost. To prevent this, you can make the binary log be synchronized to disk after every *`N`* writes to the binary log, with the `sync_binlog` system variable. See Section 5.1.3, “Server System Variables”. 1 is the safest value for `sync_binlog`, but also the slowest. Even with `sync_binlog` set to 1, there is still the chance of an inconsistency between the table content and binary log content in case of a crash. For example, if you are using `InnoDB` tables and the MySQL server processes a `COMMIT` statement, it writes the whole transaction to the binary log and then commits this transaction into `InnoDB`. If the server crashes between those two operations, the transaction is rolled back by `InnoDB` at restart but still exists in the binary log. To resolve this, you should set `--innodb_support_xa` to 1. Although this option is related to the support of XA transactions in InnoDB, it also ensures that the binary log and InnoDB data files are synchronized.

For this option to provide a greater degree of safety, the MySQL server should also be configured to synchronize the binary log and the `InnoDB` logs to disk at every transaction. The `InnoDB` logs are synchronized by default, and `sync_binlog=1` can be used to synchronize the binary log. The effect of this option is that at restart after a crash, after doing a rollback of transactions, the MySQL server cuts rolled back `InnoDB` transactions from the binary log. This ensures that the binary log reflects the exact data of `InnoDB` tables, and so, that the slave remains in synchrony with the master (not receiving a statement which has been rolled back).

If the MySQL server discovers at crash recovery that the binary log is shorter than it should have been, it lacks at least one successfully committed `InnoDB` transaction. This should not happen if `sync_binlog=1` and the disk/file system do an actual sync when they are requested to (some do not), so the server prints an error message `The binary log` *`file_name`* `is shorter than its expected size`. In this case, this binary log is not correct and replication should be restarted from a fresh snapshot of the master's data.

For MySQL 5.1.20 and later (and MySQL 5.0.46 and later for backward compatibility), the session values of the following system variables are written to the binary log and honored by the replication slave when parsing the binary log:

- `sql_mode` (except that the `NO_DIR_IN_CREATE` mode is not replicated; see Section 15.4.1.33, “Replication and Variables”)
- `foreign_key_checks`
- `unique_checks`
- `character_set_client`
- `collation_connection`
- `collation_database`
- `collation_server`
- `sql_auto_is_null`

5.2.4.1. Binary Logging Formats

A number of different logging formats are used to record information in the binary log. The exact format employed depends on the version of MySQL being used. There are three logging formats:

- Replication capabilities in MySQL originally were based on propagation of SQL statements from master to slave. This is called *statement-based logging*. You can cause this format to be used by starting the server with `--binlog-format=STATEMENT`.
- In *row-based logging*, the master writes events to the binary log that indicate how individual table rows are affected. You can cause the server to use row-based logging by starting it with `--binlog-format=ROW`.
- A third option is also available: *mixed logging*. With mixed logging, statement-based logging is used by default, but the logging mode switches automatically to row-based in certain cases as described below. You can cause MySQL to use mixed logging explicitly by starting `mysqld` with the option `--binlog-format=MIXED`.

In MySQL 5.5, the default binary logging format is statement based.

The logging format can also be set or limited by the storage engine being used. This helps to eliminate issues when replicating certain statements between a master and slave which are using different storage engines.

With statement-based replication, there may be issues with replicating nondeterministic statements. In deciding whether or not a given statement is safe for statement-based replication, MySQL determines whether it can guarantee that the statement can be replicated using statement-based logging. If MySQL cannot make this guarantee, it marks the statement as potentially unreliable and issues the warning, `Statement may not be safe to log in statement format`.

You can avoid these issues by using MySQL's row-based replication instead.

5.2.4.2. Setting The Binary Log Format

In MySQL 5.5, the default binary logging format is statement based.

You can select the binary logging format explicitly by starting the MySQL server with `--binlog-format=type`. The supported values for `type` are:

- `STATEMENT` causes logging to be statement-based.
- `ROW` causes logging to be row-based.
- `MIXED` causes logging to use mixed format.

The logging format also can be switched at runtime. To specify the format globally for all clients, set the global value of the `binlog_format` system variable:

```
mysql> SET GLOBAL binlog_format = 'STATEMENT';
mysql> SET GLOBAL binlog_format = 'ROW';
mysql> SET GLOBAL binlog_format = 'MIXED';
```

An individual client can control the logging format for its own statements by setting the session value of `binlog_format`:

```
mysql> SET SESSION binlog_format = 'STATEMENT';
mysql> SET SESSION binlog_format = 'ROW';
mysql> SET SESSION binlog_format = 'MIXED';
```

To change the global or session `binlog_format` value, you must have the `SUPER` privilege.

In addition to switching the logging format manually, a slave server may switch the format *automatically*. This happens when the server is running in either `STATEMENT` or `MIXED` format and encounters an event in the binary log that is written in `ROW` logging format. In that case, the slave switches to row-based replication temporarily for that event, and switches back to the previous format afterward.

There are several reasons why a client might want to set binary logging on a per-session basis:

- A session that makes many small changes to the database might want to use row-based logging.
- A session that performs updates that match many rows in the `WHERE` clause might want to use statement-based logging because it will be more efficient to log a few statements than many rows.

- Some statements require a lot of execution time on the master, but result in just a few rows being modified. It might therefore be beneficial to replicate them using row-based logging.

There are exceptions when you cannot switch the replication format at runtime:

- From within a stored function or a trigger
- If the `NDBCLUSTER` storage engine is enabled
- If the session is currently in row-based replication mode and has open temporary tables

Trying to switch the format in any of these cases results in an error.

Switching the replication format at runtime is not recommended when any temporary tables exist, because temporary tables are logged only when using statement-based replication, whereas with row-based replication they are not logged. With mixed replication, temporary tables are usually logged; exceptions happen with user-defined functions (UDFs) and with the `UUID()` function.

With the binary log format set to `ROW`, many changes are written to the binary log using the row-based format. Some changes, however, still use the statement-based format. Examples include all DDL (data definition language) statements such as `CREATE TABLE`, `ALTER TABLE`, or `DROP TABLE`.

The `--binlog-row-event-max-size` option is available for servers that are capable of row-based replication. Rows are stored into the binary log in chunks having a size in bytes not exceeding the value of this option. The value must be a multiple of 256. The default value is 1024.

> **Warning**
>
> When using *statement-based logging* for replication, it is possible for the data on the master and slave to become different if a statement is designed in such a way that the data modification is *nondeterministic*; that is, it is left to the will of the query optimizer. In general, this is not a good practice even outside of replication. For a detailed explanation of this issue, see Section C.5.8, “Known Issues in MySQL”.

5.2.4.3. Mixed Binary Logging Format

When running in `MIXED` logging format, automatic switching from statement-based to row-based logging takes place under the following conditions:

- When a function contains `UUID()`.
- When one or more tables with `AUTO_INCREMENT` columns are updated and a trigger or stored function is invoked. Like all other unsafe statements, this generates a warning if `binlog_format = STATEMENT`.

  For more information, see Section 15.4.1.1, “Replication and `AUTO_INCREMENT`”.
- When any `INSERT DELAYED` is executed.
- When the body of a view requires row-based replication, the statement creating the view also uses it. For example, this occurs when the statement creating a view uses the `UUID()` function.
- When a call to a UDF is involved.
- If a statement is logged by row and the session that executed the statement has any temporary tables, logging by row is used for all subsequent statements (except for those accessing temporary tables) until all temporary tables in use by that session are dropped.

  This is true whether or not any temporary tables are actually logged.

  Temporary tables cannot be logged using row-based format; thus, once row-based logging is used, all subsequent statements using that table are unsafe. The server approximates this condition by treating all statements executed during the session as unsafe until the session no longer holds any temporary tables.
- When `FOUND_ROWS()` or `ROW_COUNT()` is used. (Bug #12092, Bug #30244)
- When `USER()`, `CURRENT_USER()`, or `CURRENT_USER` is used. (Bug #28086)
- When a statement refers to one or more system variables. (Bug #31168)

Exception. The following system variables, when used with session scope (only), do not cause the logging format to switch:

- `auto_increment_increment`
- `auto_increment_offset`
- `character_set_client`
- `character_set_connection`
- `character_set_database`
- `character_set_server`
- `collation_connection`
- `collation_database`
- `collation_server`
- `foreign_key_checks`
- `identity`
- `last_insert_id`
- `lc_time_names`
- `pseudo_thread_id`
- `sql_auto_is_null`
- `time_zone`
- `timestamp`
- `unique_checks`

For information about determining system variable scope, see Section 5.1.4, “Using System Variables”.

For information about how replication treats `sql_mode`, see Section 15.4.1.33, “Replication and Variables”.

- When one of the tables involved is a log table in the `mysql` database.
- When the `LOAD_FILE()` function is used. (Bug #39701)

> **Note**
>
> A warning is generated if you try to execute a statement using statement-based logging that should be written using row-based logging. The warning is shown both in the client (in the output of `SHOW WARNINGS`) and through the `mysqld` error log. A warning is added to the `SHOW WARNINGS` table each time such a statement is executed. However, only the first statement that generated the warning for each client session is written to the error log to prevent flooding the log.

In addition to the decisions above, individual engines can also determine the logging format used when information in a table is updated. The logging capabilities of an individual engine can be defined as follows:

- If an engine supports row-based logging, the engine is said to be *row-logging capable*.
- If an engine supports statement-based logging, the engine is said to be *statement-logging capable*.

A given storage engine can support either or both logging formats. The following table lists the formats supported by each engine.

Storage Engine	Row Logging Supported	Statement Logging Supported
`ARCHIVE`	Yes	Yes
`BLACKHOLE`	Yes	Yes

Storage Engine	**Row Logging Supported**	**Statement Logging Supported**
`CSV`	Yes	Yes
`EXAMPLE`	Yes	No
`FEDERATED`	Yes	Yes
`HEAP`	Yes	Yes
`InnoDB`	Yes	Yes when the transaction isolation level is `REPEATABLE READ` or `SERIALIZABLE`; No otherwise.
`MyISAM`	Yes	Yes
`MERGE`	Yes	Yes
`NDBCLUSTER`	Yes	No

In MySQL 5.5.3 and later, whether a statement is to be logged and the logging mode to be used is determined according to the type of statement (safe, unsafe, or binary injected), the binary logging format (`STATEMENT`, `ROW`, or `MIXED`), and the logging capabilities of the storage engine (statement capable, row capable, both, or neither). Statements may be logged with or without a warning; failed statements are not logged, but generate errors in the log. This is shown in the following decision table.

Condition				**Action**	
Type	**`binlog_format`**	**SLC**	**RLC**	**Error / Warning**	**Logged as**
*	`*`	No	No	Error: Cannot execute statement: Binary logging is impossible since at least one engine is involved that is both row-incapable and statement-incapable.	`-`
Safe	`STATEMENT`	Yes	No	-	`STATEMENT`
Safe	`MIXED`	Yes	No	-	`STATEMENT`
Safe	`ROW`	Yes	No	Error: Cannot execute statement: Binary logging is impossible since `BINLOG_FORMAT = ROW` and at least one table uses a storage engine that is not capable of row-based logging.	`-`
Unsafe	`STATEMENT`	Yes	No	Warning: Unsafe statement binlogged in statement format, since `BINLOG_FORMAT = STATEMENT`	`STATEMENT`
Unsafe	`MIXED`	Yes	No	Error: Cannot execute statement: Binary logging of an unsafe statement is impossible when the storage engine is limited to statement-based logging, even if `BINLOG_FORMAT = MIXED`.	`-`
Unsafe	`ROW`	Yes	No	Error: Cannot execute statement: Binary logging is impossible since `BINLOG_FORMAT = ROW` and at least one table uses a storage engine	-

Condition				**Action**	
Type	**`binlog_format`**	**SLC**	**RLC**	**Error / Warning**	**Logged as**
				that is not capable of row-based logging.	
Row Injection	`STATEMENT`	Yes	No	`ERROR: CANNOT EXECUTE ROW INJECTION`: Binary logging is not possible since at least one table uses a storage engine that is not capable of row-based logging.	-
Row Injection	`MIXED`	Yes	No	`ERROR: CANNOT EXECUTE ROW INJECTION`: Binary logging is not possible since at least one table uses a storage engine that is not capable of row-based logging.	-
Row Injection	`ROW`	Yes	No	`ERROR: CANNOT EXECUTE ROW INJECTION`: Binary logging is not possible since at least one table uses a storage engine that is not capable of row-based logging.	-
Safe	`STATEMENT`	No	Yes	`ERROR: CANNOT EXECUTE STATEMENT`: Binary logging is impossible since `BINLOG_FORMAT = STATEMENT` and at least one table uses a storage engine that is not capable of statement-based logging.	`-`
Safe	`MIXED`	No	Yes	-	`ROW`
Safe	`ROW`	No	Yes	-	`ROW`
Unsafe	`STATEMENT`	No	Yes	`ERROR: CANNOT EXECUTE STATEMENT`: Binary logging is impossible since `BINLOG_FORMAT = STATEMENT` and at least one table uses a storage engine that is not capable of statement-based logging.	-
Unsafe	`MIXED`	No	Yes	-	`ROW`
Unsafe	`ROW`	No	Yes	-	`ROW`
Row Injection	`STATEMENT`	No	Yes	`ERROR: CANNOT EXECUTE ROW INJECTION`: Binary logging is not possible since `BINLOG_FORMAT = STATEMENT`.	`-`
Row Injection	`MIXED`	No	Yes	-	`ROW`
Row Injection	`ROW`	No	Yes	-	`ROW`
Safe	`STATEMENT`	Yes	Yes	-	`STATEMENT`

Condition				**Action**	
Type	**`binlog_format`**	**SLC**	**RLC**	**Error / Warning**	**Logged as**
Safe	`MIXED`	Yes	Yes	-	`ROW`
Safe	`ROW`	Yes	Yes	-	`ROW`
Unsafe	`STATEMENT`	Yes	Yes	WARNING: UNSAFE STATEMENT BINLOGGED IN STATEMENT FORMAT since `BINLOG_FORMAT = STATEMENT`.	`STATEMENT`
Unsafe	`MIXED`	Yes	Yes	-	`ROW`
Unsafe	`ROW`	Yes	Yes	-	`ROW`
Row Injection	`STATEMENT`	Yes	Yes	ERROR: CANNOT EXECUTE ROW INJECTION: Binary logging is not possible because `BINLOG_FORMAT = STATEMENT`.	-
Row Injection	`MIXED`	Yes	Yes	-	`ROW`
Row Injection	`ROW`	Yes	Yes	-	`ROW`

Handling of mixed-format logging in MySQL 5.5.2 and earlier. The decision-making process for binary logging changed in MySQL 5.5.3, due to the fix for Bug #39934. Prior to MySQL 5.5.3, when determining the logging mode to be used, the capabilities of all the tables affected by the event are combined, and the set of affected tables is then marked according to these rules:

- A set of tables is defined as *row-logging restricted* if the tables are row-logging capable but not statement-logging capable.
- A set of tables is defined as *statement-logging restricted* if the tables are statement-logging capable but not row-logging capable.

Once the determination of the possible logging formats required by the statement is complete it is compared to the current `binlog_format` setting. The following table is used in MySQL 5.5.2 and earlier to decide how the information is recorded in the binary log or, if appropriate, whether an error is raised. In the table, a safe operation is defined as one that is deterministic.

In MySQL 5.5.2 and earlier, several rules decide whether the statement is deterministic, as shown in the following table, where **SLR** stands for “statement-logging restricted” and **RLR** stands for “row-logging restricted”. A statement is *statement-logging restricted* if one or more of the tables it accesses is not row-logging capable. Similarly, a statement is *row-logging restricted* if any table accessed by the statement is not statement-logging capable.

Condition				**Action**	
Safe/unsafe	**`binlog_format`**	**SLR**	**RLR**	**Error/Warning**	**Logged as**
Safe	`STATEMENT`	Yes	Yes	ERROR: NOT LOGGABLE	
Safe	`STATEMENT`	Yes	No		`STATEMENT`
Safe	`STATEMENT`	No	Yes	ERROR: NOT LOGGABLE	
Safe	`STATEMENT`	No	No		`STATEMENT`
Safe	`MIXED`	Yes	Yes	ERROR: NOT LOGGABLE	
Safe	`MIXED`	Yes	No		`STATEMENT`
Safe	`MIXED`	No	Yes		`ROW`
Safe	`MIXED`	No	No		`STATEMENT`
Safe	`ROW`	Yes	Yes	ERROR: NOT LOGGABLE	
Safe	`ROW`	Yes	No	ERROR: NOT LOGGABLE	
Safe	`ROW`	No	Yes		`ROW`
Safe	`ROW`	No	No		`ROW`
Unsafe	`STATEMENT`	Yes	Yes	ERROR: NOT LOGGABLE	

Condition				Action	
Safe/unsafe	**`binlog_format`**	**SLR**	**RLR**	**Error/Warning**	**Logged as**
Unsafe	`STATEMENT`	Yes	No	`WARNING: UNSAFE`	`STATEMENT`
Unsafe	`STATEMENT`	No	Yes	`ERROR: NOT LOGGABLE`	
Unsafe	`STATEMENT`	No	No	`WARNING: UNSAFE`	`STATEMENT`
Unsafe	`MIXED`	Yes	Yes	`ERROR: NOT LOGGABLE`	
Unsafe	`MIXED`	Yes	No	`ERROR: NOT LOGGABLE`	
Unsafe	`MIXED`	No	Yes		`ROW`
Unsafe	`MIXED`	No	No		`ROW`
Unsafe	`ROW`	Yes	Yes	`ERROR: NOT LOGGABLE`	
Unsafe	`ROW`	Yes	No	`ERROR: NOT LOGGABLE`	
Unsafe	`ROW`	No	Yes		`ROW`
Unsafe	`ROW`	No	No		`ROW`

In all MySQL 5.5 releases, when a warning is produced by the determination, a standard MySQL warning is produced (and is available using `SHOW WARNINGS`). The information is also written to the `mysqld` error log. Only one error for each error instance per client connection is logged to prevent flooding the log. The log message includes the SQL statement that was attempted.

If a slave server was started with `--log-warnings` enabled, the slave prints messages to the error log to provide information about its status, such as the binary log and relay log coordinates where it starts its job, when it is switching to another relay log, when it reconnects after a disconnect, and so forth.

5.2.4.4. Logging Format for Changes to `mysql` Database Tables

The contents of the grant tables in the `mysql` database can be modified directly (for example, with `INSERT` or `DELETE`) or indirectly (for example, with `GRANT` or `CREATE USER`). Statements that affect `mysql` database tables are written to the binary log using the following rules:

- Data manipulation statements that change data in `mysql` database tables directly are logged according to the setting of the `binlog_format` system variable. This pertains to statements such as `INSERT`, `UPDATE`, `DELETE`, `REPLACE`, `DO`, `LOAD DATA INFILE`, `SELECT`, and `TRUNCATE TABLE`.
- Statements that change the `mysql` database indirectly are logged as statements regardless of the value of `binlog_format`. This pertains to statements such as `GRANT`, `REVOKE`, `SET PASSWORD`, `RENAME USER`, `CREATE` (all forms except `CREATE TABLE ... SELECT`), `ALTER` (all forms), and `DROP` (all forms).

`CREATE TABLE ... SELECT` is a combination of data definition and data manipulation. The `CREATE TABLE` part is logged using statement format and the `SELECT` part is logged according to the value of `binlog_format`.

5.2.5. The Slow Query Log

The slow query log consists of all SQL statements that took more than `long_query_time` seconds to execute and required at least `min_examined_row_limit` rows to be examined. The time to acquire the initial table locks is not counted as execution time. `mysqld` writes a statement to the slow query log after it has been executed and after all locks have been released, so log order might be different from execution order. The default value of `long_query_time` is 10. The minimum value is 0, and a resolution of microseconds is supported when logging to a file. However, the microseconds part is ignored and only integer values are written when logging to tables.

By default, the slow query log is disabled. Use `--slow_query_log[={0|1}]` to specify the initial slow query log state explicitly. With no argument or an argument of 1, `--slow_query_log` enables the log. With an argument of 0, this option disables the log. You can use `--slow_query_log_file=file_name` to specify a log file name. You can also use `--log-output` to specify the log destination (as described in Section 5.2.1, “Selecting General Query and Slow Query Log Output Destinations”). The older option to enable the slow query log file, `--log-slow-queries`, is deprecated.

If you specify no name for the slow query log file, the default name is `host_name-slow.log`. The server creates the file in the data directory unless an absolute path name is given to specify a different directory.

To control the slow log at runtime, use the global `slow_query_log` and `slow_query_log_file` system variables. Set `slow_query_log` to 0 (or `OFF`) to disable the log or to 1 (or `ON`) to enable it. Set `slow_query_log_file` to specify the name of the log file. If a log file already is open, it is closed and the new file is opened.

When the slow query log is enabled, the server writes output to any destinations specified by the `--log-output` option or `log_output` system variable. If you enable the log, the server opens the log file and writes startup messages to it. However, further logging of queries to the file does not occur unless the `FILE` log destination is selected. If the destination is `NONE`, no queries are written even if the slow query log is enabled. Setting the log file name has no effect on logging if the log destination value does not contain `FILE`.

The slow query log can be used to find queries that take a long time to execute and are therefore candidates for optimization. However, examining a long slow query log can become a difficult task. To make this easier, you can process a slow query log file using the `mysqldumpslow` command to summarize the queries that appear in the log. See Section 4.6.8, "`mysqldumpslow` — Summarize Slow Query Log Files".

In MySQL 5.5, queries that do not use indexes are logged in the slow query log if the `--log-queries-not-using-indexes` option is specified. See Section 5.1.2, "Server Command Options".

In MySQL 5.5, the `--log-slow-admin-statements` server option enables you to request logging of slow administrative statements such as `OPTIMIZE TABLE`, `ANALYZE TABLE`, and `ALTER TABLE` to the slow query log.

Queries handled by the query cache are not added to the slow query log, nor are queries that would not benefit from the presence of an index because the table has zero rows or one row.

A replication slave does not write replicated queries to the slow query log, unless it is run using the `--log-slow-slave-statements` option.

The slow query log should be protected because logged statements might contain passwords. See Section 5.3.2.1, "Administrator Guidelines for Password Security".

5.2.6. Server Log Maintenance

MySQL Server can create a number of different log files to help you see what activity is taking place. See Section 5.2, "MySQL Server Logs". However, you must clean up these files regularly to ensure that the logs do not take up too much disk space.

When using MySQL with logging enabled, you may want to back up and remove old log files from time to time and tell MySQL to start logging to new files. See Section 6.2, "Database Backup Methods".

On a Linux (Red Hat) installation, you can use the `mysql-log-rotate` script for this. If you installed MySQL from an RPM distribution, this script should have been installed automatically. You should be careful with this script if you are using the binary log for replication. You should not remove binary logs until you are certain that their contents have been processed by all slaves.

On other systems, you must install a short script yourself that you start from `cron` (or its equivalent) for handling log files.

For the binary log, you can set the `expire_logs_days` system variable to expire binary log files automatically after a given number of days (see Section 5.1.3, "Server System Variables"). If you are using replication, you should set the variable no lower than the maximum number of days your slaves might lag behind the master. To remove binary logs on demand, use the `PURGE BINARY LOGS` statement (see Section 12.5.1.1, "`PURGE BINARY LOGS` Syntax").

You can force MySQL to start using new log files by flushing the logs. Log flushing occurs when you issue a `FLUSH LOGS` statement or execute a `mysqladmin flush-logs`, `mysqladmin refresh`, `mysqldump --flush-logs`, or `mysqldump --master-data` command. See Section 12.4.6.3, "`FLUSH` Syntax", Section 4.5.2, "`mysqladmin` — Client for Administering a MySQL Server", and Section 4.5.4, "`mysqldump` — A Database Backup Program". In addition, the binary log is flushed when its size reaches the value of the `max_binlog_size` system variable.

As of MySQL 5.5.3, `FLUSH LOGS` supports optional modifiers to enable selective flushing of individual logs (for example, `FLUSH BINARY LOGS`).

A log-flushing operation does the following:

- If general query logging or slow query logging to a log file is enabled, the server closes and reopens the general query log file or slow query log file.
- If binary logging is enabled, the server closes the current binary log file and opens a new log file with the next sequence number.
- If the server was started with the `--log-error` option to cause the error log to be written to a file, the result of a log-flushing operation is version dependent:
  - As of MySQL 5.5.7, the server closes and reopens the log file.
  - Prior to MySQL 5.5.7, the server renames the current log file with the suffix `-old`, then creates a new empty log file.

The server creates a new binary log file when you flush the logs. However, it just closes and reopens the general and slow query log files. To cause new files to be created on Unix, rename the current logs before flushing them. At flush time, the server opens new logs with the original names. For example, if the general and slow query logs are named `mysql.log` and `mysql-slow.log`, you can use a series of commands like this:

```
shell> cd mysql-data-directory
shell> mv mysql.log mysql.old
shell> mv mysql-slow.log mysql-slow.old
shell> mysqladmin flush-logs
```

On Windows, use `rename` rather than `mv`.

At this point, you can make a backup of `mysql.old` and `mysql-slow.old` and then remove them from disk.

A similar strategy can be used to back up the error log file, if there is one, except that, on Windows, you cannot rename the error log file while the server has it open before MySQL 5.5.7. To rename the error log file, a stop and restart can be avoided by flushing the logs to cause the server to rename the current log file with the suffix `-old` and create a new empty error log file. For further information, see Section 5.2.2, “The Error Log”.

You can rename the general query log or slow query log at runtime by disabling the log:

```
SET GLOBAL general_log = 'OFF';
SET GLOBAL slow_query_log = 'OFF';
```

With the logs disabled, rename the log files externally; for example, from the command line. Then enable the logs again:

```
SET GLOBAL general_log = 'ON';
SET GLOBAL slow_query_log = 'ON';
```

This method works on any platform and does not require a server restart.

5.3. General Security Issues

This section describes some general security issues to be aware of and what you can do to make your MySQL installation more secure against attack or misuse. For information specifically about the access control system that MySQL uses for setting up user accounts and checking database access, see Section 5.4, “The MySQL Access Privilege System”.

For answers to some questions that are often asked about MySQL Server security issues, see Section B.9, “MySQL 5.5 FAQ: Security”.

5.3.1. General Security Guidelines

Anyone using MySQL on a computer connected to the Internet should read this section to avoid the most common security mistakes.

In discussing security, we emphasize the necessity of fully protecting the entire server host (not just the MySQL server) against all types of applicable attacks: eavesdropping, altering, playback, and denial of service. We do not cover all aspects of availability and fault tolerance here.

MySQL uses security based on Access Control Lists (ACLs) for all connections, queries, and other operations that users can attempt to perform. There is also support for SSL-encrypted connections between MySQL clients and servers. Many of the concepts discussed here are not specific to MySQL at all; the same general ideas apply to almost all applications.

When running MySQL, follow these guidelines whenever possible:

- **Do not ever give anyone (except MySQL `root` accounts) access to the `user` table in the `mysql` database!** This is critical.
- Learn the MySQL access privilege system. The `GRANT` and `REVOKE` statements are used for controlling access to MySQL. Do not grant more privileges than necessary. Never grant privileges to all hosts.

  Checklist:

  - Try `mysql -u root`. If you are able to connect successfully to the server without being asked for a password, anyone can connect to your MySQL server as the MySQL `root` user with full privileges! Review the MySQL installation instructions, paying particular attention to the information about setting a `root` password. See Section 2.10.2, “Securing the Initial MySQL Accounts”.
  - Use the `SHOW GRANTS` statement to check which accounts have access to what. Then use the `REVOKE` statement to remove those privileges that are not necessary.

- Do not store any plaintext passwords in your database. If your computer becomes compromised, the intruder can take the full list of passwords and use them. Instead, use `MD5()`, `SHA1()`, `SHA2()`, or some other one-way hashing function and store the hash value.

- Do not choose passwords from dictionaries. Special programs exist to break passwords. Even passwords like “xfish98” are very bad. Much better is “duag98” which contains the same word “fish” but typed one key to the left on a standard QWERTY keyboard. Another method is to use a password that is taken from the first characters of each word in a sentence (for example, “Mary had a little lamb” results in a password of “Mhall”). The password is easy to remember and type, but difficult to guess for someone who does not know the sentence.

- Invest in a firewall. This protects you from at least 50% of all types of exploits in any software. Put MySQL behind the firewall or in a demilitarized zone (DMZ).

  Checklist:

  - Try to scan your ports from the Internet using a tool such as `nmap`. MySQL uses port 3306 by default. This port should not be accessible from untrusted hosts. Another simple way to check whether or not your MySQL port is open is to try the following command from some remote machine, where *`server_host`* is the host name or IP address of the host on which your MySQL server runs:

    ```
    shell> telnet server_host 3306
    ```

    If you get a connection and some garbage characters, the port is open, and should be closed on your firewall or router, unless you really have a good reason to keep it open. If `telnet` hangs or the connection is refused, the port is blocked, which is how you want it to be.

- Do not trust any data entered by users of your applications. They can try to trick your code by entering special or escaped character sequences in Web forms, URLs, or whatever application you have built. Be sure that your application remains secure if a user enters something like “`; DROP DATABASE mysql;`”. This is an extreme example, but large security leaks and data loss might occur as a result of hackers using similar techniques, if you do not prepare for them.

  A common mistake is to protect only string data values. Remember to check numeric data as well. If an application generates a query such as `SELECT * FROM table WHERE ID=234` when a user enters the value `234`, the user can enter the value `234 OR 1=1` to cause the application to generate the query `SELECT * FROM table WHERE ID=234 OR 1=1`. As a result, the server retrieves every row in the table. This exposes every row and causes excessive server load. The simplest way to protect from this type of attack is to use single quotation marks around the numeric constants: `SELECT * FROM table WHERE ID='234'`. If the user enters extra information, it all becomes part of the string. In a numeric context, MySQL automatically converts this string to a number and strips any trailing nonnumeric characters from it.

  Sometimes people think that if a database contains only publicly available data, it need not be protected. This is incorrect. Even if it is permissible to display any row in the database, you should still protect against denial of service attacks (for example, those that are based on the technique in the preceding paragraph that causes the server to waste resources). Otherwise, your server becomes unresponsive to legitimate users.

  Checklist:

  - Try to enter single and double quotation marks (“`'`” and “`"`”) in all of your Web forms. If you get any kind of MySQL error, investigate the problem right away.

  - Try to modify dynamic URLs by adding `%22` (“`"`”), `%23` (“`#`”), and `%27` (“`'`”) to them.

  - Try to modify data types in dynamic URLs from numeric to character types using the characters shown in the previous examples. Your application should be safe against these and similar attacks.

  - Try to enter characters, spaces, and special symbols rather than numbers in numeric fields. Your application should remove them before passing them to MySQL or else generate an error. Passing unchecked values to MySQL is very dangerous!

  - Check the size of data before passing it to MySQL.

  - Have your application connect to the database using a user name different from the one you use for administrative purposes. Do not give your applications any access privileges they do not need.

- Many application programming interfaces provide a means of escaping special characters in data values. Properly used, this prevents application users from entering values that cause the application to generate statements that have a different effect than you intend:

  - MySQL C API: Use the `mysql_real_escape_string()` API call.

  - MySQL++: Use the `escape` and `quote` modifiers for query streams.

  - PHP: Use the `mysql_real_escape_string()` function (available as of PHP 4.3.0, prior to that PHP version use `mysql_escape_string()`, and prior to PHP 4.0.3, use `addslashes()`). Note that only `mysql_real_escape_string()` is character set-aware; the other functions can be "bypassed" when using (invalid) multi-byte character sets. In PHP 5, you can use the `mysqli` extension, which supports the improved MySQL authentication protocol and passwords, as well as prepared statements with placeholders.
  - Perl DBI: Use placeholders or the `quote()` method.
  - Ruby DBI: Use placeholders or the `quote()` method.
  - Java JDBC: Use a `PreparedStatement` object and placeholders.

  Other programming interfaces might have similar capabilities.

- Do not transmit plain (unencrypted) data over the Internet. This information is accessible to everyone who has the time and ability to intercept it and use it for their own purposes. Instead, use an encrypted protocol such as SSL or SSH. MySQL supports internal SSL connections as of version 4.0. Another technique is to use SSH port-forwarding to create an encrypted (and compressed) tunnel for the communication.

- Learn to use the `tcpdump` and `strings` utilities. In most cases, you can check whether MySQL data streams are unencrypted by issuing a command like the following:

  ```
  shell> tcpdump -l -i eth0 -w - src or dst port 3306 | strings
  ```

  This works under Linux and should work with small modifications under other systems.

  > **Warning**
  >
  > If you do not see plaintext data, this does not always mean that the information actually is encrypted. If you need high security, you should consult with a security expert.

5.3.2. Password Security in MySQL

Passwords occur in several contexts within MySQL. The following sections provide guidelines that enable administrators and end users to keep these passwords secure and avoid exposing them. There is also a discussion of how MySQL uses password hashing internally.

5.3.2.1. Administrator Guidelines for Password Security

Database administrators should use the following guidelines to keep passwords secure.

MySQL stores passwords for user accounts in the `mysql.user` table. Access to this table should never be granted to any nonadministrative accounts.

A user who has access to modify the plugin directory (the value of the `plugin_dir` system variable) or the `my.cnf` file that specifies the location of the plugin directory can replace plugins and modify the capabilities provided by plugins.

Passwords can appear as plain text in SQL statements such as `CREATE USER`, `GRANT`, and `SET PASSWORD`, or statements that invoke the `PASSWORD()` function. If these statements are logged by the MySQL server, the passwords become available to anyone with access to the logs. This applies to the general query log, the slow query log, and the binary log (see Section 5.2, "MySQL Server Logs"). To guard against unwarranted exposure to log files, they should be located in a directory that restricts access to only the server and the database administrator. If you log to tables in the `mysql` database, access to the tables should never be granted to any nonadministrative accounts.

Replication slaves store the password for the replication master in the `master.info` file. Access to this file should be restricted to the database administrator.

Database backups that include tables or log files containing passwords should be protected using a restricted access mode.

5.3.2.2. End-User Guidelines for Password Security

MySQL users should use the following guidelines to keep passwords secure.

When you run a client program to connect to the MySQL server, it is inadvisable to specify your password in a way that exposes it to discovery by other users. The methods you can use to specify your password when you run client programs are listed here, along with an assessment of the risks of each method. In short, the safest methods are to have the client program prompt for the password or to specify the password in a properly protected option file.

- Use a `-pyour_pass` or `--password=your_pass` option on the command line. For example:

  ```
  shell> mysql -u francis -pfrank db_name
  ```

  This is convenient *but insecure*, because your password becomes visible to system status programs such as `ps` that may be invoked by other users to display command lines. MySQL clients typically overwrite the command-line password argument with zeros during their initialization sequence. However, there is still a brief interval during which the value is visible. Also, on some systems this overwriting strategy is ineffective and the password remains visible to `ps`. (SystemV Unix systems and perhaps others are subject to this problem.)

  If your operating environment is set up to display your current command in the title bar of your terminal window, the password remains visible as long as the command is running, even if the command has scrolled out of view in the window content area.

- Use the `-p` or `--password` option on the command line with no password value specified. In this case, the client program solicits the password interactively:

  ```
  shell> mysql -u francis -p db_name
  Enter password: ********
  ```

  The “`*`” characters indicate where you enter your password. The password is not displayed as you enter it.

  It is more secure to enter your password this way than to specify it on the command line because it is not visible to other users. However, this method of entering a password is suitable only for programs that you run interactively. If you want to invoke a client from a script that runs noninteractively, there is no opportunity to enter the password from the keyboard. On some systems, you may even find that the first line of your script is read and interpreted (incorrectly) as your password.

- Store your password in an option file. For example, on Unix you can list your password in the `[client]` section of the `.my.cnf` file in your home directory:

  ```
  [client]
  password=your_pass
  ```

  To keep the password safe, the file should not be accessible to anyone but yourself. To ensure this, set the file access mode to `400` or `600`. For example:

  ```
  shell> chmod 600 .my.cnf
  ```

  To name from the command line a specific option file containing the password, use the `--defaults-file=file_name` option, where `file_name` is the full path name to the file. For example:

  ```
  shell> mysql --defaults-file=/home/francis/mysql-opts
  ```

  Section 4.2.3.3, “Using Option Files”, discusses option files in more detail.

- Store your password in the `MYSQL_PWD` environment variable. See Section 2.12, “Environment Variables”.

  This method of specifying your MySQL password must be considered *extremely insecure* and should not be used. Some versions of `ps` include an option to display the environment of running processes. If you set `MYSQL_PWD`, your password is exposed to any other user who runs `ps`. Even on systems without such a version of `ps`, it is unwise to assume that there are no other methods by which users can examine process environments.

On Unix, the `mysql` client writes a record of executed statements to a history file (see Section 4.5.1.3, “`mysql` History File”). By default, this file is named `.mysql_history` and is created in your home directory. Passwords can appear as plain text in SQL statements such as `CREATE USER`, `GRANT`, and `SET PASSWORD`, so if you use these statements, they are logged in the history file. To keep this file safe, use a restrictive access mode, the same way as described earlier for the `.my.cnf` file.

If your command interpreter is configured to maintain a history, any file in which the commands are saved will contain MySQL passwords entered on the command line. For example, `bash` uses `~/.bash_history`. Any such file should have a restrictive access mode.

5.3.2.3. Password Hashing in MySQL

MySQL user accounts are listed in the `user` table of the `mysql` database. Each MySQL account is assigned a password, although what is stored in the `Password` column of the `user` table is not the plaintext version of the password, but a hash value computed from it. Password hash values are computed by the `PASSWORD()` function.

MySQL uses passwords in two phases of client/server communication:

- When a client attempts to connect to the server, there is an initial authentication step in which the client must present a password that has a hash value matching the hash value stored in the `user` table for the account that the client wants to use.
- After the client connects, it can (if it has sufficient privileges) set or change the password hashes for accounts listed in the `user` table. The client can do this by using the `PASSWORD()` function to generate a password hash, or by using the `GRANT` or `SET PASSWORD` statements.

In other words, the server *uses* hash values during authentication when a client first attempts to connect. The server *generates* hash values if a connected client invokes the `PASSWORD()` function or uses a `GRANT` or `SET PASSWORD` statement to set or change a password.

The password hashing mechanism was updated in MySQL 4.1 to provide better security and to reduce the risk of passwords being intercepted. However, this new mechanism is understood only by MySQL 4.1 (and newer) servers and clients, which can result in some compatibility problems. A 4.1 or newer client can connect to a pre-4.1 server, because the client understands both the old and new password hashing mechanisms. However, a pre-4.1 client that attempts to connect to a 4.1 or newer server may run into difficulties. For example, a 3.23 `mysql` client that attempts to connect to a 5.5 server may fail with the following error message:

```
shell> mysql -h localhost -u root
Client does not support authentication protocol requested
by server; consider upgrading MySQL client
```

Another common example of this phenomenon occurs for attempts to use the older PHP `mysql` extension after upgrading to MySQL 4.1 or newer. (See Section 20.10.6, “Common Problems with MySQL and PHP”.)

The following discussion describes the differences between the old and new password mechanisms, and what you should do if you upgrade your server but need to maintain backward compatibility with pre-4.1 clients. Additional information can be found in Section C.5.2.4, “`Client does not support authentication protocol`”. This information is of particular importance to PHP programmers migrating MySQL databases from version 4.0 or lower to version 4.1 or higher.

> **Note**
>
> This discussion contrasts 4.1 behavior with pre-4.1 behavior, but the 4.1 behavior described here actually begins with 4.1.1. MySQL 4.1.0 is an “odd” release because it has a slightly different mechanism than that implemented in 4.1.1 and up. Differences between 4.1.0 and more recent versions are described further in MySQL 5.1 Reference Manual.

Prior to MySQL 4.1, password hashes computed by the `PASSWORD()` function are 16 bytes long. Such hashes look like this:

```
mysql> SELECT PASSWORD('mypass');
+--------------------+
| PASSWORD('mypass') |
+--------------------+
| 6f8c114b58f2ce9e   |
+--------------------+
```

The `Password` column of the `user` table (in which these hashes are stored) also is 16 bytes long before MySQL 4.1.

As of MySQL 4.1, the `PASSWORD()` function has been modified to produce a longer 41-byte hash value:

```
mysql> SELECT PASSWORD('mypass');
+-------------------------------------------+
| PASSWORD('mypass')                        |
+-------------------------------------------+
| *6C8989366EAF75BB670AD8EA7A7FC1176A95CEF4 |
+-------------------------------------------+
```

Accordingly, the `Password` column in the `user` table also must be 41 bytes long to store these values:

- If you perform a new installation of MySQL 5.5, the `Password` column is made 41 bytes long automatically.
- Upgrading from MySQL 4.1 (4.1.1 or later in the 4.1 series) to MySQL 5.5 should not give rise to any issues in this regard because both versions use the same password hashing mechanism. If you wish to upgrade an older release of MySQL to version 5.5, you should upgrade to version 4.1 first, then upgrade the 4.1 installation to 5.5.

A widened `Password` column can store password hashes in both the old and new formats. The format of any given password hash value can be determined two ways:

- The obvious difference is the length (16 bytes versus 41 bytes).
- A second difference is that password hashes in the new format always begin with a “`*`” character, whereas passwords in the old

format never do.

The longer password hash format has better cryptographic properties, and client authentication based on long hashes is more secure than that based on the older short hashes.

The differences between short and long password hashes are relevant both for how the server uses passwords during authentication and for how it generates password hashes for connected clients that perform password-changing operations.

The way in which the server uses password hashes during authentication is affected by the width of the `Password` column:

- If the column is short, only short-hash authentication is used.
- If the column is long, it can hold either short or long hashes, and the server can use either format:
  - Pre-4.1 clients can connect, although because they know only about the old hashing mechanism, they can authenticate only using accounts that have short hashes.
  - 4.1 and later clients can authenticate using accounts that have short or long hashes.

Even for short-hash accounts, the authentication process is actually a bit more secure for 4.1 and later clients than for older clients. In terms of security, the gradient from least to most secure is:

- Pre-4.1 client authenticating with short password hash
- 4.1 or later client authenticating with short password hash
- 4.1 or later client authenticating with long password hash

The way in which the server generates password hashes for connected clients is affected by the width of the `Password` column and by the `--old-passwords` option. A 4.1 or later server generates long hashes only if certain conditions are met: The `Password` column must be wide enough to hold long values and the `--old-passwords` option must not be given. These conditions apply as follows:

- The `Password` column must be wide enough to hold long hashes (41 bytes). If the column has not been updated and still has the pre-4.1 width of 16 bytes, the server notices that long hashes cannot fit into it and generates only short hashes when a client performs password-changing operations using `PASSWORD()`, `GRANT`, or `SET PASSWORD`. This is the behavior that occurs if you have upgraded to 4.1 but have not yet run the `mysql_upgrade` program to widen the `Password` column.
- If the `Password` column is wide, it can store either short or long password hashes. In this case, `PASSWORD()`, `GRANT`, and `SET PASSWORD` generate long hashes unless the server was started with the `--old-passwords` option. That option forces the server to generate short password hashes instead.

The purpose of the `--old-passwords` option is to enable you to maintain backward compatibility with pre-4.1 clients under circumstances where the server would otherwise generate long password hashes. The option does not affect authentication (4.1 and later clients can still use accounts that have long password hashes), but it does prevent creation of a long password hash in the `user` table as the result of a password-changing operation. Were that to occur, the account no longer could be used by pre-4.1 clients. Without the `--old-passwords` option, the following undesirable scenario is possible:

- An old client connects to an account that has a short password hash.
- The client changes its own password. Without `--old-passwords`, this results in the account having a long password hash.
- The next time the old client attempts to connect to the account, it cannot, because the account has a long password hash that requires the new hashing mechanism during authentication. (Once an account has a long password hash in the user table, only 4.1 and later clients can authenticate for it, because pre-4.1 clients do not understand long hashes.)

This scenario illustrates that, if you must support older pre-4.1 clients, it is dangerous to run a 4.1 or newer server without using the `--old-passwords` option. By running the server with `--old-passwords`, password-changing operations do not generate long password hashes and thus do not cause accounts to become inaccessible to older clients. (Those clients cannot inadvertently lock themselves out by changing their password and ending up with a long password hash.)

The downside of the `--old-passwords` option is that any passwords you create or change use short hashes, even for 4.1 clients. Thus, you lose the additional security provided by long password hashes. If you want to create an account that has a long hash (for example, for use by 4.1 clients), you must do so while running the server without `--old-passwords`.

The following scenarios are possible for running a 4.1 or later server:

Scenario 1: Short `Password` column in user table:

- Only short hashes can be stored in the `Password` column.
- The server uses only short hashes during client authentication.
- For connected clients, password hash-generating operations involving `PASSWORD()`, `GRANT`, or `SET PASSWORD` use short hashes exclusively. Any change to an account's password results in that account having a short password hash.
- The `--old-passwords` option can be used but is superfluous because with a short `Password` column, the server generates only short password hashes anyway.

Scenario 2: Long `Password` column; server not started with `--old-passwords` option:

- Short or long hashes can be stored in the `Password` column.
- 4.1 and later clients can authenticate using accounts that have short or long hashes.
- Pre-4.1 clients can authenticate only using accounts that have short hashes.
- For connected clients, password hash-generating operations involving `PASSWORD()`, `GRANT`, or `SET PASSWORD` use long hashes exclusively. A change to an account's password results in that account having a long password hash.

As indicated earlier, a danger in this scenario is that it is possible for accounts that have a short password hash to become inaccessible to pre-4.1 clients. A change to such an account's password made using `GRANT`, `PASSWORD()`, or `SET PASSWORD` results in the account being given a long password hash. From that point on, no pre-4.1 client can authenticate to that account until the client upgrades to 4.1.

To deal with this problem, you can change a password in a special way. For example, normally you use `SET PASSWORD` as follows to change an account password:

```
SET PASSWORD FOR 'some_user'@'some_host' = PASSWORD('mypass');
```

To change the password but create a short hash, use the `OLD_PASSWORD()` function instead:

```
SET PASSWORD FOR 'some_user'@'some_host' = OLD_PASSWORD('mypass');
```

`OLD_PASSWORD()` is useful for situations in which you explicitly want to generate a short hash.

Scenario 3: Long `Password` column; 4.1 or newer server started with `--old-passwords` option:

- Short or long hashes can be stored in the `Password` column.
- 4.1 and later clients can authenticate for accounts that have short or long hashes (but note that it is possible to create long hashes only when the server is started without `--old-passwords`).
- Pre-4.1 clients can authenticate only for accounts that have short hashes.
- For connected clients, password hash-generating operations involving `PASSWORD()`, `GRANT`, or `SET PASSWORD` use short hashes exclusively. Any change to an account's password results in that account having a short password hash.

In this scenario, you cannot create accounts that have long password hashes, because the `--old-passwords` option prevents generation of long hashes. Also, if you create an account with a long hash before using the `--old-passwords` option, changing the account's password while `--old-passwords` is in effect results in the account being given a short password, causing it to lose the security benefits of a longer hash.

The disadvantages for these scenarios may be summarized as follows:

In scenario 1, you cannot take advantage of longer hashes that provide more secure authentication.

In scenario 2, accounts with short hashes become inaccessible to pre-4.1 clients if you change their passwords without explicitly using `OLD_PASSWORD()`.

In scenario 3, `--old-passwords` prevents accounts with short hashes from becoming inaccessible, but password-changing operations cause accounts with long hashes to revert to short hashes, and you cannot change them back to long hashes while `--old-passwords` is in effect.

5.3.2.4. Implications of Password Hashing Changes in MySQL 4.1 for Application Programs

An upgrade to MySQL version 4.1 or later can cause compatibility issues for applications that use `PASSWORD()` to generate passwords for their own purposes. Applications really should not do this, because `PASSWORD()` should be used only to manage passwords for MySQL accounts. But some applications use `PASSWORD()` for their own purposes anyway.

If you upgrade to 4.1 or later from a pre-4.1 version of MySQL and run the server under conditions where it generates long password hashes, an application using `PASSWORD()` for its own passwords breaks. The recommended course of action in such cases is to modify the application to use another function, such as `SHA1()` or `MD5()`, to produce hashed values. If that is not possible, you can use the `OLD_PASSWORD()` function, which is provided for generate short hashes in the old format. However, you should note that `OLD_PASSWORD()` may one day no longer be supported.

If the server is running under circumstances where it generates short hashes, `OLD_PASSWORD()` is available but is equivalent to `PASSWORD()`.

PHP programmers migrating their MySQL databases from version 4.0 or lower to version 4.1 or higher should see Section 20.10, “MySQL PHP API”.

5.3.3. Making MySQL Secure Against Attackers

When you connect to a MySQL server, you should use a password. The password is not transmitted in clear text over the connection. Password handling during the client connection sequence was upgraded in MySQL 4.1.1 to be very secure. If you are still using pre-4.1.1-style passwords, the encryption algorithm is not as strong as the newer algorithm. With some effort, a clever attacker who can sniff the traffic between the client and the server can crack the password. (See Section 5.3.2.3, “Password Hashing in MySQL”, for a discussion of the different password handling methods.)

All other information is transferred as text, and can be read by anyone who is able to watch the connection. If the connection between the client and the server goes through an untrusted network, and you are concerned about this, you can use the compressed protocol to make traffic much more difficult to decipher. You can also use MySQL's internal SSL support to make the connection even more secure. See Section 5.5.8, “Using SSL for Secure Connections”. Alternatively, use SSH to get an encrypted TCP/IP connection between a MySQL server and a MySQL client. You can find an Open Source SSH client at http://www.openssh.org/, and a commercial SSH client at http://www.ssh.com/.

To make a MySQL system secure, you should strongly consider the following suggestions:

- Require all MySQL accounts to have a password. A client program does not necessarily know the identity of the person running it. It is common for client/server applications that the user can specify any user name to the client program. For example, anyone can use the `mysql` program to connect as any other person simply by invoking it as `mysql -u` *`other_user db_name`* if *`other_user`* has no password. If all accounts have a password, connecting using another user's account becomes much more difficult.

  For a discussion of methods for setting passwords, see Section 5.5.5, “Assigning Account Passwords”.

- Never run the MySQL server as the Unix `root` user. This is extremely dangerous, because any user with the `FILE` privilege is able to cause the server to create files as `root` (for example, `~root/.bashrc`). To prevent this, `mysqld` refuses to run as `root` unless that is specified explicitly using the `--user=root` option.

  `mysqld` can (and should) be run as an ordinary, unprivileged user instead. You can create a separate Unix account named `mysql` to make everything even more secure. Use this account only for administering MySQL. To start `mysqld` as a different Unix user, add a `user` option that specifies the user name in the `[mysqld]` group of the `my.cnf` option file where you specify server options. For example:

  ```
  [mysqld]
  user=mysql
  ```

  This causes the server to start as the designated user whether you start it manually or by using `mysqld_safe` or `mysql.server`. For more details, see Section 5.3.6, “How to Run MySQL as a Normal User”.

  Running `mysqld` as a Unix user other than `root` does not mean that you need to change the `root` user name in the `user` table. *User names for MySQL accounts have nothing to do with user names for Unix accounts.*

- Do not permit the use of symlinks to tables. (This capability can be disabled with the `--skip-symbolic-links` option.) This is especially important if you run `mysqld` as `root`, because anyone that has write access to the server's data directory then could delete any file in the system! See Section 7.11.3.1.2, “Using Symbolic Links for Tables on Unix”.

- Make sure that the only Unix user account with read or write privileges in the database directories is the account that is used for running `mysqld`.

- Do not grant the `PROCESS` or `SUPER` privilege to nonadministrative users. The output of `mysqladmin processlist` and `SHOW PROCESSLIST` shows the text of any statements currently being executed, so any user who is permitted to see the server process list might be able to see statements issued by other users such as `UPDATE user SET password=PASSWORD('not_secure')`.

  `mysqld` reserves an extra connection for users who have the `SUPER` privilege, so that a MySQL `root` user can log in and check server activity even if all normal connections are in use.

  The `SUPER` privilege can be used to terminate client connections, change server operation by changing the value of system variables, and control replication servers.

- Do not grant the `FILE` privilege to nonadministrative users. Any user that has this privilege can write a file anywhere in the file system with the privileges of the `mysqld` daemon. To make this a bit safer, files generated with `SELECT ... INTO OUTFILE` do not overwrite existing files and are writable by everyone.

  The `FILE` privilege may also be used to read any file that is world-readable or accessible to the Unix user that the server runs as. With this privilege, you can read any file into a database table. This could be abused, for example, by using `LOAD DATA` to load `/etc/passwd` into a table, which then can be displayed with `SELECT`.

- Stored programs and views should be written using the security guidelines discussed in Section 17.6, “Access Control for Stored Programs and Views”.

- If you do not trust your DNS, you should use IP addresses rather than host names in the grant tables. In any case, you should be very careful about creating grant table entries using host name values that contain wildcards.

- If you want to restrict the number of connections permitted to a single account, you can do so by setting the `max_user_connections` variable in `mysqld`. The `GRANT` statement also supports resource control options for limiting the extent of server use permitted to an account. See Section 12.4.1.3, “`GRANT` Syntax”.

- If the plugin directory is writable by the server, it may be possible for a user to write executable code to a file in the directory using `SELECT ... INTO DUMPFILE`. This can be prevented by making `plugin_dir` read only to the server or by setting `--secure-file-priv` to a directory where `SELECT` writes can be made safely.

5.3.4. Security-Related `mysqld` Options

The following `mysqld` options affect security:

Table 5.5. Security Option/Variable Summary

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
allow-suspicious-udfs	Yes	Yes				
automatic_sp_privileges			Yes		Global	Yes
chroot	Yes	Yes				
des-key-file	Yes	Yes				
local_infile			Yes		Global	Yes
local-infile	Yes	Yes				
- *Variable*: local_infile						
old-passwords	Yes	Yes			Both	Yes
- *Variable*: old_passwords			Yes		Both	Yes
safe-show-database	Yes	Yes	Yes		Global	Yes
safe-user-create	Yes	Yes				
secure-auth	Yes	Yes			Global	Yes
- *Variable*: secure_auth			Yes		Global	Yes
secure-file-priv	Yes	Yes			Global	No
- *Variable*: se-			Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
cure_file_priv						
skip-grant-tables	Yes	Yes				
skip-name-resolve	Yes	Yes			Global	No
- *Variable*: skip_name_resolve			Yes		Global	No
skip-networking	Yes	Yes			Global	No
- *Variable*: skip_networking			Yes		Global	No
skip-show-database	Yes	Yes			Global	No
- *Variable*: skip_show_database			Yes		Global	No

- `--allow-suspicious-udfs`

  This option controls whether user-defined functions that have only an `xxx` symbol for the main function can be loaded. By default, the option is off and only UDFs that have at least one auxiliary symbol can be loaded; this prevents attempts at loading functions from shared object files other than those containing legitimate UDFs. See Section 21.3.2.6, "User-Defined Function Security Precautions".

- `--local-infile[={0|1}]`

  If you start the server with `--local-infile=0`, clients cannot use `LOCAL` in `LOAD DATA` statements. See Section 5.3.5, "Security Issues with `LOAD DATA LOCAL`".

- `--old-passwords`

  Force the server to generate short (pre-4.1) password hashes for new passwords. This is useful for compatibility when the server must support older client programs. See Section 5.3.2.3, "Password Hashing in MySQL".

- `--safe-user-create`

  If this option is enabled, a user cannot create new MySQL users by using the `GRANT` statement unless the user has the `INSERT` privilege for the `mysql.user` table or any column in the table. If you want a user to have the ability to create new users that have those privileges that the user has the right to grant, you should grant the user the following privilege:

  ```
  GRANT INSERT(user) ON mysql.user TO 'user_name'@'host_name';
  ```

  This ensures that the user cannot change any privilege columns directly, but has to use the `GRANT` statement to give privileges to other users.

- `--secure-auth`

  Disallow authentication for accounts that have old (pre-4.1) passwords.

  The `mysql` client also has a `--secure-auth` option, which prevents connections to a server if the server requires a password in old format for the client account.

- `--secure-file-priv=path`

  This option limits the effect of the `LOAD_FILE()` function and the `LOAD DATA` and `SELECT ... INTO OUTFILE` statements to work only with files in the specified directory.

- `--skip-grant-tables`

  This option causes the server to start without using the privilege system at all, which gives anyone with access to the server *unrestricted access to all databases*. You can cause a running server to start using the grant tables again by executing `mysqladmin flush-privileges` or `mysqladmin reload` command from a system shell, or by issuing a MySQL `FLUSH PRIVILEGES` statement after connecting to the server. This option also suppresses loading of plugins that were installed with the `INSTALL PLUGIN` statement, user-defined functions (UDFs), and scheduled events. To cause plugins to be loaded anyway, use the `--plugin-load` option.

  `--skip-grant-tables` is unavailable if MySQL was configured with the `DISABLE_GRANT_OPTIONS` compiler flag. See Section 2.9.4, "MySQL Source-Configuration Options".

- `--skip-name-resolve`

  Host names are not resolved. All `Host` column values in the grant tables must be IP addresses or `localhost`.

- `--skip-networking`

  Do not permit TCP/IP connections over the network. All connections to `mysqld` must be made using Unix socket files.

- `--skip-show-database`

  With this option, the `SHOW DATABASES` statement is permitted only to users who have the `SHOW DATABASES` privilege, and the statement displays all database names. Without this option, `SHOW DATABASES` is permitted to all users, but displays each database name only if the user has the `SHOW DATABASES` privilege or some privilege for the database. Note that any global privilege is a privilege for the database.

- `--ssl*`

  Options that begin with `--ssl` specify whether to permit clients to connect using SSL and indicate where to find SSL keys and certificates. See Section 5.5.8.3, "SSL Command Options".

5.3.5. Security Issues with `LOAD DATA LOCAL`

The `LOAD DATA` statement can load a file that is located on the server host, or it can load a file that is located on the client host when the `LOCAL` keyword is specified.

There are two potential security issues with supporting the `LOCAL` version of `LOAD DATA` statements:

- The transfer of the file from the client host to the server host is initiated by the MySQL server. In theory, a patched server could be built that would tell the client program to transfer a file of the server's choosing rather than the file named by the client in the `LOAD DATA` statement. Such a server could access any file on the client host to which the client user has read access.
- In a Web environment where the clients are connecting from a Web server, a user could use `LOAD DATA LOCAL` to read any files that the Web server process has read access to (assuming that a user could run any command against the SQL server). In this environment, the client with respect to the MySQL server actually is the Web server, not the remote program being run by the user who connects to the Web server.

To deal with these problems, we changed how `LOAD DATA LOCAL` is handled as of MySQL 3.23.49 and MySQL 4.0.2 (4.0.13 on Windows):

- By default, all MySQL clients and libraries in binary distributions are compiled with the `-DENABLED_LOCAL_INFILE=1` option, to be compatible with MySQL 3.23.48 and before.
- If you build MySQL from source but do not invoke `CMake` with the `-DENABLED_LOCAL_INFILE=1` option, `LOAD DATA LOCAL` cannot be used by any client unless it is written explicitly to invoke `mysql_options(... MYSQL_OPT_LOCAL_INFILE, 0)`. See Section 20.9.3.49, "`mysql_options()`".
- You can disable all `LOAD DATA LOCAL` statements from the server side by starting `mysqld` with the `--local-infile=0` option.
- For the `mysql` command-line client, enable `LOAD DATA LOCAL` by specifying the `--local-infile[=1]` option, or disable it with the `--local-infile=0` option. For `mysqlimport`, local data file loading is off by default; enable it with the `--local` or `-L` option. In any case, successful use of a local load operation requires that the server permits it.
- If you use `LOAD DATA LOCAL` in Perl scripts or other programs that read the `[client]` group from option files, you can add the `local-infile=1` option to that group. However, to keep this from causing problems for programs that do not understand `local-infile`, specify it using the `loose-` prefix:

  ```
  [client]
  loose-local-infile=1
  ```

- If `LOAD DATA LOCAL` is disabled, either in the server or the client, a client that attempts to issue such a statement receives the following error message:

  ```
  ERROR 1148: The used command is not allowed with this MySQL version
  ```

5.3.6. How to Run MySQL as a Normal User

On Windows, you can run the server as a Windows service using a normal user account.

On Unix, the MySQL server `mysqld` can be started and run by any user. However, you should avoid running the server as the Unix `root` user for security reasons. To change `mysqld` to run as a normal unprivileged Unix user *`user_name`*, you must do the following:

1. Stop the server if it is running (use `mysqladmin shutdown`).
2. Change the database directories and files so that *`user_name`* has privileges to read and write files in them (you might need to do this as the Unix `root` user):

   ```
   shell> chown -R user_name /path/to/mysql/datadir
   ```

   If you do not do this, the server will not be able to access databases or tables when it runs as *`user_name`*.

   If directories or files within the MySQL data directory are symbolic links, `chown -R` might not follow symbolic links for you. If it does not, you will also need to follow those links and change the directories and files they point to.
3. Start the server as user *`user_name`*. Another alternative is to start `mysqld` as the Unix `root` user and use the `--user=`*`user_name`* option. `mysqld` starts up, then switches to run as the Unix user *`user_name`* before accepting any connections.
4. To start the server as the given user automatically at system startup time, specify the user name by adding a `user` option to the `[mysqld]` group of the `/etc/my.cnf` option file or the `my.cnf` option file in the server's data directory. For example:

   ```
   [mysqld]
   user=user_name
   ```

If your Unix machine itself is not secured, you should assign passwords to the MySQL `root` accounts in the grant tables. Otherwise, any user with a login account on that machine can run the `mysql` client with a `--user=root` option and perform any operation. (It is a good idea to assign passwords to MySQL accounts in any case, but especially so when other login accounts exist on the server host.) See Section 2.10, “Postinstallation Setup and Testing”.

5.4. The MySQL Access Privilege System

The primary function of the MySQL privilege system is to authenticate a user who connects from a given host and to associate that user with privileges on a database such as `SELECT`, `INSERT`, `UPDATE`, and `DELETE`. Additional functionality includes the ability to have anonymous users and to grant privileges for MySQL-specific functions such as `LOAD DATA INFILE` and administrative operations.

There are some things that you cannot do with the MySQL privilege system:

- You cannot explicitly specify that a given user should be denied access. That is, you cannot explicitly match a user and then refuse the connection.
- You cannot specify that a user has privileges to create or drop tables in a database but not to create or drop the database itself.
- A password applies globally to an account. You cannot associate a password with a specific object such as a database, table, or routine.

The user interface to the MySQL privilege system consists of SQL statements such as `CREATE USER`, `GRANT`, and `REVOKE`. See Section 12.4.1, “Account Management Statements”.

Internally, the server stores privilege information in the grant tables of the `mysql` database (that is, in the database named `mysql`). The MySQL server reads the contents of these tables into memory when it starts and bases access-control decisions on the in-memory copies of the grant tables.

The MySQL privilege system ensures that all users may perform only the operations permitted to them. As a user, when you connect to a MySQL server, your identity is determined by *the host from which you connect* and *the user name you specify*. When you issue requests after connecting, the system grants privileges according to your identity and *what you want to do*.

MySQL considers both your host name and user name in identifying you because there is no reason to assume that a given user name belongs to the same person on all hosts. For example, the user `joe` who connects from `office.example.com` need not be the same person as the user `joe` who connects from `home.example.com`. MySQL handles this by enabling you to distinguish users on different hosts that happen to have the same name: You can grant one set of privileges for connections by `joe` from `office.example.com`, and a different set of privileges for connections by `joe` from `home.example.com`. To see what privileges a given account has, use the `SHOW GRANTS` statement. For example:

```
SHOW GRANTS FOR 'joe'@'office.example.com';
SHOW GRANTS FOR 'joe'@'home.example.com';
```

MySQL access control involves two stages when you run a client program that connects to the server:

Stage 1: The server accepts or rejects the connection based on your identity and whether you can verify your identity by supplying the correct password.

Stage 2: Assuming that you can connect, the server checks each statement you issue to determine whether you have sufficient privileges to perform it. For example, if you try to select rows from a table in a database or drop a table from the database, the server verifies that you have the `SELECT` privilege for the table or the `DROP` privilege for the database.

For a more detailed description of what happens during each stage, see Section 5.4.4, “Access Control, Stage 1: Connection Verification”, and Section 5.4.5, “Access Control, Stage 2: Request Verification”.

If your privileges are changed (either by yourself or someone else) while you are connected, those changes do not necessarily take effect immediately for the next statement that you issue. For details about the conditions under which the server reloads the grant tables, see Section 5.4.6, “When Privilege Changes Take Effect”.

For general security-related advice, see Section 5.3, “General Security Issues”. For help in diagnosing privilege-related problems, see Section 5.4.7, “Causes of Access-Denied Errors”.

5.4.1. Privileges Provided by MySQL

MySQL provides privileges that apply in different contexts and at different levels of operation:

- Administrative privileges enable users to manage operation of the MySQL server. These privileges are global because they are not specific to a particular database.
- Database privileges apply to a database and to all objects within it. These privileges can be granted for specific databases, or globally so that they apply to all databases.
- Privileges for database objects such as tables, indexes, views, and stored routines can be granted for specific objects within a database, for all objects of a given type within a database (for example, all tables in a database), or globally for all objects of a given type in all databases).

Information about account privileges is stored in the `user`, `db`, `host`, `tables_priv`, `columns_priv`, and `procs_priv` tables in the `mysql` database (see Section 5.4.2, “Privilege System Grant Tables”). The MySQL server reads the contents of these tables into memory when it starts and reloads them under the circumstances indicated in Section 5.4.6, “When Privilege Changes Take Effect”. Access-control decisions are based on the in-memory copies of the grant tables.

Some releases of MySQL introduce changes to the structure of the grant tables to add new access privileges or features. Whenever you update to a new version of MySQL, you should update your grant tables to make sure that they have the current structure so that you can take advantage of any new capabilities. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

The following table shows the privilege names used at the SQL level in the `GRANT` and `REVOKE` statements, along with the column name associated with each privilege in the grant tables and the context in which the privilege applies.

Table 5.6. Permissible Privileges for `GRANT` and `REVOKE`

Privilege	Column	Context
`CREATE`	`Create_priv`	databases, tables, or indexes
`DROP`	`Drop_priv`	databases, tables, or views
`GRANT OPTION`	`Grant_priv`	databases, tables, or stored routines
`REFERENCES`	`References_priv`	databases or tables
`EVENT`	`Event_priv`	databases
`ALTER`	`Alter_priv`	tables
`DELETE`	`Delete_priv`	tables
`INDEX`	`Index_priv`	tables
`INSERT`	`Insert_priv`	tables or columns

Privilege	**Column**	**Context**
`SELECT`	`Select_priv`	tables or columns
`UPDATE`	`Update_priv`	tables or columns
`CREATE TEMPORARY TABLES`	`Create_tmp_table_priv`	tables
`LOCK TABLES`	`Lock_tables_priv`	tables
`TRIGGER`	`Trigger_priv`	tables
`CREATE VIEW`	`Create_view_priv`	views
`SHOW VIEW`	`Show_view_priv`	views
`ALTER ROUTINE`	`Alter_routine_priv`	stored routines
`CREATE ROUTINE`	`Create_routine_priv`	stored routines
`EXECUTE`	`Execute_priv`	stored routines
`FILE`	`File_priv`	file access on server host
`CREATE TABLESPACE`	`Create_tablespace_priv`	server administration
`CREATE USER`	`Create_user_priv`	server administration
`PROCESS`	`Process_priv`	server administration
`RELOAD`	`Reload_priv`	server administration
`REPLICATION CLIENT`	`Repl_client_priv`	server administration
`REPLICATION SLAVE`	`Repl_slave_priv`	server administration
`SHOW DATABASES`	`Show_db_priv`	server administration
`SHUTDOWN`	`Shutdown_priv`	server administration
`SUPER`	`Super_priv`	server administration
`ALL [PRIVILEGES]`		server administration
`USAGE`		server administration

The following list provides a general description of each privilege available in MySQL. Particular SQL statements might have more specific privilege requirements than indicated here. If so, the description for the statement in question provides the details.

- The `ALL` or `ALL PRIVILEGES` privilege specifier is shorthand. It stands for “all privileges available at a given privilege level” (except `GRANT OPTION`). For example, granting `ALL` at the global or table level grants all global privileges or all table-level privileges.

- The `ALTER` privilege enables use of `ALTER TABLE` to change the structure of tables. `ALTER TABLE` also requires the `CREATE` and `INSERT` privileges. Renaming a table requires `ALTER` and `DROP` on the old table, `ALTER`, `CREATE`, and `INSERT` on the new table.

- The `ALTER ROUTINE` privilege is needed to alter or drop stored routines (procedures and functions).

- The `CREATE` privilege enables creation of new databases and tables.

- The `CREATE ROUTINE` privilege is needed to create stored routines (procedures and functions).

- The `CREATE TABLESPACE` privilege is needed to create, alter, or drop tablespaces and log file groups.

- The `CREATE TEMPORARY TABLES` privilege enables the creation of temporary tables using the `CREATE TEMPORARY TABLE` statement.

  However, other operations on a temporary table, such as `INSERT`, `UPDATE`, or `SELECT`, require additional privileges for those operations for the database containing the temporary table, or for the nontemporary table of the same name.

  To keep privileges for temporary and nontemporary tables separate, a common workaround for this situation is to create a database dedicated to the use of temporary tables. Then for that database, a user can be granted the `CREATE TEMPORARY TABLES` privilege, along with any other privileges required for temporary table operations done by that user.

- The `CREATE USER` privilege enables use of `CREATE USER`, `DROP USER`, `RENAME USER`, and `REVOKE ALL PRIVILEGES`.

- The `CREATE VIEW` privilege enables use of `CREATE VIEW`.

- The `DELETE` privilege enables rows to be deleted from tables in a database.

- The `DROP` privilege enables you to drop (remove) existing databases, tables, and views. The `DROP` privilege is required in order to use the statement `ALTER TABLE ... DROP PARTITION` on a partitioned table. The `DROP` privilege is also required for `TRUNCATE TABLE`. *If you grant the `DROP` privilege for the `mysql` database to a user, that user can drop the database in which the MySQL access privileges are stored.*

- The `EVENT` privilege is required to create, alter, or drop events for the Event Scheduler.

- The `EXECUTE` privilege is required to execute stored routines (procedures and functions).

- The `FILE` privilege gives you permission to read and write files on the server host using the `LOAD DATA INFILE` and `SELECT ... INTO OUTFILE` statements and the `LOAD_FILE()` function. A user who has the `FILE` privilege can read any file on the server host that is either world-readable or readable by the MySQL server. (This implies the user can read any file in any database directory, because the server can access any of those files.) The `FILE` privilege also enables the user to create new files in any directory where the MySQL server has write access. As a security measure, the server will not overwrite existing files.

- The `GRANT OPTION` privilege enables you to give to other users or remove from other users those privileges that you yourself possess.

- The `INDEX` privilege enables you to create or drop (remove) indexes. `INDEX` applies to existing tables. If you have the `CREATE` privilege for a table, you can include index definitions in the `CREATE TABLE` statement.

- The `INSERT` privilege enables rows to be inserted into tables in a database. `INSERT` is also required for the `ANALYZE TABLE`, `OPTIMIZE TABLE`, and `REPAIR TABLE` table-maintenance statements.

- The `LOCK TABLES` privilege enables the use of explicit `LOCK TABLES` statements to lock tables for which you have the `SELECT` privilege. This includes the use of write locks, which prevents other sessions from reading the locked table.

- The `PROCESS` privilege pertains to display of information about the threads executing within the server (that is, information about the statements being executed by sessions). The privilege enables use of `SHOW PROCESSLIST` or `mysqladmin processlist` to see threads belonging to other accounts; you can always see your own threads.

- The `PROXY` privilege enables a user to impersonate or become known as another user. See Section 5.5.7, "Proxy Users". This privilege was added in MySQL 5.5.7.

- The `REFERENCES` privilege currently is unused.

- The `RELOAD` privilege enables use of the `FLUSH` statement. It also enables `mysqladmin` commands that are equivalent to `FLUSH` operations: `flush-hosts`, `flush-logs`, `flush-privileges`, `flush-status`, `flush-tables`, `flush-threads`, `refresh`, and `reload`.

  The `reload` command tells the server to reload the grant tables into memory. `flush-privileges` is a synonym for `reload`. The `refresh` command closes and reopens the log files and flushes all tables. The other `flush-xxx` commands perform functions similar to `refresh`, but are more specific and may be preferable in some instances. For example, if you want to flush just the log files, `flush-logs` is a better choice than `refresh`.

- The `REPLICATION CLIENT` privilege enables the use of `SHOW MASTER STATUS` and `SHOW SLAVE STATUS`.

- The `REPLICATION SLAVE` privilege should be granted to accounts that are used by slave servers to connect to the current server as their master. Without this privilege, the slave cannot request updates that have been made to databases on the master server.

- The `SELECT` privilege enables you to select rows from tables in a database. `SELECT` statements require the `SELECT` privilege only if they actually retrieve rows from a table. Some `SELECT` statements do not access tables and can be executed without permission for any database. For example, you can use `SELECT` as a simple calculator to evaluate expressions that make no reference to tables:

  ```
  SELECT 1+1;
  SELECT PI()*2;
  ```

  The `SELECT` privilege is also needed for other statements that read column values. For example, `SELECT` is needed for columns referenced on the right hand side of `col_name=expr` assignment in `UPDATE` statements or for columns named in the `WHERE` clause of `DELETE` or `UPDATE` statements.

- The `SHOW DATABASES` privilege enables the account to see database names by issuing the `SHOW DATABASE` statement. Accounts that do not have this privilege see only databases for which they have some privileges, and cannot use the statement at all if the server was started with the `--skip-show-database` option. Note that *any* global privilege is a privilege for the database.

- The `SHOW VIEW` privilege enables use of `SHOW CREATE VIEW`.

- The `SHUTDOWN` privilege enables use of the `mysqladmin shutdown` command. There is no corresponding SQL statement.
- The `SUPER` privilege enables an account to use `CHANGE MASTER TO`, `KILL` or `mysqladmin kill` to kill threads belonging to other accounts (you can always kill your own threads), `PURGE BINARY LOGS`, configuration changes using `SET GLOBAL` to modify global system variables, the `mysqladmin debug` command, enabling or disabling logging, performing updates even if the `read_only` system variable is enabled, starting and stopping replication on slave servers, specification of any account in the `DEFINER` attribute of stored programs and views, and enables you to connect (once) even if the connection limit controlled by the `max_connections` system variable is reached.

  To create or alter stored functions if binary logging is enabled, you may also need the `SUPER` privilege, as described in Section 17.7, “Binary Logging of Stored Programs”.
- The `TRIGGER` privilege enables trigger operations. You must have this privilege for a table to create, drop, or execute triggers for that table.
- The `UPDATE` privilege enables rows to be updated in tables in a database.
- The `USAGE` privilege specifier stands for “no privileges.” It is used at the global level with `GRANT` to modify account attributes such as resource limits or SSL characteristics without affecting existing account privileges.

It is a good idea to grant to an account only those privileges that it needs. You should exercise particular caution in granting the `FILE` and administrative privileges:

- The `FILE` privilege can be abused to read into a database table any files that the MySQL server can read on the server host. This includes all world-readable files and files in the server's data directory. The table can then be accessed using `SELECT` to transfer its contents to the client host.
- The `GRANT OPTION` privilege enables users to give their privileges to other users. Two users that have different privileges and with the `GRANT OPTION` privilege are able to combine privileges.
- The `ALTER` privilege may be used to subvert the privilege system by renaming tables.
- The `SHUTDOWN` privilege can be abused to deny service to other users entirely by terminating the server.
- The `PROCESS` privilege can be used to view the plain text of currently executing statements, including statements that set or change passwords.
- The `SUPER` privilege can be used to terminate other sessions or change how the server operates.
- Privileges granted for the `mysql` database itself can be used to change passwords and other access privilege information. Passwords are stored encrypted, so a malicious user cannot simply read them to know the plain text password. However, a user with write access to the `user` table `Password` column can change an account's password, and then connect to the MySQL server using that account.

5.4.2. Privilege System Grant Tables

Normally, you manipulate the contents of the grant tables in the `mysql` database indirectly by using statements such as `GRANT` and `REVOKE` to set up accounts and control the privileges available to each one. See Section 12.4.1, “Account Management Statements”. The discussion here describes the underlying structure of the grant tables and how the server uses their contents when interacting with clients.

These `mysql` database tables contain grant information:

- `user`: Contains user accounts, global privileges, and other non-privilege columns.
- `db`: Contains database-level privileges.
- `host`: Obsolete.
- `tables_priv`: Contains table-level privileges.
- `columns_priv`: Contains column-level privileges.
- `procs_priv`: Contains stored procedure and function privileges.
- `proxies_priv`: Contains proxy-user privileges.

Other tables in the `mysql` database do not hold grant information and are discussed elsewhere:

- `event`: Contains information about Event Scheduler events: See Section 17.4, “Using the Event Scheduler”.
- `func`: Contains information about user-defined functions: See Section 21.3, “Adding New Functions to MySQL”.
- `help_xxx`: These tables are used for server-side help: See Section 5.1.8, “Server-Side Help”.
- `plugin`: Contains information about server plugins: See Section 5.1.7.1, “Installing and Uninstalling Plugins”, and Section 21.2, “The MySQL Plugin API”.
- `proc`: Contains information about stored procedures and functions: See Section 17.2, “Using Stored Routines (Procedures and Functions)”.
- `servers`: Used by the `FEDERATED` storage engine: See Section 13.11.2.2, “Creating a `FEDERATED` Table Using `CREATE SERVER`”.
- `time_zone_xxx`: These tables contain time zone information: See Section 9.6, “MySQL Server Time Zone Support”.
- Tables with `_log` in their name are used for logging: See Section 5.2, “MySQL Server Logs”.

Each grant table contains scope columns and privilege columns:

- Scope columns determine the scope of each row (entry) in the tables; that is, the context in which the row applies. For example, a `user` table row with `Host` and `User` values of `'thomas.loc.gov'` and `'bob'` would be used for authenticating connections made to the server from the host `thomas.loc.gov` by a client that specifies a user name of `bob`. Similarly, a `db` table row with `Host`, `User`, and `Db` column values of `'thomas.loc.gov'`, `'bob'` and `'reports'` would be used when `bob` connects from the host `thomas.loc.gov` to access the `reports` database. The `tables_priv` and `columns_priv` tables contain scope columns indicating tables or table/column combinations to which each row applies. The `procs_priv` scope columns indicate the stored routine to which each row applies.
- Privilege columns indicate which privileges are granted by a table row; that is, what operations can be performed. The server combines the information in the various grant tables to form a complete description of a user's privileges. Section 5.4.5, “Access Control, Stage 2: Request Verification”, describes the rules that are used to do this.

The server uses the grant tables in the following manner:

- The `user` table scope columns determine whether to reject or permit incoming connections. For permitted connections, any privileges granted in the `user` table indicate the user's global privileges. Any privilege granted in this table applies to *all* databases on the server.

  > **Note**
  >
  > Because any global privilege is considered a privilege for all databases, any global privilege enables a user to see all database names with `SHOW DATABASES` or by examining the `SCHEMATA` table of `INFORMATION_SCHEMA`.

- The `db` table scope columns determine which users can access which databases from which hosts. The privilege columns determine which operations are permitted. A privilege granted at the database level applies to the database and to all objects in the database, such as tables and stored programs.
- The `host` table is used in conjunction with the `db` table when you want a given `db` table row to apply to several hosts. For example, if you want a user to be able to use a database from several hosts in your network, leave the `Host` value empty in the user's `db` table row, then populate the `host` table with a row for each of those hosts. This mechanism is described more detail in Section 5.4.5, “Access Control, Stage 2: Request Verification”.

  > **Note**
  >
  > The `host` table must be modified directly with statements such as `INSERT`, `UPDATE`, and `DELETE`. It is not affected by statements such as `GRANT` and `REVOKE` that modify the grant tables indirectly. Most MySQL installations need not use this table at all.

- The `tables_priv` and `columns_priv` tables are similar to the `db` table, but are more fine-grained: They apply at the table and column levels rather than at the database level. A privilege granted at the table level applies to the table and to all its columns. A privilege granted at the column level applies only to a specific column.
- The `procs_priv` table applies to stored routines. A privilege granted at the routine level applies only to a single routine.

- The `proxies_priv` table indicates which users can act as proxies for other users and whether proxy users can grant the `PROXY` privilege to other users.

The server uses the `user`, `db`, and `host` tables in the `mysql` database at both the first and second stages of access control (see Section 5.4, “The MySQL Access Privilege System”). The columns in the `user` and `db` tables are shown here. The `host` table is similar to the `db` table but has a specialized use as described in Section 5.4.5, “Access Control, Stage 2: Request Verification”.

Table 5.7. `user` and `db` Table Columns

Table Name	**`user`**	**`db`**
Scope columns	`Host`	`Host`
	`User`	`Db`
	`Password`	`User`
Privilege columns	`Select_priv`	`Select_priv`
	`Insert_priv`	`Insert_priv`
	`Update_priv`	`Update_priv`
	`Delete_priv`	`Delete_priv`
	`Index_priv`	`Index_priv`
	`Alter_priv`	`Alter_priv`
	`Create_priv`	`Create_priv`
	`Drop_priv`	`Drop_priv`
	`Grant_priv`	`Grant_priv`
	`Create_view_priv`	`Create_view_priv`
	`Show_view_priv`	`Show_view_priv`
	`Create_routine_priv`	`Create_routine_priv`
	`Alter_routine_priv`	`Alter_routine_priv`
	`Execute_priv`	`Execute_priv`
	`Trigger_priv`	`Trigger_priv`
	`Event_priv`	`Event_priv`
	`Create_tmp_table_priv`	`Create_tmp_table_priv`
	`Lock_tables_priv`	`Lock_tables_priv`
	`References_priv`	`References_priv`
	`Reload_priv`	
	`Shutdown_priv`	
	`Process_priv`	
	`File_priv`	
	`Show_db_priv`	
	`Super_priv`	
	`Repl_slave_priv`	
	`Repl_client_priv`	
	`Create_user_priv`	
	`Create_tablespace_priv`	
Security columns	`ssl_type`	
	`ssl_cipher`	
	`x509_issuer`	
	`x509_subject`	
	`plugin`	
	`authentication_string`	
Resource control columns	`max_questions`	
	`max_updates`	

Table Name	**`user`**	**`db`**
	`max_connections`	
	`max_user_connections`	

As of MySQL 5.5.7, the `mysql.user` table has `plugin` and `authentication_string` columns for storing authentication plugin information.

If the `plugin` column for an account row is empty, the server uses its built-in authentication for connection attempts for the account. Clients must match the password in the `Password` column of the account row.

If an account row names a plugin in the `plugin` column, the server uses it to authenticate connection attempts for the account. Whether the plugin uses the value in the `Password` column is up to the plugin.

During the second stage of access control, the server performs request verification to make sure that each client has sufficient privileges for each request that it issues. In addition to the `user`, `db`, and `host` grant tables, the server may also consult the `tables_priv` and `columns_priv` tables for requests that involve tables. The latter tables provide finer privilege control at the table and column levels. They have the columns shown in the following table.

Table 5.8. `tables_priv` and `columns_priv` Table Columns

Table Name	**`tables_priv`**	**`columns_priv`**
Scope columns	`Host`	`Host`
	`Db`	`Db`
	`User`	`User`
	`Table_name`	`Table_name`
		`Column_name`
Privilege columns	`Table_priv`	`Column_priv`
	`Column_priv`	
Other columns	`Timestamp`	`Timestamp`
	`Grantor`	

The `Timestamp` and `Grantor` columns currently are unused and are discussed no further here.

For verification of requests that involve stored routines, the server may consult the `procs_priv` table, which has the columns shown in the following table.

Table 5.9. `procs_priv` Table Columns

Table Name	**`procs_priv`**
Scope columns	`Host`
	`Db`
	`User`
	`Routine_name`
	`Routine_type`
Privilege columns	`Proc_priv`
Other columns	`Timestamp`
	`Grantor`

The `Routine_type` column is an `ENUM` column with values of `'FUNCTION'` or `'PROCEDURE'` to indicate the type of routine the row refers to. This column enables privileges to be granted separately for a function and a procedure with the same name.

The `Timestamp` and `Grantor` columns currently are unused and are discussed no further here.

The `proxies_priv` table was added in MySQL 5.5.7 and records information about proxy users. It has these columns:

- `Host`, `User`: These columns indicate the user account that has the `PROXY` privilege for the proxied account.

- `Proxied_host`, `Proxied_user`: These columns indicate the account of the proxied user.
- `Grantor`: Currently unused.
- `Timestamp`: Currently unused.
- `With_grant`: This column indicates whether the proxy account can grant the `PROXY` privilege to other accounts.

Scope columns in the grant tables contain strings. They are declared as shown here; the default value for each is the empty string.

Table 5.10. Grant Table Scope Column Types

Column Name	Type
`Host`	`CHAR(60)`
`User`	`CHAR(16)`
`Password`	`CHAR(41)`
`Db`	`CHAR(64)`
`Table_name`	`CHAR(64)`
`Column_name`	`CHAR(64)`
`Routine_name`	`CHAR(64)`

For access-checking purposes, comparisons of `User`, `Password`, `Db`, and `Table_name` values are case sensitive. Comparisons of `Host`, `Column_name`, and `Routine_name` values are not case sensitive.

In the `user`, `db`, and `host` tables, each privilege is listed in a separate column that is declared as `ENUM('N','Y') DEFAULT 'N'`. In other words, each privilege can be disabled or enabled, with the default being disabled.

In the `tables_priv`, `columns_priv`, and `procs_priv` tables, the privilege columns are declared as `SET` columns. Values in these columns can contain any combination of the privileges controlled by the table. Only those privileges listed in the column value are enabled.

Table 5.11. Set-Type Privilege Column Values

Table Name	Column Name	Possible Set Elements
`tables_priv`	`Table_priv`	`'Select', 'Insert', 'Update', 'Delete', 'Create', 'Drop', 'Grant', 'References', 'Index', 'Alter', 'Create View', 'Show view', 'Trigger'`
`tables_priv`	`Column_priv`	`'Select', 'Insert', 'Update', 'References'`
`columns_priv`	`Column_priv`	`'Select', 'Insert', 'Update', 'References'`
`procs_priv`	`Proc_priv`	`'Execute', 'Alter Routine', 'Grant'`

Administrative privileges (such as `RELOAD` or `SHUTDOWN`) are specified only in the `user` table. Administrative operations are operations on the server itself and are not database-specific, so there is no reason to list these privileges in the other grant tables. Consequently, to determine whether you can perform an administrative operation, the server need consult only the `user` table.

The `FILE` privilege also is specified only in the `user` table. It is not an administrative privilege as such, but your ability to read or write files on the server host is independent of the database you are accessing.

The `mysqld` server reads the contents of the grant tables into memory when it starts. You can tell it to reload the tables by issuing a `FLUSH PRIVILEGES` statement or executing a `mysqladmin flush-privileges` or `mysqladmin reload` command. Changes to the grant tables take effect as indicated in Section 5.4.6, “When Privilege Changes Take Effect”.

When you modify an account's privileges, it is a good idea to verify that the changes set up privileges the way you want. To check the privileges for a given account, use the `SHOW GRANTS` statement (see Section 12.4.5.22, “`SHOW GRANTS` Syntax”). For example, to determine the privileges that are granted to an account with user name and host name values of `bob` and `pc84.example.com`, use this statement:

```
SHOW GRANTS FOR 'bob'@'pc84.example.com';
```

5.4.3. Specifying Account Names

MySQL account names consist of a user name and a host name. This enables creation of accounts for users with the same name who can connect from different hosts. This section describes how to write account names, including special values and wildcard rules.

In SQL statements such as `CREATE USER`, `GRANT`, and `SET PASSWORD`, write account names using the following rules:

- Syntax for account names is `'user_name'@'host_name'`.
- An account name consisting only of a user name is equivalent to `'user_name'@'%'`. For example, `'me'` is equivalent to `'me'@'%'`.
- The user name and host name need not be quoted if they are legal as unquoted identifiers. Quotes are necessary to specify a *`user_name`* string containing special characters (such as “`-`”), or a *`host_name`* string containing special characters or wildcard characters (such as “`%`”); for example, `'test-user'@'%.com'`.
- Quote user names and host names as identifiers or as strings, using either backticks (“`` ` ``”), single quotation marks (“`'`”), or double quotation marks (“`"`”).
- The user name and host name parts, if quoted, must be quoted separately. That is, write `'me'@'localhost'`, not `'me@localhost'`; the latter is interpreted as `'me@localhost'@'%'`.
- A reference to the `CURRENT_USER()` (or `CURRENT_USER`) function is equivalent to specifying the current user's name and host name literally.

MySQL stores account names in grant tables in the `mysql` database using separate columns for the user name and host name parts:

- The `user` table contains one row for each account. The `User` and `Host` columns store the user name and host name. This table also indicates which global privileges the account has.
- Other grant tables indicate privileges an account has for databases and objects within databases. These tables have `User` and `Host` columns to store the account name. Each row in these tables associates with the account in the `user` table that has the same `User` and `Host` values.

For additional detail about grant table structure, see Section 5.4.2, “Privilege System Grant Tables”.

User names and host names have certain special values or wildcard conventions, as described following.

A user name is either a nonblank value that literally matches the user name for incoming connection attempts, or a blank value (empty string) that matches any user name. An account with a blank user name is an anonymous user. To specify an anonymous user in SQL statements, use a quoted empty user name part, such as `''@'localhost'`.

The host name part of an account name can take many forms, and wildcards are permitted:

- A host value can be a host name or an IP address. The name `'localhost'` indicates the local host. The IP address `'127.0.0.1'` indicates the loopback interface. For the local host, the host value can be the IPv6 address `'::1'`, which indicates the IPv6 loopback interface.
- You can use the wildcard characters “`%`” and “`_`” in host values. These have the same meaning as for pattern-matching operations performed with the `LIKE` operator. For example, a host value of `'%'` matches any host name, whereas a value of `'%.mysql.com'` matches any host in the `mysql.com` domain. `'192.168.1.%'` matches any host in the 192.168.1 class C network.

  Because you can use IP wildcard values in host values (for example, `'192.168.1.%'` to match every host on a subnet), someone could try to exploit this capability by naming a host `192.168.1.somewhere.com`. To foil such attempts, MySQL disallows matching on host names that start with digits and a dot. Thus, if you have a host named something like `1.2.example.com`, its name never matches the host part of account names. An IP wildcard value can match only IP addresses, not host names.
- For a host value specified as an IP address, you can specify a netmask indicating how many address bits to use for the network number. The syntax is *`host_ip/netmask`*. For example:

  ```
  CREATE USER 'david'@'192.58.197.0/255.255.255.0';
  ```

  This enables `david` to connect from any client host having an IP address *`client_ip`* for which the following condition is true:

```
client_ip & netmask = host_ip
```

That is, for the `CREATE USER` statement just shown:

```
client_ip & 255.255.255.0 = 192.58.197.0
```

IP addresses that satisfy this condition and can connect to the MySQL server are those in the range from `192.58.197.0` to `192.58.197.255`.

The netmask can only be used to tell the server to use 8, 16, 24, or 32 bits of the address. Examples:

- `192.0.0.0/255.0.0.0`: Any host on the 192 class A network
- `192.168.0.0/255.255.0.0`: Any host on the 192.168 class B network
- `192.168.1.0/255.255.255.0`: Any host on the 192.168.1 class C network
- `192.168.1.1`: Only the host with this specific IP address

The following netmask will not work because it masks 28 bits, and 28 is not a multiple of 8:

```
192.168.0.1/255.255.255.240
```

5.4.4. Access Control, Stage 1: Connection Verification

When you attempt to connect to a MySQL server, the server accepts or rejects the connection based on your identity and whether you can verify your identity by supplying the correct password. If not, the server denies access to you completely. Otherwise, the server accepts the connection, and then enters Stage 2 and waits for requests.

Your identity is based on two pieces of information:

- The client host from which you connect
- Your MySQL user name

Identity checking is performed using the three `user` table scope columns (`Host`, `User`, and `Password`). The server accepts the connection only if the `Host` and `User` columns in some `user` table row match the client host name and user name and the client supplies the password specified in that row. The rules for permissible `Host` and `User` values are given in Section 5.4.3, “Specifying Account Names”.

If the `User` column value is nonblank, the user name in an incoming connection must match exactly. If the `User` value is blank, it matches any user name. If the `user` table row that matches an incoming connection has a blank user name, the user is considered to be an anonymous user with no name, not a user with the name that the client actually specified. This means that a blank user name is used for all further access checking for the duration of the connection (that is, during Stage 2).

The `Password` column can be blank. This is not a wildcard and does not mean that any password matches. It means that the user must connect without specifying a password.

Nonblank `Password` values in the `user` table represent encrypted passwords. MySQL does not store passwords in plaintext form for anyone to see. Rather, the password supplied by a user who is attempting to connect is encrypted (using the `PASSWORD()` function). The encrypted password then is used during the connection process when checking whether the password is correct. (This is done without the encrypted password ever traveling over the connection.) See Section 5.5.1, “User Names and Passwords”.

From MySQL's point of view, the encrypted password is the *real* password, so you should never give anyone access to it. In particular, *do not give nonadministrative users read access to tables in the `mysql` database*.

The following table shows how various combinations of `Host` and `User` values in the `user` table apply to incoming connections.

`Host` Value	**`User` Value**	**Permissible Connections**
`'thomas.loc.gov'`	`'fred'`	`fred`, connecting from `thomas.loc.gov`
`'thomas.loc.gov'`	`''`	Any user, connecting from `thomas.loc.gov`
`'%'`	`'fred'`	`fred`, connecting from any host
`'%'`	`''`	Any user, connecting from any host

`Host` Value	**`User` Value**	**Permissible Connections**
`'%.loc.gov'`	`'fred'`	`fred`, connecting from any host in the `loc.gov` domain
`'x.y.%'`	`'fred'`	`fred`, connecting from `x.y.net`, `x.y.com`, `x.y.edu`, and so on; this is probably not useful
`'144.155.166.177'`	`'fred'`	`fred`, connecting from the host with IP address `144.155.166.177`
`'144.155.166.%'`	`'fred'`	`fred`, connecting from any host in the `144.155.166` class C subnet
`'144.155.166.0/255.255.255.0'`	`'fred'`	Same as previous example

It is possible for the client host name and user name of an incoming connection to match more than one row in the `user` table. The preceding set of examples demonstrates this: Several of the entries shown match a connection from `thomas.loc.gov` by `fred`.

When multiple matches are possible, the server must determine which of them to use. It resolves this issue as follows:

- Whenever the server reads the `user` table into memory, it sorts the rows.
- When a client attempts to connect, the server looks through the rows in sorted order.
- The server uses the first row that matches the client host name and user name.

To see how this works, suppose that the `user` table looks like this:

```
+-----------+----------+-
| Host      | User     | ...
+-----------+----------+-
| %         | root     | ...
| %         | jeffrey  | ...
| localhost | root     | ...
| localhost |          | ...
+-----------+----------+-
```

When the server reads the table into memory, it orders the rows with the most-specific `Host` values first. Literal host names and IP addresses are the most specific. (The specificity of a literal IP address is not affected by whether it has a netmask, so `192.168.1.13` and `192.168.1.0/255.255.255.0` are considered equally specific.) The pattern `'%'` means “any host” and is least specific. Rows with the same `Host` value are ordered with the most-specific `User` values first (a blank `User` value means “any user” and is least specific). For the `user` table just shown, the result after sorting looks like this:

```
+-----------+----------+-
| Host      | User     | ...
+-----------+----------+-
| localhost | root     | ...
| localhost |          | ...
| %         | jeffrey  | ...
| %         | root     | ...
+-----------+----------+-
```

When a client attempts to connect, the server looks through the sorted rows and uses the first match found. For a connection from `localhost` by `jeffrey`, two of the rows from the table match: the one with `Host` and `User` values of `'localhost'` and `''`, and the one with values of `'%'` and `'jeffrey'`. The `'localhost'` row appears first in sorted order, so that is the one the server uses.

Here is another example. Suppose that the `user` table looks like this:

```
+----------------+----------+-
| Host           | User     | ...
+----------------+----------+-
| %              | jeffrey  | ...
| thomas.loc.gov |          | ...
+----------------+----------+-
```

The sorted table looks like this:

```
+----------------+----------+-
| Host           | User     | ...
+----------------+----------+-
| thomas.loc.gov |          | ...
| %              | jeffrey  | ...
+----------------+----------+-
```

A connection by `jeffrey` from `thomas.loc.gov` is matched by the first row, whereas a connection by `jeffrey` from any host is matched by the second.

> **Note**
>
> It is a common misconception to think that, for a given user name, all rows that explicitly name that user are used first when the server attempts to find a match for the connection. This is not true. The preceding example illustrates this, where a connection from `thomas.loc.gov` by `jeffrey` is first matched not by the row containing `'jeffrey'` as the `User` column value, but by the row with no user name. As a result, `jeffrey` is authenticated as an anonymous user, even though he specified a user name when connecting.

If you are able to connect to the server, but your privileges are not what you expect, you probably are being authenticated as some other account. To find out what account the server used to authenticate you, use the `CURRENT_USER()` function. (See Section 11.14, “Information Functions”.) It returns a value in *`user_name@host_name`* format that indicates the `User` and `Host` values from the matching `user` table row. Suppose that `jeffrey` connects and issues the following query:

```
mysql> SELECT CURRENT_USER();
+----------------+
| CURRENT_USER() |
+----------------+
| @localhost     |
+----------------+
```

The result shown here indicates that the matching `user` table row had a blank `User` column value. In other words, the server is treating `jeffrey` as an anonymous user.

Another way to diagnose authentication problems is to print out the `user` table and sort it by hand to see where the first match is being made.

5.4.5. Access Control, Stage 2: Request Verification

After you establish a connection, the server enters Stage 2 of access control. For each request that you issue through that connection, the server determines what operation you want to perform, then checks whether you have sufficient privileges to do so. This is where the privilege columns in the grant tables come into play. These privileges can come from any of the `user`, `db`, `host`, `tables_priv`, `columns_priv`, or `procs_priv` tables. (You may find it helpful to refer to Section 5.4.2, “Privilege System Grant Tables”, which lists the columns present in each of the grant tables.)

The `user` table grants privileges that are assigned to you on a global basis and that apply no matter what the default database is. For example, if the `user` table grants you the `DELETE` privilege, you can delete rows from any table in any database on the server host! It is wise to grant privileges in the `user` table only to people who need them, such as database administrators. For other users, you should leave all privileges in the `user` table set to `'N'` and grant privileges at more specific levels only. You can grant privileges for particular databases, tables, columns, or routines.

The `db` and `host` tables grant database-specific privileges. Values in the scope columns of these tables can take the following forms:

- A blank `User` value in the `db` table matches the anonymous user. A nonblank value matches literally; there are no wildcards in user names.
- The wildcard characters “`%`” and “`_`” can be used in the `Host` and `Db` columns of either table. These have the same meaning as for pattern-matching operations performed with the `LIKE` operator. If you want to use either character literally when granting privileges, you must escape it with a backslash. For example, to include the underscore character (“`_`”) as part of a database name, specify it as “`\_`” in the `GRANT` statement.
- A `'%'` `Host` value in the `db` table means “any host.” A blank `Host` value in the `db` table means “consult the `host` table for further information” (a process that is described later in this section).
- A `'%'` or blank `Host` value in the `host` table means “any host.”
- A `'%'` or blank `Db` value in either table means “any database.”

The server reads the `db` and `host` tables into memory and sorts them at the same time that it reads the `user` table. The server sorts the `db` table based on the `Host`, `Db`, and `User` scope columns, and sorts the `host` table based on the `Host` and `Db` scope columns. As with the `user` table, sorting puts the most-specific values first and least-specific values last, and when the server looks for matching entries, it uses the first match that it finds.

The `tables_priv`, `columns_priv`, and `procs_priv` tables grant table-specific, column-specific, and routine-specific privileges. Values in the scope columns of these tables can take the following forms:

- The wildcard characters “`%`” and “`_`” can be used in the `Host` column. These have the same meaning as for pattern-matching operations performed with the `LIKE` operator.
- A `'%'` or blank `Host` value means “any host.”
- The `Db`, `Table_name`, `Column_name`, and `Routine_name` columns cannot contain wildcards or be blank.

The server sorts the `tables_priv`, `columns_priv`, and `procs_priv` tables based on the `Host`, `Db`, and `User` columns. This is similar to `db` table sorting, but simpler because only the `Host` column can contain wildcards.

The server uses the sorted tables to verify each request that it receives. For requests that require administrative privileges such as `SHUTDOWN` or `RELOAD`, the server checks only the `user` table row because that is the only table that specifies administrative privileges. The server grants access if the row permits the requested operation and denies access otherwise. For example, if you want to execute `mysqladmin shutdown` but your `user` table row does not grant the `SHUTDOWN` privilege to you, the server denies access without even checking the `db` or `host` tables. (They contain no `Shutdown_priv` column, so there is no need to do so.)

For database-related requests (`INSERT`, `UPDATE`, and so on), the server first checks the user's global privileges by looking in the `user` table row. If the row permits the requested operation, access is granted. If the global privileges in the `user` table are insufficient, the server determines the user's database-specific privileges by checking the `db` and `host` tables:

1. The server looks in the `db` table for a match on the `Host`, `Db`, and `User` columns. The `Host` and `User` columns are matched to the connecting user's host name and MySQL user name. The `Db` column is matched to the database that the user wants to access. If there is no row for the `Host` and `User`, access is denied.
2. If there is a matching `db` table row and its `Host` column is not blank, that row defines the user's database-specific privileges.
3. If the matching `db` table row's `Host` column is blank, it signifies that the `host` table enumerates which hosts should be permitted access to the database. In this case, a further lookup is done in the `host` table to find a match on the `Host` and `Db` columns. If no `host` table row matches, access is denied. If there is a match, the user's database-specific privileges are computed as the intersection (*not* the union!) of the privileges in the `db` and `host` table entries; that is, the privileges that are `'Y'` in both entries. (This way you can grant general privileges in the `db` table row and then selectively restrict them on a host-by-host basis using the `host` table entries.)

After determining the database-specific privileges granted by the `db` and `host` table entries, the server adds them to the global privileges granted by the `user` table. If the result permits the requested operation, access is granted. Otherwise, the server successively checks the user's table and column privileges in the `tables_priv` and `columns_priv` tables, adds those to the user's privileges, and permits or denies access based on the result. For stored-routine operations, the server uses the `procs_priv` table rather than `tables_priv` and `columns_priv`.

Expressed in boolean terms, the preceding description of how a user's privileges are calculated may be summarized like this:

```
global privileges
OR (database privileges AND host privileges)
OR table privileges
OR column privileges
OR routine privileges
```

It may not be apparent why, if the global `user` row privileges are initially found to be insufficient for the requested operation, the server adds those privileges to the database, table, and column privileges later. The reason is that a request might require more than one type of privilege. For example, if you execute an `INSERT INTO ... SELECT` statement, you need both the `INSERT` and the `SELECT` privileges. Your privileges might be such that the `user` table row grants one privilege and the `db` table row grants the other. In this case, you have the necessary privileges to perform the request, but the server cannot tell that from either table by itself; the privileges granted by the entries in both tables must be combined.

The `host` table is not affected by the `GRANT` or `REVOKE` statements, so it is unused in most MySQL installations. If you modify it directly, you can use it for some specialized purposes, such as to maintain a list of secure servers on the local network that are granted all privileges.

You can also use the `host` table to indicate hosts that are *not* secure. Suppose that you have a machine `public.your.domain` that is located in a public area that you do not consider secure. You can enable access to all hosts on your network except that machine by using `host` table entries like this:

```
+--------------------+----+-
| Host               | Db | ...
+--------------------+----+-
| public.your.domain | %  | ... (all privileges set to 'N')
| %.your.domain      | %  | ... (all privileges set to 'Y')
+--------------------+----+-
```

5.4.6. When Privilege Changes Take Effect

When `mysqld` starts, it reads all grant table contents into memory. The in-memory tables become effective for access control at that point.

If you modify the grant tables indirectly using account-management statements such as `GRANT`, `REVOKE`, `SET PASSWORD`, or `RENAME USER`, the server notices these changes and loads the grant tables into memory again immediately.

If you modify the grant tables directly using statements such as `INSERT`, `UPDATE`, or `DELETE`, your changes have no effect on privilege checking until you either restart the server or tell it to reload the tables. If you change the grant tables directly but forget to reload them, your changes have *no effect* until you restart the server. This may leave you wondering why your changes seem to make no difference!

To tell the server to reload the grant tables, perform a flush-privileges operation. This can be done by issuing a `FLUSH PRIVILEGES` statement or by executing a `mysqladmin flush-privileges` or `mysqladmin reload` command.

A grant table reload affects privileges for each existing client connection as follows:

- Table and column privilege changes take effect with the client's next request.
- Database privilege changes take effect the next time the client executes a `USE db_name` statement.

  Note

  Client applications may cache the database name; thus, this effect may not be visible to them without actually changing to a different database or flushing the privileges.
- Global privileges and passwords are unaffected for a connected client. These changes take effect only for subsequent connections.

If the server is started with the `--skip-grant-tables` option, it does not read the grant tables or implement any access control. Anyone can connect and do anything, *which is insecure.* To cause a server thus started to read the tables and enable access checking, flush the privileges.

5.4.7. Causes of Access-Denied Errors

If you encounter problems when you try to connect to the MySQL server, the following items describe some courses of action you can take to correct the problem.

- Make sure that the server is running. If it is not, clients cannot connect to it. For example, if an attempt to connect to the server fails with a message such as one of those following, one cause might be that the server is not running:

  ```
  shell> mysql
  ERROR 2003: Can't connect to MySQL server on 'host_name' (111)
  shell> mysql
  ERROR 2002: Can't connect to local MySQL server through socket
  '/tmp/mysql.sock' (111)
  ```

- It might be that the server is running, but you are trying to connect using a TCP/IP port, named pipe, or Unix socket file different from the one on which the server is listening. To correct this when you invoke a client program, specify a `--port` option to indicate the proper port number, or a `--socket` option to indicate the proper named pipe or Unix socket file. To find out where the socket file is, you can use this command:

  ```
  shell> netstat -ln | grep mysql
  ```

- Make sure that the server has not been configured to ignore network connections or (if you are attempting to connect remotely) that it has not been configured to listen only locally on its network interfaces. If the server was started with `--skip-networking`, it will not accept TCP/IP connections at all. If the server was started with `--bind-address=127.0.0.1`, it will listen for TCP/IP connections only locally on the loopback interface and will not accept remote connections.
- Check to make sure that there is no firewall blocking access to MySQL. Your firewall may be configured on the basis of the application being executed, or the port number used by MySQL for communication (3306 by default). Under Linux or Unix, check your IP tables (or similar) configuration to ensure that the port has not been blocked. Under Windows, applications such as ZoneAlarm or the Windows XP personal firewall may need to be configured not to block the MySQL port.
- The grant tables must be properly set up so that the server can use them for access control. For some distribution types (such as binary distributions on Windows, or RPM distributions on Linux), the installation process initializes the `mysql` database con-

taining the grant tables. For distributions that do not do this, you must initialize the grant tables manually by running the `mysql_install_db` script. For details, see Section 2.10.1, “Unix Postinstallation Procedures”.

To determine whether you need to initialize the grant tables, look for a `mysql` directory under the data directory. (The data directory normally is named `data` or `var` and is located under your MySQL installation directory.) Make sure that you have a file named `user.MYD` in the `mysql` database directory. If not, execute the `mysql_install_db` script. After running this script and starting the server, test the initial privileges by executing this command:

```
shell> mysql -u root test
```

The server should let you connect without error.

- After a fresh installation, you should connect to the server and set up your users and their access permissions:

  ```
  shell> mysql -u root mysql
  ```

  The server should let you connect because the MySQL `root` user has no password initially. That is also a security risk, so setting the password for the `root` accounts is something you should do while you're setting up your other MySQL accounts. For instructions on setting the initial passwords, see Section 2.10.2, “Securing the Initial MySQL Accounts”.

- If you have updated an existing MySQL installation to a newer version, did you run the `mysql_upgrade` script? If not, do so. The structure of the grant tables changes occasionally when new capabilities are added, so after an upgrade you should always make sure that your tables have the current structure. For instructions, see Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

- If a client program receives the following error message when it tries to connect, it means that the server expects passwords in a newer format than the client is capable of generating:

  ```
  shell> mysql
  Client does not support authentication protocol requested
  by server; consider upgrading MySQL client
  ```

  For information on how to deal with this, see Section 5.3.2.3, “Password Hashing in MySQL”, and Section C.5.2.4, “`Client does not support authentication protocol`”.

- Remember that client programs use connection parameters specified in option files or environment variables. If a client program seems to be sending incorrect default connection parameters when you have not specified them on the command line, check any applicable option files and your environment. For example, if you get `Access denied` when you run a client without any options, make sure that you have not specified an old password in any of your option files!

  You can suppress the use of option files by a client program by invoking it with the `--no-defaults` option. For example:

  ```
  shell> mysqladmin --no-defaults -u root version
  ```

  The option files that clients use are listed in Section 4.2.3.3, “Using Option Files”. Environment variables are listed in Section 2.12, “Environment Variables”.

- If you get the following error, it means that you are using an incorrect `root` password:

  ```
  shell> mysqladmin -u root -pxxxx ver
  Access denied for user 'root'@'localhost' (using password: YES)
  ```

  If the preceding error occurs even when you have not specified a password, it means that you have an incorrect password listed in some option file. Try the `--no-defaults` option as described in the previous item.

  For information on changing passwords, see Section 5.5.5, “Assigning Account Passwords”.

  If you have lost or forgotten the `root` password, see Section C.5.4.1, “How to Reset the Root Password”.

- If you change a password by using `SET PASSWORD`, `INSERT`, or `UPDATE`, you must encrypt the password using the `PASSWORD()` function. If you do not use `PASSWORD()` for these statements, the password will not work. For example, the following statement assigns a password, but fails to encrypt it, so the user is not able to connect afterward:

  ```
  SET PASSWORD FOR 'abe'@'host_name' = 'eagle';
  ```

  Instead, set the password like this:

  ```
  SET PASSWORD FOR 'abe'@'host_name' = PASSWORD('eagle');
  ```

The `PASSWORD()` function is unnecessary when you specify a password using the `CREATE USER` or `GRANT` statements or the `mysqladmin password` command. Each of those automatically uses `PASSWORD()` to encrypt the password. See Section 5.5.5, “Assigning Account Passwords”, and Section 12.4.1.1, “`CREATE USER` Syntax”.

- `localhost` is a synonym for your local host name, and is also the default host to which clients try to connect if you specify no host explicitly.

  To avoid this problem on such systems, you can use a `--host=127.0.0.1` option to name the server host explicitly. This will make a TCP/IP connection to the local `mysqld` server. You can also use TCP/IP by specifying a `--host` option that uses the actual host name of the local host. In this case, the host name must be specified in a `user` table row on the server host, even though you are running the client program on the same host as the server.

- The `Access denied` error message tells you who you are trying to log in as, the client host from which you are trying to connect, and whether you were using a password. Normally, you should have one row in the `user` table that exactly matches the host name and user name that were given in the error message. For example, if you get an error message that contains `using password: NO`, it means that you tried to log in without a password.

- If you get an `Access denied` error when trying to connect to the database with `mysql -u *user_name*`, you may have a problem with the `user` table. Check this by executing `mysql -u root mysql` and issuing this SQL statement:

  ```
  SELECT * FROM user;
  ```

  The result should include a row with the `Host` and `User` columns matching your client's host name and your MySQL user name.

- If the following error occurs when you try to connect from a host other than the one on which the MySQL server is running, it means that there is no row in the `user` table with a `Host` value that matches the client host:

  ```
  Host ... is not allowed to connect to this MySQL server
  ```

  You can fix this by setting up an account for the combination of client host name and user name that you are using when trying to connect.

  If you do not know the IP address or host name of the machine from which you are connecting, you should put a row with `'%'` as the `Host` column value in the `user` table. After trying to connect from the client machine, use a `SELECT USER()` query to see how you really did connect. Then change the `'%'` in the `user` table row to the actual host name that shows up in the log. Otherwise, your system is left insecure because it permits connections from any host for the given user name.

  On Linux, another reason that this error might occur is that you are using a binary MySQL version that is compiled with a different version of the `glibc` library than the one you are using. In this case, you should either upgrade your operating system or `glibc`, or download a source distribution of MySQL version and compile it yourself. A source RPM is normally trivial to compile and install, so this is not a big problem.

- If you specify a host name when trying to connect, but get an error message where the host name is not shown or is an IP address, it means that the MySQL server got an error when trying to resolve the IP address of the client host to a name:

  ```
  shell> mysqladmin -u root -pxxxx -h some_hostname ver
  Access denied for user 'root'@'' (using password: YES)
  ```

  If you try to connect as `root` and get the following error, it means that you do not have a row in the `user` table with a `User` column value of `'root'` and that `mysqld` cannot resolve the host name for your client:

  ```
  Access denied for user ''@'unknown'
  ```

  These errors indicate a DNS problem. To fix it, execute `mysqladmin flush-hosts` to reset the internal DNS host name cache. See Section 7.11.5.2, “How MySQL Uses DNS”.

  Some permanent solutions are:

  - Determine what is wrong with your DNS server and fix it.
  - Specify IP addresses rather than host names in the MySQL grant tables.
  - Put an entry for the client machine name in `/etc/hosts` on Unix or `\windows\hosts` on Windows.
  - Start `mysqld` with the `--skip-name-resolve` option.
  - Start `mysqld` with the `--skip-host-cache` option.

  - On Unix, if you are running the server and the client on the same machine, connect to `localhost`. Unix connections to `localhost` use a Unix socket file rather than TCP/IP.

  - On Windows, if you are running the server and the client on the same machine and the server supports named pipe connections, connect to the host name `.` (period). Connections to `.` use a named pipe rather than TCP/IP.

- If `mysql -u root test` works but `mysql -h your_hostname -u root test` results in `Access denied` (where *`your_hostname`* is the actual host name of the local host), you may not have the correct name for your host in the `user` table. A common problem here is that the `Host` value in the `user` table row specifies an unqualified host name, but your system's name resolution routines return a fully qualified domain name (or vice versa). For example, if you have an entry with host `'pluto'` in the `user` table, but your DNS tells MySQL that your host name is `'pluto.example.com'`, the entry does not work. Try adding an entry to the `user` table that contains the IP address of your host as the `Host` column value. (Alternatively, you could add an entry to the `user` table with a `Host` value that contains a wildcard; for example, `'pluto.%'`. However, use of `Host` values ending with “`%`” is *insecure* and is *not* recommended!)

- If `mysql -u user_name test` works but `mysql -u user_name other_db` does not, you have not granted access to the given user for the database named *`other_db`*.

- If `mysql -u user_name` works when executed on the server host, but `mysql -h host_name -u user_name` does not work when executed on a remote client host, you have not enabled access to the server for the given user name from the remote host.

- If you cannot figure out why you get `Access denied`, remove from the `user` table all entries that have `Host` values containing wildcards (entries that contain `'%'` or `'_'` characters). A very common error is to insert a new entry with `Host='%'` and `User='some_user'`, thinking that this enables you to specify `localhost` to connect from the same machine. The reason that this does not work is that the default privileges include an entry with `Host='localhost'` and `User=''`. Because that entry has a `Host` value `'localhost'` that is more specific than `'%'`, it is used in preference to the new entry when connecting from `localhost`! The correct procedure is to insert a second entry with `Host='localhost'` and `User='some_user'`, or to delete the entry with `Host='localhost'` and `User=''`. After deleting the entry, remember to issue a `FLUSH PRIVILEGES` statement to reload the grant tables. See also Section 5.4.4, “Access Control, Stage 1: Connection Verification”.

- If you are able to connect to the MySQL server, but get an `Access denied` message whenever you issue a `SELECT ... INTO OUTFILE` or `LOAD DATA INFILE` statement, your entry in the `user` table does not have the `FILE` privilege enabled.

- If you change the grant tables directly (for example, by using `INSERT`, `UPDATE`, or `DELETE` statements) and your changes seem to be ignored, remember that you must execute a `FLUSH PRIVILEGES` statement or a `mysqladmin flush-privileges` command to cause the server to reload the privilege tables. Otherwise, your changes have no effect until the next time the server is restarted. Remember that after you change the `root` password with an `UPDATE` statement, you will not need to specify the new password until after you flush the privileges, because the server will not know you've changed the password yet!

- If your privileges seem to have changed in the middle of a session, it may be that a MySQL administrator has changed them. Reloading the grant tables affects new client connections, but it also affects existing connections as indicated in Section 5.4.6, “When Privilege Changes Take Effect”.

- If you have access problems with a Perl, PHP, Python, or ODBC program, try to connect to the server with `mysql -u user_name db_name` or `mysql -u user_name -pyour_pass db_name`. If you are able to connect using the `mysql` client, the problem lies with your program, not with the access privileges. (There is no space between `-p` and the password; you can also use the `--password=your_pass` syntax to specify the password. If you use the `-p` or `--password` option with no password value, MySQL prompts you for the password.)

- For testing purposes, start the `mysqld` server with the `--skip-grant-tables` option. Then you can change the MySQL grant tables and use the `mysqlaccess` script to check whether your modifications have the desired effect. When you are satisfied with your changes, execute `mysqladmin flush-privileges` to tell the `mysqld` server to reload the privileges. This enables you to begin using the new grant table contents without stopping and restarting the server.

- If you get the following error, you may have a problem with the `db` or `host` table:

  ```
  Access to database denied
  ```

  If the entry selected from the `db` table has an empty value in the `Host` column, make sure that there are one or more corresponding entries in the `host` table specifying which hosts the `db` table entry applies to. This problem occurs infrequently because the `host` table is rarely used.

- If everything else fails, start the `mysqld` server with a debugging option (for example, `--debug=d,general,query`). This prints host and user information about attempted connections, as well as information about each command issued. See MySQL Internals: Porting.

- If you have any other problems with the MySQL grant tables and feel you must post the problem to the mailing list, always provide a dump of the MySQL grant tables. You can dump the tables with the `mysqldump mysql` command. To file a bug report, see the instructions at Section 1.7, “How to Report Bugs or Problems”. In some cases, you may need to restart `mysqld` with `--skip-grant-tables` to run `mysqldump`.

5.5. MySQL User Account Management

This section describes how to set up accounts for clients of your MySQL server. It discusses the following topics:

- The meaning of account names and passwords as used in MySQL and how that compares to names and passwords used by your operating system
- How to set up new accounts and remove existing accounts
- How to change passwords
- Guidelines for using passwords securely
- How to use secure connections with SSL

See also Section 12.4.1, “Account Management Statements”, which describes the syntax and use for all user-management SQL statements.

5.5.1. User Names and Passwords

MySQL stores accounts in the `user` table of the `mysql` database. An account is defined in terms of a user name and the client host or hosts from which the user can connect to the server. The account may also have a password. For information about account representation in the `user` table, see Section 5.4.2, “Privilege System Grant Tables”. MySQL 5.5 supports authentication plugins, so it is possible that an account authenticates using some external authentication method. See Section 5.5.6, “Pluggable Authentication”.

There are several distinctions between the way user names and passwords are used by MySQL and the way they are used by your operating system:

- User names, as used by MySQL for authentication purposes, have nothing to do with user names (login names) as used by Windows or Unix. On Unix, most MySQL clients by default try to log in using the current Unix user name as the MySQL user name, but that is for convenience only. The default can be overridden easily, because client programs permit any user name to be specified with a `-u` or `--user` option. Because this means that anyone can attempt to connect to the server using any user name, you cannot make a database secure in any way unless all MySQL accounts have passwords. Anyone who specifies a user name for an account that has no password is able to connect successfully to the server.

- MySQL user names can be up to 16 characters long. Operating system user names, because they are completely unrelated to MySQL user names, may be of a different maximum length. For example, Unix user names typically are limited to eight characters.

  > **Warning**
  >
  > The limit on MySQL user name length is hard-coded in the MySQL servers and clients, and trying to circumvent it by modifying the definitions of the tables in the `mysql` database *does not work*.
  >
  > You should never alter any of the tables in the `mysql` database in any manner whatsoever except by means of the procedure that is described in Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”. Attempting to redefine MySQL's system tables in any other fashion results in undefined (and unsupported!) behavior.

- It is best to use only ASCII characters for user names and passwords.

- The server uses MySQL passwords stored in the `user` table to authenticate client connections using MySQL built-in authentication. These passwords have nothing to do with passwords for logging in to your operating system. There is no necessary connection between the “external” password you use to log in to a Windows or Unix machine and the password you use to access the MySQL server on that machine.

  If the server authenticates a client using a plugin, the authentication method that the plugin implements may or may not use the password in the `user` table. In this case, it is possible that an external password is also used to authenticate to the MySQL server.

- MySQL encrypts passwords stored in the `user` table using its own algorithm. This encryption is the same as that implemented by the `PASSWORD()` SQL function but differs from that used during the Unix login process. Unix password encryption is the same as that implemented by the `ENCRYPT()` SQL function. See the descriptions of the `PASSWORD()` and `ENCRYPT()` functions in Section 11.13, “Encryption and Compression Functions”.

From version 4.1 on, MySQL employs a stronger authentication method that has better password protection during the connection process than in earlier versions. It is secure even if TCP/IP packets are sniffed or the `mysql` database is captured. (In earlier versions, even though passwords are stored in encrypted form in the `user` table, knowledge of the encrypted password value could be used to connect to the MySQL server.) Section 5.3.2.3, “Password Hashing in MySQL”, discusses password encryption further.

When you install MySQL, the grant tables are populated with an initial set of accounts. The names and access privileges for these accounts are described in Section 2.10.2, “Securing the Initial MySQL Accounts”, which also discusses how to assign passwords to them. Thereafter, you normally set up, modify, and remove MySQL accounts using statements such as `CREATE USER`, `GRANT`, and `REVOKE`. See Section 12.4.1, “Account Management Statements”.

When you connect to a MySQL server with a command-line client, specify the user name and password as necessary for the account that you want to use:

```
shell> mysql --user=monty --password=password db_name
```

If you prefer short options, the command looks like this:

```
shell> mysql -u monty -ppassword db_name
```

There must be *no space* between the `-p` option and the following password value.

If you omit the *`password`* value following the `--password` or `-p` option on the command line, the client prompts for one.

Specifying a password on the command line should be considered insecure. See Section 5.3.2.2, “End-User Guidelines for Password Security”. You can use an option file to avoid giving the password on the command line.

For additional information about specifying user names, passwords, and other connection parameters, see Section 4.2.2, “Connecting to the MySQL Server”.

5.5.2. Adding User Accounts

You can create MySQL accounts in two ways:

- By using statements intended for creating accounts, such as `CREATE USER` or `GRANT`. These statements cause the server to make appropriate modifications to the grant tables.
- By manipulating the MySQL grant tables directly with statements such as `INSERT`, `UPDATE`, or `DELETE`.

The preferred method is to use account-creation statements because they are more concise and less error-prone than manipulating the grant tables directly. `CREATE USER` and `GRANT` are described in Section 12.4.1, “Account Management Statements”.

Another option for creating accounts is to use one of several available third-party programs that offer capabilities for MySQL account administration. `phpMyAdmin` is one such program.

The following examples show how to use the `mysql` client program to set up new accounts. These examples assume that privileges have been set up according to the defaults described in Section 2.10.2, “Securing the Initial MySQL Accounts”. This means that to make changes, you must connect to the MySQL server as the MySQL `root` user, and the `root` account must have the `INSERT` privilege for the `mysql` database and the `RELOAD` administrative privilege.

As noted in the examples where appropriate, some of the statements will fail if the server's SQL mode has been set to enable certain restrictions. In particular, strict mode (`STRICT_TRANS_TABLES`, `STRICT_ALL_TABLES`) and `NO_AUTO_CREATE_USER` will prevent the server from accepting some of the statements. Workarounds are indicated for these cases. For more information about SQL modes and their effect on grant table manipulation, see Section 5.1.6, “Server SQL Modes”, and Section 12.4.1.3, “`GRANT` Syntax”.

First, use the `mysql` program to connect to the server as the MySQL `root` user:

```
shell> mysql --user=root mysql
```

If you have assigned a password to the `root` account, you will also need to supply a `--password` or `-p` option, both for this `mysql` command and for those later in this section.

After connecting to the server as `root`, you can add new accounts. The following statements use `GRANT` to set up four new accounts:

```
mysql> CREATE USER 'monty'@'localhost' IDENTIFIED BY 'some_pass';
mysql> GRANT ALL PRIVILEGES ON *.* TO 'monty'@'localhost'
    ->     WITH GRANT OPTION;
mysql> CREATE USER 'monty'@'%' IDENTIFIED BY 'some_pass';
mysql> GRANT ALL PRIVILEGES ON *.* TO 'monty'@'%'
    ->     WITH GRANT OPTION;
mysql> CREATE USER 'admin'@'localhost';
mysql> GRANT RELOAD,PROCESS ON *.* TO 'admin'@'localhost';
mysql> CREATE USER 'dummy'@'localhost';
```

The accounts created by these statements have the following properties:

- Two of the accounts have a user name of `monty` and a password of `some_pass`. Both accounts are superuser accounts with full privileges to do anything. The `'monty'@'localhost'` account can be used only when connecting from the local host. The `'monty'@'%'` account uses the `'%'` wildcard for the host part, so it can be used to connect from any host.

  It is necessary to have both accounts for `monty` to be able to connect from anywhere as `monty`. Without the `localhost` account, the anonymous-user account for `localhost` that is created by `mysql_install_db` would take precedence when `monty` connects from the local host. As a result, `monty` would be treated as an anonymous user. The reason for this is that the anonymous-user account has a more specific `Host` column value than the `'monty'@'%'` account and thus comes earlier in the `user` table sort order. (`user` table sorting is discussed in Section 5.4.4, "Access Control, Stage 1: Connection Verification".)

- The `'admin'@'localhost'` account has no password. This account can be used only by `admin` to connect from the local host. It is granted the `RELOAD` and `PROCESS` administrative privileges. These privileges enable the `admin` user to execute the `mysqladmin reload`, `mysqladmin refresh`, and `mysqladmin flush-`*`xxx`* commands, as well as `mysqladmin processlist` . No privileges are granted for accessing any databases. You could add such privileges later by issuing other `GRANT` statements.

- The `'dummy'@'localhost'` account has no password. This account can be used only to connect from the local host. No privileges are granted. It is assumed that you will grant specific privileges to the account later.

The statements that create accounts with no password will fail if the `NO_AUTO_CREATE_USER` SQL mode is enabled. To deal with this, use an `IDENTIFIED BY` clause that specifies a nonempty password.

To check the privileges for an account, use `SHOW GRANTS`:

```
mysql> SHOW GRANTS FOR 'admin'@'localhost';
+-----------------------------------------------------+
| Grants for admin@localhost                          |
+-----------------------------------------------------+
| GRANT RELOAD, PROCESS ON *.* TO 'admin'@'localhost' |
+-----------------------------------------------------+
```

As an alternative to `CREATE USER` and `GRANT`, you can create the same accounts directly by issuing `INSERT` statements and then telling the server to reload the grant tables using `FLUSH PRIVILEGES`:

```
shell> mysql --user=root mysql
mysql> INSERT INTO user
    ->     VALUES('localhost','monty',PASSWORD('some_pass'),
    ->     'Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y');
mysql> INSERT INTO user
    ->     VALUES('%','monty',PASSWORD('some_pass'),
    ->     'Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y',
    ->     'Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y',
    ->     '','','','',0,0,0,0);
mysql> INSERT INTO user SET Host='localhost',User='admin',
    ->     Reload_priv='Y', Process_priv='Y';
mysql> INSERT INTO user (Host,User,Password)
    ->     VALUES('localhost','dummy','');
mysql> FLUSH PRIVILEGES;
```

When you create accounts with `INSERT`, it is necessary to use `FLUSH PRIVILEGES` to tell the server to reload the grant tables. Otherwise, the changes go unnoticed until you restart the server. With `CREATE USER`, `FLUSH PRIVILEGES` is unnecessary.

The reason for using the `PASSWORD()` function with `INSERT` is to encrypt the password. The `CREATE USER` statement encrypts the password for you, so `PASSWORD()` is unnecessary.

The `'Y'` values enable privileges for the accounts. Depending on your MySQL version, you may have to use a different number of `'Y'` values in the first two `INSERT` statements. The `INSERT` statement for the `admin` account employs the more readable extended `INSERT` syntax using `SET`.

In the `INSERT` statement for the `dummy` account, only the `Host`, `User`, and `Password` columns in the `user` table row are assigned values. None of the privilege columns are set explicitly, so MySQL assigns them all the default value of `'N'`. This is equivalent to what `CREATE USER` does.

If strict SQL mode is enabled, all columns that have no default value must have a value specified. In this case, `INSERT` statements must explicitly specify values for the `ssl_cipher`, `x509_issuer`, and `x509_subject` columns.

To set up a superuser account, it is necessary only to insert a `user` table row with all privilege columns set to `'Y'`. The `user` table privileges are global, so no entries in any of the other grant tables are needed.

The next examples create three accounts and give them access to specific databases. Each of them has a user name of `custom` and password of `obscure`.

To create the accounts with `CREATE USER` and `GRANT`, use the following statements:

```
shell> mysql --user=root mysql
mysql> CREATE USER 'custom'@'localhost' IDENTIFIED BY 'obscure';
mysql> GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP
    ->     ON bankaccount.*
    ->     TO 'custom'@'localhost';
mysql> CREATE USER 'custom'@'host47.example.com' IDENTIFIED BY 'obscure';
mysql> GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP
    ->     ON expenses.*
    ->     TO 'custom'@'host47.example.com';
mysql> CREATE USER 'custom'@'server.domain' IDENTIFIED BY 'obscure';
mysql> GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP
    ->     ON customer.*
    ->     TO 'custom'@'server.domain';
```

The three accounts can be used as follows:

- The first account can access the `bankaccount` database, but only from the local host.
- The second account can access the `expenses` database, but only from the host `host47.example.com`.
- The third account can access the `customer` database, but only from the host `server.domain`.

To set up the `custom` accounts without `GRANT`, use `INSERT` statements as follows to modify the grant tables directly:

```
shell> mysql --user=root mysql
mysql> INSERT INTO user (Host,User,Password)
    ->     VALUES('localhost','custom',PASSWORD('obscure'));
mysql> INSERT INTO user (Host,User,Password)
    ->     VALUES('host47.example.com','custom',PASSWORD('obscure'));
mysql> INSERT INTO user (Host,User,Password)
    ->     VALUES('server.domain','custom',PASSWORD('obscure'));
mysql> INSERT INTO db
    ->     (Host,Db,User,Select_priv,Insert_priv,
    ->     Update_priv,Delete_priv,Create_priv,Drop_priv)
    ->     VALUES('localhost','bankaccount','custom',
    ->     'Y','Y','Y','Y','Y','Y');
mysql> INSERT INTO db
    ->     (Host,Db,User,Select_priv,Insert_priv,
    ->     Update_priv,Delete_priv,Create_priv,Drop_priv)
    ->     VALUES('host47.example.com','expenses','custom',
    ->     'Y','Y','Y','Y','Y','Y');
mysql> INSERT INTO db
    ->     (Host,Db,User,Select_priv,Insert_priv,
    ->     Update_priv,Delete_priv,Create_priv,Drop_priv)
    ->     VALUES('server.domain','customer','custom',
    ->     'Y','Y','Y','Y','Y','Y');
mysql> FLUSH PRIVILEGES;
```

The first three `INSERT` statements add `user` table entries that permit the user `custom` to connect from the various hosts with the given password, but grant no global privileges (all privileges are set to the default value of `'N'`). The next three `INSERT` statements add `db` table entries that grant privileges to `custom` for the `bankaccount`, `expenses`, and `customer` databases, but only when accessed from the proper hosts. As usual when you modify the grant tables directly, you must tell the server to reload them with `FLUSH PRIVILEGES` so that the privilege changes take effect.

To create a user who has access from all machines in a given domain (for example, `mydomain.com`), you can use the “`%`” wildcard character in the host part of the account name:

```
mysql> CREATE USER 'myname'@'%.mydomain.com' IDENTIFIED BY 'mypass';
```

To do the same thing by modifying the grant tables directly, do this:

```
mysql> INSERT INTO user (Host,User,Password,...)
    ->     VALUES('%.mydomain.com','myname',PASSWORD('mypass'),...);
```

```
mysql> FLUSH PRIVILEGES;
```

5.5.3. Removing User Accounts

To remove an account, use the `DROP USER` statement, which is described in Section 12.4.1.2, “`DROP USER` Syntax”.

5.5.4. Setting Account Resource Limits

One means of limiting use of MySQL server resources is to set the global `max_user_connections` system variable to a nonzero value. This limits the number of simultaneous connections that can be made by any given account, but places no limits on what a client can do once connected. In addition, setting `max_user_connections` does not enable management of individual accounts. Both types of control are of interest to many MySQL administrators, particularly those working for Internet Service Providers.

In MySQL 5.5, you can limit use of the following server resources for individual accounts:

- The number of queries that an account can issue per hour
- The number of updates that an account can issue per hour
- The number of times an account can connect to the server per hour
- The number of simultaneous connections to the server by an account

Any statement that a client can issue counts against the query limit (unless its results are served from the query cache). Only statements that modify databases or tables count against the update limit.

An “account” in this context corresponds to a row in the `mysql.user` table. That is, a connection is assessed against the `User` and `Host` values in the `user` table row that applies to the connection. For example, an account `'usera'@'%.example.com'` corresponds to a row in the `user` table that has `User` and `Host` values of `usera` and `%.example.com`, to permit `usera` to connect from any host in the `example.com` domain. In this case, the server applies resource limits in this row collectively to all connections by `usera` from any host in the `example.com` domain because all such connections use the same account.

Before MySQL 5.0.3, an “account” was assessed against the actual host from which a user connects. This older method accounting may be selected by starting the server with the `--old-style-user-limits` option. In this case, if `usera` connects simultaneously from `host1.example.com` and `host2.example.com`, the server applies the account resource limits separately to each connection. If `usera` connects again from `host1.example.com`, the server applies the limits for that connection together with the existing connection from that host.

To set resource limits for an account, use the `GRANT` statement (see Section 12.4.1.3, “`GRANT` Syntax”). Provide a `WITH` clause that names each resource to be limited. The default value for each limit is zero (no limit). For example, to create a new account that can access the `customer` database, but only in a limited fashion, issue these statements:

```
mysql> CREATE USER 'francis'@'localhost' IDENTIFIED BY 'frank';
mysql> GRANT ALL ON customer.* TO 'francis'@'localhost'
    ->     WITH MAX_QUERIES_PER_HOUR 20
    ->          MAX_UPDATES_PER_HOUR 10
    ->          MAX_CONNECTIONS_PER_HOUR 5
    ->          MAX_USER_CONNECTIONS 2;
```

The limit types need not all be named in the `WITH` clause, but those named can be present in any order. The value for each per-hour limit should be an integer representing a count per hour. For `MAX_USER_CONNECTIONS`, the limit is an integer representing the maximum number of simultaneous connections by the account. If this limit is set to zero, the global `max_user_connections` system variable value determines the number of simultaneous connections. If `max_user_connections` is also zero, there is no limit for the account.

To modify existing limits for an account, use a `GRANT USAGE` statement at the global level (`ON *.*`). The following statement changes the query limit for `francis` to 100:

```
mysql> GRANT USAGE ON *.* TO 'francis'@'localhost'
    ->     WITH MAX_QUERIES_PER_HOUR 100;
```

The statement modifies only the limit value specified and leaves the account otherwise unchanged.

To remove a limit, set its value to zero. For example, to remove the limit on how many times per hour `francis` can connect, use this statement:

```
mysql> GRANT USAGE ON *.* TO 'francis'@'localhost'
    ->     WITH MAX_CONNECTIONS_PER_HOUR 0;
```

As mentioned previously, the simultaneous-connection limit for an account is determined from the `MAX_USER_CONNECTIONS` limit and the `max_user_connections` system variable. Suppose that the global `max_user_connections` value is 10 and three accounts have resource limits specified with `GRANT`:

```
GRANT ... TO 'user1'@'localhost' WITH MAX_USER_CONNECTIONS 0;
GRANT ... TO 'user2'@'localhost' WITH MAX_USER_CONNECTIONS 5;
GRANT ... TO 'user3'@'localhost' WITH MAX_USER_CONNECTIONS 20;
```

`user1` has a connection limit of 10 (the global `max_user_connections` value) because it has a zero `MAX_USER_CONNECTIONS` limit). `user2` and `user3` have connection limits of 5 and 20, respectively, because they have nonzero `MAX_USER_CONNECTIONS` limits.

The server stores resource limits for an account in the `user` table row corresponding to the account. The `max_questions`, `max_updates`, and `max_connections` columns store the per-hour limits, and the `max_user_connections` column stores the `MAX_USER_CONNECTIONS` limit. (See Section 5.4.2, “Privilege System Grant Tables”.)

Resource-use counting takes place when any account has a nonzero limit placed on its use of any of the resources.

As the server runs, it counts the number of times each account uses resources. If an account reaches its limit on number of connections within the last hour, further connections for the account are rejected until that hour is up. Similarly, if the account reaches its limit on the number of queries or updates, further queries or updates are rejected until the hour is up. In all such cases, an appropriate error message is issued.

Resource counting is done per account, not per client. For example, if your account has a query limit of 50, you cannot increase your limit to 100 by making two simultaneous client connections to the server. Queries issued on both connections are counted together.

The current per-hour resource-use counts can be reset globally for all accounts, or individually for a given account:

- To reset the current counts to zero for all accounts, issue a `FLUSH USER_RESOURCES` statement. The counts also can be reset by reloading the grant tables (for example, with a `FLUSH PRIVILEGES` statement or a `mysqladmin reload` command).
- The counts for an individual account can be set to zero by re-granting it any of its limits. To do this, use `GRANT USAGE` as described earlier and specify a limit value equal to the value that the account currently has.

Counter resets do not affect the `MAX_USER_CONNECTIONS` limit.

All counts begin at zero when the server starts; counts are not carried over through a restart.

For the `MAX_USER_CONNECTIONS` limit, an edge case can occur if the account currently has open the maximum number of connections permitted to it: A disconnect followed quickly by a connect can result in an error (`ER_TOO_MANY_USER_CONNECTIONS` or `ER_USER_LIMIT_REACHED`) if the server has not fully processed the disconnect by the time the connect occurs. When the server finishes disconnect processing, another connection will once more be permitted.

5.5.5. Assigning Account Passwords

Required credentials for clients that connect to the MySQL server can include a password. This section describes how to assign passwords for MySQL accounts. In MySQL 5.5, it is also possible for clients to authenticate using plugins. For information, see Section 5.5.6, “Pluggable Authentication”.

To assign a password when you create a new account with `CREATE USER`, include an `IDENTIFIED BY` clause:

```
mysql> CREATE USER 'jeffrey'@'localhost'
    -> IDENTIFIED BY 'mypass';
```

To assign or change a password for an existing account, one way is to issue a `SET PASSWORD` statement:

```
mysql> SET PASSWORD FOR
    -> 'jeffrey'@'localhost' = PASSWORD('mypass');
```

MySQL stores passwords in the `user` table in the `mysql` database. Only users such as `root` that have update access to the `mysql` database can change the password for other users. If you are not connected as an anonymous user, you can change your own password by omitting the `FOR` clause:

```
mysql> SET PASSWORD = PASSWORD('mypass');
```

You can also use a `GRANT USAGE` statement at the global level (`ON *.*`) to assign a password to an account without affecting the account's current privileges:

```
mysql> GRANT USAGE ON *.* TO 'jeffrey'@'localhost'
    -> IDENTIFIED BY 'mypass';
```

To assign a password from the command line, use the `mysqladmin` command:

```
shell> mysqladmin -u user_name -h host_name password "newpwd"
```

The account for which this command sets the password is the one with a `user` table row that matches *`user_name`* in the `User` column and the client host *from which you connect* in the `Host` column.

It is preferable to assign passwords using one of the preceding methods, but it is also possible to modify the `user` table directly. In this case, you must also use `FLUSH PRIVILEGES` to cause the server to reread the grant tables. Otherwise, the change remains unnoticed by the server until you restart it.

- To establish a password for a new account, provide a value for the `Password` column:

  ```
  mysql> INSERT INTO mysql.user (Host,User,Password)
      -> VALUES('localhost','jeffrey',PASSWORD('mypass'));
  mysql> FLUSH PRIVILEGES;
  ```

- To change the password for an existing account, use `UPDATE` to set the `Password` column value:

  ```
  mysql> UPDATE mysql.user SET Password = PASSWORD('bagel')
      -> WHERE Host = 'localhost' AND User = 'francis';
  mysql> FLUSH PRIVILEGES;
  ```

During authentication when a client connects to the server, MySQL treats the password in the `user` table as an encrypted hash value (the value that `PASSWORD()` would return for the password). When assigning a password to an account, it is important to store an encrypted value, not the plaintext password. Use the following guidelines:

- When you assign a password using `CREATE USER`, `GRANT` with an `IDENTIFIED BY` clause, or the `mysqladmin password` command, they encrypt the password for you. Specify the literal plaintext password:

  ```
  mysql> CREATE USER 'jeffrey'@'localhost'
      -> IDENTIFIED BY 'mypass';
  ```

- For `CREATE USER` or `GRANT`, you can avoid sending the plaintext password if you know the hash value that `PASSWORD()` would return for the password. Specify the hash value preceded by the keyword `PASSWORD`:

  ```
  mysql> CREATE USER 'jeffrey'@'localhost'
      -> IDENTIFIED BY PASSWORD '*90E462C37378CED12064BB3388827D2BA3A9B689';
  ```

- When you assign an account a nonempty password using `SET PASSWORD`, `INSERT`, or `UPDATE`, you must use the `PASSWORD()` function to encrypt the password, otherwise the password is stored as plaintext. Suppose that you assign a password like this:

  ```
  mysql> SET PASSWORD FOR
      -> 'jeffrey'@'localhost' = 'mypass';
  ```

  The result is that the literal value `'mypass'` is stored as the password in the `user` table, not the encrypted value. When `jeffrey` attempts to connect to the server using this password, the value is encrypted and compared to the value stored in the `user` table. However, the stored value is the literal string `'mypass'`, so the comparison fails and the server rejects the connection with an `Access denied` error.

In MySQL 5.5, enabling the `read_only` system variable prevents the use of the `SET PASSWORD` statement by any user not having the `SUPER` privilege.

> **Note**
>
> `PASSWORD()` encryption differs from Unix password encryption. See Section 5.5.1, “User Names and Passwords”.

5.5.6. Pluggable Authentication

Before MySQL 5.5.7, when a client connects to the server, the server uses the user name provided by the client and the client host to determine which `mysql.user` table account row to use for authentication. The server authenticates the password provided by the client against the `Password` column of the account row.

As of MySQL 5.5.7, the server authenticates clients using plugins. Selection of the proper row from the `mysql.user` table is based on the user name and client host, as before, but the server authenticates the client credentials as follows:

- The server determines which authentication plugin applies for the user:
  - If the account row specifies no plugin name, the server uses built-in authentication against the password stored in the account row. MySQL includes two built-in authentication plugins that cannot be disabled These plugins provide native password checking and pre-MySQL 4.1.1 authentication that uses shorter password hash values. This is the same authentication provided by MySQL servers older than 5.5.7 that matches the password against the `Password` column of the account row.
  - If the account row specifies a plugin, the server invokes it to authenticate the user. If the server cannot find the plugin, an error occurs.
- The plugin returns a status to the server indicating whether the user is permitted to connect.
- If the user is permitted to connect, the plugin may also return a user name to indicate that the user is a proxy for another user. In this case, the connecting user is a proxy for another user: The proxy user impersonates the proxied user. While the connection lasts, the proxy user has the access privileges of the proxied user. For more information, see Section 5.5.7, “Proxy Users”.

In general, pluggable authentication uses corresponding plugins on the server and client sides:

- Install the server plugin so that the server can use it to authenticate client connections.
- Create MySQL accounts that specify use of the plugin for authentication.
- When a client connects, the server plugin knows which client plugin it should communicate with.

Several authentication plugins are available in MySQL. The following sections provide details about specific plugins. If you are interested in writing your own authentication plugins, see Section 21.2.4.9, “Writing Authentication Plugins”.

The remainder of this section provides general instructions for installing and using such plugins. The instructions use an an example authentication plugin included in MySQL distributions (see Section 5.5.6.2, “The Test Authentication Plugin”). The plugin has these characteristics:

- The server-side plugin name is `test_plugin_server`.
- The client-side plugin name is `auth_test_plugin`.
- Both plugins are located in the shared library object file named `auth_test_plugin.so` in the plugin directory (the directory named by the `plugin_dir` system variable). The file name suffix might be different on your system.

The following installation procedure is similar for other authentication plugins; substitute the appropriate plugin and file names.

1. Install the server-side test plugin at server startup or at runtime:
   - To install the plugin at startup, use the `--plugin-load` option. For example, use these lines in a `my.cnf` option file:

     ```
     [mysqld]
     plugin-load=test_plugin_server=auth_test_plugin.so
     ```

     With this plugin-loading method, the option must be given each time the plugin should be installed. If the server is started without the option, the plugin is not installed.
   - To install the plugin at runtime, use the `INSTALL PLUGIN` statement:

     ```
     mysql> INSTALL PLUGIN test_plugin_server SONAME 'auth_test_plugin.so';
     ```

     This installs the plugin permanently and need be done only once.
2. Verify that the plugin is installed. For example, use `SHOW PLUGINS`:

   ```
   mysql> SHOW PLUGINS\G
   ...
   *************************** 21. row ***************************
   ```

```
   Name: test_plugin_server
 Status: ACTIVE
   Type: AUTHENTICATION
Library: auth_test_plugin.so
License: GPL
```

For other ways to check the plugin, see Section 5.1.7.2, “Obtaining Server Plugin Information”.

3. To specify that a MySQL user must be authenticated using the plugin, name it in the `IDENTIFIED WITH` clause of the `CREATE USER` statement that creates the user:

```
CREATE USER 'testuser'@'localhost' IDENTIFIED WITH test_plugin_server;
```

4. Connect to the server using a client program. Because the test plugin authenticates the same way as native MySQL authentication, provide the usual `--user` and `--password` options that you normally use when you connect to the server. For example:

```
shell> mysql --user=your_name --password=your_pass
```

For connections by `testuser`, the server sees that the account must be authenticated using the server-side plugin named `test_plugin_server` and communicates with the client program that it must use the client-side plugin named `auth_test_plugin`. To shorten client/server negotiation and avoid a round trip in the protocol, you can use a `--default-auth=auth_test_plugin` option on the `mysql` command line to specify explicitly which plugin to use.

If `mysql` does not find the plugin, specify a `--plugin-dir=dir_name` option to indicate where the plugin is located.

> **Note**
>
> If you start the server with the `--skip-grant-tables` option, authentication plugins are not used even if loaded because the server performs no client authentication and permits any client to connect. Because this is insecure, you might want to use `--skip-grant-tables` in conjunction with `--skip-networking` to prevent remote clients from connecting.

5.5.6.1. The Built-In Native and Old-Password Authentication Plugins

MySQL includes two built-in plugins that implement the same kind of authentication that older servers provide:

- The native authentication plugin implements the same default authentication against the `mysql.user` table as used prior to the implementation of pluggable authentication.
- The old-password plugin Implements authentication as used before MySQL 4.1.1 that is based on shorter password hash values. For information about this authentication method, see Section 5.3.2.3, “Password Hashing in MySQL”.

The built-in authentication plugins are backward compatible. Clients older than MySQL 5.5.7 do not support authentication plugins but use built-in authentication, so they can connect to servers from 5.5.7 and up.

The following tables show the plugin names.

Table 5.12. MySQL Native Authentication Plugin

Server-side plugin name	`mysql_native_password`
Client-side plugin name	`mysql_native_password`
Library object file name	None (built in)

Table 5.13. MySQL Old-Password Authentication Plugin

Server-side plugin name	`mysql_old_password`
Client-side plugin name	`mysql_old_password`
Library object file name	None (built in)

Each plugin exists in both client and server form. MySQL client programs use `mysql_native_password` by default. The `--default-auth` option can be used to specify either plugin explicitly:

```
shell> mysql --default-auth=mysql_native_password ...
shell> mysql --default-auth=mysql_old_password ...
```

For general information about pluggable authentication in MySQL, see Section 5.5.6, “Pluggable Authentication”.

5.5.6.2. The Test Authentication Plugin

MySQL includes a test plugin that authenticates using MySQL native authentication, but is a loadable plugin (not built in) and must be installed prior to use. It can use either native or old-password authentication.

The following table shows the plugin and library file names. The file name suffix might be different on your system. The file location is the directory named by the `plugin_dir` system variable. For installation information, see Section 5.5.6, “Pluggable Authentication”.

Table 5.14. MySQL Test Authentication Plugin

Server-side plugin name	`test_plugin_server`
Client-side plugin name	`auth_test_plugin`
Library object file name	`auth_test_plugin.so`

The test plugin source code is separate from the server source, unlike the built-in native plugin, so it can be examined as a relatively simple example demonstrating how to write a loadable authentication plugin.

Because the test plugin authenticates the same way as native MySQL authentication, provide the usual `--user` and `--password` options that you normally use for accounts that use native authentication when you connect to the server. For example:

```
shell> mysql --user=your_name --password=your_pass
```

For general information about pluggable authentication in MySQL, see Section 5.5.6, “Pluggable Authentication”.

5.5.6.3. The Clear Text Client-Side Authentication Plugin

MySQL includes a client-side authentication plugin that sends the password to the server without hashing or encryption.

The following table shows the plugin name.

Table 5.15. MySQL Clear Text Authentication Plugin

Server-side plugin name	None, see discussion
Client-side plugin name	`mysql_clear_password`
Library object file name	None (built in)

With native MySQL authentication, the client performs one-way hashing on the password before sending it to the server. This enables the client to avoid sending the password in clear text. See Section 5.3.2.3, “Password Hashing in MySQL”. However, because the hash algorithm is one way, the original password cannot be recovered on the server side.

One-way hashing cannot be done for authentication schemes that require the server to receive the password as entered on the client side. In such cases, the `mysql_clear_password` client-side plugin can be used to send the password to the server in clear text. This plugin is built into the MySQL client library as of MySQL 5.5.10. There is no corresponding server-side plugin. Rather, the client-side plugin can be used by any server-side plugin that needs a clear text password.

For general information about pluggable authentication in MySQL, see Section 5.5.6, “Pluggable Authentication”.

> **Note**
>
> Sending passwords in clear text may be a security problem in some configurations. To avoid problems if there is any possibility that the password would be intercepted, clients should connect to MySQL Server using a method that protects the password. Possibilities include SSL (see Section 5.5.8, “Using SSL for Secure Connections”), IPsec, or a private network.

5.5.6.4. The Socket Peer-Credential Authentication Plugin

MySQL includes a server-side authentication plugin that authenticates clients that connect from the local host through the Unix socket file.

The following table shows the plugin and library file names. The file name suffix might be different on your system. The file location is the directory named by the `plugin_dir` system variable. For installation information, see Section 5.5.6, “Pluggable Authentication”.

Table 5.16. MySQL Socket Peer-Credential Authentication Plugin

Server-side plugin name	`auth_socket`
Client-side plugin name	None, see discussion
Library object file name	`auth_socket.so`

The `auth_socket` authentication plugin authenticates clients that connect from the local host through the Unix socket file. The plugin uses the `SO_PEERCRED` socket option to obtain information about the user running the client program. The plugin checks whether the user name matches the MySQL user name specified by the client program to the server, and permits the connection only if the names match. The plugin can be built only on systems that support the `SO_PEERCRED` option, such as Linux. This plugin is available as of MySQL 5.5.10.

Suppose that a MySQL account is created for a user named `valerie` who is to be authenticated by the `auth_socket` plugin for connections from the local host through the socket file:

```
CREATE USER 'valerie'@'localhost' IDENTIFIED WITH auth_socket;
```

If a user on the local host with a login name of `stefanie` invokes `mysql` with the option `--user=valerie` to connect through the socket file, the server uses `auth_socket` to authenticate the client. The plugin determines that the `--user` option value (`valerie`) differs from the client user's name (`stephanie`) and refuses the connection. If a user named `valerie` tries the same thing, the plugin finds that the user name and the MySQL user name are both `valerie` and permits the connection. However, the plugin refuses the connection even for `valerie` if the connection is made using a different protocol, such as TCP/IP.

For general information about pluggable authentication in MySQL, see Section 5.5.6, “Pluggable Authentication”.

5.5.7. Proxy Users

If authentication to the MySQL server for an externally defined user occurs through an authentication plugin, the plugin may request that the external user be treated by the server as a differently named MySQL user. This enables the external user to have the privileges of the second user.

Consider the following definitions:

```
CREATE USER 'external_auth'@'localhost'
  IDENTIFIED WITH auth_plugin AS ...;
CREATE USER 'employee'@'localhost'
  IDENTIFIED BY ...;
GRANT PROXY
  ON 'employee'@'localhost'
  TO 'external_auth'@'localhost';
```

Now when a client connects as `external_auth` from the local host, MySQL uses `auth_plugin` to perform authentication. Based on some external criteria, `auth_plugin` may return the `employee` user name to the server to request that this client should become the `employee` local user.

In this case, `external_auth` is a “proxy user” (a user who can impersonate or become known as another user) and `employee` is a “proxied user” (a user whose identity can be taken by a proxy user).

The server verifies that external proxy authentication for `employee` is possible through the `external_auth` user. It does this by checking that the `external_auth` user has the `PROXY` privilege for `employee` user. An error occurs if `external_auth` does not have the `PROXY` privilege for `employee`.

For information about authentication plugins, see Section 5.5.6, “Pluggable Authentication”.

Granting Proxy Privileges

A special `PROXY` privilege is needed to enable an external authentication account to connect as another user. To grant it, use the `GRANT` statement. For example:

```
GRANT PROXY ON 'proxied_user' TO 'proxy_user';
```

`proxied_user` must represent a valid locally authenticated user at connection time or connection attempts fail. *`proxy_user`* must represent a valid externally authenticated MySQL user at connection time or connection attempts fail.

The corresponding `REVOKE` syntax is:

```
REVOKE PROXY ON 'proxied_user' FROM 'proxy_user';
```

MySQL `GRANT` and `REVOKE` syntax extensions work as usual. For example:

```
GRANT PROXY ON 'a' TO 'b', 'c', 'd';
GRANT PROXY ON ''@'' TO 'd';
GRANT PROXY ON 'a' TO 'd' IDENTIFIED BY ...;
GRANT PROXY ON 'a' TO 'd' WITH GRANT OPTION;
REVOKE PROXY ON 'a' FROM 'b', 'c', 'd';
```

In the preceding example, `''@''` is the default proxy user and means “any user.” The default proxy user is discussed later in this section.

The `PROXY` privilege can be granted in these cases:

- By *`proxied_user`* for itself: The value of `USER()` must exactly match `CURRENT_USER()` and *`proxied_user`*, for both the user name and host name parts of the account name.
- By a user that has `GRANT PROXY ... WITH GRANT OPTION` for *`proxied_user`*.

The `root` account created by default during MySQL installation has the `PROXY ... WITH GRANT OPTION` privilege for all users. For example, `root` can do this:

```
CREATE USER 'admin'@'localhost' IDENTIFIED BY 'test';
GRANT PROXY ON ''@'' TO 'admin'@'localhost' WITH GRANT OPTION;
```

Now the `admin` user can manage all the specific `GRANT PROXY` mappings. For example, `admin` can do this:

```
GRANT PROXY ON sally TO joe;
```

Default Proxy Users

To specify that some or all users should connect using an external plugin, create a “blank” MySQL user, set it up to use plugin authentication, and let the plugin return the real authenticated user name (if different from the blank user). For example, suppose that there exists a (hypothetical) plugin named `ldap_plugin` that implements LDAP authentication:

```
CREATE USER ''@'' IDENTIFIED WITH ldap_plugin AS 'O=Oracle, OU=MySQL';
CREATE USER 'developer'@'localhost' IDENTIFIED BY 'test';
CREATE USER 'manager'@'localhost' IDENTIFIED BY 'test2';
GRANT PROXY ON 'manager'@'localhost' TO ''@'';
GRANT PROXY ON 'developer'@'localhost' TO ''@'';
```

Now assume that a client tries to connect as follows:

```
mysql --user=myuser --password='myuser_pass' ...
```

The server will not find `myuser` defined as a MySQL user. But because there is a blank user (`''@''`), it invokes `ldap_plugin`, passing it `myuser` and `myuser_pass`.

Suppose that `ldap_plugin` finds in the LDAP directory that `myuser` is a developer. It returns `developer` to the MySQL server. The server finds that `''@''` can authenticate as `developer` (because it has the `PROXY` privilege to do so) and accepts the connection, setting `USER()` and `CURRENT_USER()` as follows:

```
mysql> SELECT USER(), CURRENT_USER;
+------------------+---------------------+
| USER()           | CURRENT_USER        |
+------------------+---------------------+
| myuser@localhost | developer@localhost |
+------------------+---------------------+
```

The session proceeds with `myuser` having the privileges of `developer`.

If the plugin instead finds that the user is a manager, it returns `manager` and the session proceeds with `myuser` having the privileges of `manager`.

For simplicity, external authentication cannot be multilevel: Neither the credentials for `developer` nor those for `manager` are taken into account in the preceding example. However, they are still used if a client tries to authenticate directly against the `developer` or `manager` account, which is why those accounts should be assigned passwords.

Proxy User System Variables

Two system variables help trace the proxy login process:

- `proxy_user`: The proxy user account name used when connecting. This is null if proxying is not used. Using the example shown earlier, this variable will be set as follows:

```
mysql> SELECT @@proxy_user;
+--------------+
| @@proxy_user |
+--------------+
| ''@''        |
+--------------+
```

- `external_user`: Sometimes the authentication plugin may use an external user to connect to the MySQL server. For example, when using Windows native authentication, a plugin that authenticates using the windows API does not need the login ID passed to it. However, it still uses an Windows user ID to authenticate. The plugin may return this external user ID (or the first 512 UTF-8 bytes of it) to the server using the `external_user` read-only session variable. If there is no external user, this variable contains an empty string.

5.5.8. Using SSL for Secure Connections

MySQL supports secure (encrypted) connections between MySQL clients and the server using the Secure Sockets Layer (SSL) protocol. This section discusses how to use SSL connections. For information on how to require users to use SSL connections, see the discussion of the `REQUIRE` clause of the `GRANT` statement in Section 12.4.1.3, “`GRANT` Syntax”.

The standard configuration of MySQL is intended to be as fast as possible, so encrypted connections are not used by default. For applications that require the security provided by encrypted connections, the extra computation to encrypt the data is worthwhile.

MySQL enables encryption on a per-connection basis. You can choose a normal unencrypted connection or a secure encrypted SSL connection according the requirements of individual applications.

Secure connections are based on the OpenSSL API and are available through the MySQL C API. Replication uses the C API, so secure connections can be used between master and slave servers.

Another way to connect securely is from within an SSH connection to the MySQL server host. For an example, see Section 5.5.9, “Connecting to MySQL Remotely from Windows with SSH”.

5.5.8.1. Basic SSL Concepts

To understand how MySQL uses SSL, it is necessary to explain some basic SSL and X509 concepts. People who are familiar with these can skip this part of the discussion.

By default, MySQL uses unencrypted connections between the client and the server. This means that someone with access to the network could watch all your traffic and look at the data being sent or received. They could even change the data while it is in transit between client and server. To improve security a little, you can compress client/server traffic by using the `--compress` option when invoking client programs. However, this does not foil a determined attacker.

When you need to move information over a network in a secure fashion, an unencrypted connection is unacceptable. Encryption is the way to make any kind of data unreadable. In fact, today's practice requires many additional security elements from encryption algorithms. They should resist many kind of known attacks such as changing the order of encrypted messages or replaying data twice.

SSL is a protocol that uses different encryption algorithms to ensure that data received over a public network can be trusted. It has mechanisms to detect any data change, loss, or replay. SSL also incorporates algorithms that provide identity verification using the X509 standard.

X509 makes it possible to identify someone on the Internet. It is most commonly used in e-commerce applications. In basic terms, there should be some company called a “Certificate Authority” (or CA) that assigns electronic certificates to anyone who needs them. Certificates rely on asymmetric encryption algorithms that have two encryption keys (a public key and a secret key). A certificate owner can show the certificate to another party as proof of identity. A certificate consists of its owner's public key. Any data encrypted with this public key can be decrypted only using the corresponding secret key, which is held by the owner of the certificate.

If you need more information about SSL, X509, or encryption, use your favorite Internet search engine to search for the keywords in which you are interested.

5.5.8.2. Using SSL Connections

To use SSL connections between the MySQL server and client programs, your system must support either OpenSSL or yaSSL and your version of MySQL must be built with SSL support.

To make it easier to use secure connections, MySQL is bundled with yaSSL. (MySQL and yaSSL employ the same licensing model, whereas OpenSSL uses an Apache-style license.) yaSSL support initially was available only for a few platforms, but now it is available on all MySQL platforms supported by Oracle Corporation.

To get secure connections to work with MySQL and SSL, you must do the following:

1. If you are not using a binary (precompiled) version of MySQL that has been built with SSL support, and you are going to use OpenSSL rather than the bundled yaSSL library, install OpenSSL if it has not already been installed. We have tested MySQL with OpenSSL 0.9.6. To obtain OpenSSL, visit http://www.openssl.org.

   Building MySQL using OpenSSL requires a shared OpenSSL library, otherwise linker errors occur. Alternatively, build MySQL using yaSSL.

2. If you are not using a binary (precompiled) version of MySQL that has been built with SSL support, configure a MySQL source distribution to use SSL. When you configure MySQL, invoke `CMake` like this:

   ```
   shell> cmake . -DWITH_SSL=bundled
   ```

   That configures the distribution to use the bundled yaSSL library. To use the system SSL library instead, specify the option as `-DWITH_SSL=system` instead. See Section 2.9.4, "MySQL Source-Configuration Options".

   Note that yaSSL support on Unix platforms requires that either `/dev/urandom` or `/dev/random` be available to retrieve true random numbers. For additional information (especially regarding yaSSL on Solaris versions prior to 2.8 and HP-UX), see Bug #13164.

3. Make sure that the `user` in the `mysql` database includes the SSL-related columns (beginning with `ssl_` and `x509_`). If your `user` table does not have these columns, it must be upgraded; see Section 4.4.7, "`mysql_upgrade` — Check Tables for MySQL Upgrade".

4. To check whether a server binary is compiled with SSL support, invoke it with the `--ssl` option. An error will occur if the server does not support SSL:

   ```
   shell> mysqld --ssl --help
   060525 14:18:52 [ERROR] mysqld: unknown option '--ssl'
   ```

   To check whether a running `mysqld` server supports SSL, examine the value of the `have_ssl` system variable (if you have no `have_ssl` variable, check for `have_openssl`):

   ```
   mysql> SHOW VARIABLES LIKE 'have_ssl';
   +---------------+-------+
   | Variable_name | Value |
   +---------------+-------+
   | have_ssl      | YES   |
   +---------------+-------+
   ```

   If the value is `YES`, the server supports SSL connections. If the value is `DISABLED`, the server supports SSL connections but was not started with the appropriate `--ssl-xxx` options (described later in this section).

To enable SSL connections, the proper SSL-related options must be used (see Section 5.5.8.3, "SSL Command Options").

To start the MySQL server so that it permits clients to connect using SSL, use the options that identify the key and certificate files the server needs when establishing a secure connection:

```
shell> mysqld --ssl-ca=ca-cert.pem \
       --ssl-cert=server-cert.pem \
       --ssl-key=server-key.pem
```

- `--ssl-ca` identifies the Certificate Authority (CA) certificate.
- `--ssl-cert` identifies the server public key. This can be sent to the client and authenticated against the CA certificate that it

has.

- `--ssl-key` identifies the server private key.

To establish a secure connection to a MySQL server with SSL support, the options that a client must specify depend on the SSL requirements of the user account that the client uses. (See the discussion of the `REQUIRE` clause in Section 12.4.1.3, "`GRANT` Syntax".)

If the account has no special SSL requirements or was created using a `GRANT` statement that includes the `REQUIRE SSL` option, a client can connect securely by using just the `--ssl-ca` option:

```
shell> mysql --ssl-ca=ca-cert.pem
```

To require that a client certificate also be specified, create the account using the `REQUIRE X509` option. Then the client must also specify the proper client key and certificate files or the server will reject the connection:

```
shell> mysql --ssl-ca=ca-cert.pem \
       --ssl-cert=client-cert.pem \
       --ssl-key=client-key.pem
```

In other words, the options are similar to those used for the server. Note that the Certificate Authority certificate has to be the same.

A client can determine whether the current connection with the server uses SSL by checking the value of the `Ssl_cipher` status variable. The value of `Ssl_cipher` is nonempty if SSL is used, and empty otherwise. For example:

```
mysql> SHOW STATUS LIKE 'Ssl_cipher';
+---------------+--------------------+
| Variable_name | Value              |
+---------------+--------------------+
| Ssl_cipher    | DHE-RSA-AES256-SHA |
+---------------+--------------------+
```

For the `mysql` client, you can use the `STATUS` or `\s` command and check the `SSL` line:

```
mysql> \s
...
SSL:                    Not in use
...
```

Or:

```
mysql> \s
...
SSL:                    Cipher in use is DHE-RSA-AES256-SHA
...
```

To establish a secure connection from within an application program, use the `mysql_ssl_set()` C API function to set the appropriate certificate options before calling `mysql_real_connect()`. See Section 20.9.3.67, "`mysql_ssl_set()`". After the connection is established, you can use `mysql_get_ssl_cipher()` to determine whether SSL is in use. A non-`NULL` return value indicates a secure connection and names the SSL cipher used for encryption. A `NULL` return value indicates that SSL is not being used. See Section 20.9.3.33, "`mysql_get_ssl_cipher()`".

5.5.8.3. SSL Command Options

The following list describes options that are used for specifying the use of SSL, certificate files, and key files. They can be given on the command line or in an option file. These options are not available unless MySQL has been built with SSL support. See Section 5.5.8.2, "Using SSL Connections".

Table 5.17. SSL Option/Variable Summary

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
have_openssl			Yes		Global	No
have_ssl			Yes		Global	No
skip-ssl	Yes	Yes				
ssl	Yes	Yes				
ssl-ca	Yes	Yes			Global	No
- *Variable*: ssl_ca			Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
ssl-capath	Yes	Yes			Global	No
- *Variable*: ssl_capath			Yes		Global	No
ssl-cert	Yes	Yes			Global	No
- *Variable*: ssl_cert			Yes		Global	No
ssl-cipher	Yes	Yes			Global	No
- *Variable*: ssl_cipher			Yes		Global	No
ssl-key	Yes	Yes			Global	No
- *Variable*: ssl_key			Yes		Global	No
ssl-verify-server-cert	Yes	Yes				

- `--ssl`

  For the server, this option specifies that the server permits SSL connections. For a client program, it permits the client to connect to the server using SSL. This option is not sufficient in itself to cause an SSL connection to be used. You must also specify the `--ssl-ca` option, and possibly the `--ssl-cert` and `--ssl-key` options.

  This option is more often used in its opposite form to override any other SSL options and indicate that SSL should *not* be used. To do this, specify the option as `--skip-ssl` or `--ssl=0`.

  Note that use of `--ssl` does not *require* an SSL connection. For example, if the server or client is compiled without SSL support, a normal unencrypted connection is used.

  The secure way to require use of an SSL connection is to create an account on the server that includes a `REQUIRE SSL` clause in the `GRANT` statement. Then use that account to connect to the server, where both the server and the client have SSL support enabled.

  The `REQUIRE` clause permits other SSL-related restrictions as well. The description of `REQUIRE` in Section 12.4.1.3, "`GRANT` Syntax", provides additional detail about which SSL command options may or must be specified by clients that connect using accounts that are created using the various `REQUIRE` options.

- `--ssl-ca=*file_name*`

  The path to a file that contains a list of trusted SSL CAs.

- `--ssl-capath=*directory_name*`

  The path to a directory that contains trusted SSL CA certificates in PEM format.

- `--ssl-cert=*file_name*`

  The name of the SSL certificate file to use for establishing a secure connection.

- `--ssl-cipher=*cipher_list*`

  A list of permissible ciphers to use for SSL encryption. For greatest portability, *`cipher_list`* should be a list of one or more cipher names, separated by colons. Examples:

  ```
  --ssl-cipher=AES128-SHA
  --ssl-cipher=DHE-RSA-AES256-SHA:AES128-SHA
  ```

  This format is understood both by OpenSSL and yaSSL. OpenSSL supports a more flexible syntax for specifying ciphers, as described in the OpenSSL documentation at http://www.openssl.org/docs/apps/ciphers.html. However, this extended syntax will fail if used with a MySQL installation compiled against yaSSL.

  If no cipher in the list is supported, SSL connections will not work.

- `--ssl-key=*file_name*`

  The name of the SSL key file to use for establishing a secure connection.

- `--ssl-verify-server-cert`

  This option is available for client programs only, not the server. It causes the server's Common Name value in the certificate that the server sends to the client to be verified against the host name that the client uses for connecting to the server, and the connection is rejected if there is a mismatch. This feature can be used to prevent man-in-the-middle attacks. Verification is disabled by default.

If you use SSL when establishing a client connection, you can tell the client not to authenticate the server certificate by specifying neither `--ssl-ca` nor `--ssl-capath`. The server still verifies the client according to any applicable requirements established using `GRANT` statements for the client, and it still uses any `--ssl-ca`/`--ssl-capath` values that were passed to server at startup time.

5.5.8.4. Setting Up SSL Certificates for MySQL

This section demonstrates how to set up SSL certificate and key files for use by MySQL servers and clients. The first example shows a simplified procedure such as you might use from the command line. The second shows a script that contains more detail. The first two examples are intended for use on Unix and both use the `openssl` command that is part of OpenSSL. The third example describes how to set up SSL files on Windows.

Following the third example, instructions are given for using the files to test SSL connections. You can also use the files as described in Section 5.5.8.2, “Using SSL Connections”.

Example 1: Creating SSL Files from the Command Line on Unix

The following example shows a set of commands to create MySQL server and client certificate and key files. You will need to respond to several prompts by the `openssl` commands. To generate test files, you can press Enter to all prompts. To generate files for production use, you should provide nonempty responses.

```
# Create clean environment
shell> rm -rf newcerts
shell> mkdir newcerts && cd newcerts

# Create CA certificate
shell> openssl genrsa 2048 > ca-key.pem
shell> openssl req -new -x509 -nodes -days 1000 \
         -key ca-key.pem -out ca-cert.pem

# Create server certificate, remove passphrase, and sign it
shell> openssl req -newkey rsa:2048 -days 1000 \
         -nodes -keyout server-key.pem -out server-req.pem
shell> openssl rsa -in server-key.pem -out server-key.pem
shell> openssl x509 -req -in server-req.pem -days 1000 \
         -CA ca-cert.pem -CAkey ca-key.pem -set_serial 01 -out server-cert.pem

# Create client certificate, remove passphrase, and sign it
shell> openssl req -newkey rsa:2048 -days 1000 \
         -nodes -keyout client-key.pem -out client-req.pem
shell> openssl rsa -in client-key.pem -out client-key.pem
shell> openssl x509 -req -in client-req.pem -days 1000 \
         -CA ca-cert.pem -CAkey ca-key.pem -set_serial 01 -out client-cert.pem
```

After generating the certificates, verify them:

```
mysql> openssl verify -CAfile ca-cert.pem server-cert.pem client-cert.pem
```

Example 2: Creating SSL Files Using a Script on Unix

Here is an example script that shows how to set up SSL certificates for MySQL:

```
DIR=`pwd`/openssl
PRIV=$DIR/private

mkdir $DIR $PRIV $DIR/newcerts
cp /usr/share/ssl/openssl.cnf $DIR
replace ./demoCA $DIR -- $DIR/openssl.cnf

# Create necessary files: $database, $serial and $new_certs_dir
# directory (optional)

touch $DIR/index.txt
echo "01" > $DIR/serial

#
# Generation of Certificate Authority(CA)
#

openssl req -new -x509 -keyout $PRIV/cakey.pem -out $DIR/ca-cert.pem \
    -days 3600 -config $DIR/openssl.cnf

# Sample output:
# Using configuration from /home/monty/openssl/openssl.cnf
# Generating a 1024 bit RSA private key
# ................++++++
# .........++++++
# writing new private key to '/home/monty/openssl/private/cakey.pem'
# Enter PEM pass phrase:
# Verifying password - Enter PEM pass phrase:
# -----
# You are about to be asked to enter information that will be
# incorporated into your certificate request.
# What you are about to enter is what is called a Distinguished Name
# or a DN.
# There are quite a few fields but you can leave some blank
# For some fields there will be a default value,
# If you enter '.', the field will be left blank.
# -----
# Country Name (2 letter code) [AU]:FI
# State or Province Name (full name) [Some-State]:.
# Locality Name (eg, city) []:
# Organization Name (eg, company) [Internet Widgits Pty Ltd]:MySQL AB
# Organizational Unit Name (eg, section) []:
# Common Name (eg, YOUR name) []:MySQL admin
# Email Address []:

#
# Create server request and key
#
openssl req -new -keyout $DIR/server-key.pem -out \
    $DIR/server-req.pem -days 3600 -config $DIR/openssl.cnf

# Sample output:
# Using configuration from /home/monty/openssl/openssl.cnf
# Generating a 1024 bit RSA private key
# ..++++++
# ..........++++++
# writing new private key to '/home/monty/openssl/server-key.pem'
# Enter PEM pass phrase:
# Verifying password - Enter PEM pass phrase:
# -----
# You are about to be asked to enter information that will be
# incorporated into your certificate request.
# What you are about to enter is what is called a Distinguished Name
# or a DN.
# There are quite a few fields but you can leave some blank
# For some fields there will be a default value,
# If you enter '.', the field will be left blank.
# -----
# Country Name (2 letter code) [AU]:FI
# State or Province Name (full name) [Some-State]:.
# Locality Name (eg, city) []:
# Organization Name (eg, company) [Internet Widgits Pty Ltd]:MySQL AB
# Organizational Unit Name (eg, section) []:
# Common Name (eg, YOUR name) []:MySQL server
# Email Address []:
#
# Please enter the following 'extra' attributes
# to be sent with your certificate request
# A challenge password []:
# An optional company name []:

#
# Remove the passphrase from the key
#
openssl rsa -in $DIR/server-key.pem -out $DIR/server-key.pem

#
# Sign server cert
#
openssl ca  -policy policy_anything -out $DIR/server-cert.pem \
    -config $DIR/openssl.cnf -infiles $DIR/server-req.pem

# Sample output:
# Using configuration from /home/monty/openssl/openssl.cnf
# Enter PEM pass phrase:
# Check that the request matches the signature
# Signature ok
# The Subjects Distinguished Name is as follows
# countryName           :PRINTABLE:'FI'
# organizationName      :PRINTABLE:'MySQL AB'
# commonName            :PRINTABLE:'MySQL admin'
# Certificate is to be certified until Sep 13 14:22:46 2003 GMT
# (365 days)
# Sign the certificate? [y/n]:y
#
#
# 1 out of 1 certificate requests certified, commit? [y/n]y
# Write out database with 1 new entries
# Data Base Updated

#
# Create client request and key
#
openssl req -new -keyout $DIR/client-key.pem -out \
    $DIR/client-req.pem -days 3600 -config $DIR/openssl.cnf

# Sample output:
# Using configuration from /home/monty/openssl/openssl.cnf
# Generating a 1024 bit RSA private key
# .....................................++++++
# .............................................++++++
# writing new private key to '/home/monty/openssl/client-key.pem'
# Enter PEM pass phrase:
# Verifying password - Enter PEM pass phrase:
# -----
# You are about to be asked to enter information that will be
# incorporated into your certificate request.
# What you are about to enter is what is called a Distinguished Name
# or a DN.
# There are quite a few fields but you can leave some blank
# For some fields there will be a default value,
# If you enter '.', the field will be left blank.
# -----
# Country Name (2 letter code) [AU]:FI
# State or Province Name (full name) [Some-State]:.
# Locality Name (eg, city) []:
# Organization Name (eg, company) [Internet Widgits Pty Ltd]:MySQL AB
# Organizational Unit Name (eg, section) []:
# Common Name (eg, YOUR name) []:MySQL user
# Email Address []:
#
# Please enter the following 'extra' attributes
# to be sent with your certificate request
# A challenge password []:
# An optional company name []:

#
# Remove the passphrase from the key
#
openssl rsa -in $DIR/client-key.pem -out $DIR/client-key.pem

#
# Sign client cert
#

openssl ca  -policy policy_anything -out $DIR/client-cert.pem \
    -config $DIR/openssl.cnf -infiles $DIR/client-req.pem

# Sample output:
# Using configuration from /home/monty/openssl/openssl.cnf
# Enter PEM pass phrase:
# Check that the request matches the signature
# Signature ok
# The Subjects Distinguished Name is as follows
# countryName           :PRINTABLE:'FI'
# organizationName      :PRINTABLE:'MySQL AB'
# commonName            :PRINTABLE:'MySQL user'
# Certificate is to be certified until Sep 13 16:45:17 2003 GMT
# (365 days)
# Sign the certificate? [y/n]:y
#
#
# 1 out of 1 certificate requests certified, commit? [y/n]y
# Write out database with 1 new entries
# Data Base Updated

#
# Create a my.cnf file that you can use to test the certificates
#

cnf=""
cnf="$cnf [client]"
cnf="$cnf ssl-ca=$DIR/ca-cert.pem"
cnf="$cnf ssl-cert=$DIR/client-cert.pem"
cnf="$cnf ssl-key=$DIR/client-key.pem"
cnf="$cnf [mysqld]"
cnf="$cnf ssl-ca=$DIR/ca-cert.pem"
cnf="$cnf ssl-cert=$DIR/server-cert.pem"
cnf="$cnf ssl-key=$DIR/server-key.pem"
echo $cnf | replace " " '
' > $DIR/my.cnf
```

Example 3: Creating SSL Files on Windows

Download OpenSSL for Windows. An overview of available packages can be seen here: http://www.slproweb.com/products/Win32OpenSSL.html Choose the Win32 OpenSSL Light or Win64 OpenSSL Light package, depending on your architecture (32-bit or 64-bit). The default installation location will be `C:\OpenSSL-Win32` or `C:\OpenSSL-Win64`, depending on which package you downloaded. The following instructions assume a default location of `C:\OpenSSL-Win32`. Modify this as necessary if you are using the 64-bit package.

if a message occurs during setup indicating `'...critical component is missing: Microsoft Visual C++ 2008 Redistributables'`, cancel the setup and download one of the following packages as well, again depending on your architecture (32-bit or 64-bit):

- Visual C++ 2008 Redistributables (x86), available at: http://www.microsoft.com/downloads/details.aspx?familyid=9B2DA534-3E03-4391-8A4D-074B9F2BC1BF
- Visual C++ 2008 Redistributables (x64), available at: http://www.microsoft.com/downloads/details.aspx?familyid=bd2a6171-e2d6-4230-b809-9a8d7548c1b6

After installing the additional package, restart the OpenSSL setup.

During installation, leave the default `C:\OpenSSL-Win32` as the install path, and also leave the default option `'Copy OpenSSL DLL files to the Windows system directory'` selected.

When the installation has finished, add `C:\OpenSSL-Win32\bin` to the Windows System Path variable of your server:

1. On the Windows desktop, right-click the My Computer icon, and select Properties.
2. Select the Advanced tab from the SYSTEM PROPERTIES menu that appears, and click the ENVIRONMENT VARIABLES button.
3. Under **SYSTEM VARIABLES**, select Path, then click the EDIT button. The EDIT SYSTEM VARIABLE dialogue should appear.
4. Add `';C:\OpenSSL-Win32\bin'` to the end (notice the semicolon).
5. Press OK 3 times.
6. Check that OpenSSL was correctly integrated into the Path variable by opening a new command console (`Start>Run>cmd.exe`) and verifying that OpenSSL is available:

```
Microsoft Windows [Version ...]
Copyright (c) 2006 Microsoft Corporation. All rights reserved.

C:\Windows\system32>cd \

C:\>openssl
OpenSSL> exit <<< If you see the OpenSSL prompt, installation was successful.

C:\>
```

Depending on your version of Windows, the preceding instructions might be slightly different.

After OpenSSL has been installed, use instructions similar to those from from Example 1 (shown earlier in this section), with the following changes:

- Change the following Unix commands:

  ```
  # Create clean environment
  shell> rm -rf newcerts
  shell> mkdir newcerts && cd newcerts
  ```

  On Windows, use these commands instead:

  ```
  # Create clean environment
  shell> md c:\newcerts
  shell> cd c:\newcerts
  ```

- When a `'\'` character is shown at the end of a command line, this `'\'` character must be removed and the command lines entered all on a single line.

Testing SSL Connections

To test SSL connections, start the server as follows, where `$DIR` is the path name to the directory where the sample `my.cnf` option file (or `my.ini` on Windows) is located:

```
shell> mysqld --defaults-file=$DIR/my.cnf &
```

Then invoke a client program using the same option file:

```
shell> mysql --defaults-file=$DIR/my.cnf
```

If you have a MySQL source distribution, you can also test your setup by modifying the preceding `my.cnf` file to refer to the demonstration certificate and key files in the `mysql-test/std_data` directory of the distribution.

5.5.9. Connecting to MySQL Remotely from Windows with SSH

This section describes how to get a secure connection to a remote MySQL server with SSH. The information was provided by David Carlson `<dcarlson@mplcomm.com>`.

1. Install an SSH client on your Windows machine. As a user, the best nonfree one I have found is from `SecureCRT` from http://www.vandyke.com/. Another option is `f-secure` from http://www.f-secure.com/. You can also find some free ones on `Google` at http://directory.google.com/Top/Computers/Internet/Protocols/SSH/Clients/Windows/.
2. Start your Windows SSH client. Set `Host_Name = yourmysqlserver_URL_or_IP`. Set `userid=your_userid` to log in to your server. This `userid` value might not be the same as the user name of your MySQL account.
3. Set up port forwarding. Either do a remote forward (Set `local_port: 3306`, `remote_host: yourmysqlservername_or_ip`, `remote_port: 3306`) or a local forward (Set `port: 3306`, `host: localhost`, `remote port: 3306`).
4. Save everything, otherwise you will have to redo it the next time.
5. Log in to your server with the SSH session you just created.
6. On your Windows machine, start some ODBC application (such as Access).
7. Create a new file in Windows and link to MySQL using the ODBC driver the same way you normally do, except type in `localhost` for the MySQL host server, not `yourmysqlservername`.

At this point, you should have an ODBC connection to MySQL, encrypted using SSH.

5.5.10. Auditing MySQL Account Activity

Applications can use the following guidelines to perform auditing that ties database activity to MySQL accounts.

MySQL accounts correspond to rows in the `mysql.user` table. When a client connects successfully, the server authenticates the client to a particular row in this table. The `User` and `Host` column values in this row uniquely identify the account and correspond to the `'user_name'@'host_name'` format in which account names are written in SQL statements.

The account used to authenticate a client determines which privileges the client has. Normally, the `CURRENT_USER()` function can be invoked to determine which account this is for the client user. Its value is constructed from the `User` and `Host` columns of the `user` table row for the account.

However, there are circumstances under which the `CURRENT_USER()` value corresponds not to the client user but to a different account. This occurs in contexts when privilege checking is not based the client's account:

- Stored routines (procedures and functions) defined with the `SQL SECURITY DEFINER` characteristic
- Views defined with the `SQL SECURITY DEFINER` characteristic
- Triggers and events

In those contexts, privilege checking is done against the `DEFINER` account and `CURRENT_USER()` refers to that account, not to the account for the client who invoked the stored routine or view or who caused the trigger to activate. To determine the invoking user, you can call the `USER()` function, which returns a value indicating the actual user name provided by the client and the host from which the client connected. However, this value does not necessarily correspond directly to an account in the `user` table, because the `USER()` value never contains wildcards, whereas account values (as returned by `CURRENT_USER()`) may contain user name and host name wildcards.

For example, a blank user name matches any user, so an account of `''@'localhost'` enables clients to connect as an anonymous user from the local host with any user name. If this case, if a client connects as `user1` from the local host, `USER()` and `CURRENT_USER()` return different values:

```
mysql> SELECT USER(), CURRENT_USER();
+-----------------+----------------+
| USER()          | CURRENT_USER() |
+-----------------+----------------+
| user1@localhost | @localhost     |
+-----------------+----------------+
```

The host name part of an account can contain wildcards, too. If the host name contains a `'%'` or `'_'` pattern character or uses netmask notation, the account can be used for clients connecting from multiple hosts and the `CURRENT_USER()` value will not indicate which one. For example, the account `'user2'@'%.example.com'` can be used by `user2` to connect from any host in the `example.com` domain. If `user2` connects from `remote.example.com`, `USER()` and `CURRENT_USER()` return different values:

```
mysql> SELECT USER(), CURRENT_USER();
+--------------------------+---------------------+
| USER()                    | CURRENT_USER()       |
+---------------------------+----------------------+
| user2@remote.example.com | user2@%.example.com |
+---------------------------+----------------------+
```

If an application must invoke `USER()` for user auditing (for example, if it does auditing from within triggers) but must also be able to associate the `USER()` value with an account in the `user` table, it is necessary to avoid accounts that contain wildcards in the `User` or `Host` column. Specifically, do not permit `User` to be empty (which creates an anonymous-user account), and do not permit pattern characters or netmask notation in `Host` values. All accounts must have a nonempty `User` value and literal `Host` value.

With respect to the previous examples, the `''@'localhost'` and `'user2'@'%.example.com'` accounts should be changed not to use wildcards:

```
RENAME USER ''@'localhost' TO 'user1'@'localhost';
RENAME USER 'user2'@'%.example.com' TO 'user2'@'remote.example.com';
```

If `user2` must be able to connect from several hosts in the `example.com` domain, there should be a separate account for each host.

To extract the user name or host name part from a `CURRENT_USER()` or `USER()` value, use the `SUBSTRING()` function:

```
mysql> SELECT SUBSTRING_INDEX(CURRENT_USER(),'@',1);
+---------------------------------------+
| SUBSTRING_INDEX(CURRENT_USER(),'@',1) |
+---------------------------------------+
| user1                                 |
+---------------------------------------+

mysql> SELECT SUBSTRING_INDEX(CURRENT_USER(),'@',-1);
+----------------------------------------+
| SUBSTRING_INDEX(CURRENT_USER(),'@',-1) |
+----------------------------------------+
| localhost                              |
+----------------------------------------+
```

5.6. Running Multiple MySQL Instances on One Machine

In some cases, you might want to run multiple instances of MySQL on a single machine. You might want to test a new MySQL release while leaving an existing production setup undisturbed. Or you might want to give different users access to different `mysqld` servers that they manage themselves. (For example, you might be an Internet Service Provider that wants to provide independent MySQL installations for different customers.)

It is possible to use a different MySQL server binary per instance, or use the same binary for multiple instances, or any combination of the two approaches. For example, you might run a server from MySQL 5.1 and one from MySQL 5.5, to see how different versions handle a given workload. Or you might run multiple instances of the current production version, each managing a different set of databases.

Whether or not you use distinct server binaries, each instance that you run must be configured with unique values for several operating parameters. This eliminates the potential for conflict between instances. Parameters can be set on the command line, in option files, or by setting environment variables. See Section 4.2.3, “Specifying Program Options”. To see the values used by a given instance, connect to it and execute a `SHOW VARIABLES` statement.

The primary resource managed by a MySQL instance is the data directory. Each instance should use a different data directory, the location of which is specified using the `--datadir=path` option. For methods of configuring each instance with its own data directory, and warnings about the dangers of failing to do so, see Section 5.6.1, “Setting Up Multiple Data Directories”.

In addition to using different data directories, several other options must have different values for each server instance:

- `--port=port_num`

  `--port` controls the port number for TCP/IP connections. Alternatively, if the host has multiple network addresses, you can use `--bind-address` to cause each server to listen to a different address.

- `--socket=path`

  `--socket` controls the Unix socket file path on Unix or the named pipe name on Windows. On Windows, it is necessary to specify distinct pipe names only for those servers configured to permit named-pipe connections.

- `--shared-memory-base-name=name`

  This option is used only on Windows. It designates the shared-memory name used by a Windows server to permit clients to connect using shared memory. It is necessary to specify distinct shared-memory names only for those servers configured to permit shared-memory connections.

- `--pid-file=file_name`

  This option indicates the path name of the file in which the server writes its process ID.

If you use the following log file options, their values must differ for each server:

- `--general_log_file=file_name`
- `--log-bin[=file_name]`
- `--slow_query_log_file=file_name`
- `--log-error[=file_name]`

For further discussion of log file options, see Section 5.2, “MySQL Server Logs”.

To achieve better performance, you can specify the following option differently for each server, to spread the load between several physical disks:

- `--tmpdir=path`

Having different temporary directories also makes it easier to determine which MySQL server created any given temporary file.

If you have multiple MySQL installations in different locations, you can specify the base directory for each installation with the `--basedir=path` option. This causes each instance to automatically use a different data directory, log files, and PID file because the default for each of those parameters is relative to the base directory. In that case, the only other options you need to specify are the `--socket` and `--port` options. Suppose that you install different versions of MySQL using `tar` file binary distributions. These install in different locations, so you can start the server for each installation using the command `bin/mysqld_safe` under its corresponding base directory. `mysqld_safe` determines the proper `--basedir` option to pass to `mysqld`, and you need specify only the `--socket` and `--port` options to `mysqld_safe`.

As discussed in the following sections, it is possible to start additional servers by specifying appropriate command options or by setting environment variables. However, if you need to run multiple servers on a more permanent basis, it is more convenient to use option files to specify for each server those option values that must be unique to it. The `--defaults-file` option is useful for this purpose.

5.6.1. Setting Up Multiple Data Directories

Each MySQL Instance on a machine should have its own data directory. The location is specified using the `--datadir=path` option.

There are different methods of setting up a data directory for a new instance:

- Create a new data directory
- Copy an existing data directory

The following discussion provides more detail about each method.

> **Warning**
>
> Normally, you should never have two servers that update data in the same databases. This may lead to unpleasant surprises if your operating system does not support fault-free system locking. If (despite this warning) you run multiple servers using the same data directory and they have logging enabled, you must use the appropriate options to specify log file names that are unique to each server. Otherwise, the servers try to log to the same files.
>
> Even when the preceding precautions are observed, this kind of setup works only with `MyISAM` and `MERGE` tables, and not with any of the other storage engines. Also, this warning against sharing a data directory among servers always applies in an NFS environment. Permitting multiple MySQL servers to access a common data directory over NFS is a *very bad idea*. The primary problem is that NFS is the speed bottleneck. It is not meant for such use. Another risk with NFS is that you must devise a way to ensure that two or more servers do not interfere with each other. Usually NFS file locking is handled by the `lockd` daemon, but at the moment there is no platform that performs locking 100% reliably in every situation.

Create a New Data Directory

With this method, the data directory will be in the same state as when you first install MySQL. It will have the default set of MySQL accounts and no user data.

On Unix, initialize the data directory by running `mysql_install_db`. See Section 2.10.1, “Unix Postinstallation Procedures”.

On Windows, the data directory is included in the MySQL distribution:

- MySQL Zip archive distributions for Windows contain an unmodified data directory. You can unpack such a distribution into a temporary location, then copy it `data` directory to where you are setting up the new instance.
- As of MySQL 5.5.5, Windows MSI package installers create and set up the data directory that the installed server will use, but also create a pristine “template” data directory named `data` under the installation directory. After an installation has been performed using an MSI package, the template data directory can be copied to set up additional MySQL instances.

Copy an Existing Data Directory

With this method, any MySQL accounts or user data present in the data directory are carried over to the new data directory.

1. Stop the existing MySQL instance using the data directory. This must be a clean shutdown so that the instance flushes any pending changes to disk.
2. Copy the data directory to the location where the new data directory should be.
3. Copy the `my.cnf` or `my.ini` option file used by the existing instance. This serves as a basis for the new instance.
4. Modify the new option file so that any pathnames referring to the original data directory refer to the new data directory. Also, modify any other options that must be unique per instance, such as the TCP/IP port number and the log files. For a list of parameters that must be unique per instance, see Section 5.6, “Running Multiple MySQL Instances on One Machine”.
5. Start the new instance, telling it to use the new option file.

5.6.2. Running Multiple MySQL Instances on Windows

You can run multiple servers on Windows by starting them manually from the command line, each with appropriate operating parameters, or by installing several servers as Windows services and running them that way. General instructions for running MySQL from the command line or as a service are given in Section 2.3, “Installing MySQL on Microsoft Windows”. The following sections describe how to start each server with different values for those options that must be unique per server, such as the data directory. These options are listed in Section 5.6, “Running Multiple MySQL Instances on One Machine”.

5.6.2.1. Starting Multiple MySQL Instances at the Windows Command Line

The procedure for starting a single MySQL server manually from the command line is described in Section 2.3.5.5, “Starting MySQL from the Windows Command Line”. To start multiple servers this way, you can specify the appropriate options on the command line or in an option file. It is more convenient to place the options in an option file, but it is necessary to make sure that each server gets its own set of options. To do this, create an option file for each server and tell the server the file name with a `--defaults-file` option when you run it.

Suppose that you want to run `mysqld` on port 3307 with a data directory of `C:\mydata1`, and `mysqld-debug` on port 3308 with a data directory of `C:\mydata2`. Use this procedure:

1. Make sure that each data directory exists, including its own copy of the `mysql` database that contains the grant tables.
2. Create two option files. For example, create one file named `C:\my-opts1.cnf` that looks like this:

   ```
   [mysqld]
   datadir = C:/mydata1
   port = 3307
   ```

   Create a second file named `C:\my-opts2.cnf` that looks like this:

   ```
   [mysqld]
   datadir = C:/mydata2
   port = 3308
   ```

3. Use the `--defaults-file` option to start each server with its own option file:

   ```
   C:\> C:\mysql\bin\mysqld --defaults-file=C:\my-opts1.cnf
   C:\> C:\mysql\bin\mysqld-debug --defaults-file=C:\my-opts2.cnf
   ```

   Each server starts in the foreground (no new prompt appears until the server exits later), so you will need to issue those two commands in separate console windows.

To shut down the servers, connect to each using the appropriate port number:

```
C:\> C:\mysql\bin\mysqladmin --port=3307 shutdown
C:\> C:\mysql\bin\mysqladmin --port=3308 shutdown
```

Servers configured as just described permit clients to connect over TCP/IP. If your version of Windows supports named pipes and you also want to permit named-pipe connections, use the `mysqld` or `mysqld-debug` server and specify options that enable the named pipe and specify its name. Each server that supports named-pipe connections must use a unique pipe name. For example, the `C:\my-opts1.cnf` file might be written like this:

```
[mysqld]
datadir = C:/mydata1
port = 3307
enable-named-pipe
socket = mypipe1
```

Modify `C:\my-opts2.cnf` similarly for use by the second server. Then start the servers as described previously.

A similar procedure applies for servers that you want to permit shared-memory connections. Enable such connections with the `--shared-memory` option and specify a unique shared-memory name for each server with the `--shared-memory-base-name` option.

5.6.2.2. Starting Multiple MySQL Instances as Windows Services

On Windows, a MySQL server can run as a Windows service. The procedures for installing, controlling, and removing a single MySQL service are described in Section 2.3.5.7, “Starting MySQL as a Windows Service”.

To set up multiple MySQL services, you must make sure that each instance uses a different service name in addition to the other parameters that must be unique per instance.

For the following instructions, suppose that you want to run the `mysqld` server from two different versions of MySQL that are installed at `C:\mysql-5.1.55` and `C:\mysql-5.5.16`, respectively. (This might be the case if you are running 5.1.55 as your production server, but also want to conduct tests using 5.5.16.)

To install MySQL as a Windows service, use the `--install` or `--install-manual` option. For information about these options, see Section 2.3.5.7, “Starting MySQL as a Windows Service”.

Based on the preceding information, you have several ways to set up multiple services. The following instructions describe some examples. Before trying any of them, shut down and remove any existing MySQL services.

- **Approach 1:** Specify the options for all services in one of the standard option files. To do this, use a different service name for each server. Suppose that you want to run the 5.1.55 `mysqld` using the service name of `mysqld1` and the 5.5.16 `mysqld` using the service name `mysqld2`. In this case, you can use the `[mysqld1]` group for 5.1.55 and the `[mysqld2]` group for 5.5.16. For example, you can set up `C:\my.cnf` like this:

  ```
  # options for mysqld1 service
  [mysqld1]
  basedir = C:/mysql-5.1.55
  port = 3307
  enable-named-pipe
  socket = mypipe1

  # options for mysqld2 service
  [mysqld2]
  basedir = C:/mysql-5.5.16
  port = 3308
  enable-named-pipe
  socket = mypipe2
  ```

  Install the services as follows, using the full server path names to ensure that Windows registers the correct executable program for each service:

  ```
  C:\> C:\mysql-5.1.55\bin\mysqld --install mysqld1
  C:\> C:\mysql-5.5.16\bin\mysqld --install mysqld2
  ```

To start the services, use the services manager, or use `NET START` with the appropriate service names:

```
C:\> NET START mysqld1
C:\> NET START mysqld2
```

To stop the services, use the services manager, or use `NET STOP` with the appropriate service names:

```
C:\> NET STOP mysqld1
C:\> NET STOP mysqld2
```

- **Approach 2:** Specify options for each server in separate files and use `--defaults-file` when you install the services to tell each server what file to use. In this case, each file should list options using a `[mysqld]` group.

  With this approach, to specify options for the 5.1.55 `mysqld`, create a file `C:\my-opts1.cnf` that looks like this:

  ```
  [mysqld]
  basedir = C:/mysql-5.1.55
  port = 3307
  enable-named-pipe
  socket = mypipe1
  ```

  For the 5.5.16 `mysqld`, create a file `C:\my-opts2.cnf` that looks like this:

  ```
  [mysqld]
  basedir = C:/mysql-5.5.16
  port = 3308
  enable-named-pipe
  socket = mypipe2
  ```

  Install the services as follows (enter each command on a single line):

  ```
  C:\> C:\mysql-5.1.55\bin\mysqld --install mysqld1
             --defaults-file=C:\my-opts1.cnf
  C:\> C:\mysql-5.5.16\bin\mysqld --install mysqld2
             --defaults-file=C:\my-opts2.cnf
  ```

  When you install a MySQL server as a service and use a `--defaults-file` option, the service name must precede the option.

  After installing the services, start and stop them the same way as in the preceding example.

To remove multiple services, use `mysqld --remove` for each one, specifying a service name following the `--remove` option. If the service name is the default (`MySQL`), you can omit it.

5.6.3. Running Multiple MySQL Instances on Unix

One way is to run multiple MySQL instances on Unix is to compile different servers with different default TCP/IP ports and Unix socket files so that each one listens on different network interfaces. Compiling in different base directories for each installation also results automatically in a separate, compiled-in data directory, log file, and PID file location for each server.

Assume that an existing 5.1 server is configured for the default TCP/IP port number (3306) and Unix socket file (`/tmp/mysql.sock`). To configure a new 5.5.16 server to have different operating parameters, use a `CMake` command something like this:

```
shell> cmake . -DMYSQL_TCP_PORT=port_number \
             -DMYSQL_UNIX_ADDR=file_name \
             -DCMAKE_INSTALL_PREFIX=/usr/local/mysql-5.5.16
```

Here, *`port_number`* and *`file_name`* must be different from the default TCP/IP port number and Unix socket file path name, and the `CMAKE_INSTALL_PREFIX` value should specify an installation directory different from the one under which the existing MySQL installation is located.

If you have a MySQL server listening on a given port number, you can use the following command to find out what operating parameters it is using for several important configurable variables, including the base directory and Unix socket file name:

```
shell> mysqladmin --host=host_name --port=port_number variables
```

With the information displayed by that command, you can tell what option values *not* to use when configuring an additional server.

If you specify `localhost` as the host name, `mysqladmin` defaults to using a Unix socket file connection rather than TCP/IP.

To explicitly specify the connection protocol, use the `--protocol={TCP|SOCKET|PIPE|MEMORY}` option.

You need not compile a new MySQL server just to start with a different Unix socket file and TCP/IP port number. It is also possible to use the same server binary and start each invocation of it with different parameter values at runtime. One way to do so is by using command-line options:

```
shell> mysqld_safe --socket=file_name --port=port_number
```

To start a second server, provide different `--socket` and `--port` option values, and pass a `--datadir=path` option to `mysqld_safe` so that the server uses a different data directory.

Alternatively, put the options for each server in a different option file, then start each server using a `--defaults-file` option that specifies the path to the appropriate option file. For example, if the option files for two server instances are named `/usr/local/mysql/my.cnf` and `/usr/local/mysql/my.cnf2`, start the servers like this: command:

```
shell> mysqld_safe --defaults-file=/usr/local/mysql/my.cnf
shell> mysqld_safe --defaults-file=/usr/local/mysql/my.cnf2
```

Another way to achieve a similar effect is to use environment variables to set the Unix socket file name and TCP/IP port number:

```
shell> MYSQL_UNIX_PORT=/tmp/mysqld-new.sock
shell> MYSQL_TCP_PORT=3307
shell> export MYSQL_UNIX_PORT MYSQL_TCP_PORT
shell> mysql_install_db --user=mysql
shell> mysqld_safe --datadir=/path/to/datadir &
```

This is a quick way of starting a second server to use for testing. The nice thing about this method is that the environment variable settings apply to any client programs that you invoke from the same shell. Thus, connections for those clients are automatically directed to the second server.

Section 2.12, “Environment Variables”, includes a list of other environment variables you can use to affect MySQL programs.

On Unix, the `mysqld_multi` script provides another way to start multiple servers. See Section 4.3.4, “`mysqld_multi` — Manage Multiple MySQL Servers”.

5.6.4. Using Client Programs in a Multiple-Server Environment

To connect with a client program to a MySQL server that is listening to different network interfaces from those compiled into your client, you can use one of the following methods:

- Start the client with `--host=host_name --port=port_number` to connect using TCP/IP to a remote server, with `--host=127.0.0.1 --port=port_number` to connect using TCP/IP to a local server, or with `--host=localhost --socket=file_name` to connect to a local server using a Unix socket file or a Windows named pipe.
- Start the client with `--protocol=TCP` to connect using TCP/IP, `--protocol=SOCKET` to connect using a Unix socket file, `--protocol=PIPE` to connect using a named pipe, or `--protocol=MEMORY` to connect using shared memory. For TCP/IP connections, you may also need to specify `--host` and `--port` options. For the other types of connections, you may need to specify a `--socket` option to specify a Unix socket file or Windows named-pipe name, or a `--shared-memory-base-name` option to specify the shared-memory name. Shared-memory connections are supported only on Windows.
- On Unix, set the `MYSQL_UNIX_PORT` and `MYSQL_TCP_PORT` environment variables to point to the Unix socket file and TCP/IP port number before you start your clients. If you normally use a specific socket file or port number, you can place commands to set these environment variables in your `.login` file so that they apply each time you log in. See Section 2.12, “Environment Variables”.
- Specify the default Unix socket file and TCP/IP port number in the `[client]` group of an option file. For example, you can use `C:\my.cnf` on Windows, or the `.my.cnf` file in your home directory on Unix. See Section 4.2.3.3, “Using Option Files”.
- In a C program, you can specify the socket file or port number arguments in the `mysql_real_connect()` call. You can also have the program read option files by calling `mysql_options()`. See Section 20.9.3, “C API Function Descriptions”.
- If you are using the Perl `DBD::mysql` module, you can read options from MySQL option files. For example:

  ```
  $dsn = "DBI:mysql:test;mysql_read_default_group=client;"
          . "mysql_read_default_file=/usr/local/mysql/data/my.cnf";
  $dbh = DBI->connect($dsn, $user, $password);
  ```

  See Section 20.11, “MySQL Perl API”.

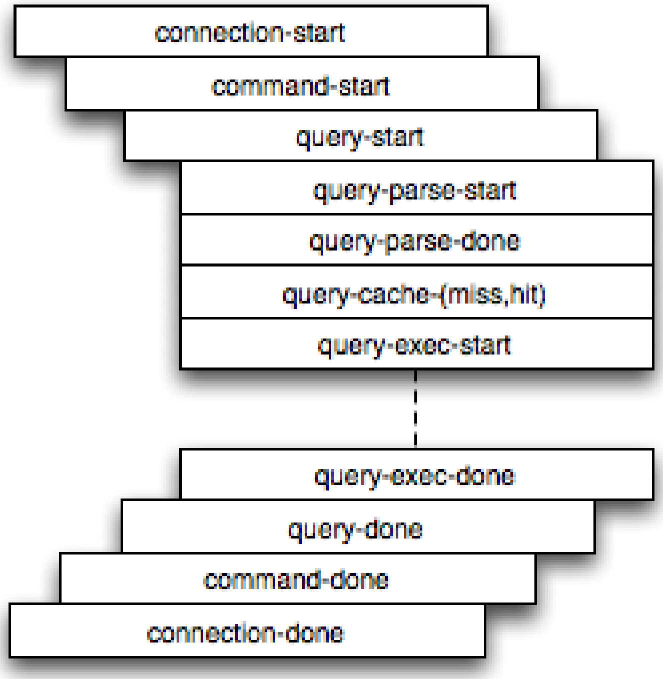
Other programming interfaces may provide similar capabilities for reading option files.

5.7. Tracing `mysqld` Using DTrace

The DTrace probes in the MySQL server are designed to provide information about the execution of queries within MySQL and the different areas of the system being utilized during that process. The organization and triggering of the probes means that the execution of an entire query can be monitored with one level of probes (`query-start` and `query-done`) but by monitoring other probes you can get successively more detailed information about the execution of the query in terms of the locks used, sort methods and even row-by-row and storage-engine level execution information.

The DTrace probes are organized so that you can follow the entire query process, from the point of connection from a client, through the query execution, row-level operations, and back out again. You can think of the probes as being fired within a specific sequence during a typical client connect/execute/disconnect sequence, as shown in the following figure.

Figure 5.1. The MySQL Architecture Using Pluggable Storage Engines



Global information is provided in the arguments to the DTrace probes at various levels. Global information, that is, the connection ID and user/host and where relevant the query string, is provided at key levels (`connection-start`, `command-start`, `query-start`, and `query-exec-start`). As you go deeper into the probes, it is assumed either you are only interested in the individual executions (row-level probes provide information on the database and table name only), or that you will combine the row-level probes with the notional parent probes to provide the information about a specific query. Examples of this will be given as the format and arguments of each probe are provided.

For more information on DTrace and writing DTrace scripts, read the DTrace User Guide.

MySQL 5.5 includes support for DTrace probes on Solaris 10 Update 5 (Solaris 5/08) on SPARC, x86 and x86_64 platforms. Probes are also supported on Mac OS X 10.4 and higher. Enabling the probes should be automatic on these platforms. To explicitly enable or disable the probes during building, use the `-DENABLE_DTRACE=1` or `-DENABLE_DTRACE=0` option to `CMake`.

5.7.1. `mysqld` DTrace Probe Reference

MySQL supports the following static probes, organized into groups of functionality.

Table 5.18. MySQL DTrace Probes

Group	Probes	Introduced
Connection	`connection-start`, `connection-done`	5.4.0
Command	`command-start`, `command-done`	5.4.0
Query	`query-start`, `query-done`	5.4.0
Query Parsing	`query-parse-start`, `query-parse-done`	5.4.0
Query Cache	`query-cache-hit`, `query-cache-miss`	5.4.0
Query Execution	`query-exec-start`, `query-exec-done`	5.4.0
Row Level	`insert-row-start`, `insert-row-done`	5.4.0
	`update-row-start`, `update-row-done`	5.4.0
	`delete-row-start`, `delete-row-done`	5.4.0
Row Reads	`read-row-start`, `read-row-done`	5.4.0
Index Reads	`index-read-row-start`, `index-read-row-done`	5.4.0
Lock	`handler-rdlock-start`, `handler-rdlock-done`	5.4.0
	`handler-wrlock-start`, `handler-wrlock-done`	5.4.0
	`handler-unlock-start`, `handler-unlock-done`	5.4.0
Filesort	`filesort-start`, `filesort-done`	5.4.0
Statement	`select-start`, `select-done`	5.4.0
	`insert-start`, `insert-done`	5.4.0
	`insert-select-start`, `insert-select-done`	5.4.0
	`update-start`, `update-done`	5.4.0
	`multi-update-start`, `multi-update-done`	5.4.0
	`delete-start`, `delete-done`	5.4.0
	`multi-delete-start`, `multi-delete-done`	5.4.0
Network	`net-read-start`, `net-read-done`, `net-write-start`, `net-write-done`	5.4.0
Keycache	`keycache-read-start`, `keycache-read-block`, `keycache-read-done`, `keycache-read-hit`, `keycache-read-miss`, `keycache-write-start`, `keycache-write-block`, `keycache-write-done`	5.4.0

> **Note**
>
> When extracting the argument data from the probes, each argument is available as `argN`, starting with `arg0`. To identify each argument within the definitions they are provided with a descriptive name, but you must access the information using the corresponding `argN` parameter.

5.7.1.1. Connection Probes

The `connection-start` and `connection-done` probes enclose a connection from a client, regardless of whether the connection is through a socket or network connection.

```
connection-start(connectionid, user, host)
connection-done(status, connectionid)
```

- `connection-start`: Triggered after a connection and successful login/authentication have been completed by a client. The arguments contain the connection information:
  - `connectionid`: An `unsigned long` containing the connection ID. This is the same as the process ID shown as the `Id` value in the output from `SHOW PROCESSLIST`.
  - `user`: The username used when authenticating. The value will be blank for the anonymous user.
  - `host`: The host of the client connection. For a connection made using UNIX sockets, the value will be blank.
- `connection-done`: Triggered just as the connection to the client has been closed. The arguments are:
  - `status`: The status of the connection when it was closed. A logout operation will have a value of 0; any other termination of the connection has a nonzero value.
  - `connectionid`: The connection ID of the connection that was closed.

The following D script will quantify and summarize the average duration of individual connections, and provide a count, dumping the information every 60 seconds:

```
#!/usr/sbin/dtrace -s


mysql*:::connection-start
{
  self->start = timestamp;
}

mysql*:::connection-done
/self->start/
{
  @ = quantize(((timestamp - self->start)/1000000));
  self->start = 0;
}

tick-60s
{
  printa(@);
}
```

When executed on a server with a large number of clients you might see output similar to this:

```
  1  57413                        :tick-60s

           value  ------------- Distribution ------------- count
              -1 |                                         0
               0 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ 30011
               1 |                                         59
               2 |                                         5
               4 |                                         20
               8 |                                         29
              16 |                                         18
              32 |                                         27
              64 |                                         30
             128 |                                         11
             256 |                                         10
             512 |                                         1
            1024 |                                         6
            2048 |                                         8
            4096 |                                         9
            8192 |                                         8
           16384 |                                         2
           32768 |                                         1
           65536 |                                         1
          131072 |                                         0
          262144 |                                         1
          524288 |                                         0
```

5.7.1.2. Command Probes

The command probes are executed before and after a client command is executed, including any SQL statement that might be executed during that period. Commands include operations such as the initialization of the DB, use of the `COM_CHANGE_USER` operation (supported by the MySQL protocol), and manipulation of prepared statements. Many of these commands are used only by the MySQL client API from various connectors such as PHP and Java.

```
command-start(connectionid, command, user, host)
command-done(status)
```

- `command-start`: Triggered when a command is submitted to the server.
  - `connectionid`: The connection ID of the client executing the command.
  - `command`: An integer representing the command that was executed. Possible values are shown in the following table.

Value	**Name**	**Description**
00	COM_SLEEP	Internal thread state
01	COM_QUIT	Close connection
02	COM_INIT_DB	Select database (`USE ...`)
03	COM_QUERY	Execute a query
04	COM_FIELD_LIST	Get a list of fields
05	COM_CREATE_DB	Create a database (deprecated)
06	COM_DROP_DB	Drop a database (deprecated)
07	COM_REFRESH	Refresh connection

Value	Name	Description
08	COM_SHUTDOWN	Shutdown server
09	COM_STATISTICS	Get statistics
10	COM_PROCESS_INFO	Get processes (`SHOW PROCESSLIST`)
11	COM_CONNECT	Initialize connection
12	COM_PROCESS_KILL	Kill process
13	COM_DEBUG	Get debug information
14	COM_PING	Ping
15	COM_TIME	Internal thread state
16	COM_DELAYED_INSERT	Internal thread state
17	COM_CHANGE_USER	Change user
18	COM_BINLOG_DUMP	Used by a replication slave or `mysqlbinlog` to initiate a binary log read
19	COM_TABLE_DUMP	Used by a replication slave to get the master table information
20	COM_CONNECT_OUT	Used by a replication slave to log a connection to the server
21	COM_REGISTER_SLAVE	Used by a replication slave during registration
22	COM_STMT_PREPARE	Prepare a statement
23	COM_STMT_EXECUTE	Execute a statement
24	COM_STMT_SEND_LONG_DATA	Used by a client when requesting extended data
25	COM_STMT_CLOSE	Close a prepared statement
26	COM_STMT_RESET	Reset a prepared statement
27	COM_SET_OPTION	Set a server option
28	COM_STMT_FETCH	Fetch a prepared statement

  - `user`: The user executing the command.
  - `host`: The client host.
- `command-done`: Triggered when the command execution completes. The `status` argument contains 0 if the command executed successfully, or 1 if the statement was terminated before normal completion.

The `command-start` and `command-done` probes are best used when combined with the statement probes to get an idea of overall execution time.

5.7.1.3. Query Probes

The `query-start` and `query-done` probes are triggered when a specific query is received by the server and when the query has been completed and the information has been successfully sent to the client.

```
query-start(query, connectionid, database, user, host)
query-done(status)
```

- `query-start`: Triggered after the query string has been received from the client. The arguments are:
  - `query`: The full text of the submitted query.
  - `connectionid`: The connection ID of the client that submitted the query. The connection ID equals the connection ID returned when the client first connects and the `Id` value in the output from `SHOW PROCESSLIST`.
  - `database`: The database name on which the query is being executed.

  - `user`: The username used to connect to the server.
  - `host`: The hostname of the client.
- `query-done`: Triggered once the query has been executed and the information has been returned to the client. The probe includes a single argument, `status`, which returns 0 when the query is successfully executed and 1 if there was an error.

You can get a simple report of the execution time for each query using the following D script:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

dtrace:::BEGIN
{
   printf("%-20s %-20s %-40s %-9s\n", "Who", "Database", "Query", "Time(ms)");
}

mysql*:::query-start
{
   self->query = copyinstr(arg0);
   self->connid = arg1;
   self->db    = copyinstr(arg2);
   self->who   = strjoin(copyinstr(arg3),strjoin("@",copyinstr(arg4)));
   self->querystart = timestamp;
}

mysql*:::query-done
{
   printf("%-20s %-20s %-40s %-9d\n",self->who,self->db,self->query,
          (timestamp - self->querystart) / 1000000);
}
```

When executing the above script you should get a basic idea of the execution time of your queries:

```
shell> ./query.d
Who                  Database             Query                                    Time(ms)
root@localhost       test                 select * from t1 order by i limit 10     0
root@localhost       test                 set global query_cache_size=0            0
root@localhost       test                 select * from t1 order by i limit 10     776
root@localhost       test                 select * from t1 order by i limit 10     773
root@localhost       test                 select * from t1 order by i desc limit 10 795
```

5.7.1.4. Query Parsing Probes

The query parsing probes are triggered before the original SQL statement is parsed and when the parsing of the statement and determination of the execution model required to process the statement has been completed:

```
query-parse-start(query)
query-parse-done(status)
```

- `query-parse-start`: Triggered just before the statement is parsed by the MySQL query parser. The single argument, `query`, is a string containing the full text of the original query.
- `query-parse-done`: Triggered when the parsing of the original statement has been completed. The `status` is an integer describing the status of the operation. A `0` indicates that the query was successfully parsed. A `1` indicates that the parsing of the query failed.

For example, you could monitor the execution time for parsing a given query using the following D script:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

mysql*:::query-parse-start
{
   self->parsestart = timestamp;
   self->parsequery = copyinstr(arg0);
}

mysql*:::query-parse-done
/arg0 == 0/
{
   printf("Parsing %s: %d microseconds\n", self->parsequery,((timestamp - self->parsestart)/1000));
}

mysql*:::query-parse-done
/arg0 != 0/
```

```
{
   printf("Error parsing %s: %d microseconds\n", self->parsequery,((timestamp - self->parsestart)/1000));
}
```

In the above script a predicate is used on `query-parse-done` so that different output is generated based on the status value of the probe.

When running the script and monitoring the execution:

```
shell> ./query-parsing.d
Error parsing select from t1 join (t2) on (t1.i = t2.i) order by t1.s,t1.i limit 10: 36 ms
Parsing select * from t1 join (t2) on (t1.i = t2.i) order by t1.s,t1.i limit 10: 176 ms
```

5.7.1.5. Query Cache Probes

The query cache probes are fired when executing any query. The `query-cache-hit` query is triggered when a query exists in the query cache and can be used to return the query cache information. The arguments contain the original query text and the number of rows returned from the query cache for the query. If the query is not within the query cache, or the query cache is not enabled, then the `query-cache-miss` probe is triggered instead.

```
query-cache-hit(query, rows)
query-cache-miss(query)
```

- `query-cache-hit`: Triggered when the query has been found within the query cache. The first argument, `query`, contains the original text of the query. The second argument, `rows`, is an integer containing the number of rows in the cached query.
- `query-cache-miss`: Triggered when the query is not found within the query cache. The first argument, `query`, contains the original text of the query.

The query cache probes are best combined with a probe on the main query so that you can determine the differences in times between using or not using the query cache for specified queries. For example, in the following D script, the query and query cache information are combined into the information output during monitoring:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

dtrace:::BEGIN
{
   printf("%-20s %-20s %-40s %2s %-9s\n", "Who", "Database", "Query", "QC", "Time(ms)");
}

mysql*:::query-start
{
   self->query = copyinstr(arg0);
   self->connid = arg1;
   self->db    = copyinstr(arg2);
   self->who   = strjoin(copyinstr(arg3),strjoin("@",copyinstr(arg4)));
   self->querystart = timestamp;
   self->qc = 0;
}

mysql*:::query-cache-hit
{
   self->qc = 1;
}

mysql*:::query-cache-miss
{
   self->qc = 0;
}

mysql*:::query-done
{
   printf("%-20s %-20s %-40s %-2s %-9d\n",self->who,self->db,self->query,(self->qc ? "Y" : "N"),
          (timestamp - self->querystart) / 1000000);
}
```

When executing the script you can see the effects of the query cache. Initially the query cache is disabled. If you set the query cache size and then execute the query multiple times you should see that the query cache is being used to return the query data:

```
shell> ./query-cache.d
root@localhost       test                 select * from t1 order by i limit 10     N  1072
root@localhost                            set global query_cache_size=262144       N  0
root@localhost       test                 select * from t1 order by i limit 10     N  781
root@localhost       test                 select * from t1 order by i limit 10     Y  0
```

5.7.1.6. Query Execution Probes

The query execution probe is triggered when the actual execution of the query starts, after the parsing and checking the query cache but before any privilege checks or optimization. By comparing the difference between the start and done probes you can monitor the time actually spent servicing the query (instead of just handling the parsing and other elements of the query).

```
query-exec-start(query, connectionid, database, user, host, exec_type)
query-exec-done(status)
```

> **Note**
>
> The information provided in the arguments for `query-start` and `query-exec-start` are almost identical and designed so that you can choose to monitor either the entire query process (using `query-start`) or only the execution (using `query-exec-start`) while exposing the core information about the user, client, and query being executed.

- `query-exec-start`: Triggered when the execution of a individual query is started. The arguments are:
  - `query`: The full text of the submitted query.
  - `connectionid`: The connection ID of the client that submitted the query. The connection ID equals the connection ID returned when the client first connects and the `Id` value in the output from `SHOW PROCESSLIST`.
  - `database`: The database name on which the query is being executed.
  - `user`: The username used to connect to the server.
  - `host`: The hostname of the client.
  - `exec_type`: The type of execution. Execution types are determined based on the contents of the query and where it was submitted. The values for each type are shown in the following table.

Value	Description
0	Executed query from sql_parse, top-level query.
1	Executed prepared statement
2	Executed cursor statement
3	Executed query in stored procedure

- `query-exec-done`: Triggered when the execution of the query has completed. The probe includes a single argument, `status`, which returns 0 when the query is successfully executed and 1 if there was an error.

5.7.1.7. Row-Level Probes

The `*row-{start,done}` probes are triggered each time a row operation is pushed down to a storage engine. For example, if you execute an `INSERT` statement with 100 rows of data, then the `insert-row-start` and `insert-row-done` probes will be triggered 100 times each, for each row insert.

```
insert-row-start(database, table)
insert-row-done(status)

update-row-start(database, table)
update-row-done(status)

delete-row-start(database, table)
delete-row-done(status)
```

- `insert-row-start`: Triggered before a row is inserted into a table.
- `insert-row-done`: Triggered after a row is inserted into a table.
- `update-row-start`: Triggered before a row is updated in a table.
- `update-row-done`: Triggered before a row is updated in a table.
- `delete-row-start`: Triggered before a row is deleted from a table.

- `delete-row-done`: Triggered before a row is deleted from a table.

The arguments supported by the probes are consistent for the corresponding `start` and `done` probes in each case:

- `database`: The database name.
- `table`: The table name.
- `status`: The status; 0 for success or 1 for failure.

Because the row-level probes are triggered for each individual row access, these probes can be triggered many thousands of times each second, which may have a detrimental effect on both the monitoring script and MySQL. The DTrace environment should limit the triggering on these probes to prevent the performance being adversely affected. Either use the probes sparingly, or use counter or aggregation functions to report on these probes and then provide a summary when the script terminates or as part of a `query-done` or `query-exec-done` probes.

The following example script summarizes the duration of each row operation within a larger query:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

dtrace:::BEGIN
{
   printf("%-2s %-10s %-10s %9s %9s %-s \n",
          "St", "Who", "DB", "ConnID", "Dur ms", "Query");
}

mysql*:::query-start
{
   self->query = copyinstr(arg0);
   self->who   = strjoin(copyinstr(arg3),strjoin("@",copyinstr(arg4)));
   self->db    = copyinstr(arg2);
   self->connid = arg1;
   self->querystart = timestamp;
   self->rowdur = 0;
}

mysql*:::query-done
{
   this->elapsed = (timestamp - self->querystart) /1000000;
   printf("%2d %-10s %-10s %9d %9d %s\n",
          arg0, self->who, self->db,
          self->connid, this->elapsed, self->query);
}

mysql*:::query-done
/ self->rowdur /
{
   printf("%34s %9d %s\n", "", (self->rowdur/1000000), "-> Row ops");
}

mysql*:::insert-row-start
{
   self->rowstart = timestamp;
}

mysql*:::delete-row-start
{
   self->rowstart = timestamp;
}

mysql*:::update-row-start
{
   self->rowstart = timestamp;
}

mysql*:::insert-row-done
{
   self->rowdur += (timestamp-self->rowstart);
}

mysql*:::delete-row-done
{
   self->rowdur += (timestamp-self->rowstart);
}

mysql*:::update-row-done
{
   self->rowdur += (timestamp-self->rowstart);
}
```

Running the above script with a query that inserts data into a table, you can monitor the exact time spent performing the raw row insertion:

```
St Who        DB             ConnID    Dur ms Query
 0 @localhost test               13     20767 insert into t1(select * from t2)
                                         4827 -> Row ops
```

5.7.1.8. Read Row Probes

The read row probes are triggered at a storage engine level each time a row read operation occurs. These probes are specified within each storage engine (as opposed to the `*row-start` probes which are in the storage engine interface). These probes can therefore be used to monitor individual storage engine row-level operations and performance. Because these probes are triggered around the storage engine row read interface, they may be hit a significant number of times during a basic query.

```
read-row-start(database, table, scan_flag)
read-row-done(status)
```

- `read-row-start`: Triggered when a row is read by the storage engine from the specified `database` and `table`. The `scan_flag` is set to 1 (true) when the read is part of a table scan (that is, a sequential read), or 0 (false) when the read is of a specific record.
- `read-row-done`: Triggered when a row read operation within a storage engine completes. The `status` returns 0 on success, or a positive value on failure.

5.7.1.9. Index Probes

The index probes are triggered each time a a row is read using one of the indexes for the specified table. The probe is triggered within the corresponding storage engine for the table.

```
index-read-row-start(database, table)
index-read-row-done(status)
```

- `index-read-row-start`: Triggered when a row is read by the storage engine from the specified `database` and `table`.
- `index-read-row-done`: Triggered when an indexed row read operation within a storage engine completes. The `status` returns 0 on success, or a positive value on failure.

5.7.1.10. Lock Probes

The lock probes are called whenever an external lock is requested by MySQL for a table using the corresponding lock mechanism on the table as defined by the table's engine type. There are three different types of lock, the read lock, write lock, and unlock operations. Using the probes you can determine the duration of the external locking routine (that is, the time taken by the storage engine to implement the lock, including any time waiting for another lock to become free) and the total duration of the lock/unlock process.

```
handler-rdlock-start(database, table)
handler-rdlock-done(status)

handler-wrlock-start(database, table)
handler-wrlock-done(status)

handler-unlock-start(database, table)
handler-unlock-done(status)
```

- `handler-rdlock-start`: Triggered when a read lock is requested on the specified `database` and `table`.
- `handler-wrlock-start`: Triggered when a write lock is requested on the specified `database` and `table`.
- `handler-unlock-start`: Triggered when an unlock request is made on the specified `database` and `table`.
- `handler-rdlock-done`: Triggered when a read lock request completes. The `status` is 0 if the lock operation succeeded, or `>0` on failure.
- `handler-wrlock-done`: Triggered when a write lock request completes. The `status` is 0 if the lock operation succeeded, or `>0` on failure.
- `handler-unlock-done`: Triggered when an unlock request completes. The `status` is 0 if the unlock operation succeeded, or `>0` on failure.

You can use arrays to monitor the locking and unlocking of individual tables and then calculate the duration of the entire table lock using the following script:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

mysql*:::handler-rdlock-start
{
   self->rdlockstart = timestamp;
   this->lockref = strjoin(copyinstr(arg0),strjoin("@",copyinstr(arg1)));
   self->lockmap[this->lockref] = self->rdlockstart;
   printf("Start: Lock->Read   %s.%s\n",copyinstr(arg0),copyinstr(arg1));
}

mysql*:::handler-wrlock-start
{
   self->wrlockstart = timestamp;
   this->lockref = strjoin(copyinstr(arg0),strjoin("@",copyinstr(arg1)));
   self->lockmap[this->lockref] = self->rdlockstart;
   printf("Start: Lock->Write  %s.%s\n",copyinstr(arg0),copyinstr(arg1));
}

mysql*:::handler-unlock-start
{
   self->unlockstart = timestamp;
   this->lockref = strjoin(copyinstr(arg0),strjoin("@",copyinstr(arg1)));
   printf("Start: Lock->Unlock %s.%s (%d ms lock duration)\n",
          copyinstr(arg0),copyinstr(arg1),
          (timestamp - self->lockmap[this->lockref])/1000000);
}

mysql*:::handler-rdlock-done
{
   printf("End:   Lock->Read   %d ms\n",
          (timestamp - self->rdlockstart)/1000000);
}

mysql*:::handler-wrlock-done
{
   printf("End:   Lock->Write  %d ms\n",
          (timestamp - self->wrlockstart)/1000000);
}

mysql*:::handler-unlock-done
{
   printf("End:   Lock->Unlock %d ms\n",
          (timestamp - self->unlockstart)/1000000);
}
```

When executed, you should get information both about the duration of the locking process itself, and of the locks on a specific table:

```
Start: Lock->Read   test.t2
End:   Lock->Read   0 ms
Start: Lock->Unlock test.t2 (25743 ms lock duration)
End:   Lock->Unlock 0 ms
Start: Lock->Read   test.t2
End:   Lock->Read   0 ms
Start: Lock->Unlock test.t2 (1 ms lock duration)
End:   Lock->Unlock 0 ms
Start: Lock->Read   test.t2
End:   Lock->Read   0 ms
Start: Lock->Unlock test.t2 (1 ms lock duration)
End:   Lock->Unlock 0 ms
Start: Lock->Read   test.t2
End:   Lock->Read   0 ms
```

5.7.1.11. Filesort Probes

The filesort probes are triggered whenever a filesort operation is applied to a table. For more information on filesort and the conditions under which it occurs, see Section 7.13.9, "`ORDER BY` Optimization".

```
filesort-start(database, table)
filesort-done(status, rows)
```

- `filesort-start`: Triggered when the filesort operation starts on a table. The two arguments to the probe, `database` and `table`, will identify the table being sorted.
- `filesort-done`: Triggered when the filesort operation completes. Two arguments are supplied, the `status` (0 for success, 1 for failure), and the number of rows sorted during the filesort process.

An example of this is in the following script, which tracks the duration of the filesort process in addition to the duration of the main query:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

dtrace:::BEGIN
{
   printf("%-2s %-10s %-10s %9s %18s %-s \n",
          "St", "Who", "DB", "ConnID", "Dur microsec", "Query");
}

mysql*:::query-start
{
   self->query = copyinstr(arg0);
   self->who   = strjoin(copyinstr(arg3),strjoin("@",copyinstr(arg4)));
   self->db    = copyinstr(arg2);
   self->connid = arg1;
   self->querystart = timestamp;
   self->filesort = 0;
   self->fsdb = "";
   self->fstable = "";
}

mysql*:::filesort-start
{
  self->filesort = timestamp;
  self->fsdb = copyinstr(arg0);
  self->fstable = copyinstr(arg1);
}

mysql*:::filesort-done
{
   this->elapsed = (timestamp - self->filesort) /1000;
   printf("%2d %-10s %-10s %9d %18d Filesort on %s\n",
          arg0, self->who, self->fsdb,
          self->connid, this->elapsed, self->fstable);
}

mysql*:::query-done
{
   this->elapsed = (timestamp - self->querystart) /1000;
   printf("%2d %-10s %-10s %9d %18d %s\n",
          arg0, self->who, self->db,
          self->connid, this->elapsed, self->query);
}
```

Executing a query on a large table with an `ORDER BY` clause that triggers a filesort, and then creating an index on the table and then repeating the same query, you can see the difference in execution speed:

```
St Who        DB            ConnID       Dur microsec Query
 0 @localhost test              14           11335469 Filesort on t1
 0 @localhost test              14           11335787 select * from t1 order by i limit 100
 0 @localhost test              14          466734378 create index t1a on t1 (i)
 0 @localhost test              14              26472 select * from t1 order by i limit 100
```

5.7.1.12. Statement Probes

The individual statement probes are provided to give specific information about different statement types. For the start probes the string of the query is provided as a the only argument. Depending on the statement type, the information provided by the corresponding done probe will differ. For all done probes the status of the operation (`0` for success, `>0` for failure) is provided. For `SELECT`, `INSERT`, `INSERT ... (SELECT FROM ...)`, `DELETE`, and `DELETE FROM t1,t2` operations the number of rows affected is returned.

For `UPDATE` and `UPDATE t1,t2 ...` statements the number of rows matched and the number of rows actually changed is provided. This is because the number of rows actually matched by the corresponding `WHERE` clause, and the number of rows changed can differ. MySQL does not update the value of a row if the value already matches the new setting.

```
select-start(query)
select-done(status,rows)

insert-start(query)
insert-done(status,rows)

insert-select-start(query)
insert-select-done(status,rows)

update-start(query)
update-done(status,rowsmatched,rowschanged)

multi-update-start(query)
multi-update-done(status,rowsmatched,rowschanged)

delete-start(query)
delete-done(status,rows)

multi-delete-start(query)
```

```
multi-delete-done(status,rows)
```

- `select-start`: Triggered before a `SELECT` statement.
- `select-done`: Triggered at the end of a `SELECT` statement.
- `insert-start`: Triggered before a `INSERT` statement.
- `insert-done`: Triggered at the end of an `INSERT` statement.
- `insert-select-start`: Triggered before an `INSERT ... SELECT` statement.
- `insert-select-done`: Triggered at the end of an `INSERT ... SELECT` statement.
- `update-start`: Triggered before an `UPDATE` statement.
- `update-done`: Triggered at the end of an `UPDATE` statement.
- `multi-update-start`: Triggered before an `UPDATE` statement involving multiple tables.
- `multi-update-done`: Triggered at the end of an `UPDATE` statement involving multiple tables.
- `delete-start`: Triggered before a `DELETE` statement.
- `delete-done`: Triggered at the end of a `DELETE` statement.
- `multi-delete-start`: Triggered before a `DELETE` statement involving multiple tables.
- `multi-delete-done`: Triggered at the end of a `DELETE` statement involving multiple tables.

The arguments for the statement probes are:

- `query`: The query string.
- `status`: The status of the query. `0` for success, and `>0` for failure.
- `rows`: The number of rows affected by the statement. This returns the number rows found for `SELECT`, the number of rows deleted for `DELETE`, and the number of rows successfully inserted for `INSERT`.
- `rowsmatched`: The number of rows matched by the `WHERE` clause of an `UPDATE` operation.
- `rowschanged`: The number of rows actually changed during an `UPDATE` operation.

You use these probes to monitor the execution of these statement types without having to monitor the user or client executing the statements. A simple example of this is to track the execution times:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

dtrace:::BEGIN
{
   printf("%-60s %-8s %-8s %-8s\n", "Query", "RowsU", "RowsM", "Dur (ms)");
}

mysql*:::update-start, mysql*:::insert-start,
mysql*:::delete-start, mysql*:::multi-delete-start,
mysql*:::multi-delete-done, mysql*:::select-start,
mysql*:::insert-select-start, mysql*:::multi-update-start
{
    self->query = copyinstr(arg0);
    self->querystart = timestamp;
}

mysql*:::insert-done, mysql*:::select-done,
mysql*:::delete-done, mysql*:::multi-delete-done, mysql*:::insert-select-done
/ self->querystart /
{
    this->elapsed = ((timestamp - self->querystart)/1000000);
    printf("%-60s %-8d %-8d %d\n",
           self->query,
           0,
           arg1,
           this->elapsed);
    self->querystart = 0;
}
```

```
mysql*:::update-done, mysql*:::multi-update-done
/ self->querystart /
{
    this->elapsed = ((timestamp - self->querystart)/1000000);
    printf("%-60s %-8d %-8d %d\n",
           self->query,
           arg1,
           arg2,
           this->elapsed);
    self->querystart = 0;
}
```

When executed you can see the basic execution times and rows matches:

```
Query                                                        RowsU    RowsM    Dur (ms)
select * from t2                                             0        275      0
insert into t2 (select * from t2)                            0        275      9
update t2 set i=5 where i > 75                               110      110      8
update t2 set i=5 where i < 25                               254      134      12
delete from t2 where i < 5                                   0        0        0
```

Another alternative is to use the aggregation functions in DTrace to aggregate the execution time of individual statements together:

```
#!/usr/sbin/dtrace -s

#pragma D option quiet


mysql*:::update-start, mysql*:::insert-start,
mysql*:::delete-start, mysql*:::multi-delete-start,
mysql*:::multi-delete-done, mysql*:::select-start,
mysql*:::insert-select-start, mysql*:::multi-update-start
{
    self->querystart = timestamp;
}

mysql*:::select-done
{
        @statements["select"] = sum(((timestamp - self->querystart)/1000000));
}

mysql*:::insert-done, mysql*:::insert-select-done
{
        @statements["insert"] = sum(((timestamp - self->querystart)/1000000));
}

mysql*:::update-done, mysql*:::multi-update-done
{
        @statements["update"] = sum(((timestamp - self->querystart)/1000000));
}

mysql*:::delete-done, mysql*:::multi-delete-done
{
        @statements["delete"] = sum(((timestamp - self->querystart)/1000000));
}

tick-30s
{
        printa(@statements);
}
```

The script just shown aggregates the times spent doing each operation, which could be used to help benchmark a standard suite of tests.

```
 delete                                                            0
  update                                                            0
  insert                                                           23
  select                                                         2484

  delete                                                            0
  update                                                            0
  insert                                                           39
  select                                                        10744

  delete                                                            0
  update                                                           26
  insert                                                           56
  select                                                        10944

  delete                                                            0
  update                                                           26
  insert                                                         2287
  select                                                        15985
```

5.7.1.13. Network Probes

The network probes monitor the transfer of information from the MySQL server and clients of all types over the network. The probes are defined as follows:

```
net-read-start()
net-read-done(status, bytes)
net-write-start(bytes)
net-write-done(status)
```

- `net-read-start`: Triggered when a network read operation is started.
- `net-read-done`: Triggered when the network read operation completes. The `status` is an `integer` representing the return status for the operation, `0` for success and `1` for failure. The `bytes` argument is an integer specifying the number of bytes read during the process.
- `net-start-bytes`: Triggered when data is written to a network socket. The single argument, `bytes`, specifies the number of bytes written to the network socket.
- `net-write-done`: Triggered when the network write operation has completed. The single argument, `status`, is an integer representing the return status for the operation, `0` for success and `1` for failure.

You can use the network probes to monitor the time spent reading from and writing to network clients during execution. The following D script provides an example of this. Both the cumlative time for the read or write is calculated, and the number of bytes. Note that the dynamic variable size has been increased (using the `dynvarsize` option) to cope with the rapid firing of the individual probes for the network reads/writes.

```
#!/usr/sbin/dtrace -s

#pragma D option quiet
#pragma D option dynvarsize=4m

dtrace:::BEGIN
{
   printf("%-2s %-30s %-10s %9s %18s %-s \n",
          "St", "Who", "DB", "ConnID", "Dur microsec", "Query");
}

mysql*:::query-start
{
   self->query = copyinstr(arg0);
   self->who   = strjoin(copyinstr(arg3),strjoin("@",copyinstr(arg4)));
   self->db    = copyinstr(arg2);
   self->connid = arg1;
   self->querystart = timestamp;
   self->netwrite = 0;
   self->netwritecum = 0;
   self->netwritebase = 0;
   self->netread = 0;
   self->netreadcum = 0;
   self->netreadbase = 0;
}

mysql*:::net-write-start
{
   self->netwrite += arg0;
   self->netwritebase = timestamp;
}

mysql*:::net-write-done
{
   self->netwritecum += (timestamp - self->netwritebase);
   self->netwritebase = 0;
}

mysql*:::net-read-start
{
   self->netreadbase = timestamp;
}

mysql*:::net-read-done
{
   self->netread += arg1;
   self->netreadcum += (timestamp - self->netreadbase);
   self->netreadbase = 0;
}

mysql*:::query-done
{
   this->elapsed = (timestamp - self->querystart) /1000000;
   printf("%2d %-30s %-10s %9d %18d %s\n",
          arg0, self->who, self->db,
          self->connid, this->elapsed, self->query);
   printf("Net read: %d bytes (%d ms) write: %d bytes (%d ms)\n",
               self->netread, (self->netreadcum/1000000),
               self->netwrite, (self->netwritecum/1000000));
}
```

When executing the above script on a machine with a remote client, you can see that approximately a third of the time spent executing the query is related to writing the query results back to the client.

```
St Who                            DB            ConnID       Dur microsec Query
 0 root@::ffff:192.168.0.108      test              31              3495 select * from t1 limit 1000000
Net read: 0 bytes (0 ms) write: 10000075 bytes (1220 ms)
```

5.7.1.14. Keycache Probes

The keycache probes are triggered when using the index key cache used with the MyISAM storage engine. Probes exist to monitor when data is read into the keycache, cached key data is written from the cache into a cached file, or when accessing the keycache.

Keycache usage indicates when data is read or written from the index files into the cache, and can be used to monitor how efficient the memory allocated to the keycache is being used. A high number of keycache reads across a range of queries may indicate that the keycache is too small for size of data being accessed.

```
keycache-read-start(filepath, bytes, mem_used, mem_free)
keycache-read-block(bytes)
keycache-read-hit()
keycache-read-miss()
keycache-read-done(mem_used, mem_free)
keycache-write-start(filepath, bytes, mem_used, mem_free)
keycache-write-block(bytes)
keycache-write-done(mem_used, mem_free)
```

When reading data from the index files into the keycache, the process first initializes the read operation (indicated by `keycache-read-start`), then loads blocks of data (`keycache-read-block`), and then the read block is either matches the data being identified (`keycache-read-hit`) or more data needs to be read (`keycache-read-miss`). Once the read operation has completed, reading stops with the `keycache-read-done`.

Data will be read from the index file into the keycache only when the specified key is not already within the keycache.

- `keycache-read-start`: Triggered when the keycache read operation is started. Data is read from the specified `filepath`, reading the specified number of `bytes`. The `mem_used` and `mem_avail` indicate memory currently used by the keycache and the amount of memory available within the keycache.
- `keycache-read-block`: Triggered when the keycache reads a block of data, of the specified number of `bytes`, from the index file into the keycache.
- `keycache-read-hit`: Triggered when the block of data read from the index file matches the key data requested.
- `keycache-read-miss`: Triggered when the block of data read from the index file does not match the key data needed.
- `keycache-read-done`: Triggered when the keycache read operation has completed. The `mem_used` and `mem_avail` indicate memory currently used by the keycache and the amount of memory available within the keycache.

Keycache writes occur when the index information is updated during an `INSERT`, `UPDATE`, or `DELETE` operation, and the cached key information is flushed back to the index file.

- `keycache-write-start`: Triggered when the keycache write operation is started. Data is written to the specified `filepath`, reading the specified number of `bytes`. The `mem_used` and `mem_avail` indicate memory currently used by the keycache and the amount of memory available within the keycache.
- `keycache-write-block`: Triggered when the keycache writes a block of data, of the specified number of `bytes`, to the index file from the keycache.
- `keycache-write-done`: Triggered when the keycache write operation has completed. The `mem_used` and `mem_avail` indicate memory currently used by the keycache and the amount of memory available within the keycache.

Chapter 6. Backup and Recovery

It is important to back up your databases so that you can recover your data and be up and running again in case problems occur, such as system crashes, hardware failures, or users deleting data by mistake. Backups are also essential as a safeguard before upgrading a MySQL installation, and they can be used to transfer a MySQL installation to another system or to set up replication slave servers.

MySQL offers a variety of backup strategies from which you can choose the methods that best suit the requirements for your installation. This chapter discusses several backup and recovery topics with which you should be familiar:

- Types of backups: Logical versus physical, full versus incremental, and so forth.
- Methods for creating backups.
- Recovery methods, including point-in-time recovery.
- Backup scheduling, compression, and encryption.
- Table maintenance, to enable recovery of corrupt tables.

Additional Resources

Resources related to backup or to maintaining data availability include the following:

- Customers of MySQL Enterprise Edition can use the MySQL Enterprise Backup product for backups. For an overview of the MySQL Enterprise Backup product, see Chapter 23, *MySQL Enterprise Backup*.
- A forum dedicated to backup issues is available at http://forums.mysql.com/list.php?93.
- Details for `mysqldump`, `mysqlhotcopy`, and other MySQL backup programs can be found in Chapter 4, *MySQL Programs*.
- The syntax of the SQL statements described here is given in Chapter 12, *SQL Statement Syntax*.
- For additional information about `InnoDB` backup procedures, see Section 13.3.7, “Backing Up and Recovering an `InnoDB` Database”.
- Replication enables you to maintain identical data on multiple servers. This has several benefits, such as enabling client query load to be distributed over servers, availability of data even if a given server is taken offline or fails, and the ability to make backups with no impact on the master by using a slave server. See Chapter 15, *Replication*.
- MySQL Cluster provides a high-availability, high-redundancy version of MySQL adapted for the distributed computing environment. See MySQL Cluster NDB 6.X/7.X, which provides information about MySQL Cluster NDB 7.0 and 7.1 (based on MySQL 5.1 but containing the latest improvements and fixes for the `NDBCLUSTER` storage engine).

  > **Note**
  >
  > The `NDBCLUSTER` storage engine is currently not supported in MySQL 5.5.
- Distributed Replicated Block Device (DRBD) is another high-availability solution. It works by replicating a block device from a primary server to a secondary server at the block level. See Chapter 14, *High Availability and Scalability*

6.1. Backup and Recovery Types

This section describes the characteristics of different types of backups.

Physical (Raw) Versus Logical Backups

Physical backups consist of raw copies of the directories and files that store database contents. This type of backup is suitable for large, important databases that need to be recovered quickly when problems occur.

Logical backups save information represented as logical database structure (`CREATE DATABASE`, `CREATE TABLE` statements) and content (`INSERT` statements or delimited-text files). This type of backup is suitable for smaller amounts of data where you might edit the data values or table structure, or recreate the data on a different machine architecture.

Physical backup methods have these characteristics:

- The backup consists of exact copies of database directories and files. Typically this is a copy of all or part of the MySQL data directory.
- Physical backup methods are faster than logical because they involve only file copying without conversion.
- Output is more compact than for logical backup.
- Because backup speed and compactness are important for busy, important databases, the MySQL Enterprise Backup product performs physical backups. For an overview of the MySQL Enterprise Backup product, see Chapter 23, *MySQL Enterprise Backup*.
- Backup and restore granularity ranges from the level of the entire data directory down to the level of individual files. This may or may not provide for table-level granularity, depending on storage engine. For example, `InnoDB` tables can each be in a separate file, or share file storage with other `InnoDB` tables; each `MyISAM` table corresponds uniquely to a set of files.
- In addition to databases, the backup can include any related files such as log or configuration files.
- Data from `MEMORY` tables is tricky to back up this way because their contents are not stored on disk. (The MySQL Enterprise Backup product has a feature where you can retrieve data from `MEMORY` tables during a backup.)
- Backups are portable only to other machines that have identical or similar hardware characteristics.
- Backups can be performed while the MySQL server is not running. If the server is running, it is necessary to perform appropriate locking so that the server does not change database contents during the backup. MySQL Enterprise Backup does this locking automatically for tables that require it.
- Physical backup tools include the `mysqlbackup` of MySQL Enterprise Backup for `InnoDB` or any other tables, file system-level commands (such as `cp`, `scp`, `tar`, `rsync`), or `mysqlhotcopy` for `MyISAM` tables.
- For restore:
  - MySQL Enterprise Backup restores `InnoDB` and other tables that it backed up.
  - `ndb_restore` restores `NDB` tables.
  - Files copied at the file system level or with `mysqlhotcopy` can be copied back to their original locations with file system commands.

Logical backup methods have these characteristics:

- The backup is done by querying the MySQL server to obtain database structure and content information.
- Backup is slower than physical methods because the server must access database information and convert it to logical format. If the output is written on the client side, the server must also send it to the backup program.
- Output is larger than for physical backup, particularly when saved in text format.
- Backup and restore granularity is available at the server level (all databases), database level (all tables in a particular database), or table level. This is true regardless of storage engine.
- The backup does not include log or configuration files, or other database-related files that are not part of databases.
- Backups stored in logical format are machine independent and highly portable.
- Logical backups are performed with the MySQL server running. The server is not taken offline.
- Logical backup tools include the `mysqldump` program and the `SELECT ... INTO OUTFILE` statement. These work for any storage engine, even `MEMORY`.
- To restore logical backups, SQL-format dump files can be processed using the `mysql` client. To load delimited-text files, use the `LOAD DATA INFILE` statement or the `mysqlimport` client.

Online Versus Offline Backups

Online backups take place while the MySQL server is running so that the database information can be obtained from the server.

Offline backups take place while the server is stopped. This distinction can also be described as “hot” versus “cold” backups; a “warm” backup is one where the server remains running but locked against modifying data while you access database files externally.

Online backup methods have these characteristics:

- The backup is less intrusive to other clients, which can connect to the MySQL server during the backup and may be able to access data depending on what operations they need to perform.
- Care must be taken to impose appropriate locking so that data modifications do not take place that would compromise backup integrity. The MySQL Enterprise Backup product does such locking automatically.

Offline backup methods have these characteristics:

- Clients can be affected adversely because the server is unavailable during backup. For that reason, such backups are often taken from a replication slave server that can be taken offline without harming availability.
- The backup procedure is simpler because there is no possibility of interference from client activity.

A similar distinction between online and offline applies for recovery operations, and similar characteristics apply. However, it is more likely that clients will be affected for online recovery than for online backup because recovery requires stronger locking. During backup, clients might be able to read data while it is being backed up. Recovery modifies data and does not just read it, so clients must be prevented from accessing data while it is being restored.

Local Versus Remote Backups

A local backup is performed on the same host where the MySQL server runs, whereas a remote backup is done from a different host. For some types of backups, the backup can be initiated from a remote host even if the output is written locally on the server. host.

- `mysqldump` can connect to local or remote servers. For SQL output (`CREATE` and `INSERT` statements), local or remote dumps can be done and generate output on the client. For delimited-text output (with the `--tab` option), data files are created on the server host.
- `mysqlhotcopy` performs only local backups: It connects to the server to lock it against data modifications and then copies local table files.
- `SELECT ... INTO OUTFILE` can be initiated from a local or remote client host, but the output file is created on the server host.
- Physical backup methods typically are initiated locally on the MySQL server host so that the server can be taken offline, although the destination for copied files might be remote.

Snapshot Backups

Some file system implementations enable “snapshots” to be taken. These provide logical copies of the file system at a given point in time, without requiring a physical copy of the entire file system. (For example, the implementation may use copy-on-write techniques so that only parts of the file system modified after the snapshot time need be copied.) MySQL itself does not provide the capability for taking file system snapshots. It is available through third-party solutions such as Veritas, LVM, or ZFS.

Full Versus Incremental Backups

A full backup includes all data managed by a MySQL server at a given point in time. An incremental backup consists of the changes made to the data during a given time span (from one point in time to another). MySQL has different ways to perform full backups, such as those described earlier in this section. Incremental backups are made possible by enabling the server's binary log, which the server uses to record data changes.

Full Versus Point-in-Time (Incremental) Recovery

A full recovery restores all data from a full backup. This restores the server instance to the state that it had when the backup was made. If that state is not sufficiently current, a full recovery can be followed by recovery of incremental backups made since the full backup, to bring the server to a more up-to-date state.

Incremental recovery is recovery of changes made during a given time span. This is also called point-in-time recovery because it makes a server's state current up to a given time. Point-in-time recovery is based on the binary log and typically follows a full recovery from the backup files that restores the server to its state when the backup was made. Then the data changes written in the binary log files are applied as incremental recovery to redo data modifications and bring the server up to the desired point in time.

Table Maintenance

Data integrity can be compromised if tables become corrupt. For `InnoDB` tables, this is not a typical issue. For programs to check `MyISAM` tables and repair them if problems are found, see Section 6.6, “`MyISAM` Table Maintenance and Crash Recovery”.

Backup Scheduling, Compression, and Encryption

Backup scheduling is valuable for automating backup procedures. Compression of backup output reduces space requirements, and encryption of the output provides better security against unauthorized access of backed-up data. MySQL itself does not provide these capabilities. The MySQL Enterprise Backup product can compress `InnoDB` backups, and compression or encryption of backup output can be achieved using file system utilities. Other third-party solutions may be available.

6.2. Database Backup Methods

This section summarizes some general methods for making backups.

Making a Hot Backup with MySQL Enterprise Backup

Customers of MySQL Enterprise Edition can use the MySQL Enterprise Backup product to do physical backups of entire instances or selected databases, tables, or both. This product includes features for incremental and compressed backups. Backing up the physical database files makes restore much faster than logical techniques such as the `mysqldump` command. `InnoDB` tables are copied using a hot backup mechanism. (Ideally, the `InnoDB` tables should represent a substantial majority of the data.) Tables from other storage engines are copied using a warm backup mechanism. For an overview of the MySQL Enterprise Backup product, see Chapter 23, *MySQL Enterprise Backup*.

Making Backups by Copying Table Files

For storage engines that represent each table using its own files, tables can be backed up by copying those files. For example, `MyISAM` tables are stored as files, so it is easy to do a backup by copying files (`*.frm`, `*.MYD`, and `*.MYI` files). To get a consistent backup, stop the server or lock and flush the relevant tables:

```
FLUSH TABLES tbl_list WITH READ LOCK;
```

You need only a read lock; this enables other clients to continue to query the tables while you are making a copy of the files in the database directory. The flush is needed to ensure that the all active index pages are written to disk before you start the backup. See Section 12.3.5, “`LOCK TABLES` and `UNLOCK TABLES` Syntax”, and Section 12.4.6.3, “`FLUSH` Syntax”.

You can also create a binary backup simply by copying all table files, as long as the server isn't updating anything. The `mysqlhotcopy` script uses this method. (But note that table file copying methods do not work if your database contains `InnoDB` tables. `mysqlhotcopy` does not work for `InnoDB` tables because `InnoDB` does not necessarily store table contents in database directories. Also, even if the server is not actively updating data, `InnoDB` may still have modified data cached in memory and not flushed to disk.

Making Delimited-Text File Backups

To create a text file containing a table's data, you can use `SELECT * INTO OUTFILE 'file_name' FROM tbl_name`. The file is created on the MySQL server host, not the client host. For this statement, the output file cannot already exist because permitting files to be overwritten constitutes a security risk. See Section 12.2.9, “`SELECT` Syntax”. This method works for any kind of data file, but saves only table data, not the table structure.

Another way to create text data files (along with files containing `CREATE TABLE` statements for the backed up tables) is to use `mysqldump` with the `--tab` option. See Section 6.4.3, “Dumping Data in Delimited-Text Format with `mysqldump`”.

To reload a delimited-text data file, use `LOAD DATA INFILE` or `mysqlimport`.

Making Backups with `mysqldump` or `mysqlhotcopy`

The `mysqldump` program and the `mysqlhotcopy` script can make backups. `mysqldump` is more general because it can back up all kinds of tables. `mysqlhotcopy` works only with some storage engines. (See Section 6.4, “Using `mysqldump` for Backups”, and Section 4.6.9, “`mysqlhotcopy` — A Database Backup Program”.)

For `InnoDB` tables, it is possible to perform an online backup that takes no locks on tables using the `--single-transaction` option to `mysqldump`. See Section 6.3.1, "Establishing a Backup Policy".

Making Incremental Backups by Enabling the Binary Log

MySQL supports incremental backups: You must start the server with the `--log-bin` option to enable binary logging; see Section 5.2.4, "The Binary Log". The binary log files provide you with the information you need to replicate changes to the database that are made subsequent to the point at which you performed a backup. At the moment you want to make an incremental backup (containing all changes that happened since the last full or incremental backup), you should rotate the binary log by using `FLUSH LOGS`. This done, you need to copy to the backup location all binary logs which range from the one of the moment of the last full or incremental backup to the last but one. These binary logs are the incremental backup; at restore time, you apply them as explained in Section 6.5, "Point-in-Time (Incremental) Recovery Using the Binary Log". The next time you do a full backup, you should also rotate the binary log using `FLUSH LOGS`, `mysqldump --flush-logs`, or `mysqlhotcopy --flushlog`. See Section 4.5.4, "`mysqldump` — A Database Backup Program", and Section 4.6.9, "`mysqlhotcopy` — A Database Backup Program".

Making Backups Using Replication Slaves

If you have performance problems with your master server while making backups, one strategy that can help is to set up replication and perform backups on the slave rather than on the master. See Section 15.3.1, "Using Replication for Backups".

If you are backing up a slave replication server, you should back up its `master.info` and `relay-log.info` files when you back up the slave's databases, regardless of the backup method you choose. These information files are always needed to resume replication after you restore the slave's data. If your slave is replicating `LOAD DATA INFILE` statements, you should also back up any `SQL_LOAD-*` files that exist in the directory that the slave uses for this purpose. The slave needs these files to resume replication of any interrupted `LOAD DATA INFILE` operations. The location of this directory is the value of the `--slave-load-tmpdir` option. If the server was not started with that option, the directory location is the value of the `tmpdir` system variable.

Recovering Corrupt Tables

If you have to restore `MyISAM` tables that have become corrupt, try to recover them using `REPAIR TABLE` or `myisamchk -r` first. That should work in 99.9% of all cases. If `myisamchk` fails, see Section 6.6, "`MyISAM` Table Maintenance and Crash Recovery".

Making Backups Using a File System Snapshot

If you are using a Veritas file system, you can make a backup like this:

1. From a client program, execute `FLUSH TABLES WITH READ LOCK`.
2. From another shell, execute `mount vxfs snapshot`.
3. From the first client, execute `UNLOCK TABLES`.
4. Copy files from the snapshot.
5. Unmount the snapshot.

Similar snapshot capabilities may be available in other file systems, such as LVM or ZFS.

6.3. Example Backup and Recovery Strategy

This section discusses a procedure for performing backups that enables you to recover data after several types of crashes:

- Operating system crash
- Power failure
- File system crash
- Hardware problem (hard drive, motherboard, and so forth)

The example commands do not include options such as `--user` and `--password` for the `mysqldump` and `mysql` client programs. You should include such options as necessary to enable client programs to connect to the MySQL server.

Assume that data is stored in the `InnoDB` storage engine, which has support for transactions and automatic crash recovery. Assume also that the MySQL server is under load at the time of the crash. If it were not, no recovery would ever be needed.

For cases of operating system crashes or power failures, we can assume that MySQL's disk data is available after a restart. The `InnoDB` data files might not contain consistent data due to the crash, but `InnoDB` reads its logs and finds in them the list of pending committed and noncommitted transactions that have not been flushed to the data files. `InnoDB` automatically rolls back those transactions that were not committed, and flushes to its data files those that were committed. Information about this recovery process is conveyed to the user through the MySQL error log. The following is an example log excerpt:

```
InnoDB: Database was not shut down normally.
InnoDB: Starting recovery from log files...
InnoDB: Starting log scan based on checkpoint at
InnoDB: log sequence number 0 13674004
InnoDB: Doing recovery: scanned up to log sequence number 0 13739520
InnoDB: Doing recovery: scanned up to log sequence number 0 13805056
InnoDB: Doing recovery: scanned up to log sequence number 0 13870592
InnoDB: Doing recovery: scanned up to log sequence number 0 13936128
...
InnoDB: Doing recovery: scanned up to log sequence number 0 20555264
InnoDB: Doing recovery: scanned up to log sequence number 0 20620800
InnoDB: Doing recovery: scanned up to log sequence number 0 20664692
InnoDB: 1 uncommitted transaction(s) which must be rolled back
InnoDB: Starting rollback of uncommitted transactions
InnoDB: Rolling back trx no 16745
InnoDB: Rolling back of trx no 16745 completed
InnoDB: Rollback of uncommitted transactions completed
InnoDB: Starting an apply batch of log records to the database...
InnoDB: Apply batch completed
InnoDB: Started
mysqld: ready for connections
```

For the cases of file system crashes or hardware problems, we can assume that the MySQL disk data is *not* available after a restart. This means that MySQL fails to start successfully because some blocks of disk data are no longer readable. In this case, it is necessary to reformat the disk, install a new one, or otherwise correct the underlying problem. Then it is necessary to recover our MySQL data from backups, which means that backups must already have been made. To make sure that is the case, design and implement a backup policy.

6.3.1. Establishing a Backup Policy

To be useful, backups must be scheduled regularly. A full backup (a snapshot of the data at a point in time) can be done in MySQL with several tools. For example, `InnoDB Hot Backup` provides online nonblocking physical backup of the `InnoDB` data files, and `mysqldump` provides online logical backup. This discussion uses `mysqldump`.

Assume that we make a full backup of all our `InnoDB` tables in all databases using the following command on Sunday at 1 p.m., when load is low:

```
shell> mysqldump --single-transaction --all-databases > backup_sunday_1_PM.sql
```

The resulting `.sql` file produced by `mysqldump` contains a set of SQL `INSERT` statements that can be used to reload the dumped tables at a later time.

This backup operation acquires a global read lock on all tables at the beginning of the dump (using `FLUSH TABLES WITH READ LOCK`). As soon as this lock has been acquired, the binary log coordinates are read and the lock is released. If long updating statements are running when the `FLUSH` statement is issued, the backup operation may stall until those statements finish. After that, the dump becomes lock-free and does not disturb reads and writes on the tables.

It was assumed earlier that the tables to back up are `InnoDB` tables, so `--single-transaction` uses a consistent read and guarantees that data seen by `mysqldump` does not change. (Changes made by other clients to `InnoDB` tables are not seen by the `mysqldump` process.) If the backup operation includes nontransactional tables, consistency requires that they do not change during the backup. For example, for the `MyISAM` tables in the `mysql` database, there must be no administrative changes to MySQL accounts during the backup.

Full backups are necessary, but it is not always convenient to create them. They produce large backup files and take time to generate. They are not optimal in the sense that each successive full backup includes all data, even that part that has not changed since the previous full backup. It is more efficient to make an initial full backup, and then to make incremental backups. The incremental backups are smaller and take less time to produce. The tradeoff is that, at recovery time, you cannot restore your data just by reloading the full backup. You must also process the incremental backups to recover the incremental changes.

To make incremental backups, we need to save the incremental changes. In MySQL, these changes are represented in the binary log, so the MySQL server should always be started with the `--log-bin` option to enable that log. With binary logging enabled, the server writes each data change into a file while it updates data. Looking at the data directory of a MySQL server that was started with the `--log-bin` option and that has been running for some days, we find these MySQL binary log files:

```
-rw-rw---- 1 guilhem  guilhem   1277324 Nov 10 23:59 gbichot2-bin.000001
```

```
-rw-rw---- 1 guilhem  guilhem         4 Nov 10 23:59 gbichot2-bin.000002
-rw-rw---- 1 guilhem  guilhem        79 Nov 11 11:06 gbichot2-bin.000003
-rw-rw---- 1 guilhem  guilhem       508 Nov 11 11:08 gbichot2-bin.000004
-rw-rw---- 1 guilhem  guilhem 220047446 Nov 12 16:47 gbichot2-bin.000005
-rw-rw---- 1 guilhem  guilhem    998412 Nov 14 10:08 gbichot2-bin.000006
-rw-rw---- 1 guilhem  guilhem       361 Nov 14 10:07 gbichot2-bin.index
```

Each time it restarts, the MySQL server creates a new binary log file using the next number in the sequence. While the server is running, you can also tell it to close the current binary log file and begin a new one manually by issuing a `FLUSH LOGS` SQL statement or with a `mysqladmin flush-logs` command. `mysqldump` also has an option to flush the logs. The `.index` file in the data directory contains the list of all MySQL binary logs in the directory.

The MySQL binary logs are important for recovery because they form the set of incremental backups. If you make sure to flush the logs when you make your full backup, the binary log files created afterward contain all the data changes made since the backup. Let's modify the previous `mysqldump` command a bit so that it flushes the MySQL binary logs at the moment of the full backup, and so that the dump file contains the name of the new current binary log:

```
shell> mysqldump --single-transaction --flush-logs --master-data=2 \
         --all-databases > backup_sunday_1_PM.sql
```

After executing this command, the data directory contains a new binary log file, `gbichot2-bin.000007`, because the `--flush-logs` option causes the server to flush its logs. The `--master-data` option causes `mysqldump` to write binary log information to its output, so the resulting `.sql` dump file includes these lines:

```
-- Position to start replication or point-in-time recovery from
-- CHANGE MASTER TO MASTER_LOG_FILE='gbichot2-bin.000007',MASTER_LOG_POS=4;
```

Because the `mysqldump` command made a full backup, those lines mean two things:

- The dump file contains all changes made before any changes written to the `gbichot2-bin.000007` binary log file or newer.
- All data changes logged after the backup are not present in the dump file, but are present in the `gbichot2-bin.000007` binary log file or newer.

On Monday at 1 p.m., we can create an incremental backup by flushing the logs to begin a new binary log file. For example, executing a `mysqladmin flush-logs` command creates `gbichot2-bin.000008`. All changes between the Sunday 1 p.m. full backup and Monday 1 p.m. will be in the `gbichot2-bin.000007` file. This incremental backup is important, so it is a good idea to copy it to a safe place. (For example, back it up on tape or DVD, or copy it to another machine.) On Tuesday at 1 p.m., execute another `mysqladmin flush-logs` command. All changes between Monday 1 p.m. and Tuesday 1 p.m. will be in the `gbichot2-bin.000008` file (which also should be copied somewhere safe).

The MySQL binary logs take up disk space. To free up space, purge them from time to time. One way to do this is by deleting the binary logs that are no longer needed, such as when we make a full backup:

```
shell> mysqldump --single-transaction --flush-logs --master-data=2 \
         --all-databases --delete-master-logs > backup_sunday_1_PM.sql
```

> **Note**
>
> Deleting the MySQL binary logs with `mysqldump --delete-master-logs` can be dangerous if your server is a replication master server, because slave servers might not yet fully have processed the contents of the binary log. The description for the `PURGE BINARY LOGS` statement explains what should be verified before deleting the MySQL binary logs. See Section 12.5.1.1, “`PURGE BINARY LOGS` Syntax”.

6.3.2. Using Backups for Recovery

Now, suppose that we have a catastrophic crash on Wednesday at 8 a.m. that requires recovery from backups. To recover, first we restore the last full backup we have (the one from Sunday 1 p.m.). The full backup file is just a set of SQL statements, so restoring it is very easy:

```
shell> mysql < backup_sunday_1_PM.sql
```

At this point, the data is restored to its state as of Sunday 1 p.m.. To restore the changes made since then, we must use the incremental backups; that is, the `gbichot2-bin.000007` and `gbichot2-bin.000008` binary log files. Fetch the files if necessary from where they were backed up, and then process their contents like this:

```
shell> mysqlbinlog gbichot2-bin.000007 gbichot2-bin.000008 | mysql
```

We now have recovered the data to its state as of Tuesday 1 p.m., but still are missing the changes from that date to the date of the crash. To not lose them, we would have needed to have the MySQL server store its MySQL binary logs into a safe location (RAID disks, SAN, ...) different from the place where it stores its data files, so that these logs were not on the destroyed disk. (That is, we can start the server with a `--log-bin` option that specifies a location on a different physical device from the one on which the data directory resides. That way, the logs are safe even if the device containing the directory is lost.) If we had done this, we would have the `gbichot2-bin.000009` file (and any subsequent files) at hand, and we could apply them using `mysqlbinlog` and `mysql` to restore the most recent data changes with no loss up to the moment of the crash:

```
shell> mysqlbinlog gbichot2-bin.000009 ... | mysql
```

For more information about using `mysqlbinlog` to process binary log files, see Section 6.5, "Point-in-Time (Incremental) Recovery Using the Binary Log".

6.3.3. Backup Strategy Summary

In case of an operating system crash or power failure, `InnoDB` itself does all the job of recovering data. But to make sure that you can sleep well, observe the following guidelines:

- Always run the MySQL server with the `--log-bin` option, or even `--log-bin=log_name`, where the log file name is located on some safe media different from the drive on which the data directory is located. If you have such safe media, this technique can also be good for disk load balancing (which results in a performance improvement).
- Make periodic full backups, using the `mysqldump` command shown earlier in Section 6.3.1, "Establishing a Backup Policy", that makes an online, nonblocking backup.
- Make periodic incremental backups by flushing the logs with `FLUSH LOGS` or `mysqladmin flush-logs`.

6.4. Using `mysqldump` for Backups

This section describes how to use `mysqldump` to produce dump files, and how to reload dump files. A dump file can be used in several ways:

- As a backup to enable data recovery in case of data loss.
- As a source of data for setting up replication slaves.
- As a source of data for experimentation:
  - To make a copy of a database that you can use without changing the original data.
  - To test potential upgrade incompatibilities.

`mysqldump` produces two types of output, depending on whether the `--tab` option is given:

- Without `--tab`, `mysqldump` writes SQL statements to the standard output. This output consists of `CREATE` statements to create dumped objects (databases, tables, stored routines, and so forth), and `INSERT` statements to load data into tables. The output can be saved in a file and reloaded later using `mysql` to recreate the dumped objects. Options are available to modify the format of the SQL statements, and to control which objects are dumped.
- With `--tab`, `mysqldump` produces two output files for each dumped table. The server writes one file as tab-delimited text, one line per table row. This file is named `tbl_name.txt` in the output directory. The server also sends a `CREATE TABLE` statement for the table to `mysqldump`, which writes it as a file named `tbl_name.sql` in the output directory.

6.4.1. Dumping Data in SQL Format with `mysqldump`

This section describes how to use `mysqldump` to create SQL-format dump files. For information about reloading such dump files, see Section 6.4.2, "Reloading SQL-Format Backups".

By default, `mysqldump` writes information as SQL statements to the standard output. You can save the output in a file:

```
shell> mysqldump [arguments] > file_name
```

To dump all databases, invoke `mysqldump` with the `--all-databases` option:

```
shell> mysqldump --all-databases > dump.sql
```

To dump only specific databases, name them on the command line and use the `--databases` option:

```
shell> mysqldump --databases db1 db2 db3 > dump.sql
```

The `--databases` option causes all names on the command line to be treated as database names. Without this option, `mysqldump` treats the first name as a database name and those following as table names.

With `--all-databases` or `--databases`, `mysqldump` writes `CREATE DATABASE` and `USE` statements prior to the dump output for each database. This ensures that when the dump file is reloaded, it creates each database if it does not exist and makes it the default database so database contents are loaded into the same database from which they came. If you want to cause the dump file to force a drop of each database before recreating it, use the `--add-drop-database` option as well. In this case, `mysqldump` writes a `DROP DATABASE` statement preceding each `CREATE DATABASE` statement.

To dump a single database, name it on the command line:

```
shell> mysqldump --databases test > dump.sql
```

In the single-database case, it is permissible to omit the `--databases` option:

```
shell> mysqldump test > dump.sql
```

The difference between the two preceding commands is that without `--databases`, the dump output contains no `CREATE DATABASE` or `USE` statements. This has several implications:

- When you reload the dump file, you must specify a default database name so that the server knows which database to reload.
- For reloading, you can specify a database name different from the original name, which enables you to reload the data into a different database.
- If the database to be reloaded does not exist, you must create it first.
- Because the output will contain no `CREATE DATABASE` statement, the `--add-drop-database` option has no effect. If you use it, it produces no `DROP DATABASE` statement.

To dump only specific tables from a database, name them on the command line following the database name:

```
shell> mysqldump test t1 t3 t7 > dump.sql
```

6.4.2. Reloading SQL-Format Backups

To reload a dump file written by `mysqldump` that consists of SQL statements, use it as input to the `mysql` client. If the dump file was created by `mysqldump` with the `--all-databases` or `--databases` option, it contains `CREATE DATABASE` and `USE` statements and it is not necessary to specify a default database into which to load the data:

```
shell> mysql < dump.sql
```

Alternatively, from within `mysql`, use a `source` command:

```
mysql> source dump.sql
```

If the file is a single-database dump not containing `CREATE DATABASE` and `USE` statements, create the database first (if necessary):

```
shell> mysqladmin create db1
```

Then specify the database name when you load the dump file:

```
shell> mysql db1 < dump.sql
```

Alternatively, from within `mysql`, create the database, select it as the default database, and load the dump file:

```
mysql> CREATE DATABASE IF NOT EXISTS db1;
mysql> USE db1;
mysql> source dump.sql
```

6.4.3. Dumping Data in Delimited-Text Format with `mysqldump`

This section describes how to use `mysqldump` to create delimited-text dump files. For information about reloading such dump files, see Section 6.4.4, “Reloading Delimited-Text Format Backups”.

If you invoke `mysqldump` with the `--tab=dir_name` option, it uses `dir_name` as the output directory and dumps tables individually in that directory using two files for each table. The table name is the basename for these files. For a table named `t1`, the files are named `t1.sql` and `t1.txt`. The `.sql` file contains a `CREATE TABLE` statement for the table. The `.txt` file contains the table data, one line per table row.

The following command dumps the contents of the `db1` database to files in the `/tmp` database:

```
shell> mysqldump --tab=/tmp db1
```

The `.txt` files containing table data are written by the server, so they are owned by the system account used for running the server. The server uses `SELECT ... INTO OUTFILE` to write the files, so you must have the `FILE` privilege to perform this operation, and an error occurs if a given `.txt` file already exists.

The server sends the `CREATE` definitions for dumped tables to `mysqldump`, which writes them to `.sql` files. These files therefore are owned by the user who executes `mysqldump`.

It is best that `--tab` be used only for dumping a local server. If you use it with a remote server, the `--tab` directory must exist on both the local and remote hosts, and the `.txt` files will be written by the server in the remote directory (on the server host), whereas the `.sql` files will be written by `mysqldump` in the local directory (on the client host).

For `mysqldump --tab`, the server by default writes table data to `.txt` files one line per row with tabs between column values, no quotation marks around column values, and newline as the line terminator. (These are the same defaults as for `SELECT ... INTO OUTFILE`.)

To enable data files to be written using a different format, `mysqldump` supports these options:

- `--fields-terminated-by=str`

  The string for separating column values (default: tab).

- `--fields-enclosed-by=char`

  The character within which to enclose column values (default: no character).

- `--fields-optionally-enclosed-by=char`

  The character within which to enclose non-numeric column values (default: no character).

- `--fields-escaped-by=char`

  The character for escaping special characters (default: no escaping).

- `--lines-terminated-by=str`

  The line-termination string (default: newline).

Depending on the value you specify for any of these options, it might be necessary on the command line to quote or escape the value appropriately for your command interpreter. Alternatively, specify the value using hex notation. Suppose that you want `mysqldump` to quote column values within double quotation marks. To do so, specify double quote as the value for the `--fields-enclosed-by` option. But this character is often special to command interpreters and must be treated specially. For example, on Unix, you can quote the double quote like this:

```
--fields-enclosed-by='"'
```

On any platform, you can specify the value in hex:

```
--fields-enclosed-by=0x22
```

It is common to use several of the data-formatting options together. For example, to dump tables in comma-separated values format with lines terminated by carriage-return/newline pairs (`\r\n`), use this command (enter it on a single line):

```
shell> mysqldump --tab=/tmp --fields-terminated-by=,
         --fields-enclosed-by='"' --lines-terminated-by=0x0d0a db1
```

Should you use any of the data-formatting options to dump table data, you will need to specify the same format when you reload data files later, to ensure proper interpretation of the file contents.

6.4.4. Reloading Delimited-Text Format Backups

For backups produced with `mysqldump --tab`, each table is represented in the output directory by an `.sql` file containing the `CREATE TABLE` statement for the table, and a `.txt` file containing the table data. To reload a table, first change location into the output directory. Then process the `.sql` file with `mysql` to create an empty table and process the `.txt` file to load the data into the table:

```
shell> mysql db1 < t1.sql
shell> mysqlimport db1 t1.txt
```

An alternative to using `mysqlimport` to load the data file is to use the `LOAD DATA INFILE` statement from within the `mysql` client:

```
mysql> USE db1;
mysql> LOAD DATA INFILE 't1.txt' INTO TABLE t1;
```

If you used any data-formatting options with `mysqldump` when you initially dumped the table, you must use the same options with `mysqlimport` or `LOAD DATA INFILE` to ensure proper interpretation of the data file contents:

```
shell> mysqlimport --fields-terminated-by=,
         --fields-enclosed-by='"' --lines-terminated-by=0x0d0a db1 t1.txt
```

Or:

```
mysql> USE db1;
mysql> LOAD DATA INFILE 't1.txt' INTO TABLE t1
    -> FIELDS TERMINATED BY ',' FIELDS ENCLOSED BY '"'
    -> LINES TERMINATED BY '\r\n';
```

6.4.5. `mysqldump` Tips

This section surveys techniques that enable you to use `mysqldump` to solve specific problems:

- How to make a copy a database
- How to copy a database from one server to another
- How to dump stored programs (stored procedures and functions, triggers, and events)
- How to dump definitions and data separately

6.4.5.1. Making a Copy of a Database

```
shell> mysqldump db1 > dump.sql
shell> mysqladmin create db2
shell> mysql db2 < dump.sql
```

Do not use `--databases` on the `mysqldump` command line because that causes `USE db1` to be included in the dump file, which overrides the effect of naming `db2` on the `mysql` command line.

6.4.5.2. Copy a Database from one Server to Another

On Server 1:

```
shell> mysqldump --databases db1 > dump.sql
```

Copy the dump file from Server 1 to Server 2.

On Server 2:

```
shell> mysql < dump.sql
```

Use of `--databases` with the `mysqldump` command line causes the dump file to include `CREATE DATABASE` and `USE` statements that create the database if it does exist and make it the default database for the reloaded data.

Alternatively, you can omit `--databases` from the `mysqldump` command. Then you will need to create the database on Server 2 (if necessary) and specify it as the default database when you reload the dump file.

On Server 1:

```
shell> mysqldump db1 > dump.sql
```

On Server 2:

```
shell> mysqladmin create db1
shell> mysql db1 < dump.sql
```

You can specify a different database name in this case, so omitting `--databases` from the `mysqldump` command enables you to dump data from one database and load it into another.

6.4.5.3. Dumping Stored Programs

Several options control how `mysqldump` handles stored programs (stored procedures and functions, triggers, and events):

- `--events`: Dump Event Scheduler events
- `--routines`: Dump stored procedures and functions
- `--triggers`: Dump triggers for tables

The `--triggers` option is enabled by default so that when tables are dumped, they are accompanied by any triggers they have. The other options are disabled by default and must be specified explicitly to dump the corresponding objects. To disable any of these options explicitly, use its skip form: `--skip-events`, `--skip-routines`, or `--skip-triggers`.

6.4.5.4. Dumping Table Definitions and Content Separately

The `--no-data` option tells `mysqldump` not to dump table data, resulting in the dump file containing only statements to create the tables. Conversely, the `--no-create-info` option tells `mysqldump` to suppress `CREATE` statements from the output, so that the dump file contains only table data.

For example, to dump table definitions and data separately for the `test` database, use these commands:

```
shell> mysqldump --no-data test > dump-defs.sql
shell> mysqldump --no-create-info test > dump-data.sql
```

For a definition-only dump, add the `--routines` and `--events` options to also include stored routine and event definitions:

```
shell> mysqldump --no-data --routines --events test > dump-defs.sql
```

6.4.5.5. Using `mysqldump` to Test for Upgrade Incompatibilities

When contemplating a MySQL upgrade, it is prudent to install the newer version separately from your current production version. Then you can dump the database and database object definitions from the production server and load them into the new server to verify that they are handled properly. (This is also useful for testing downgrades.)

On the production server:

```
shell> mysqldump --all-databases --no-data --routines --events > dump-defs.sql
```

On the upgraded server:

```
shell> mysql < dump-defs.sql
```

Because the dump file does not contain table data, it can be processed quickly. This enables you to spot potential incompatibilities without waiting for lengthy data-loading operations. Look for warnings or errors while the dump file is being processed.

After you have verified that the definitions are handled properly, dump the data and try to load it into the upgraded server.

On the production server:

```
shell> mysqldump --all-databases --no-create-info > dump-data.sql
```

On the upgraded server:

```
shell> mysql < dump-data.sql
```

Now check the table contents and run some test queries.

6.5. Point-in-Time (Incremental) Recovery Using the Binary Log

Point-in-time recovery refers to recovery of data changes made since a given point in time. Typically, this type of recovery is performed after restoring a full backup that brings the server to its state as of the time the backup was made. (The full backup can be made in several ways, such as those listed in Section 6.2, “Database Backup Methods”.) Point-in-time recovery then brings the server up to date incrementally from the time of the full backup to a more recent time.

Point-in-time recovery is based on these principles:

- The source of information for point-in-time recovery is the set of incremental backups represented by the binary log files generated subsequent to the full backup operation. Therefore, the server must be started with the `--log-bin` option to enable binary logging (see Section 5.2.4, “The Binary Log”).

  To restore data from the binary log, you must know the name and location of the current binary log files. By default, the server creates binary log files in the data directory, but a path name can be specified with the `--log-bin` option to place the files in a different location. Section 5.2.4, “The Binary Log”.

  To see a listing of all binary log files, use this statement:

  ```
  mysql> SHOW BINARY LOGS;
  ```

  To determine the name of the current binary log file, issue the following statement:

  ```
  mysql> SHOW MASTER STATUS;
  ```

- The `mysqlbinlog` utility converts the events in the binary log files from binary format to text so that they can be executed or viewed. `mysqlbinlog` has options for selecting sections of the binary log based on event times or position of events within the log. See Section 4.6.7, “`mysqlbinlog` — Utility for Processing Binary Log Files”.

- Executing events from the binary log causes the data modifications they represent to be redone. This enables recovery of data changes for a given span of time. To execute events from the binary log, process `mysqlbinlog` output using the `mysql` client:

  ```
  shell> mysqlbinlog binlog_files | mysql -u root -p
  ```

- Viewing log contents can be useful when you need to determine event times or positions to select partial log contents prior to executing events. To view events from the log, send `mysqlbinlog` output into a paging program:

  ```
  shell> mysqlbinlog binlog_files | more
  ```

  Alternatively, save the output in a file and view the file in a text editor:

  ```
  shell> mysqlbinlog binlog_files > tmpfile
  shell> ... edit tmpfile ...
  ```

- Saving the output in a file is useful as a preliminary to executing the log contents with certain events removed, such as an accidental `DROP DATABASE`. You can delete from the file any statements not to be executed before executing its contents. After editing the file, execute the contents as follows:

  ```
  shell> mysql -u root -p < tmpfile
  ```

If you have more than one binary log to execute on the MySQL server, the safe method is to process them all using a single connection to the server. Here is an example that demonstrates what may be *unsafe*:

```
shell> mysqlbinlog binlog.000001 | mysql -u root -p # DANGER!!
shell> mysqlbinlog binlog.000002 | mysql -u root -p # DANGER!!
```

Processing binary logs this way using different connections to the server causes problems if the first log file contains a `CREATE TEMPORARY TABLE` statement and the second log contains a statement that uses the temporary table. When the first `mysql` process terminates, the server drops the temporary table. When the second `mysql` process attempts to use the table, the server reports "unknown table."

To avoid problems like this, use a *single* connection to execute the contents of all binary logs that you want to process. Here is one way to do so:

```
shell> mysqlbinlog binlog.000001 binlog.000002 | mysql -u root -p
```

Another approach is to write all the logs to a single file and then process the file:

```
shell> mysqlbinlog binlog.000001 >  /tmp/statements.sql
shell> mysqlbinlog binlog.000002 >> /tmp/statements.sql
shell> mysql -u root -p -e "source /tmp/statements.sql"
```

6.5.1. Point-in-Time Recovery Using Event Times

To indicate the start and end times for recovery, specify the `--start-datetime` and `--stop-datetime` options for `mysqlbinlog`, in `DATETIME` format. As an example, suppose that exactly at 10:00 a.m. on April 20, 2005 an SQL statement was executed that deleted a large table. To restore the table and data, you could restore the previous night's backup, and then execute the following command:

```
shell> mysqlbinlog --stop-datetime="2005-04-20 9:59:59" \
         /var/log/mysql/bin.123456 | mysql -u root -p
```

This command recovers all of the data up until the date and time given by the `--stop-datetime` option. If you did not detect the erroneous SQL statement that was entered until hours later, you will probably also want to recover the activity that occurred afterward. Based on this, you could run `mysqlbinlog` again with a start date and time, like so:

```
shell> mysqlbinlog --start-datetime="2005-04-20 10:01:00" \
         /var/log/mysql/bin.123456 | mysql -u root -p
```

In this command, the SQL statements logged from 10:01 a.m. on will be re-executed. The combination of restoring of the previous night's dump file and the two `mysqlbinlog` commands restores everything up until one second before 10:00 a.m. and everything from 10:01 a.m. on.

To use this method of point-in-time recovery, you should examine the log to be sure of the exact times to specify for the commands. To display the log file contents without executing them, use this command:

```
shell> mysqlbinlog /var/log/mysql/bin.123456 > /tmp/mysql_restore.sql
```

Then open the `/tmp/mysql_restore.sql` file with a text editor to examine it.

Excluding specific changes by specifying times for `mysqlbinlog` does not work well if multiple statements executed at the same time as the one to be excluded.

6.5.2. Point-in-Time Recovery Using Event Positions

Instead of specifying dates and times, the `--start-position` and `--stop-position` options for `mysqlbinlog` can be used for specifying log positions. They work the same as the start and stop date options, except that you specify log position numbers rather than dates. Using positions may enable you to be more precise about which part of the log to recover, especially if many transactions occurred around the same time as a damaging SQL statement. To determine the position numbers, run `mysqlbinlog` for a range of times near the time when the unwanted transaction was executed, but redirect the results to a text file for examination. This can be done like so:

```
shell> mysqlbinlog --start-datetime="2005-04-20 9:55:00" \
         --stop-datetime="2005-04-20 10:05:00" \
         /var/log/mysql/bin.123456 > /tmp/mysql_restore.sql
```

This command creates a small text file in the `/tmp` directory that contains the SQL statements around the time that the deleterious SQL statement was executed. Open this file with a text editor and look for the statement that you do not want to repeat. Determine the positions in the binary log for stopping and resuming the recovery and make note of them. Positions are labeled as `log_pos` followed by a number. After restoring the previous backup file, use the position numbers to process the binary log file. For example, you would use commands something like these:

```
shell> mysqlbinlog --stop-position=368312 /var/log/mysql/bin.123456 \
         | mysql -u root -p
```

```
shell> mysqlbinlog --start-position=368315 /var/log/mysql/bin.123456 \
         | mysql -u root -p
```

The first command recovers all the transactions up until the stop position given. The second command recovers all transactions from the starting position given until the end of the binary log. Because the output of `mysqlbinlog` includes `SET TIMESTAMP` statements before each SQL statement recorded, the recovered data and related MySQL logs will reflect the original times at which the transactions were executed.

6.6. `MyISAM` Table Maintenance and Crash Recovery

This section discusses how to use `myisamchk` to check or repair `MyISAM` tables (tables that have `.MYD` and `.MYI` files for storing data and indexes). For general `myisamchk` background, see Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”. Other table-repair information can be found at Section 2.11.4, “Rebuilding or Repairing Tables or Indexes”.

You can use `myisamchk` to check, repair, or optimize database tables. The following sections describe how to perform these operations and how to set up a table maintenance schedule. For information about using `myisamchk` to get information about your tables, see Section 4.6.3.5, “Obtaining Table Information with `myisamchk`”.

Even though table repair with `myisamchk` is quite secure, it is always a good idea to make a backup *before* doing a repair or any maintenance operation that could make a lot of changes to a table.

`myisamchk` operations that affect indexes can cause `FULLTEXT` indexes to be rebuilt with full-text parameters that are incompatible with the values used by the MySQL server. To avoid this problem, follow the guidelines in Section 4.6.3.1, “`myisamchk` General Options”.

`MyISAM` table maintenance can also be done using the SQL statements that perform operations similar to what `myisamchk` can do:

- To check `MyISAM` tables, use `CHECK TABLE`.
- To repair `MyISAM` tables, use `REPAIR TABLE`.
- To optimize `MyISAM` tables, use `OPTIMIZE TABLE`.
- To analyze `MyISAM` tables, use `ANALYZE TABLE`.

For additional information about these statements, see Section 12.4.2, “Table Maintenance Statements”.

These statements can be used directly or by means of the `mysqlcheck` client program. One advantage of these statements over `myisamchk` is that the server does all the work. With `myisamchk`, you must make sure that the server does not use the tables at the same time so that there is no unwanted interaction between `myisamchk` and the server.

6.6.1. Using `myisamchk` for Crash Recovery

This section describes how to check for and deal with data corruption in MySQL databases. If your tables become corrupted frequently, you should try to find the reason why. See Section C.5.4.2, “What to Do If MySQL Keeps Crashing”.

For an explanation of how `MyISAM` tables can become corrupted, see Section 13.5.4, “`MyISAM` Table Problems”.

If you run `mysqld` with external locking disabled (which is the default), you cannot reliably use `myisamchk` to check a table when `mysqld` is using the same table. If you can be certain that no one will access the tables through `mysqld` while you run `myisamchk`, you only have to execute `mysqladmin flush-tables` before you start checking the tables. If you cannot guarantee this, you must stop `mysqld` while you check the tables. If you run `myisamchk` to check tables that `mysqld` is updating at the same time, you may get a warning that a table is corrupt even when it is not.

If the server is run with external locking enabled, you can use `myisamchk` to check tables at any time. In this case, if the server tries to update a table that `myisamchk` is using, the server will wait for `myisamchk` to finish before it continues.

If you use `myisamchk` to repair or optimize tables, you *must* always ensure that the `mysqld` server is not using the table (this also applies if external locking is disabled). If you do not stop `mysqld`, you should at least do a `mysqladmin flush-tables` before you run `myisamchk`. Your tables *may become corrupted* if the server and `myisamchk` access the tables simultaneously.

When performing crash recovery, it is important to understand that each `MyISAM` table *`tbl_name`* in a database corresponds to the three files in the database directory shown in the following table.

File	**Purpose**
`tbl_name``.frm`	Definition (format) file

File	Purpose
`tbl_name.MYD`	Data file
`tbl_name.MYI`	Index file

Each of these three file types is subject to corruption in various ways, but problems occur most often in data files and index files.

`myisamchk` works by creating a copy of the `.MYD` data file row by row. It ends the repair stage by removing the old `.MYD` file and renaming the new file to the original file name. If you use `--quick`, `myisamchk` does not create a temporary `.MYD` file, but instead assumes that the `.MYD` file is correct and generates only a new index file without touching the `.MYD` file. This is safe, because `myisamchk` automatically detects whether the `.MYD` file is corrupt and aborts the repair if it is. You can also specify the `--quick` option twice to `myisamchk`. In this case, `myisamchk` does not abort on some errors (such as duplicate-key errors) but instead tries to resolve them by modifying the `.MYD` file. Normally the use of two `--quick` options is useful only if you have too little free disk space to perform a normal repair. In this case, you should at least make a backup of the table before running `myisamchk`.

6.6.2. How to Check `MyISAM` Tables for Errors

To check a `MyISAM` table, use the following commands:

- `myisamchk tbl_name`

  This finds 99.99% of all errors. What it cannot find is corruption that involves *only* the data file (which is very unusual). If you want to check a table, you should normally run `myisamchk` without options or with the `-s` (silent) option.

- `myisamchk -m tbl_name`

  This finds 99.999% of all errors. It first checks all index entries for errors and then reads through all rows. It calculates a checksum for all key values in the rows and verifies that the checksum matches the checksum for the keys in the index tree.

- `myisamchk -e tbl_name`

  This does a complete and thorough check of all data (`-e` means “extended check”). It does a check-read of every key for each row to verify that they indeed point to the correct row. This may take a long time for a large table that has many indexes. Normally, `myisamchk` stops after the first error it finds. If you want to obtain more information, you can add the `-v` (verbose) option. This causes `myisamchk` to keep going, up through a maximum of 20 errors.

- `myisamchk -e -i tbl_name`

  This is like the previous command, but the `-i` option tells `myisamchk` to print additional statistical information.

In most cases, a simple `myisamchk` command with no arguments other than the table name is sufficient to check a table.

6.6.3. How to Repair `MyISAM` Tables

The discussion in this section describes how to use `myisamchk` on `MyISAM` tables (extensions `.MYI` and `.MYD`).

You can also use the `CHECK TABLE` and `REPAIR TABLE` statements to check and repair `MyISAM` tables. See Section 12.4.2.2, “`CHECK TABLE` Syntax”, and Section 12.4.2.5, “`REPAIR TABLE` Syntax”.

Symptoms of corrupted tables include queries that abort unexpectedly and observable errors such as these:

- `tbl_name.frm` is locked against change
- Can't find file `tbl_name.MYI` (Errcode: `nnn`)
- Unexpected end of file
- Record file is crashed
- Got error `nnn` from table handler

To get more information about the error, run `perror nnn`, where `nnn` is the error number. The following example shows how to use `perror` to find the meanings for the most common error numbers that indicate a problem with a table:

```
shell> perror 126 127 132 134 135 136 141 144 145
```

```
MySQL error code 126 = Index file is crashed
MySQL error code 127 = Record-file is crashed
MySQL error code 132 = Old database file
MySQL error code 134 = Record was already deleted (or record file crashed)
MySQL error code 135 = No more room in record file
MySQL error code 136 = No more room in index file
MySQL error code 141 = Duplicate unique key or constraint on write or update
MySQL error code 144 = Table is crashed and last repair failed
MySQL error code 145 = Table was marked as crashed and should be repaired
```

Note that error 135 (no more room in record file) and error 136 (no more room in index file) are not errors that can be fixed by a simple repair. In this case, you must use `ALTER TABLE` to increase the `MAX_ROWS` and `AVG_ROW_LENGTH` table option values:

```
ALTER TABLE tbl_name MAX_ROWS=xxx AVG_ROW_LENGTH=yyy;
```

If you do not know the current table option values, use `SHOW CREATE TABLE`.

For the other errors, you must repair your tables. `myisamchk` can usually detect and fix most problems that occur.

The repair process involves up to four stages, described here. Before you begin, you should change location to the database directory and check the permissions of the table files. On Unix, make sure that they are readable by the user that `mysqld` runs as (and to you, because you need to access the files you are checking). If it turns out you need to modify files, they must also be writable by you.

This section is for the cases where a table check fails (such as those described in Section 6.6.2, “How to Check `MyISAM` Tables for Errors”), or you want to use the extended features that `myisamchk` provides.

The `myisamchk` options used for table maintenance with are described in Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”. `myisamchk` also has variables that you can set to control memory allocation that may improve performance. See Section 4.6.3.6, “`myisamchk` Memory Usage”.

If you are going to repair a table from the command line, you must first stop the `mysqld` server. Note that when you do `mysqladmin shutdown` on a remote server, the `mysqld` server is still available for a while after `mysqladmin` returns, until all statement-processing has stopped and all index changes have been flushed to disk.

Stage 1: Checking your tables

Run `myisamchk *.MYI` or `myisamchk -e *.MYI` if you have more time. Use the `-s` (silent) option to suppress unnecessary information.

If the `mysqld` server is stopped, you should use the `--update-state` option to tell `myisamchk` to mark the table as “checked.”

You have to repair only those tables for which `myisamchk` announces an error. For such tables, proceed to Stage 2.

If you get unexpected errors when checking (such as `out of memory` errors), or if `myisamchk` crashes, go to Stage 3.

Stage 2: Easy safe repair

First, try `myisamchk -r -q tbl_name` (`-r -q` means “quick recovery mode”). This attempts to repair the index file without touching the data file. If the data file contains everything that it should and the delete links point at the correct locations within the data file, this should work, and the table is fixed. Start repairing the next table. Otherwise, use the following procedure:

1. Make a backup of the data file before continuing.
2. Use `myisamchk -r tbl_name` (`-r` means “recovery mode”). This removes incorrect rows and deleted rows from the data file and reconstructs the index file.
3. If the preceding step fails, use `myisamchk --safe-recover tbl_name`. Safe recovery mode uses an old recovery method that handles a few cases that regular recovery mode does not (but is slower).

> **Note**
>
> If you want a repair operation to go much faster, you should set the values of the `sort_buffer_size` and `key_buffer_size` variables each to about 25% of your available memory when running `myisamchk`.

If you get unexpected errors when repairing (such as `out of memory` errors), or if `myisamchk` crashes, go to Stage 3.

Stage 3: Difficult repair

You should reach this stage only if the first 16KB block in the index file is destroyed or contains incorrect information, or if the index file is missing. In this case, it is necessary to create a new index file. Do so as follows:

1. Move the data file to a safe place.
2. Use the table description file to create new (empty) data and index files:

   ```
   shell> mysql db_name
   mysql> SET autocommit=1;
   mysql> TRUNCATE TABLE tbl_name;
   mysql> quit
   ```

3. Copy the old data file back onto the newly created data file. (Do not just move the old file back onto the new file. You want to retain a copy in case something goes wrong.)

> **Important**
>
> If you are using replication, you should stop it prior to performing the above procedure, since it involves file system operations, and these are not logged by MySQL.

Go back to Stage 2. `myisamchk -r -q` should work. (This should not be an endless loop.)

You can also use the `REPAIR TABLE tbl_name USE_FRM` SQL statement, which performs the whole procedure automatically. There is also no possibility of unwanted interaction between a utility and the server, because the server does all the work when you use `REPAIR TABLE`. See Section 12.4.2.5, “`REPAIR TABLE` Syntax”.

Stage 4: Very difficult repair

You should reach this stage only if the `.frm` description file has also crashed. That should never happen, because the description file is not changed after the table is created:

1. Restore the description file from a backup and go back to Stage 3. You can also restore the index file and go back to Stage 2. In the latter case, you should start with `myisamchk -r`.
2. If you do not have a backup but know exactly how the table was created, create a copy of the table in another database. Remove the new data file, and then move the `.frm` description and `.MYI` index files from the other database to your crashed database. This gives you new description and index files, but leaves the `.MYD` data file alone. Go back to Stage 2 and attempt to reconstruct the index file.

6.6.4. `MyISAM` Table Optimization

To coalesce fragmented rows and eliminate wasted space that results from deleting or updating rows, run `myisamchk` in recovery mode:

```
shell> myisamchk -r tbl_name
```

You can optimize a table in the same way by using the `OPTIMIZE TABLE` SQL statement. `OPTIMIZE TABLE` does a table repair and a key analysis, and also sorts the index tree so that key lookups are faster. There is also no possibility of unwanted interaction between a utility and the server, because the server does all the work when you use `OPTIMIZE TABLE`. See Section 12.4.2.4, “`OPTIMIZE TABLE` Syntax”.

`myisamchk` has a number of other options that you can use to improve the performance of a table:

- `--analyze` or `-a`: Perform key distribution analysis. This improves join performance by enabling the join optimizer to better choose the order in which to join the tables and which indexes it should use.
- `--sort-index` or `-S`: Sort the index blocks. This optimizes seeks and makes table scans that use indexes faster.
- `--sort-records=index_num` or `-R index_num`: Sort data rows according to a given index. This makes your data much more localized and may speed up range-based `SELECT` and `ORDER BY` operations that use this index.

For a full description of all available options, see Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”.

6.6.5. Setting Up a `MyISAM` Table Maintenance Schedule

It is a good idea to perform table checks on a regular basis rather than waiting for problems to occur. One way to check and repair `MyISAM` tables is with the `CHECK TABLE` and `REPAIR TABLE` statements. See Section 12.4.2, “Table Maintenance Statements”.

Another way to check tables is to use `myisamchk`. For maintenance purposes, you can use `myisamchk -s`. The `-s` option (short for `--silent`) causes `myisamchk` to run in silent mode, printing messages only when errors occur.

It is also a good idea to enable automatic `MyISAM` table checking. For example, whenever the machine has done a restart in the middle of an update, you usually need to check each table that could have been affected before it is used further. (These are “expected crashed tables.”) To cause the server to check `MyISAM` tables automatically, start it with the `--myisam-recover-options` option. See Section 5.1.2, “Server Command Options”.

You should also check your tables regularly during normal system operation. For example, you can run a `cron` job to check important tables once a week, using a line like this in a `crontab` file:

```
35 0 * * 0 /path/to/myisamchk --fast --silent /path/to/datadir/*/*.MYI
```

This prints out information about crashed tables so that you can examine and repair them as necessary.

To start with, execute `myisamchk -s` each night on all tables that have been updated during the last 24 hours. As you see that problems occur infrequently, you can back off the checking frequency to once a week or so.

Normally, MySQL tables need little maintenance. If you are performing many updates to `MyISAM` tables with dynamic-sized rows (tables with `VARCHAR`, `BLOB`, or `TEXT` columns) or have tables with many deleted rows you may want to defragment/reclaim space from the tables from time to time. You can do this by using `OPTIMIZE TABLE` on the tables in question. Alternatively, if you can stop the `mysqld` server for a while, change location into the data directory and use this command while the server is stopped:

```
shell> myisamchk -r -s --sort-index --sort_buffer_size=16M */*.MYI
```

Chapter 7. Optimization

This chapter explains how to optimize MySQL performance and provides examples. Optimization involves configuring, tuning, and measuring performance, at several levels. Depending on your job role (developer, DBA, or a combination of both), you might optimize at the level of individual SQL statements, entire applications, a single database server, or multiple networked database servers. Sometimes you can be proactive and plan in advance for performance, while other times you might troubleshoot a configuration or code issue after a problem occurs. Optimizing CPU and memory usage can also improve scalability, allowing the database to handle more load without slowing down.

7.1. Optimization Overview

Database performance depends on several factors at the database level, such as tables, queries, and configuration settings. These software constructs result in CPU and I/O operations at the hardware level, which you must minimize and make as efficient as possible. As you work on database performance, you start by learning the high-level rules and guidelines for the software side, and measuring performance using wall-clock time. As you become an expert, you learn more about what happens internally, and start measuring things such as CPU cycles and I/O operations.

Typical users aim to get the best database performance out of their existing software and hardware configurations. Advanced users look for opportunities to improve the MySQL software itself, or develop their own storage engines and hardware appliances to expand the MySQL ecosystem.

Optimizing at the Database Level

The most important factor in making a database application fast is its basic design:

- Are the tables structured properly? In particular, do the columns have the right data types, and does each table have the appropriate columns for the type of work? For example, applications that perform frequent updates often have many tables with few columns, while applications that analyze large amounts of data often have few tables with many columns.
- Are the right indexes in place to make queries efficient?
- Are you using the appropriate storage engine for each table, and taking advantage of the strengths and features of each storage engine you use? In particular, the choice of a transactional storage engine such as `InnoDB` or a non-transactional one such as `MyISAM` can be very important for performance and scalability.

  > **Note**
  >
  > In MySQL 5.5 and higher, `InnoDB` is the default storage engine for new tables. In practice, the advanced `InnoDB` performance features mean that `InnoDB` tables often outperform the simpler `MyISAM` tables, especially for a busy database.

- Does each table use an appropriate row format? This choice also depends on the storage engine used for the table. In particular, compressed tables use less disk space and so require less disk I/O to read and write the data. Compression is available in the `InnoDB` storage engine, and for read-only tables in the `MyISAM` storage engine.
- Does the application use an appropriate locking strategy? For example, by allowing shared access when possible so that database operations can run concurrently, and requesting exclusive access when appropriate so that critical operations get top priority. Again, the choice of storage engine is significant. The `InnoDB` storage engine handles most locking issues without involvement from you, allowing for better concurrency in the database and reducing the amount of experimentation and tuning for your code.
- Are all memory areas used for caching sized correctly? That is, large enough to hold frequently accessed data, but not so large that they overload physical memory and cause paging. The main memory areas to configure are the `InnoDB` buffer pool, the `MyISAM` key cache, and the MySQL query cache.

Optimizing at the Hardware Level

Any database application eventually hits hardware limits as the database becomes more and more busy. A DBA must evaluate whether it is possible to tune the application or reconfigure the server to avoid these bottlenecks, or whether more hardware resources are required. System bottlenecks typically arise from these sources:

- Disk seeks. It takes time for the disk to find a piece of data. With modern disks, the mean time for this is usually lower than 10ms, so we can in theory do about 100 seeks a second. This time improves slowly with new disks and is very hard to optimize for a single table. The way to optimize seek time is to distribute the data onto more than one disk.

- Disk reading and writing. When the disk is at the correct position, we need to read or write the data. With modern disks, one disk delivers at least 10–20MB/s throughput. This is easier to optimize than seeks because you can read in parallel from multiple disks.
- CPU cycles. When the data is in main memory, we must process it to get our result. Having small tables compared to the amount of memory is the most common limiting factor. But with small tables, speed is usually not the problem.
- Memory bandwidth. When the CPU needs more data than can fit in the CPU cache, main memory bandwidth becomes a bottleneck. This is an uncommon bottleneck for most systems, but one to be aware of.

Balancing Portability and Performance

To use performance-oriented SQL extensions in a portable MySQL program, you can wrap MySQL-specific keywords in a statement within `/*! */` comment delimiters. Other SQL servers ignore the commented keywords. For information about writing comments, see Section 8.6, “Comment Syntax”.

7.2. Optimizing SQL Statements

The core logic of a database application is performed through SQL statements, whether issued directly through an interpreter or submitted behind the scenes through an API. The tuning guidelines in this section help to speed up all kinds of MySQL applications. The guidelines cover SQL operations that read and write data, the behind-the-scenes overhead for SQL operations in general, and operations used in specific scenarios such as database monitoring.

7.2.1. Optimizing `SELECT` Statements

Queries, in the form of `SELECT` statements, perform all the lookup operations in the database. Tuning these statements is a top priority, whether to achieve sub-second response times for dynamic web pages, or to chop hours off the time to generate huge overnight reports.

Besides `SELECT` statements, the tuning techniques for queries also apply to constructs such as `CREATE TABLE...AS SELECT`, `INSERT INTO...SELECT`, and `WHERE` clauses in `DELETE` statements. Those statements have additional performance considerations because they combine write operations with the read-oriented query operations.

The main considerations for optimizing queries are:

- Set up indexes on columns used in the `WHERE` clause, to speed up evaluation, filtering, and the final retrieval of results. To avoid wasted disk space, construct a small set of indexes that speed up many related queries used in your application.
- Minimize the number of table scans in your queries, particularly for big tables.
- Keep table statistics up to date, so the optimizer has the information needed to construct an efficient execution plan.
- Learn the tuning techniques, indexing techniques, and configuration parameters that are specific to the storage engine for each table. Both `InnoDB` and `InnoDB` have a set of guidelines to enable and sustain high performance in queries.
- Isolate and tune any part of the query, such as a function call, that takes excessive time. Remember that such a function might get called millions of times for a big query or insert operation.
- Avoid transforming the query in ways that make it hard to understand, especially if the optimizer does some of the same transformations automatically.
- If a performance issue is not easily solved by one of the basic guidelines, investigate the internal details of the specific query by reading the `EXPLAIN` plan and adjusting your indexes, `WHERE` clauses, join clauses, and so on. (When you reach a certain level of expertise, reading the `EXPLAIN` plan might be your first step for every query.)
- Adjust the size and properties of the memory areas that MySQL uses for caching. With efficient use of the `InnoDB` buffer pool, `MyISAM` key cache, and the MySQL query cache, repeated queries run faster because the results are retrieved from memory the second and subsequent times.
- Even for a query that runs fast using the cache memory areas, you might still optimize further so that they require less cache memory, making your application more scalable. Scalability means that your application can handle more simultaneous users, larger requests, and so on without experiencing a big drop in performance.
- Deal with locking issues, where the speed of your query might be affected by other sessions accessing the tables at the same time.

7.2.1.1. Speed of `SELECT` Statements

In general, when you want to make a slow `SELECT ... WHERE` query faster, the first thing to check is whether you can add an index. Indexes are especially important for queries that reference different tables, using features such as joins and foreign keys. You can use the `EXPLAIN` statement to determine which indexes are used for a `SELECT`. See Section 7.8.1, “Optimizing Queries with `EXPLAIN`”, and Section 7.3.1, “How MySQL Uses Indexes”.

7.2.1.2. How MySQL Optimizes `WHERE` Clauses

This section discusses optimizations that can be made for processing `WHERE` clauses. The examples use `SELECT` statements, but the same optimizations apply for `WHERE` clauses in `DELETE` and `UPDATE` statements.

Some examples of queries that are very fast:

```
SELECT COUNT(*) FROM tbl_name;

SELECT MIN(key_part1),MAX(key_part1) FROM tbl_name;

SELECT MAX(key_part2) FROM tbl_name
  WHERE key_part1=constant;

SELECT ... FROM tbl_name
  ORDER BY key_part1,key_part2,... LIMIT 10;

SELECT ... FROM tbl_name
  ORDER BY key_part1 DESC, key_part2 DESC, ... LIMIT 10;
```

MySQL resolves the following queries using only the entries from a secondary index, if the indexed columns are numeric:

```
SELECT key_part1,key_part2 FROM tbl_name WHERE key_part1=val;

SELECT COUNT(*) FROM tbl_name
  WHERE key_part1=val1 AND key_part2=val2;

SELECT key_part2 FROM tbl_name GROUP BY key_part1;
```

The following queries use the index data to retrieve the rows in sorted order without a separate sorting pass:

```
SELECT ... FROM tbl_name
  ORDER BY key_part1,key_part2,... ;

SELECT ... FROM tbl_name
  ORDER BY key_part1 DESC, key_part2 DESC, ... ;
```

You might be tempted to rewrite your queries to make arithmetic operations faster, while sacrificing readability. Because MySQL does similar optimizations automatically, you can often avoid this work, and leave the query in a more understandable and maintainable form. Some of the optimizations performed by MySQL follow:

> **Note**
>
> Because work on the MySQL optimizer is ongoing, not all of the optimizations that MySQL performs are documented here.

- Removal of unnecessary parentheses:

  ```
     ((a AND b) AND c OR (((a AND b) AND (c AND d))))
  -> (a AND b AND c) OR (a AND b AND c AND d)
  ```

- Constant folding:

  ```
     (a<b AND b=c) AND a=5
  -> b>5 AND b=c AND a=5
  ```

- Constant condition removal (needed because of constant folding):

  ```
     (B>=5 AND B=5) OR (B=6 AND 5=5) OR (B=7 AND 5=6)
  -> B=5 OR B=6
  ```

- Constant expressions used by indexes are evaluated only once.
- `COUNT(*)` on a single table without a `WHERE` is retrieved directly from the table information for `MyISAM` and `MEMORY` tables. This is also done for any `NOT NULL` expression when used with only one table.

- Early detection of invalid constant expressions. MySQL quickly detects that some `SELECT` statements are impossible and returns no rows.
- `HAVING` is merged with `WHERE` if you do not use `GROUP BY` or aggregate functions (`COUNT()`, `MIN()`, and so on).
- For each table in a join, a simpler `WHERE` is constructed to get a fast `WHERE` evaluation for the table and also to skip rows as soon as possible.
- All constant tables are read first before any other tables in the query. A constant table is any of the following:
    - An empty table or a table with one row.
    - A table that is used with a `WHERE` clause on a `PRIMARY KEY` or a `UNIQUE` index, where all index parts are compared to constant expressions and are defined as `NOT NULL`.

  All of the following tables are used as constant tables:

```
SELECT * FROM t WHERE primary_key=1;
SELECT * FROM t1,t2
  WHERE t1.primary_key=1 AND t2.primary_key=t1.id;
```

- The best join combination for joining the tables is found by trying all possibilities. If all columns in `ORDER BY` and `GROUP BY` clauses come from the same table, that table is preferred first when joining.
- If there is an `ORDER BY` clause and a different `GROUP BY` clause, or if the `ORDER BY` or `GROUP BY` contains columns from tables other than the first table in the join queue, a temporary table is created.
- If you use the `SQL_SMALL_RESULT` option, MySQL uses an in-memory temporary table.
- Each table index is queried, and the best index is used unless the optimizer believes that it is more efficient to use a table scan. At one time, a scan was used based on whether the best index spanned more than 30% of the table, but a fixed percentage no longer determines the choice between using an index or a scan. The optimizer now is more complex and bases its estimate on additional factors such as table size, number of rows, and I/O block size.
- MySQL can sometimes produce query results using data from the index, without consulting the table data. If all columns used from the index are numeric, only the index data is used to resolve the query.
- Before each row is output, those that do not match the `HAVING` clause are skipped.

7.2.1.3. Optimizing `LIMIT` Queries

If you need only a specified number of rows from a result set, use a `LIMIT` clause in the query, rather than fetching the whole result set and throwing away the extra data.

MySQL sometimes optimizes a query that has a `LIMIT` *`row_count`* clause and no `HAVING` clause:

- If you select only a few rows with `LIMIT`, MySQL uses indexes in some cases when normally it would prefer to do a full table scan.
- If you use `LIMIT` *`row_count`* with `ORDER BY`, MySQL ends the sorting as soon as it has found the first *`row_count`* rows of the sorted result, rather than sorting the entire result. If ordering is done by using an index, this is very fast. If a filesort must be done, all rows that match the query without the `LIMIT` clause are selected, and most or all of them are sorted, before the first *`row_count`* are found. After the initial rows have been found, MySQL does not sort any remainder of the result set.
- When combining `LIMIT` *`row_count`* with `DISTINCT`, MySQL stops as soon as it finds *`row_count`* unique rows.
- In some cases, a `GROUP BY` can be resolved by reading the key in order (or doing a sort on the key) and then calculating summaries until the key value changes. In this case, `LIMIT` *`row_count`* does not calculate any unnecessary `GROUP BY` values.
- As soon as MySQL has sent the required number of rows to the client, it aborts the query unless you are using `SQL_CALC_FOUND_ROWS`.
- `LIMIT 0` quickly returns an empty set. This can be useful for checking the validity of a query. When using one of the MySQL APIs, it can also be employed for obtaining the types of the result columns. (This trick does not work in the MySQL Monitor (the `mysql` program), which merely displays `Empty set` in such cases; instead, use `SHOW COLUMNS` or `DESCRIBE` for this purpose.)
- When the server uses temporary tables to resolve the query, it uses the `LIMIT` *`row_count`* clause to calculate how much space is required.

7.2.1.4. How to Avoid Table Scans

Frequently, a table scan is a danger sign that a query can be speeded up significantly. For tables with more than a few rows, consider redesigning the query by adding an index for one or more of the columns tested in the `WHERE` clause. Put extra effort into avoiding table scans for queries that perform joins or reference foreign keys. If the nature of the data means there is no way to avoid reading all the rows, then it might not be practical to make the query faster, or making it faster might involve extensive restructuring of your tables that is beyond the scope of this section.

The output from `EXPLAIN` shows `ALL` in the `type` column when MySQL uses a table scan to resolve a query. This usually happens under the following conditions:

- The `ON` or `WHERE` clauses do not reference any indexed columns that the query can use. Consider adding an index, or refining those clauses to refer to an indexed column.
- The table is so small that it is faster to perform a table scan than to bother with a key lookup. This is common for tables with fewer than 10 rows and a short row length. Don't worry in this case.
- You are comparing indexed columns with constant values and MySQL has calculated (based on the index tree) that the constants cover too large a part of the table and that a table scan would be faster. See Section 7.2.1.2, "How MySQL Optimizes `WHERE` Clauses". For example, to query census data only for males or only for females, MySQL must read most of the data blocks in the table, so locating the rows through the index would add unnecessary overhead. Don't worry if you encounter this condition for occasional big reports. If these reports are frequent or truly time-critical, and the table is huge, you might partition, shard, or create dimension tables using the relevant column.
- You are using a key with low cardinality (many rows match the key value) through another column. In this case, MySQL assumes that by using the key it probably will do many key lookups and that a table scan would be faster.

For small tables, a table scan often is appropriate and the performance impact is negligible. For large tables, try the following techniques to avoid having the optimizer incorrectly choose a table scan:

- Minimize the `OR` keywords in your `WHERE` clauses. If there is no index that helps to locate the values on *both* sides of the `OR`, any row could potentially be part of the result set, so all rows must be tested, and that requires a full table scan. If you have one index that helps to optimize one side of an `OR` query, and a different index that helps to optimize the other side, use a `UNION` operator to run separate fast queries and merge the results afterward.
- With tables that use the `MEMORY` storage engine, if you run queries that examine ranges of values (using operators such as `>`, `<=`, or `BETWEEN` on the indexed columns), create the index with the `USING BTREE` clause. The default (`USING HASH`) is fast for retrieving individual rows with an equality operator (`=` or `<=>`), but is much slower (requiring a full table scan) to examine a range of column values. A `MEMORY` table created with the `USING BTREE` clause is still fast for equality comparisons, so use that clause for your `MEMORY` tables that handle a variety of queries.
- Use `ANALYZE TABLE tbl_name` to update the key distributions for the scanned table. See Section 12.4.2.1, "`ANALYZE TABLE` Syntax".
- Use `FORCE INDEX` for the scanned table to tell MySQL that table scans are very expensive compared to using the given index:

  ```
  SELECT * FROM t1, t2 FORCE INDEX (index_for_column)
    WHERE t1.col_name=t2.col_name;
  ```

  See Section 12.2.9.2, "Index Hint Syntax".
- Start `mysqld` with the `--max-seeks-for-key=1000` option or use `SET max_seeks_for_key=1000` to tell the optimizer to assume that no key scan causes more than 1,000 key seeks. See Section 5.1.3, "Server System Variables".

7.2.2. Optimizing DML Statements

This section explains how to speed up the data manipulation language (DML) statements, `INSERT`, `UPDATE`, and `DELETE`. Traditional OLTP applications and modern web applications typically do many small DML operations, where concurrency is vital. Data analysis and reporting applications typically run DML operations that affect many rows at once, where the main considerations is the I/O to write large amounts of data and keep indexes up-to-date. For inserting and updating large volumes of data (known in the industry as ETL, for "extract-transform-load"), sometimes you use other SQL statements or external commands, that mimic the effects of `INSERT`, `UPDATE`, and `DELETE` statements.

7.2.2.1. Speed of `INSERT` Statements

To optimize insert speed, combine many small operations into a single large operation. Ideally, you make a single connection, send the data for many new rows at once, and delay all index updates and consistency checking until the very end.

The time required for inserting a row is determined by the following factors, where the numbers indicate approximate proportions:

- Connecting: (3)
- Sending query to server: (2)
- Parsing query: (2)
- Inserting row: (1 × size of row)
- Inserting indexes: (1 × number of indexes)
- Closing: (1)

This does not take into consideration the initial overhead to open tables, which is done once for each concurrently running query.

The size of the table slows down the insertion of indexes by log *`N`*, assuming B-tree indexes.

You can use the following methods to speed up inserts:

- If you are inserting many rows from the same client at the same time, use `INSERT` statements with multiple `VALUES` lists to insert several rows at a time. This is considerably faster (many times faster in some cases) than using separate single-row `INSERT` statements. If you are adding data to a nonempty table, you can tune the `bulk_insert_buffer_size` variable to make data insertion even faster. See Section 5.1.3, “Server System Variables”.
- When loading a table from a text file, use `LOAD DATA INFILE`. This is usually 20 times faster than using `INSERT` statements. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”.
- Take advantage of the fact that columns have default values. Insert values explicitly only when the value to be inserted differs from the default. This reduces the parsing that MySQL must do and improves the insert speed.
- See Section 7.5.4, “Bulk Data Loading for `InnoDB` Tables” for tips specific to `InnoDB` tables.
- See Section 7.6.2, “Bulk Data Loading for `MyISAM` Tables” for tips specific to `MyISAM` tables.

7.2.2.2. Speed of `UPDATE` Statements

An update statement is optimized like a `SELECT` query with the additional overhead of a write. The speed of the write depends on the amount of data being updated and the number of indexes that are updated. Indexes that are not changed do not get updated.

Another way to get fast updates is to delay updates and then do many updates in a row later. Performing multiple updates together is much quicker than doing one at a time if you lock the table.

For a `MyISAM` table that uses dynamic row format, updating a row to a longer total length may split the row. If you do this often, it is very important to use `OPTIMIZE TABLE` occasionally. See Section 12.4.2.4, “`OPTIMIZE TABLE` Syntax”.

7.2.2.3. Speed of `DELETE` Statements

The time required to delete individual rows in a `MyISAM` table is exactly proportional to the number of indexes. To delete rows more quickly, you can increase the size of the key cache by increasing the `key_buffer_size` system variable. See Section 7.11.2, “Tuning Server Parameters”.

To delete all rows from a `MyISAM` table, `TRUNCATE TABLE` *`tbl_name`* is faster than than `DELETE FROM` *`tbl_name`*. Truncate operations are not transaction-safe; an error occurs when attempting one in the course of an active transaction or active table lock. See Section 12.1.27, “`TRUNCATE TABLE` Syntax”.

7.2.3. Optimizing Database Privileges

The more complex your privilege setup, the more overhead applies to all SQL statements. Simplifying the privileges established by `GRANT` statements enables MySQL to reduce permission-checking overhead when clients execute statements. For example, if you do not grant any table-level or column-level privileges, the server need not ever check the contents of the `tables_priv` and `columns_priv` tables. Similarly, if you place no resource limits on any accounts, the server does not have to perform resource counting. If you have a very high statement-processing load, consider using a simplified grant structure to reduce permission-checking overhead.

7.2.4. Optimizing `INFORMATION_SCHEMA` Queries

Applications that monitor the database can make frequent use of the `INFORMATION_SCHEMA` tables. Certain types of queries for `INFORMATION_SCHEMA` tables can be optimized to execute more quickly. The goal is to minimize file operations (for example, scanning a directory or opening a table file) to collect the information that makes up these dynamic tables. These optimizations do have an effect on how collations are used for searches in `INFORMATION_SCHEMA` tables. For more information, see Section 9.1.7.9, “Collation and `INFORMATION_SCHEMA` Searches”.

1) Try to use constant lookup values for database and table names in the `WHERE` clause

You can take advantage of this principle as follows:

- To look up databases or tables, use expressions that evaluate to a constant, such as literal values, functions that return a constant, or scalar subqueries.
- Avoid queries that use a nonconstant database name lookup value (or no lookup value) because they require a scan of the data directory to find matching database directory names.
- Within a database, avoid queries that use a nonconstant table name lookup value (or no lookup value) because they require a scan of the database directory to find matching table files.

This principle applies to the `INFORMATION_SCHEMA` tables shown in the following table, which shows the columns for which a constant lookup value enables the server to avoid a directory scan. For example, if you are selecting from `TABLES`, using a constant lookup value for `TABLE_SCHEMA` in the `WHERE` clause enables a data directory scan to be avoided.

Table	Column to specify to avoid data directory scan	Column to specify to avoid database directory scan
`COLUMNS`	`TABLE_SCHEMA`	`TABLE_NAME`
`KEY_COLUMN_USAGE`	`TABLE_SCHEMA`	`TABLE_NAME`
`PARTITIONS`	`TABLE_SCHEMA`	`TABLE_NAME`
`REFERENTIAL_CONSTRAINTS`	`CONSTRAINT_SCHEMA`	`TABLE_NAME`
`STATISTICS`	`TABLE_SCHEMA`	`TABLE_NAME`
`TABLES`	`TABLE_SCHEMA`	`TABLE_NAME`
`TABLE_CONSTRAINTS`	`TABLE_SCHEMA`	`TABLE_NAME`
`TRIGGERS`	`EVENT_OBJECT_SCHEMA`	`EVENT_OBJECT_TABLE`
`VIEWS`	`TABLE_SCHEMA`	`TABLE_NAME`

The benefit of a query that is limited to a specific constant database name is that checks need be made only for the named database directory. Example:

```
SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
WHERE TABLE_SCHEMA = 'test';
```

Use of the literal database name `test` enables the server to check only the `test` database directory, regardless of how many databases there might be. By contrast, the following query is less efficient because it requires a scan of the data directory to determine which database names match the pattern `'test%'`:

```
SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
WHERE TABLE_SCHEMA LIKE 'test%';
```

For a query that is limited to a specific constant table name, checks need be made only for the named table within the corresponding database directory. Example:

```
SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
WHERE TABLE_SCHEMA = 'test' AND TABLE_NAME = 't1';
```

Use of the literal table name `t1` enables the server to check only the files for the `t1` table, regardless of how many tables there might be in the `test` database. By contrast, the following query requires a scan of the `test` database directory to determine which table names match the pattern `'t%'`:

```
SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
WHERE TABLE_SCHEMA = 'test' AND TABLE_NAME LIKE 't%';
```

The following query requires a scan of the database directory to determine matching database names for the pattern `'test%'`, and for each matching database, it requires a scan of the database directory to determine matching table names for the pattern `'t%'`:

```
SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
WHERE TABLE_SCHEMA = 'test%' AND TABLE_NAME LIKE 't%';
```

2) Write queries that minimize the number of table files that must be opened

For queries that refer to certain `INFORMATION_SCHEMA` table columns, several optimizations are available that minimize the number of table files that must be opened. Example:

```
SELECT TABLE_NAME, ENGINE FROM INFORMATION_SCHEMA.TABLES
WHERE TABLE_SCHEMA = 'test';
```

In this case, after the server has scanned the database directory to determine the names of the tables in the database, those names become available with no further file system lookups. Thus, `TABLE_NAME` requires no files to be opened. The `ENGINE` (storage engine) value can be determined by opening the table's `.frm` file, without touching other table files such as the `.MYD` or `.MYI` file.

Some values, such as `INDEX_LENGTH` for `MyISAM` tables, require opening the `.MYD` or `.MYI` file as well.

The file-opening optimization types are denoted thus:

- `SKIP_OPEN_TABLE`: Table files do not need to be opened. The information has already become available within the query by scanning the database directory.
- `OPEN_FRM_ONLY`: Only the table's `.frm` file need be opened.
- `OPEN_TRIGGER_ONLY`: Only the table's `.TRG` file need be opened.
- `OPEN_FULL_TABLE`: The unoptimized information lookup. The `.frm`, `.MYD`, and `.MYI` files must be opened.

The following list indicates how the preceding optimization types apply to `INFORMATION_SCHEMA` table columns. For tables and columns not named, none of the optimizations apply.

- `COLUMNS`: `OPEN_FRM_ONLY` applies to all columns
- `KEY_COLUMN_USAGE`: `OPEN_FULL_TABLE` applies to all columns
- `PARTITIONS`: `OPEN_FULL_TABLE` applies to all columns
- `REFERENTIAL_CONSTRAINTS`: `OPEN_FULL_TABLE` applies to all columns
- `STATISTICS`:

Column	**Optimization type**
`TABLE_CATALOG`	`OPEN_FRM_ONLY`
`TABLE_SCHEMA`	`OPEN_FRM_ONLY`
`TABLE_NAME`	`OPEN_FRM_ONLY`
`NON_UNIQUE`	`OPEN_FRM_ONLY`
`INDEX_SCHEMA`	`OPEN_FRM_ONLY`
`INDEX_NAME`	`OPEN_FRM_ONLY`
`SEQ_IN_INDEX`	`OPEN_FRM_ONLY`
`COLUMN_NAME`	`OPEN_FRM_ONLY`
`COLLATION`	`OPEN_FRM_ONLY`
`CARDINALITY`	`OPEN_FULL_TABLE`
`SUB_PART`	`OPEN_FRM_ONLY`
`PACKED`	`OPEN_FRM_ONLY`
`NULLABLE`	`OPEN_FRM_ONLY`
`INDEX_TYPE`	`OPEN_FULL_TABLE`

Column	Optimization type
`COMMENT`	`OPEN_FRM_ONLY`

- `TABLES`:

Column	Optimization type
`TABLE_CATALOG`	`SKIP_OPEN_TABLE`
`TABLE_SCHEMA`	`SKIP_OPEN_TABLE`
`TABLE_NAME`	`SKIP_OPEN_TABLE`
`TABLE_TYPE`	`OPEN_FRM_ONLY`
`ENGINE`	`OPEN_FRM_ONLY`
`VERSION`	`OPEN_FRM_ONLY`
`ROW_FORMAT`	`OPEN_FULL_TABLE`
`TABLE_ROWS`	`OPEN_FULL_TABLE`
`AVG_ROW_LENGTH`	`OPEN_FULL_TABLE`
`DATA_LENGTH`	`OPEN_FULL_TABLE`
`MAX_DATA_LENGTH`	`OPEN_FULL_TABLE`
`INDEX_LENGTH`	`OPEN_FULL_TABLE`
`DATA_FREE`	`OPEN_FULL_TABLE`
`AUTO_INCREMENT`	`OPEN_FULL_TABLE`
`CREATE_TIME`	`OPEN_FULL_TABLE`
`UPDATE_TIME`	`OPEN_FULL_TABLE`
`CHECK_TIME`	`OPEN_FULL_TABLE`
`TABLE_COLLATION`	`OPEN_FRM_ONLY`
`CHECKSUM`	`OPEN_FULL_TABLE`
`CREATE_OPTIONS`	`OPEN_FRM_ONLY`
`TABLE_COMMENT`	`OPEN_FRM_ONLY`

- `TABLE_CONSTRAINTS`: `OPEN_FULL_TABLE` applies to all columns
- `TRIGGERS`: `OPEN_TRIGGER_ONLY` applies to all columns
- `VIEWS`:

Column	Optimization type
`TABLE_CATALOG`	`OPEN_FRM_ONLY`
`TABLE_SCHEMA`	`OPEN_FRM_ONLY`
`TABLE_NAME`	`OPEN_FRM_ONLY`
`VIEW_DEFINITION`	`OPEN_FRM_ONLY`
`CHECK_OPTION`	`OPEN_FRM_ONLY`
`IS_UPDATABLE`	`OPEN_FULL_TABLE`
`DEFINER`	`OPEN_FRM_ONLY`
`SECURITY_TYPE`	`OPEN_FRM_ONLY`
`CHARACTER_SET_CLIENT`	`OPEN_FRM_ONLY`
`COLLATION_CONNECTION`	`OPEN_FRM_ONLY`

3) Use `EXPLAIN` to determine whether the server can use `INFORMATION_SCHEMA` optimizations for a query

This applies particularly for `INFORMATION_SCHEMA` queries that search for information from more than one database, which might take a long time and impact performance. The `Extra` value in `EXPLAIN` output indicates which, if any, of the optimizations described earlier the server can use to evaluate `INFORMATION_SCHEMA` queries. The following examples demonstrate the kinds of information you can expect to see in the `Extra` value.

```
mysql> EXPLAIN SELECT TABLE_NAME FROM INFORMATION_SCHEMA.VIEWS WHERE
    -> TABLE_SCHEMA = 'test' AND TABLE_NAME = 'v1'\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: VIEWS
         type: ALL
possible_keys: NULL
          key: TABLE_SCHEMA,TABLE_NAME
      key_len: NULL
          ref: NULL
         rows: NULL
        Extra: Using where; Open_frm_only; Scanned 0 databases
```

Use of constant database and table lookup values enables the server to avoid directory scans. For references to `VIEWS.TABLE_NAME`, only the `.frm` file need be opened.

```
mysql> EXPLAIN SELECT TABLE_NAME, ROW_FORMAT FROM INFORMATION_SCHEMA.TABLES\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: TABLES
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: NULL
        Extra: Open_full_table; Scanned all databases
```

No lookup values are provided (there is no `WHERE` clause), so the server must scan the data directory and each database directory. For each table thus identified, the table name and row format are selected. `TABLE_NAME` requires no further table files to be opened (the `SKIP_OPEN_TABLE` optimization applies). `ROW_FORMAT` requires all table files to be opened (`OPEN_FULL_TABLE` applies). `EXPLAIN` reports `OPEN_FULL_TABLE` because it is more expensive than `SKIP_OPEN_TABLE`.

```
mysql> EXPLAIN SELECT TABLE_NAME, TABLE_TYPE FROM INFORMATION_SCHEMA.TABLES
    -> WHERE TABLE_SCHEMA = 'test'\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: TABLES
         type: ALL
possible_keys: NULL
          key: TABLE_SCHEMA
      key_len: NULL
          ref: NULL
         rows: NULL
        Extra: Using where; Open_frm_only; Scanned 1 database
```

No table name lookup value is provided, so the server must scan the `test` database directory. For the `TABLE_NAME` and `TABLE_TYPE` columns, the `SKIP_OPEN_TABLE` and `OPEN_FRM_ONLY` optimizations apply, respectively. `EXPLAIN` reports `OPEN_FRM_ONLY` because it is more expensive.

```
mysql> EXPLAIN SELECT B.TABLE_NAME
    -> FROM INFORMATION_SCHEMA.TABLES AS A, INFORMATION_SCHEMA.COLUMNS AS B
    -> WHERE A.TABLE_SCHEMA = 'test'
    -> AND A.TABLE_NAME = 't1'
    -> AND B.TABLE_NAME = A.TABLE_NAME\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: A
         type: ALL
possible_keys: NULL
          key: TABLE_SCHEMA,TABLE_NAME
      key_len: NULL
          ref: NULL
         rows: NULL
        Extra: Using where; Skip_open_table; Scanned 0 databases
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: B
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: NULL
        Extra: Using where; Open_frm_only; Scanned all databases;
               Using join buffer
```

For the first `EXPLAIN` output row: Constant database and table lookup values enable the server to avoid directory scans for `TABLES` values. References to `TABLES.TABLE_NAME` require no further table files.

For the second `EXPLAIN` output row: All `COLUMNS` table values are `OPEN_FRM_ONLY` lookups, so `COLUMNS.TABLE_NAME` requires the `.frm` file to be opened.

```
mysql> EXPLAIN SELECT * FROM INFORMATION_SCHEMA.COLLATIONS\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: COLLATIONS
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: NULL
        Extra:
```

In this case, no optimizations apply because `COLLATIONS` is not one of the `INFORMATION_SCHEMA` tables for which optimizations are available.

7.2.5. Other Optimization Tips

This section lists a number of miscellaneous tips for improving query processing speed:

- If your application makes several database requests to perform related updates, combining the statements into a stored routine can help performance. Similarly, if your application computes a single result based on several column values or large volumes of data, combining the computation into a UDF (user-defined function) can help performance. The resulting fast database operations are then available to be reused by other queries, applications, and even code written in different programming languages. See Section 17.2, “Using Stored Routines (Procedures and Functions)” and Section 21.3, “Adding New Functions to MySQL” for more information.
- To fix any compression issues that occur with `ARCHIVE` tables, use `OPTIMIZE TABLE`. See Section 13.8, “The `ARCHIVE` Storage Engine”.
- If possible, classify reports as “live” or as “statistical”, where data needed for statistical reports is created only from summary tables that are generated periodically from the live data.
- If you have data that does not conform well to a rows-and-columns table structure, you can pack and store data into a `BLOB` column. In this case, you must provide code in your application to pack and unpack information, but this might save I/O operations to read and write the sets of related values.
- With Web servers, store images and other binary assets as files, with the path name stored in the database rather than the file itself. Most Web servers are better at caching files than database contents, so using files is generally faster. (Although you must handle backups and storage issues yourself in this case.)
- If you need really high speed, look at the low-level MySQL interfaces. For example, by accessing the MySQL `InnoDB` or `MyISAM` storage engine directly, you could get a substantial speed increase compared to using the SQL interface.
- Replication can provide a performance benefit for some operations. You can distribute client retrievals among replication servers to split up the load. To avoid slowing down the master while making backups, you can make backups using a slave server. See Chapter 15, *Replication*.

7.3. Optimization and Indexes

The best way to improve the performance of `SELECT` operations is to create indexes on one or more of the columns that are tested in the query. The index entries act like pointers to the table rows, allowing the query to quickly determine which rows match a condition in the `WHERE` clause, and retrieve the other column values for those rows. All MySQL data types can be indexed.

Although it can be tempting to create an indexes for every possible column used in a query, unnecessary indexes waste space and waste time for MySQL to determine which indexes to use. You must find the right balance to achieve fast queries using the optimal set of indexes.

7.3.1. How MySQL Uses Indexes

Indexes are used to find rows with specific column values quickly. Without an index, MySQL must begin with the first row and then read through the entire table to find the relevant rows. The larger the table, the more this costs. If the table has an index for the columns in question, MySQL can quickly determine the position to seek to in the middle of the data file without having to look at all the data. If a table has 1,000 rows, this is at least 100 times faster than reading sequentially.

Most MySQL indexes (`PRIMARY KEY`, `UNIQUE`, `INDEX`, and `FULLTEXT`) are stored in B-trees. Exceptions are that indexes on spatial data types use R-trees, and that `MEMORY` tables also support hash indexes.

In general, indexes are used as described in the following discussion. Characteristics specific to hash indexes (as used in `MEMORY` tables) are described at the end of this section.

MySQL uses indexes for these operations:

- To find the rows matching a `WHERE` clause quickly.
- To eliminate rows from consideration. If there is a choice between multiple indexes, MySQL normally uses the index that finds the smallest number of rows (the most selective index).
- To retrieve rows from other tables when performing joins. MySQL can use indexes on columns more efficiently if they are declared as the same type and size. In this context, `VARCHAR` and `CHAR` are considered the same if they are declared as the same size. For example, `VARCHAR(10)` and `CHAR(10)` are the same size, but `VARCHAR(10)` and `CHAR(15)` are not.

  Comparison of dissimilar columns may prevent use of indexes if values cannot be compared directly without conversion. Suppose that a numeric column is compared to a string column. For a given value such as `1` in the numeric column, it might compare equal to any number of values in the string column such as `'1'`, `' 1'`, `'00001'`, or `'01.e1'`. This rules out use of any indexes for the string column.
- To find the `MIN()` or `MAX()` value for a specific indexed column *`key_col`*. This is optimized by a preprocessor that checks whether you are using `WHERE key_part_N = constant` on all key parts that occur before *`key_col`* in the index. In this case, MySQL does a single key lookup for each `MIN()` or `MAX()` expression and replaces it with a constant. If all expressions are replaced with constants, the query returns at once. For example:

  ```
  SELECT MIN(key_part2),MAX(key_part2)
    FROM tbl_name WHERE key_part1=10;
  ```
- To sort or group a table if the sorting or grouping is done on a leftmost prefix of a usable key (for example, `ORDER BY key_part1, key_part2`). If all key parts are followed by `DESC`, the key is read in reverse order. See Section 7.13.9, “`ORDER BY` Optimization”, and Section 7.13.10, “`GROUP BY` Optimization”.
- In some cases, a query can be optimized to retrieve values without consulting the data rows. (An index that provides all the necessary results for a query is called a covering index.) If a query uses only columns from a table that are numeric and that form a leftmost prefix for some key, the selected values can be retrieved from the index tree for greater speed:

  ```
  SELECT key_part3 FROM tbl_name
    WHERE key_part1=1
  ```

Indexes are less important for queries on small tables, or big tables where report queries process most or all of the rows. When a query needs to access most of the rows, reading sequentially is faster than working through an index. Sequential reads minimize disk seeks, even if not all the rows are needed for the query. See Section 7.2.1.4, “How to Avoid Table Scans” for details.

7.3.2. Using Primary Keys

The primary key for a table represents the column or set of columns that you use in your most vital queries. It has an associated index, for fast query performance. Query performance benefits from the `NOT NULL` optimization, because it cannot include any `NULL` values. With the `InnoDB` storage engine, the table data is physically organized to do ultra-fast lookups and sorts based on the primary key column or columns.

If your table is big and important, but does not have an obvious column or set of columns to use as a primary key, you might create a separate column with auto-increment values to use as the primary key. These unique IDs can serve as pointers to corresponding rows in other tables when you join tables using foreign keys.

7.3.3. Using Foreign Keys

If a table has many columns, and you query many different combinations of columns, it might be efficient to split the less-frequently used data into separate tables with a few columns each, and relate them back to the main table by duplicating the numeric ID column from the main table. That way, each small table can have a primary key for fast lookups of its data, and you can query just the set of columns that you need using a join operation. Depending on how the data is distributed, the queries might perform less I/O and take up less cache memory because the relevant columns are packed together on disk. (To maximize performance, queries try to read as few data blocks as possible from disk; tables with only a few columns can fit more rows in each data block.)

7.3.4. Column Indexes

The most common type of index involves a single column, storing copies of the values from that column in a data structure, allowing fast lookups for the rows with the corresponding column values. The B-tree data structure lets the index quickly find a specific value, a set of values, or a range of values, corresponding to operators such as `=`, `>`, `≤`, `BETWEEN`, `IN`, and so on, in a `WHERE` clause.

The maximum number of indexes per table and the maximum index length is defined per storage engine. See Chapter 13, *Storage Engines*. All storage engines support at least 16 indexes per table and a total index length of at least 256 bytes. Most storage engines have higher limits.

Prefix Indexes

With `col_name(N)` syntax in an index specification, you can create an index that uses only the first `N` characters of a string column. Indexing only a prefix of column values in this way can make the index file much smaller. When you index a `BLOB` or `TEXT` column, you *must* specify a prefix length for the index. For example:

```
CREATE TABLE test (blob_col BLOB, INDEX(blob_col(10)));
```

Prefixes can be up to 1000 bytes long (767 bytes for `InnoDB` tables).

> **Note**
>
> Prefix limits are measured in bytes, while the prefix length in `CREATE TABLE` statements is interpreted as number of characters. *Take this into account when specifying a prefix length for a column that uses a multi-byte character set.*

FULLTEXT Indexes

You can also create `FULLTEXT` indexes. These are used for full-text searches. Only the `MyISAM` storage engine supports `FULLTEXT` indexes and only for `CHAR`, `VARCHAR`, and `TEXT` columns. Indexing always takes place over the entire column and column prefix indexing is not supported. For details, see Section 11.9, “Full-Text Search Functions”.

Spatial Indexes

You can also create indexes on spatial data types. Currently, only `MyISAM` supports R-tree indexes on spatial types. Other storage engines use B-trees for indexing spatial types (except for `ARCHIVE`, which does not support spatial type indexing).

Indexes in the MEMORY Storage Engine

The `MEMORY` storage engine uses `HASH` indexes by default, but also supports `BTREE` indexes.

7.3.5. Multiple-Column Indexes

MySQL can create composite indexes (that is, indexes on multiple columns). An index may consist of up to 16 columns. For certain data types, you can index a prefix of the column (see Section 7.3.4, “Column Indexes”).

MySQL can use multiple-column indexes for queries that test all the columns in the index, or queries that test just the first column, the first two columns, the first three columns, and so on. Specify the columns in the right order, so that a single composite index can speed up several kinds of queries on the same table.

A multiple-column index can be considered a sorted array containing values that are created by concatenating the values of the indexed columns.

> **Note**
>
> As an alternative to a composite index, you can introduce a column that is “hashed” based on information from other columns. If this column is short, reasonably unique, and indexed, it might be faster than a “wide” index on many columns. In MySQL, it is very easy to use this extra column:
>
> ```
> SELECT * FROM tbl_name
>   WHERE hash_col=MD5(CONCAT(col1,col2))
>   AND col1='constant' AND col2='constant';
> ```

Suppose that a table has the following specification:

```
CREATE TABLE test (
    id         INT NOT NULL,
    last_name  CHAR(30) NOT NULL,
    first_name CHAR(30) NOT NULL,
    PRIMARY KEY (id),
    INDEX name (last_name,first_name)
```

```
);
```

The `name` index is an index over the `last_name` and `first_name` columns. The index can be used for queries that specify values in a known range for `last_name`, or for both `last_name` and `first_name`. Therefore, the `name` index is used in the following queries:

```
SELECT * FROM test WHERE last_name='Widenius';

SELECT * FROM test
  WHERE last_name='Widenius' AND first_name='Michael';

SELECT * FROM test
  WHERE last_name='Widenius'
  AND (first_name='Michael' OR first_name='Monty');

SELECT * FROM test
  WHERE last_name='Widenius'
  AND first_name >='M' AND first_name < 'N';
```

However, the `name` index is *not* used in the following queries:

```
SELECT * FROM test WHERE first_name='Michael';

SELECT * FROM test
  WHERE last_name='Widenius' OR first_name='Michael';
```

Suppose that you issue the following `SELECT` statement:

```
mysql> SELECT * FROM tbl_name WHERE col1=val1 AND col2=val2;
```

If a multiple-column index exists on `col1` and `col2`, the appropriate rows can be fetched directly. If separate single-column indexes exist on `col1` and `col2`, the optimizer attempts to use the Index Merge optimization (see Section 7.13.2, "Index Merge Optimization"), or attempts to find the most restrictive index by deciding which index finds fewer rows and using that index to fetch the rows.

If the table has a multiple-column index, any leftmost prefix of the index can be used by the optimizer to find rows. For example, if you have a three-column index on `(col1, col2, col3)`, you have indexed search capabilities on `(col1)`, `(col1, col2)`, and `(col1, col2, col3)`.

MySQL cannot use an index if the columns do not form a leftmost prefix of the index. Suppose that you have the `SELECT` statements shown here:

```
SELECT * FROM tbl_name WHERE col1=val1;
SELECT * FROM tbl_name WHERE col1=val1 AND col2=val2;

SELECT * FROM tbl_name WHERE col2=val2;
SELECT * FROM tbl_name WHERE col2=val2 AND col3=val3;
```

If an index exists on `(col1, col2, col3)`, only the first two queries use the index. The third and fourth queries do involve indexed columns, but `(col2)` and `(col2, col3)` are not leftmost prefixes of `(col1, col2, col3)`.

7.3.6. Verifying Index Usage

Always check whether all your queries really use the indexes that you have created in the tables. Use the `EXPLAIN` statement, as described in Section 7.8.1, "Optimizing Queries with `EXPLAIN`".

7.3.7. `InnoDB` and `MyISAM` Index Statistics Collection

Storage engines collect statistics about tables for use by the optimizer. Table statistics are based on value groups, where a value group is a set of rows with the same key prefix value. For optimizer purposes, an important statistic is the average value group size.

MySQL uses the average value group size in the following ways:

- To estimate how may rows must be read for each `ref` access
- To estimate how many row a partial join will produce; that is, the number of rows that an operation of this form will produce:

  ```
  (...) JOIN tbl_name ON tbl_name.key = expr
  ```

As the average value group size for an index increases, the index is less useful for those two purposes because the average number of rows per lookup increases: For the index to be good for optimization purposes, it is best that each index value target a small number of rows in the table. When a given index value yields a large number of rows, the index is less useful and MySQL is less likely to use it.

The average value group size is related to table cardinality, which is the number of value groups. The `SHOW INDEX` statement displays a cardinality value based on *`N/S`*, where *`N`* is the number of rows in the table and *`S`* is the average value group size. That ratio yields an approximate number of value groups in the table.

For a join based on the `<=>` comparison operator, `NULL` is not treated differently from any other value: `NULL <=> NULL`, just as *`N`* `<=>` *`N`* for any other *`N`*.

However, for a join based on the `=` operator, `NULL` is different from non-`NULL` values: *`expr1`* `=` *`expr2`* is not true when *`expr1`* or *`expr2`* (or both) are `NULL`. This affects `ref` accesses for comparisons of the form *`tbl_name.key`* `=` *`expr`*: MySQL will not access the table if the current value of *`expr`* is `NULL`, because the comparison cannot be true.

For `=` comparisons, it does not matter how many `NULL` values are in the table. For optimization purposes, the relevant value is the average size of the non-`NULL` value groups. However, MySQL does not currently enable that average size to be collected or used.

For `InnoDB` and `MyISAM` tables, you have some control over collection of table statistics by means of the `innodb_stats_method` and `myisam_stats_method` system variables, respectively. These variables have three possible values, which differ as follows:

- When the variable is set to `nulls_equal`, all `NULL` values are treated as identical (that is, they all form a single value group).

  If the `NULL` value group size is much higher than the average non-`NULL` value group size, this method skews the average value group size upward. This makes index appear to the optimizer to be less useful than it really is for joins that look for non-`NULL` values. Consequently, the `nulls_equal` method may cause the optimizer not to use the index for `ref` accesses when it should.

- When the variable is set to `nulls_unequal`, `NULL` values are not considered the same. Instead, each `NULL` value forms a separate value group of size 1.

  If you have many `NULL` values, this method skews the average value group size downward. If the average non-`NULL` value group size is large, counting `NULL` values each as a group of size 1 causes the optimizer to overestimate the value of the index for joins that look for non-`NULL` values. Consequently, the `nulls_unequal` method may cause the optimizer to use this index for `ref` lookups when other methods may be better.

- When the variable is set to `nulls_ignored`, `NULL` values are ignored.

If you tend to use many joins that use `<=>` rather than `=`, `NULL` values are not special in comparisons and one `NULL` is equal to another. In this case, `nulls_equal` is the appropriate statistics method.

The `innodb_stats_method` and `myisam_stats_method` system variables have global and session values. Setting the global value affects statistics collection for tables from the corresponding storage engine. Setting the session value affects statistics collection only for the current client connection. This means that you can force a table's statistics to be regenerated with a given method without affecting other clients by setting the session value of the appropriate variable, `innodb_stats_method` or `myisam_stats_method`.

To regenerate table statistics, you can use any of the following methods:

- Execute `myisamchk --stats_method=`*`method_name`*` --analyze`
- Change the table to cause its statistics to go out of date (for example, insert a row and then delete it), and then set `myisam_stats_method` and issue an `ANALYZE TABLE` statement

Some caveats regarding the use of `innodb_stats_method` and `myisam_stats_method`:

- You can force table statistics to be collected explicitly, as just described. However, MySQL may also collect statistics automatically. For example, if during the course of executing statements for a table, some of those statements modify the table, MySQL may collect statistics. (This may occur for bulk inserts or deletes, or some `ALTER TABLE` statements, for example.) If this happens, the statistics are collected using whatever value `innodb_stats_method` or `myisam_stats_method` has at the time. Thus, if you collect statistics using one method, but the system variable is set to the other method when a table's statistics are collected automatically later, the other method will be used.
- There is no way to tell which method was used to generate statistics for a given table.

- These variables apply only to `InnoDB` and `MyISAM` tables. Other storage engines have only one method for collecting table statistics. Usually it is closer to the `nulls_equal` method.

7.3.8. Comparison of B-Tree and Hash Indexes

Understanding the B-tree and hash data structures can help predict how different queries perform on different storage engines that use these data structures in their indexes, particularly for the `MEMORY` storage engine that lets you choose B-tree or hash indexes.

B-Tree Index Characteristics

A B-tree index can be used for column comparisons in expressions that use the `=`, `>`, `>=`, `<`, `<=`, or `BETWEEN` operators. The index also can be used for `LIKE` comparisons if the argument to `LIKE` is a constant string that does not start with a wildcard character. For example, the following `SELECT` statements use indexes:

```
SELECT * FROM tbl_name WHERE key_col LIKE 'Patrick%';
SELECT * FROM tbl_name WHERE key_col LIKE 'Pat%_ck%';
```

In the first statement, only rows with `'Patrick' <= key_col < 'Patricl'` are considered. In the second statement, only rows with `'Pat' <= key_col < 'Pau'` are considered.

The following `SELECT` statements do not use indexes:

```
SELECT * FROM tbl_name WHERE key_col LIKE '%Patrick%';
SELECT * FROM tbl_name WHERE key_col LIKE other_col;
```

In the first statement, the `LIKE` value begins with a wildcard character. In the second statement, the `LIKE` value is not a constant.

If you use `... LIKE '%string%'` and `string` is longer than three characters, MySQL uses the *Turbo Boyer-Moore algorithm* to initialize the pattern for the string and then uses this pattern to perform the search more quickly.

A search using `col_name IS NULL` employs indexes if `col_name` is indexed.

Any index that does not span all `AND` levels in the `WHERE` clause is not used to optimize the query. In other words, to be able to use an index, a prefix of the index must be used in every `AND` group.

The following `WHERE` clauses use indexes:

```
... WHERE index_part1=1 AND index_part2=2 AND other_column=3
    /* index = 1 OR index = 2 */
... WHERE index=1 OR A=10 AND index=2
    /* optimized like "index_part1='hello'" */
... WHERE index_part1='hello' AND index_part3=5
    /* Can use index on index1 but not on index2 or index3 */
... WHERE index1=1 AND index2=2 OR index1=3 AND index3=3;
```

These `WHERE` clauses do *not* use indexes:

```
    /* index_part1 is not used */
... WHERE index_part2=1 AND index_part3=2

    /*  Index is not used in both parts of the WHERE clause  */
... WHERE index=1 OR A=10

    /* No index spans all rows  */
... WHERE index_part1=1 OR index_part2=10
```

Sometimes MySQL does not use an index, even if one is available. One circumstance under which this occurs is when the optimizer estimates that using the index would require MySQL to access a very large percentage of the rows in the table. (In this case, a table scan is likely to be much faster because it requires fewer seeks.) However, if such a query uses `LIMIT` to retrieve only some of the rows, MySQL uses an index anyway, because it can much more quickly find the few rows to return in the result.

Hash Index Characteristics

Hash indexes have somewhat different characteristics from those just discussed:

- They are used only for equality comparisons that use the `=` or `<=>` operators (but are *very* fast). They are not used for comparison operators such as `<` that find a range of values. Systems that rely on this type of single-value lookup are known as “key-value stores”; to use MySQL for such applications, use hash indexes wherever possible.
- The optimizer cannot use a hash index to speed up `ORDER BY` operations. (This type of index cannot be used to search for the

next entry in order.)

- MySQL cannot determine approximately how many rows there are between two values (this is used by the range optimizer to decide which index to use). This may affect some queries if you change a `MyISAM` table to a hash-indexed `MEMORY` table.
- Only whole keys can be used to search for a row. (With a B-tree index, any leftmost prefix of the key can be used to find rows.)

7.4. Optimizing Database Structure

In your role as a database designer, look for the most efficient way to organize your schemas, tables, and columns. As when tuning application code, you minimize I/O, keep related items together, and plan ahead so that performance stays high as the data volume increases. Starting with an efficient database design makes it easier for team members to write high-performing application code, and makes the database likely to endure as applications evolve and are rewritten.

7.4.1. Optimizing Data Size

Design your tables to minimize their space on the disk. This can result in huge improvements by reducing the amount of data written to and read from disk. Smaller tables normally require less main memory while their contents are being actively processed during query execution. Any space reduction for table data also results in smaller indexes that can be processed faster.

MySQL supports many different storage engines (table types) and row formats. For each table, you can decide which storage and indexing method to use. Choosing the proper table format for your application can give you a big performance gain. See Chapter 13, *Storage Engines*.

You can get better performance for a table and minimize storage space by using the techniques listed here:

Table Columns

- Use the most efficient (smallest) data types possible. MySQL has many specialized types that save disk space and memory. For example, use the smaller integer types if possible to get smaller tables. `MEDIUMINT` is often a better choice than `INT` because a `MEDIUMINT` column uses 25% less space.
- Declare columns to be `NOT NULL` if possible. It makes SQL operations faster, by enabling better use of indexes and eliminating overhead for testing whether each value is `NULL`. You also save some storage space, one bit per column. If you really need `NULL` values in your tables, use them. Just avoid the default setting that allows `NULL` values in every column.

Row Format

- `InnoDB` tables use a compact storage format. In versions of MySQL earlier than 5.0.3, `InnoDB` rows contain some redundant information, such as the number of columns and the length of each column, even for fixed-size columns. By default, tables are created in the compact format (`ROW_FORMAT=COMPACT`). If you wish to downgrade to older versions of MySQL, you can request the old format with `ROW_FORMAT=REDUNDANT`.

  The presence of the compact row format decreases row storage space by about 20% at the cost of increasing CPU use for some operations. If your workload is a typical one that is limited by cache hit rates and disk speed it is likely to be faster. If it is a rare case that is limited by CPU speed, it might be slower.

  The compact `InnoDB` format also changes how `CHAR` columns containing UTF-8 data are stored. With `ROW_FORMAT=REDUNDANT`, a UTF-8 `CHAR(N)` occupies 3 × *N* bytes, given that the maximum length of a UTF-8 encoded character is three bytes. Many languages can be written primarily using single-byte UTF-8 characters, so a fixed storage length often wastes space. With `ROW_FORMAT=COMPACT` format, `InnoDB` allocates a variable amount of storage in the range from *N* to 3 × *N* bytes for these columns by stripping trailing spaces if necessary. The minimum storage length is kept as *N* bytes to facilitate in-place updates in typical cases.
- To minimize space even further by storing table data in compressed form, specify `ROW_FORMAT=COMPRESSED` when creating `InnoDB` tables, or run the `myisampack` command on an existing `MyISAM` table. (`InnoDB` tables compressed tables are readable and writeable, while `MyISAM` compressed tables are read-only.)
- For `MyISAM` tables, if you do not have any variable-length columns (`VARCHAR`, `TEXT`, or `BLOB` columns), a fixed-size row format is used. This is faster but may waste some space. See Section 13.5.3, “`MyISAM` Table Storage Formats”. You can hint that you want to have fixed length rows even if you have `VARCHAR` columns with the `CREATE TABLE` option `ROW_FORMAT=FIXED`.

Indexes

- The primary index of a table should be as short as possible. This makes identification of each row easy and efficient. For `InnoDB` tables, the primary key columns are duplicated in each secondary index entry, so a short primary key saves considerable space if you have many secondary indexes.

- Create only the indexes that you need to improve query performance. Indexes are good for retrieval, but slow down insert and update operations. If you access a table mostly by searching on a combination of columns, create a single composite index on them rather than a separate index for each column. The first part of the index should be the column most used. If you *always* use many columns when selecting from the table, the first column in the index should be the one with the most duplicates, to obtain better compression of the index.

- If it is very likely that a long string column has a unique prefix on the first number of characters, it is better to index only this prefix, using MySQL's support for creating an index on the leftmost part of the column (see Section 12.1.11, “`CREATE INDEX` Syntax”). Shorter indexes are faster, not only because they require less disk space, but because they also give you more hits in the index cache, and thus fewer disk seeks. See Section 7.11.2, “Tuning Server Parameters”.

Joins

- In some circumstances, it can be beneficial to split into two a table that is scanned very often. This is especially true if it is a dynamic-format table and it is possible to use a smaller static format table that can be used to find the relevant rows when scanning the table.

- Declare columns with identical information in different tables with identical data types, to speed up joins based on the corresponding columns.

- Keep column names simple, so that you can use the same name across different tables and simplify join queries. For example, in a table named `customer`, use a column name of `name` instead of `customer_name`. To make your names portable to other SQL servers, consider keeping them shorter than 18 characters.

Normalization

- Normally, try to keep all data nonredundant (observing what is referred to in database theory as *third normal form*). Instead of repeating lengthy values such as names and addresses, assign them unique IDs, repeat these IDs as needed across multiple smaller tables, and join the tables in queries by referencing the IDs in the join clause.

- If speed is more important than disk space and the maintenance costs of keeping multiple copies of data, for example in a business intelligence scenario where you analyze all the data from large tables, you can relax the normalization rules, duplicating information or creating summary tables to gain more speed.

7.4.2. Optimizing MySQL Data Types

7.4.2.1. Optimizing for Numeric Data

- For unique IDs or other values that can be represented as either strings or numbers, prefer numeric columns to string columns. Since large numeric values can be stored in fewer bytes than the corresponding strings, it is faster and takes less memory to transfer and compare them.

- If you are using numeric data, it is faster in many cases to access information from a database (using a live connection) than to access a text file. Information in the database is likely to be stored in a more compact format than in the text file, so accessing it involves fewer disk accesses. You also save code in your application because you can avoid parsing the text file to find line and column boundaries.

7.4.2.2. Optimizing for Character and String Types

For character and string columns, follow these guidelines:

- Use binary collation order for fast comparison and sort operations, when you do not need language-specific collation features. You can use the BINARY operator to use binary collation within a particular query.

- When comparing values from different columns, declare those columns with the same character set and collation wherever possible, to avoid string conversions while running the query.

- For column values less than 8KB in size, use binary `VARCHAR` instead of `BLOB`. The `GROUP BY` and `ORDER BY` clauses can generate temporary tables, and these temporary tables can use the `MEMORY` storage engine if the original table does not contain any `BLOB` columns.

- If a table contains string columns such as name and address, but many queries do not retrieve those columns, consider splitting the string columns into a separate table and using join queries with a foreign key when necessary. When MySQL retrieves any value from a row, it reads a data block containing all the columns of that row (and possibly other adjacent rows). Keeping each row small, with only the most frequently used columns, allows more rows to fit in each data block. Such compact tables reduce disk I/O and memory usage for common queries.

- When you use a randomly generated value as a primary key in an `InnoDB` table, prefix it with an ascending value such as the current date and time if possible. When consecutive primary values are physically stored near each other, `InnoDB` can insert and retrieve them faster.

- See Section 7.4.2.1, “Optimizing for Numeric Data” for reasons why a numeric column is usually preferable to an equivalent string column.

7.4.2.3. Optimizing for BLOB Types

- When storing a large blob containing textual data, consider compressing it first. Do not use this technique when the entire table is compressed by `InnoDB` or `MyISAM`.

- For a table with several columns, to reduce memory requirements for queries that do not use the BLOB column, consider splitting the BLOB column into a separate table and referencing it with a join query when needed.

- Since the performance requirements to retrieve and display a BLOB value might be very different from other data types, you could put the BLOB-specific table on a different storage device or even a separate database instance. For example, to retrieve a BLOB might require a large sequential disk read that is better suited to a traditional hard drive than to an SSD device.

- See Section 7.4.2.2, “Optimizing for Character and String Types” for reasons why a binary `VARCHAR` column is sometimes preferable to an equivalent BLOB column.

- Rather than testing for equality against a very long text string, you can store a hash of the column value in a separate column, index that column, and test the hashed value in queries. (Use the `MD5()` or `CRC32()` function to produce the hash value.) Since hash functions can produce duplicate results for different inputs, you still include a clause `AND blob_column = long_string_value` in the query to guard against false matches; the performance benefit comes from the smaller, easily scanned index for the hashed values.

7.4.3. Optimizing for Many Tables

Some techniques for keeping individual queries fast involve splitting data across many tables. When the number of tables runs into the thousands or even millions, the overhead of dealing with all these tables becomes a new performance consideration.

7.4.3.1. How MySQL Opens and Closes Tables

When you execute a `mysqladmin status` command, you should see something like this:

```
Uptime: 426 Running threads: 1 Questions: 11082
Reloads: 1 Open tables: 12
```

The `Open tables` value of 12 can be somewhat puzzling if you have only six tables.

MySQL is multi-threaded, so there may be many clients issuing queries for a given table simultaneously. To minimize the problem with multiple client sessions having different states on the same table, the table is opened independently by each concurrent session. This uses additional memory but normally increases performance. With `MyISAM` tables, one extra file descriptor is required for the data file for each client that has the table open. (By contrast, the index file descriptor is shared between all sessions.)

The `table_open_cache` and `max_connections` system variables affect the maximum number of files the server keeps open. If you increase one or both of these values, you may run up against a limit imposed by your operating system on the per-process number of open file descriptors. Many operating systems permit you to increase the open-files limit, although the method varies widely from system to system. Consult your operating system documentation to determine whether it is possible to increase the limit and how to do so.

`table_open_cache` is related to `max_connections`. For example, for 200 concurrent running connections, specify a table cache size of at least `200 * N`, where *`N`* is the maximum number of tables per join in any of the queries which you execute. You must also reserve some extra file descriptors for temporary tables and files.

Make sure that your operating system can handle the number of open file descriptors implied by the `table_open_cache` setting. If `table_open_cache` is set too high, MySQL may run out of file descriptors and refuse connections, fail to perform queries, and be very unreliable. You also have to take into account that the `MyISAM` storage engine needs two file descriptors for each unique open table. You can increase the number of file descriptors available to MySQL using the `--open-files-limit` startup option to `mysqld`. See Section C.5.2.18, “`'File'` Not Found and Similar Errors”.

The cache of open tables is kept at a level of `table_open_cache` entries. The default value is 400; this can be changed with the `--table_open_cache` option to `mysqld`. Note that MySQL may temporarily open more tables than this to execute queries.

MySQL closes an unused table and removes it from the table cache under the following circumstances:

- When the cache is full and a thread tries to open a table that is not in the cache.
- When the cache contains more than `table_open_cache` entries and a table in the cache is no longer being used by any threads.
- When a table flushing operation occurs. This happens when someone issues a `FLUSH TABLES` statement or executes a `mysqladmin flush-tables` or `mysqladmin refresh` command.

When the table cache fills up, the server uses the following procedure to locate a cache entry to use:

- Tables that are not currently in use are released, beginning with the table least recently used.
- If a new table needs to be opened, but the cache is full and no tables can be released, the cache is temporarily extended as necessary. When the cache is in a temporarily extended state and a table goes from a used to unused state, the table is closed and released from the cache.

A `MyISAM` table is opened for each concurrent access. This means the table needs to be opened twice if two threads access the same table or if a thread accesses the table twice in the same query (for example, by joining the table to itself). Each concurrent open requires an entry in the table cache. The first open of any `MyISAM` table takes two file descriptors: one for the data file and one for the index file. Each additional use of the table takes only one file descriptor for the data file. The index file descriptor is shared among all threads.

If you are opening a table with the `HANDLER tbl_name OPEN` statement, a dedicated table object is allocated for the thread. This table object is not shared by other threads and is not closed until the thread calls `HANDLER tbl_name CLOSE` or the thread terminates. When this happens, the table is put back in the table cache (if the cache is not full). See Section 12.2.4, “`HANDLER` Syntax”.

You can determine whether your table cache is too small by checking the `mysqld` status variable `Opened_tables`, which indicates the number of table-opening operations since the server started:

```
mysql> SHOW GLOBAL STATUS LIKE 'Opened_tables';
+---------------+-------+
| Variable_name | Value |
+---------------+-------+
| Opened_tables | 2741  |
+---------------+-------+
```

If the value is very large or increases rapidly, even when you have not issued many `FLUSH TABLES` statements, increase the table cache size. See Section 5.1.3, “Server System Variables”, and Section 5.1.5, “Server Status Variables”.

7.4.3.2. Disadvantages of Creating Many Tables in the Same Database

If you have many `MyISAM` tables in the same database directory, open, close, and create operations are slow. If you execute `SELECT` statements on many different tables, there is a little overhead when the table cache is full, because for every table that has to be opened, another must be closed. You can reduce this overhead by increasing the number of entries permitted in the table cache.

7.4.3.3. How MySQL Uses Internal Temporary Tables

In some cases, the server creates internal temporary tables while processing queries. Such a table can be held in memory and processed by the `MEMORY` storage engine, or stored on disk and processed by the `MyISAM` storage engine. The server may create a temporary table initially as an in-memory table, then convert it to an on-disk table if it becomes too large. Users have no direct control over when the server creates an internal temporary table or which storage engine the server uses to manage it.

Temporary tables can be created under conditions such as these:

- If there is an `ORDER BY` clause and a different `GROUP BY` clause, or if the `ORDER BY` or `GROUP BY` contains columns from tables other than the first table in the join queue, a temporary table is created.
- `DISTINCT` combined with `ORDER BY` may require a temporary table.
- If you use the `SQL_SMALL_RESULT` option, MySQL uses an in-memory temporary table, unless the query also contains elements (described later) that require on-disk storage.

To determine whether a query requires a temporary table, use `EXPLAIN` and check the `Extra` column to see whether it says `Using temporary`. See Section 7.8.1, "Optimizing Queries with `EXPLAIN`".

Some conditions prevent the use of an in-memory temporary table, in which case the server uses an on-disk table instead:

- Presence of a `BLOB` or `TEXT` column in the table
- Presence of any column in a `GROUP BY` or `DISTINCT` clause larger than 512 bytes
- Presence of any column larger than 512 bytes in the `SELECT` list, if `UNION` or `UNION ALL` is used

If an internal temporary table is created initially as an in-memory table but becomes too large, MySQL automatically converts it to an on-disk table. The maximum size for in-memory temporary tables is the minimum of the `tmp_table_size` and `max_heap_table_size` values. This differs from `MEMORY` tables explicitly created with `CREATE TABLE`: For such tables, the `max_heap_table_size` system variable determines how large the table is permitted to grow and there is no conversion to on-disk format.

When the server creates an internal temporary table (either in memory or on disk), it increments the `Created_tmp_tables` status variable. If the server creates the table on disk (either initially or by converting an in-memory table) it increments the `Created_tmp_disk_tables` status variable.

7.5. Optimizing for `InnoDB` Tables

`InnoDB` is the storage engine that MySQL customers typically use in production databases where reliability and concurrency are important. Because `InnoDB` is the default storage engine in MySQL 5.5 and higher, you can expect to see `InnoDB` tables more often than before. This section explains how to optimize database operations for `InnoDB` tables.

7.5.1. Optimizing Storage Layout for `InnoDB` Tables

- Once your data reaches a stable size, or a growing table has increased by tens or some hundreds of megabytes, consider using the `OPTIMIZE TABLE` statement to reorganize the table and compact any wasted space. The reorganized tables require less disk I/O to perform full table scans. This is a straightforward technique that can improve performance when other techniques such as improving index usage or tuning application code are not practical.

  `OPTIMIZE TABLE` copies the data part of the table and rebuilds the indexes. The benefits come from improved packing of data within indexes, and reduced fragmentation within the tablespaces and on disk. The benefits vary depending on the data in each table. You may find that there are significant gains for some and not for others, or that the gains decrease over time until you next optimize the table. This operation can be slow if the table is large or if the indexes being rebuilt don't fit into the buffer pool. The first run after adding a lot of data to a table is often much slower than later runs.
- In `InnoDB`, having a long `PRIMARY KEY` (either a single column with a lengthy value, or several columns that form a long composite value) wastes a lot of disk space. The primary key value for a row is duplicated in all the secondary index records that point to the same row. (See Section 13.3.11, "`InnoDB` Table and Index Structures".) Create an `AUTO_INCREMENT` column as the primary key if your primary key is long, or index a prefix of a long `VARCHAR` column instead of the entire column.
- Use the `VARCHAR` data type instead of `CHAR` to store variable-length strings or for columns with many `NULL` values. A `CHAR(N)` column always takes *`N`* characters to store data, even if the string is shorter or its value is `NULL`. Smaller tables fit better in the buffer pool and reduce disk I/O.

  When using `COMPACT` row format (the default `InnoDB` format in MySQL 5.5) and variable-length character sets, such as `utf8` or `sjis`, `CHAR(N)` columns occupy a variable amount of space, but still at least *`N`* bytes.
- For tables that are big, or contain lots of repetitive text or numeric data, consider using `COMPRESSED` row format. Less disk I/O is required to bring data into the buffer pool, or to perform full table scans. Before making a permanent decision, measure the amount of compression you can achieve by using `COMPRESSED` versus `COMPACT` row format.

7.5.2. Optimizing `InnoDB` Transaction Management

To optimize `InnoDB` transaction processing, find the ideal balance between the performance overhead of transactional features and the workload of your server. For example, an application might encounter performance issues if it commits thousands of times per second, and different performance issues if it commits only every 2-3 hours.

- The default MySQL setting `AUTOCOMMIT=1` can impose performance limitations on a busy database server. Where practical, wrap several related DML operations into a single transaction, by issuing `SET AUTOCOMMIT=0` or a `START TRANSACTION` statement, followed by a `COMMIT` statement after making all the changes.

  `InnoDB` must flush the log to disk at each transaction commit if that transaction made modifications to the database. When each change is followed by a commit (as with the default autocommit setting), the I/O throughput of the storage device puts a cap on the number of potential operations per second.

- Avoid performing rollbacks after inserting, updating, or deleting huge numbers of rows. If a big transaction is slowing down server performance, rolling it back can make the problem worse, potentially taking several times as long to perform as the original DML operations. Killing the database process does not help, because the rollback starts again on server startup.

  To minimize the chance of this issue occurring: increase the size of the buffer pool so that all the DML changes can be cached rather than immediately written to disk; set `innodb_change_buffering=all` so that update and delete operations are buffered in addition to inserts; and consider issuing `COMMIT` statements periodically during the big DML operation, possibly breaking a single delete or update into multiple statements that operate on smaller numbers of rows.

  To get rid of a runaway rollback once it occurs, increase the buffer pool so that the rollback becomes CPU-bound and runs fast, or kill the server and restart with `innodb_force_recovery=3`, as explained in Section 13.3.7.1, “The `InnoDB` Recovery Process”.

  This issue is expected to be less prominent in MySQL 5.5 and up, or in MySQL 5.1 with the InnoDB Plugin, because the default setting `innodb_change_buffering=all` allows update and delete operations to be cached in memory, making them faster to perform in the first place, and also faster to roll back if needed. Make sure to use this parameter setting on servers that process long-running transactions with many inserts, updates, or deletes.

- If you can afford the loss of some of the latest committed transactions if a crash occurs, you can set the `innodb_flush_log_at_trx_commit` parameter to 0. `InnoDB` tries to flush the log once per second anyway, although the flush is not guaranteed. Also, set the value of `innodb_support_xa` to 0, which will reduce the number of disk flushes due to synchronizing on disk data and the binary log.

- When rows are modified or deleted, the rows and associated undo logs are not physically removed immediately, or even immediately after the transaction commits. The old data is preserved until transactions that started earlier or concurrently are finished, so that those transactions can access the previous state of modified or deleted rows. Thus, a long-running transaction can prevent `InnoDB` from purging data that was changed by a different transaction.

- When rows are modified or deleted within a long-running transaction, other transactions using the `READ COMMITTED` and `REPEATABLE READ` isolation levels have to do more work to reconstruct the older data if they read those same rows.

- When a long-running transaction modifies a table, queries against that table from other transactions do not make use of the covering index technique. Queries that normally could retrieve all the result columns from a secondary index, instead look up the appropriate values from the table data.

7.5.3. Optimizing `InnoDB` Logging

- Make your log files big, even as big as the buffer pool. When `InnoDB` has written the log files full, it must write the modified contents of the buffer pool to disk in a checkpoint. Small log files cause many unnecessary disk writes. Although historically big log files caused lengthy recovery times, recovery is now much faster and you can confidently use large log files.

- Make the log buffer quite large as well (on the order of 8MB).

7.5.4. Bulk Data Loading for `InnoDB` Tables

These performance tips supplement the general guidelines for fast inserts in Section 7.2.2.1, “Speed of `INSERT` Statements”.

- When importing data into `InnoDB`, turn off autocommit mode, because it performs a log flush to disk for every insert. To disable autocommit during your import operation, surround it with `SET autocommit` and `COMMIT` statements:

  ```
  SET autocommit=0;
  ... SQL import statements ...
  ```

```
COMMIT;
```

The `mysqldump` option `--opt` creates dump files that are fast to import into an `InnoDB` table, even without wrapping them with the `SET autocommit` and `COMMIT` statements.

- If you have `UNIQUE` constraints on secondary keys, you can speed up table imports by temporarily turning off the uniqueness checks during the import session:

  ```
  SET unique_checks=0;
  ... SQL import statements ...
  SET unique_checks=1;
  ```

  For big tables, this saves a lot of disk I/O because `InnoDB` can use its insert buffer to write secondary index records in a batch. Be certain that the data contains no duplicate keys.

- If you have `FOREIGN KEY` constraints in your tables, you can speed up table imports by turning off the foreign key checks for the duration of the import session:

  ```
  SET foreign_key_checks=0;
  ... SQL import statements ...
  SET foreign_key_checks=1;
  ```

  For big tables, this can save a lot of disk I/O.

- Use the multiple-row `INSERT` syntax to reduce communication overhead between the client and the server if you need to insert many rows:

  ```
  INSERT INTO yourtable VALUES (1,2), (5,5), ...;
  ```

  This tip is valid for inserts into any table, not just `InnoDB` tables.

- When doing bulk inserts into tables with auto-increment columns, set `innodb_autoinc_lock_mode` to 2 or 3 instead of the default value 1. See Section 13.3.5.3.2, “Configurable `InnoDB` Auto-Increment Locking” for details.

7.5.5. Optimizing `InnoDB` Queries

To tune queries for `InnoDB` tables, create an appropriate set of indexes on each table. See Section 7.3.1, “How MySQL Uses Indexes” for details. Follow these guidelines for `InnoDB` indexes:

- Because each `InnoDB` table has a primary key (whether you request one or not), specify a set of primary key columns for each table, columns that are used in the most important and time-critical queries.

- Do not specify too many or too long columns in the primary key, because these column values are duplicated in each secondary index.

- Do not create a separate secondary index for each column, because each query can only make use of one index. Indexes on rarely tested columns or columns with only a few different values might not be helpful for any queries. If you have many queries for the same table, testing different combinations of columns, try to create a small number of concatenated indexes rather than a large number of single-column indexes. If an index contains all the columns needed for the result set (known as a covering index), the query might be able to avoid reading the table data at all.

- If an indexed column cannot contain any `NULL` values, declare it as `NOT NULL` when you create the table. The optimizer can better determine which index is most effective to use for a query, when it knows whether each column contains `NULL` values or not.

- If you often have recurring queries for tables that are not updated frequently, enable the query cache:

  ```
  [mysqld]
  query_cache_type = 1
  query_cache_size = 10M
  ```

7.5.6. Optimizing `InnoDB` DDL Operations

- For DDL operations on tables and indexes (`CREATE`, `ALTER`, and `DROP` statements), the most significant aspect for `InnoDB` tables is that creating and dropping secondary indexes is much faster in MySQL 5.5 and higher, than in MySQL 5.1 and before.

See Section 13.4.2, “Fast Index Creation in the InnoDB Storage Engine” for details.

- “Fast index creation” makes it faster in some cases to drop an index before loading data into a table, then re-create the index after loading the data.
- Use `TRUNCATE TABLE` to empty a table, not `DELETE FROM tbl_name`. Foreign key constraints can make a `TRUNCATE` statement work like a regular `DELETE` statement, in which case a sequence of commands like `DROP TABLE` and `CREATE TABLE` might be fastest.
- Because the primary key is integral to the storage layout of each `InnoDB` table, and changing the definition of the primary key involves reorganizing the whole table, always set up the primary key as part of the `CREATE TABLE` statement, and plan ahead so that you do not need to `ALTER` or `DROP` the primary key afterward.

7.5.7. Optimizing `InnoDB` Disk I/O

If you follow the best practices for database design and the tuning techniques for SQL operations, but your database is still slowed by heavy disk I/O activity, explore these low-level techniques related to disk I/O. If the Unix `top` tool or the Windows Task Manager shows that the CPU usage percentage with your workload is less than 70%, your workload is probably disk-bound.

- When table data is cached in the `InnoDB` buffer pool, it can be processed over and over by queries without requiring any disk I/O. Specify the size of the buffer pool with the `innodb_buffer_pool_size` option. This memory area is important enough that busy databases often specify a size approximately 80% of the amount of of physical memory. For more information, see Section 7.9.1, “The `InnoDB` Buffer Pool”.
- In some versions of GNU/Linux and Unix, flushing files to disk with the Unix `fsync()` call (which `InnoDB` uses by default) and similar methods is surprisingly slow. If database write performance is an issue, conduct benchmarks with the `innodb_flush_method` parameter set to `O_DSYNC`.
- When using the `InnoDB` storage engine on Solaris 10 for x86_64 architecture (AMD Opteron), use direct I/O for `InnoDB`-related files, to avoid degradation of `InnoDB` performance. To use direct I/O for an entire UFS file system used for storing `InnoDB`-related files, mount it with the `forcedirectio` option; see `mount_ufs(1M)`. (The default on Solaris 10/x86_64 is *not* to use this option.) To apply direct I/O only to `InnoDB` file operations rather than the whole file system, set `innodb_flush_method = O_DIRECT`. With this setting, `InnoDB` calls `directio()` instead of `fcntl()` for I/O to data files (not for I/O to log files).
- When using the `InnoDB` storage engine with a large `innodb_buffer_pool_size` value on any release of Solaris 2.6 and up and any platform (sparc/x86/x64/amd64), conduct benchmarks with `InnoDB` data files and log files on raw devices or on a separate direct I/O UFS file system, using the `forcedirectio` mount option as described earlier. (It is necessary to use the mount option rather than setting `innodb_flush_method` if you want direct I/O for the log files.) Users of the Veritas file system VxFS should use the `convosync=direct` mount option.

  Do not place other MySQL data files, such as those for `MyISAM` tables, on a direct I/O file system. Executables or libraries *must not* be placed on a direct I/O file system.
- If you have additional storage devices available to set up a RAID configuration or symbolic links to different disks, Section 7.11.3, “Optimizing Disk I/O” for additional low-level I/O tips.

7.5.8. Optimizing `InnoDB` Configuration Variables

Different settings work best for servers with light, predictable loads, versus servers that are running near full capacity all the time, or that experience spikes of high activity.

Because the `InnoDB` storage engine performs many of its optimizations automatically, many performance-tuning tasks involve monitoring to ensure that the database is performing well, and changing configuration options when performance drops. See Section 13.4.7.17, “Integration with MySQL PERFORMANCE_SCHEMA” for information about detailed `InnoDB` performance monitoring.

For information about the most important and most recent `InnoDB` performance features, see Section 13.4.7, “InnoDB Performance and Scalability Enhancements”. Even if you have used `InnoDB` tables in prior versions, these features might be new to you, because they are from the “InnoDB Plugin”. The Plugin co-existed alongside the built-in `InnoDB` in MySQL 5.1, and becomes the default storage engine in MySQL 5.5 and higher.

The main configuration steps you can perform include:

- Enabling `InnoDB` to use high-performance memory allocators on systems that include them. See Section 13.4.7.3, “Using Operating System Memory Allocators”.

- Controlling the types of DML operations for which `InnoDB` buffers the changed data, to avoid frequent small disk writes. See Section 13.4.7.4, “Controlling InnoDB Change Buffering”. Because the default is to buffer all types of DML operations, only change this setting if you need to reduce the amount of buffering.
- Turning the adaptive hash indexing feature on and off. See Section 13.4.7.5, “Controlling Adaptive Hash Indexing”. You might change this setting during periods of unusual activity, then restore it to its original setting.
- Setting a limit on the number of concurrent threads that `InnoDB` processes, if context switching is a bottleneck. See Section 13.4.7.6, “Changes Regarding Thread Concurrency”.
- Controlling the amount of prefetching that `InnoDB` does with its read-ahead operations. When the system has unused I/O capacity, more read-ahead can improve the performance of queries. Too much read-ahead can cause periodic drops in performance on a heavily loaded system. See Section 13.4.7.7, “Changes in the Read-Ahead Algorithm”.
- Increasing the number of background threads for read or write operations, if you have a high-end I/O subsystem that is not fully utilized by the default values. See Section 13.4.7.8, “Multiple Background I/O Threads”.
- Controlling how much I/O `InnoDB` performs in the background. See Section 13.4.7.11, “Controlling the Master Thread I/O Rate”. The amount of background I/O is higher than in MySQL 5.1, so you might scale back this setting if you observe periodic drops in performance.
- Controlling the algorithm that determines when `InnoDB` performs certain types of background writes. See Section 13.4.7.12, “Controlling the Flushing Rate of Dirty Pages”. The algorithm works for some types of workloads but not others, so might turn off this setting if you observe periodic drops in performance.
- Taking advantage of multicore processors and their cache memory configuration, to minimize delays in context switching. See Section 13.4.7.14, “Control of Spin Lock Polling”.
- Preventing one-time operations such as table scans from interfering with the frequently accessed data stored in the `InnoDB` buffer cache. See Section 13.4.7.15, “Making Buffer Pool Scan Resistant”.
- Adjusting your log files to a size that makes sense for reliability and crash recovery. See Section 13.4.7.16, “Improvements to Crash Recovery Performance”. Historically, people have kept their `InnoDB` log files small to avoid long startup times after a crash. Internal improvements in `InnoDB` make startup much faster, so the log file size is not such a performance factor anymore. If your log files are artificially small, increasing the size can help performance by reducing the I/O that occurs as redo log records are recycled.
- Configuring the size and number of instances for the `InnoDB` buffer pool, especially important for systems with multi-gigabyte buffer pools. See Section 13.4.7.18, “Improvements to Performance from Multiple Buffer Pools”.
- Increasing the maximum number of concurrent transactions, which dramatically improves scalability for the busiest databases. See Section 13.4.7.19, “Better Scalability with Multiple Rollback Segments”. Although this feature does not require any action during day-to-day operation, you must perform a slow shutdown during or after upgrading the database to MySQL 5.5 to enable the higher limit.
- Moving purge operations (a type of garbage collection) into a background thread. See Section 13.4.7.20, “Better Scalability with Improved Purge Scheduling”. To effectively measure the results of this setting, tune the other I/O-related and thread-related configuration settings first.
- Reducing the amount of switching that `InnoDB` does between concurrent threads, so that SQL operations on a busy server do not queue up and form a “traffic jam”. Set a value for the `innodb_thread_concurrency` option, up to approximately 32 for a high-powered modern system. Increase the value for the `innodb_concurrency_tickets` option, typically to 5000 or so, This combination of options sets a cap on the number of threads that `InnoDB` processes at any one time, and allows each thread to do substantial work before being swapped out, so that the number of waiting threads stays low and operations can complete without excessive context switching.

7.5.9. Optimizing `InnoDB` for Systems with Many Tables

- `InnoDB` computes index cardinality values for a table the first time that table is accessed after startup, instead of storing such values in the table. This step can take significant time on systems that partition the data into many tables. Since this overhead only applies to the initial table open operation, to “warm up” a table for later use, access it immediately after startup by issuing a statement such as `SELECT 1 FROM` *`tbl_name`* `LIMIT 1`.

7.6. Optimizing for `MyISAM` Tables

The `MyISAM` storage engine performs best with read-mostly data or with low-concurrency operations, because table locks limit the ability to perform simultaneous updates. In MySQL 5.5, `InnoDB` is the default storage engine rather than `MyISAM`.

7.6.1. Optimizing `MyISAM` Queries

Some general tips for speeding up queries on `MyISAM` tables:

- To help MySQL better optimize queries, use `ANALYZE TABLE` or run `myisamchk --analyze` on a table after it has been loaded with data. This updates a value for each index part that indicates the average number of rows that have the same value. (For unique indexes, this is always 1.) MySQL uses this to decide which index to choose when you join two tables based on a nonconstant expression. You can check the result from the table analysis by using `SHOW INDEX FROM tbl_name` and examining the `Cardinality` value. `myisamchk --description --verbose` shows index distribution information.
- To sort an index and data according to an index, use `myisamchk --sort-index --sort-records=1` (assuming that you want to sort on index 1). This is a good way to make queries faster if you have a unique index from which you want to read all rows in order according to the index. The first time you sort a large table this way, it may take a long time.
- Try to avoid complex `SELECT` queries on `MyISAM` tables that are updated frequently, to avoid problems with table locking that occur due to contention between readers and writers.
- `MyISAM` supports concurrent inserts: If a table has no free blocks in the middle of the data file, you can `INSERT` new rows into it at the same time that other threads are reading from the table. If it is important to be able to do this, consider using the table in ways that avoid deleting rows. Another possibility is to run `OPTIMIZE TABLE` to defragment the table after you have deleted a lot of rows from it. This behavior is altered by setting the `concurrent_insert` variable. You can force new rows to be appended (and therefore permit concurrent inserts), even in tables that have deleted rows. See Section 7.10.3, “Concurrent Inserts”.
- For `MyISAM` tables that change frequently, try to avoid all variable-length columns (`VARCHAR`, `BLOB`, and `TEXT`). The table uses dynamic row format if it includes even a single variable-length column. See Chapter 13, *Storage Engines*.
- It is normally not useful to split a table into different tables just because the rows become large. In accessing a row, the biggest performance hit is the disk seek needed to find the first byte of the row. After finding the data, most modern disks can read the entire row fast enough for most applications. The only cases where splitting up a table makes an appreciable difference is if it is a `MyISAM` table using dynamic row format that you can change to a fixed row size, or if you very often need to scan the table but do not need most of the columns. See Chapter 13, *Storage Engines*.
- Use `ALTER TABLE ... ORDER BY expr1, expr2, ...` if you usually retrieve rows in `expr1, expr2, ...` order. By using this option after extensive changes to the table, you may be able to get higher performance.
- If you often need to calculate results such as counts based on information from a lot of rows, it may be preferable to introduce a new table and update the counter in real time. An update of the following form is very fast:

  ```
  UPDATE tbl_name SET count_col=count_col+1 WHERE key_col=constant;
  ```

  This is very important when you use MySQL storage engines such as `MyISAM` that has only table-level locking (multiple readers with single writers). This also gives better performance with most database systems, because the row locking manager in this case has less to do.
- Use `INSERT DELAYED` when you do not need to know when your data is written. This reduces the overall insertion impact because many rows can be written with a single disk write.
- Use `INSERT LOW_PRIORITY` when you want to give `SELECT` statements higher priority than your inserts.

  Use `SELECT HIGH_PRIORITY` to get retrievals that jump the queue. That is, the `SELECT` is executed even if there is another client waiting to do a write.

  `LOW_PRIORITY` and `HIGH_PRIORITY` have an effect only for storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`).
- Use `OPTIMIZE TABLE` periodically to avoid fragmentation with dynamic-format `MyISAM` tables. See Section 13.5.3, “`MyISAM` Table Storage Formats”.
- Declaring a `MyISAM` table with the `DELAY_KEY_WRITE=1` table option makes index updates faster because they are not flushed to disk until the table is closed. The downside is that if something kills the server while such a table is open, you must ensure that the table is okay by running the server with the `--myisam-recover-options` option, or by running `myisamchk` before restarting the server. (However, even in this case, you should not lose anything by using `DELAY_KEY_WRITE`, because the key information can always be generated from the data rows.)
- Strings are automatically prefix- and end-space compressed in `MyISAM` indexes. See Section 12.1.11, “`CREATE INDEX` Syntax”.

- You can increase performance by caching queries or answers in your application and then executing many inserts or updates together. Locking the table during this operation ensures that the index cache is only flushed once after all updates. You can also take advantage of MySQL's query cache to achieve similar results; see Section 7.9.3, "The MySQL Query Cache".

7.6.2. Bulk Data Loading for `MyISAM` Tables

These performance tips supplement the general guidelines for fast inserts in Section 7.2.2.1, "Speed of `INSERT` Statements".

- To improve performance when multiple clients insert a lot of rows, use the `INSERT DELAYED` statement. See Section 12.2.5.2, "`INSERT DELAYED` Syntax". This technique works for `MyISAM` and some other storage engines, but not `InnoDB`.
- For a `MyISAM` table, you can use concurrent inserts to add rows at the same time that `SELECT` statements are running, if there are no deleted rows in middle of the data file. See Section 7.10.3, "Concurrent Inserts".
- With some extra work, it is possible to make `LOAD DATA INFILE` run even faster for a `MyISAM` table when the table has many indexes. Use the following procedure:

  1. Execute a `FLUSH TABLES` statement or a `mysqladmin flush-tables` command.
  2. Use `myisamchk --keys-used=0 -rq /path/to/db/tbl_name` to remove all use of indexes for the table.
  3. Insert data into the table with `LOAD DATA INFILE`. This does not update any indexes and therefore is very fast.
  4. If you intend only to read from the table in the future, use `myisampack` to compress it. See Section 13.5.3.3, "Compressed Table Characteristics".
  5. Re-create the indexes with `myisamchk -rq /path/to/db/tbl_name`. This creates the index tree in memory before writing it to disk, which is much faster that updating the index during `LOAD DATA INFILE` because it avoids lots of disk seeks. The resulting index tree is also perfectly balanced.
  6. Execute a `FLUSH TABLES` statement or a `mysqladmin flush-tables` command.

  `LOAD DATA INFILE` performs the preceding optimization automatically if the `MyISAM` table into which you insert data is empty. The main difference between automatic optimization and using the procedure explicitly is that you can let `myisamchk` allocate much more temporary memory for the index creation than you might want the server to allocate for index re-creation when it executes the `LOAD DATA INFILE` statement.

  You can also disable or enable the nonunique indexes for a `MyISAM` table by using the following statements rather than `myisamchk`. If you use these statements, you can skip the `FLUSH TABLE` operations:

  ```
  ALTER TABLE tbl_name DISABLE KEYS;
  ALTER TABLE tbl_name ENABLE KEYS;
  ```

- To speed up `INSERT` operations that are performed with multiple statements for nontransactional tables, lock your tables:

  ```
  LOCK TABLES a WRITE;
  INSERT INTO a VALUES (1,23),(2,34),(4,33);
  INSERT INTO a VALUES (8,26),(6,29);
  ...
  UNLOCK TABLES;
  ```

  This benefits performance because the index buffer is flushed to disk only once, after all `INSERT` statements have completed. Normally, there would be as many index buffer flushes as there are `INSERT` statements. Explicit locking statements are not needed if you can insert all rows with a single `INSERT`.

  Locking also lowers the total time for multiple-connection tests, although the maximum wait time for individual connections might go up because they wait for locks. Suppose that five clients attempt to perform inserts simultaneously as follows:

  - Connection 1 does 1000 inserts
  - Connections 2, 3, and 4 do 1 insert
  - Connection 5 does 1000 inserts

  If you do not use locking, connections 2, 3, and 4 finish before 1 and 5. If you use locking, connections 2, 3, and 4 probably do not finish before 1 or 5, but the total time should be about 40% faster.

  `INSERT`, `UPDATE`, and `DELETE` operations are very fast in MySQL, but you can obtain better overall performance by adding locks around everything that does more than about five successive inserts or updates. If you do very many successive inserts, you could do a `LOCK TABLES` followed by an `UNLOCK TABLES` once in a while (each 1,000 rows or so) to permit other threads to access table. This would still result in a nice performance gain.

`INSERT` is still much slower for loading data than `LOAD DATA INFILE`, even when using the strategies just outlined.

- To increase performance for `MyISAM` tables, for both `LOAD DATA INFILE` and `INSERT`, enlarge the key cache by increasing the `key_buffer_size` system variable. See Section 7.11.2, "Tuning Server Parameters".

7.6.3. Speed of `REPAIR TABLE` Statements

`REPAIR TABLE` for `MyISAM` tables is similar to using `myisamchk` for repair operations, and some of the same performance optimizations apply:

- `myisamchk` has variables that control memory allocation. You may be able to its improve performance by setting these variables, as described in Section 4.6.3.6, "`myisamchk` Memory Usage".
- For `REPAIR TABLE`, the same principle applies, but because the repair is done by the server, you set server system variables instead of `myisamchk` variables. Also, in addition to setting memory-allocation variables, increasing the `myisam_max_sort_file_size` system variable increases the likelihood that the repair will use the faster filesort method and avoid the slower repair by key cache method. Set the variable to the maximum file size for your system, after checking to be sure that there is enough free space to hold a copy of the table files. The free space must be available in the file system containing the original table files.

Suppose that a `myisamchk` table-repair operation is done using the following options to set its memory-allocation variables:

```
--key_buffer_size=128M --sort_buffer_size=256M
--read_buffer_size=64M --write_buffer_size=64M
```

Some of those `myisamchk` variables correspond to server system variables:

`myisamchk` Variable	**System Variable**
`key_buffer_size`	`key_buffer_size`
`sort_buffer_size`	`myisam_sort_buffer_size`
`read_buffer_size`	`read_buffer_size`
`write_buffer_size`	none

Each of the server system variables can be set at runtime, and some of them (`myisam_sort_buffer_size`, `read_buffer_size`) have a session value in addition to a global value. Setting a session value limits the effect of the change to your current session and does not affect other users. Changing a global-only variable (`key_buffer_size`, `myisam_max_sort_file_size`) affects other users as well. For `key_buffer_size`, you must take into account that the buffer is shared with those users. For example, if you set the `myisamchk` `key_buffer_size` variable to 128MB, you could set the corresponding `key_buffer_size` system variable larger than that (if it is not already set larger), to permit key buffer use by activity in other sessions. However, changing the global key buffer size invalidates the buffer, causing increased disk I/O and slowdown for other sessions. An alternative that avoids this problem is to use a separate key cache, assign to it the indexes from the table to be repaired, and deallocate it when the repair is complete. See Section 7.9.2.2, "Multiple Key Caches".

Based on the preceding remarks, a `REPAIR TABLE` operation can be done as follows to use settings similar to the `myisamchk` command. Here a separate 128MB key buffer is allocated and the file system is assumed to permit a file size of at least 100GB.

```
SET SESSION myisam_sort_buffer_size = 256*1024*1024;
SET SESSION read_buffer_size = 64*1024*1024;
SET GLOBAL myisam_max_sort_file_size = 100*1024*1024*1024;
SET GLOBAL repair_cache.key_buffer_size = 128*1024*1024;
CACHE INDEX tbl_name IN repair_cache;
LOAD INDEX INTO CACHE tbl_name;
REPAIR TABLE tbl_name ;
SET GLOBAL repair_cache.key_buffer_size = 0;
```

If you intend to change a global variable but want to do so only for the duration of a `REPAIR TABLE` operation to minimally affect other users, save its value in a user variable and restore it afterward. For example:

```
SET @old_myisam_sort_buffer_size = @@global.myisam_max_sort_file_size;
SET GLOBAL myisam_max_sort_file_size = 100*1024*1024*1024;
REPAIR TABLE tbl_name ;
SET GLOBAL myisam_max_sort_file_size = @old_myisam_max_sort_file_size;
```

The system variables that affect `REPAIR TABLE` can be set globally at server startup if you want the values to be in effect by default. For example, add these lines to the server `my.cnf` file:

```
[mysqld]
myisam_sort_buffer_size=256M
key_buffer_size=1G
myisam_max_sort_file_size=100G
```

These settings do not include `read_buffer_size`. Setting `read_buffer_size` globally to a large value does so for all sessions and can cause performance to suffer due to excessive memory allocation for a server with many simultaneous sessions.

7.7. Optimizing for `MEMORY` Tables

Consider using `MEMORY` tables for noncritical data that is accessed often, and is read-only or rarely updated. Benchmark your application against equivalent `InnoDB` or `MyISAM` tables under a realistic workload, to confirm that any additional performance is worth the risk of losing data, or the overhead of copying data from a disk-based table at application start.

For best performance with `MEMORY` tables, examine the kinds of queries against each table, and specify the type to use for each associated index, either a B-tree index or a hash index. On the `CREATE INDEX` statement, use the clause `USING BTREE` or `USING HASH`. B-tree indexes are fast for queries that do greater-than or less-than comparisons through operators such as `>` or `BETWEEN`. Hash indexes are only fast for queries that look up single values through the `=` operator, or a restricted set of values through the `IN` operator. For why `USING BTREE` is often a better choice than the default `USING HASH`, see Section 7.2.1.4, "How to Avoid Table Scans". For implementation details of the different types of `MEMORY` indexes, see Section 7.3.8, "Comparison of B-Tree and Hash Indexes".

7.8. Understanding the Query Execution Plan

Depending on the details of your tables, columns, indexes, and the conditions in your `WHERE` clause, the MySQL optimizer considers many techniques to efficiently perform the lookups involved in an SQL query. A query on a huge table can be performed without reading all the rows; a join involving several tables can be performed without comparing every combination of rows. The set of operations that the optimizer chooses to perform the most efficient query is called the "query execution plan", also known as the `EXPLAIN` plan. Your goals are to recognize the aspects of the `EXPLAIN` plan that indicate a query is optimized well, and to learn the SQL syntax and indexing techniques to improve the plan if you see some inefficient operations.

7.8.1. Optimizing Queries with `EXPLAIN`

The `EXPLAIN` statement can be used either as a way to obtain information about how MySQL executes a `SELECT` statement or as a synonym for `DESCRIBE`:

- When you precede a `SELECT` statement with the keyword `EXPLAIN`, MySQL displays information from the optimizer about the query execution plan. That is, MySQL explains how it would process the `SELECT`, including information about how tables are joined and in which order. `EXPLAIN EXTENDED` can be used to provide additional information.

  The following sections describe how to use `EXPLAIN` and `EXPLAIN EXTENDED` to obtain query execution plan information.

- `EXPLAIN PARTITIONS` is useful only when examining queries involving partitioned tables. For details, see Section 16.3.4, "Obtaining Information About Partitions".

- `EXPLAIN` *`tbl_name`* is synonymous with `DESCRIBE` *`tbl_name`* or `SHOW COLUMNS FROM` *`tbl_name`*.

  For a description of the `DESCRIBE` and `SHOW COLUMNS` statements, see Section 12.8.1, "`DESCRIBE` Syntax", and Section 12.4.5.6, "`SHOW COLUMNS` Syntax".

With the help of `EXPLAIN`, you can see where you should add indexes to tables to get a faster `SELECT` that uses indexes to find rows. You can also use `EXPLAIN` to check whether the optimizer joins the tables in an optimal order. To give a hint to the optimizer to use a join order corresponding to the order in which the tables are named in the `SELECT` statement, begin the statement with `SELECT STRAIGHT_JOIN` rather than just `SELECT`. (See Section 12.2.9, "`SELECT` Syntax".)

If you have a problem with indexes not being used when you believe that they should be, run `ANALYZE TABLE` to update table statistics such as cardinality of keys, that can affect the choices the optimizer makes. See Section 12.4.2.1, "`ANALYZE TABLE` Syntax".

7.8.2. `EXPLAIN` Output Format

`EXPLAIN` returns a row of information for each table used in the `SELECT` statement. The tables are listed in the output in the order that MySQL would read them while processing the query. MySQL resolves all joins using a nested-loop join method. This means that MySQL reads a row from the first table, and then finds a matching row in the second table, the third table, and so on. When all tables are processed, MySQL outputs the selected columns and backtracks through the table list until a table is found for which there are more matching rows. The next row is read from this table and the process continues with the next table.

When the `EXTENDED` keyword is used, `EXPLAIN` produces extra information that can be viewed by issuing a `SHOW WARNINGS` statement following the `EXPLAIN` statement. This information displays how the optimizer qualifies table and column names in the `SELECT` statement, what the `SELECT` looks like after the application of rewriting and optimization rules, and possibly other notes about the optimization process. `EXPLAIN EXTENDED` also displays the `filtered` column.

> **Note**
>
> You cannot use the `EXTENDED` and `PARTITIONS` keywords together in the same `EXPLAIN` statement.

Each output row from `EXPLAIN` provides information about one table. Each row contains the values summarized in Table 7.1, “`EXPLAIN` Output Columns”, and described in more detail following the table.

Table 7.1. `EXPLAIN` Output Columns

Column	Meaning
`id`	The `SELECT` identifier
`select_type`	The `SELECT` type
`table`	The table for the output row
`type`	The join type
`possible_keys`	The possible indexes to choose
`key`	The index actually chosen
`key_len`	The length of the chosen key
`ref`	The columns compared to the index
`rows`	Estimate of rows to be examined
`Extra`	Additional information

- `id`

  The `SELECT` identifier. This is the sequential number of the `SELECT` within the query.

- `select_type`

  The type of `SELECT`, which can be any of those shown in the following table.

`select_type` Value	Meaning
`SIMPLE`	Simple `SELECT` (not using `UNION` or subqueries)
`PRIMARY`	Outermost `SELECT`
`UNION`	Second or later `SELECT` statement in a `UNION`
`DEPENDENT UNION`	Second or later `SELECT` statement in a `UNION`, dependent on outer query
`UNION RESULT`	Result of a `UNION`.
`SUBQUERY`	First `SELECT` in subquery
`DEPENDENT SUBQUERY`	First `SELECT` in subquery, dependent on outer query
`DERIVED`	Derived table `SELECT` (subquery in `FROM` clause)
`UNCACHEABLE SUBQUERY`	A subquery for which the result cannot be cached and must be re-evaluated for each row of the outer query
`UNCACHEABLE UNION`	The second or later select in a `UNION` that belongs to an uncacheable subquery (see `UNCACHEABLE SUBQUERY`)

`DEPENDENT` typically signifies the use of a correlated subquery. See Section 12.2.10.7, “Correlated Subqueries”.

`DEPENDENT SUBQUERY` evaluation differs from `UNCACHEABLE SUBQUERY` evaluation. For `DEPENDENT SUBQUERY`, the subquery is re-evaluated only once for each set of different values of the variables from its outer context. For `UNCACHEABLE SUBQUERY`, the subquery is re-evaluated for each row of the outer context. Cacheability of subqueries is subject to the restrictions detailed in Section 7.9.3.1, “How the Query Cache Operates”. For example, referring to user variables makes a subquery uncacheable.

- `table`

  The table to which the row of output refers.

- `type`

  The join type. The different join types are listed here, ordered from the best type to the worst:

  - `system`

    The table has only one row (= system table). This is a special case of the `const` join type.

  - `const`

    The table has at most one matching row, which is read at the start of the query. Because there is only one row, values from the column in this row can be regarded as constants by the rest of the optimizer. `const` tables are very fast because they are read only once.

    `const` is used when you compare all parts of a `PRIMARY KEY` or `UNIQUE` index to constant values. In the following queries, *`tbl_name`* can be used as a `const` table:

    ```
    SELECT * FROM tbl_name WHERE primary_key=1;

    SELECT * FROM tbl_name
      WHERE primary_key_part1=1 AND primary_key_part2=2;
    ```

  - `eq_ref`

    One row is read from this table for each combination of rows from the previous tables. Other than the `system` and `const` types, this is the best possible join type. It is used when all parts of an index are used by the join and the index is a `PRIMARY KEY` or `UNIQUE NOT NULL` index.

    `eq_ref` can be used for indexed columns that are compared using the `=` operator. The comparison value can be a constant or an expression that uses columns from tables that are read before this table. In the following examples, MySQL can use an `eq_ref` join to process *`ref_table`*:

    ```
    SELECT * FROM ref_table,other_table
      WHERE ref_table.key_column=other_table.column;

    SELECT * FROM ref_table,other_table
      WHERE ref_table.key_column_part1=other_table.column
      AND ref_table.key_column_part2=1;
    ```

  - `ref`

    All rows with matching index values are read from this table for each combination of rows from the previous tables. `ref` is used if the join uses only a leftmost prefix of the key or if the key is not a `PRIMARY KEY` or `UNIQUE` index (in other words, if the join cannot select a single row based on the key value). If the key that is used matches only a few rows, this is a good join type.

    `ref` can be used for indexed columns that are compared using the `=` or `<=>` operator. In the following examples, MySQL can use a `ref` join to process *`ref_table`*:

    ```
    SELECT * FROM ref_table WHERE key_column=expr;

    SELECT * FROM ref_table,other_table
      WHERE ref_table.key_column=other_table.column;

    SELECT * FROM ref_table,other_table
      WHERE ref_table.key_column_part1=other_table.column
      AND ref_table.key_column_part2=1;
    ```

  - `fulltext`

    The join is performed using a `FULLTEXT` index.

  - `ref_or_null`

    This join type is like `ref`, but with the addition that MySQL does an extra search for rows that contain `NULL` values. This join type optimization is used most often in resolving subqueries. In the following examples, MySQL can use a `ref_or_null` join to process *`ref_table`*:

```
SELECT * FROM ref_table
  WHERE key_column=expr OR key_column IS NULL;
```

See Section 7.13.4, “`IS NULL` Optimization”.

- `index_merge`

  This join type indicates that the Index Merge optimization is used. In this case, the `key` column in the output row contains a list of indexes used, and `key_len` contains a list of the longest key parts for the indexes used. For more information, see Section 7.13.2, “Index Merge Optimization”.

- `unique_subquery`

  This type replaces `ref` for some `IN` subqueries of the following form:

  ```
  value IN (SELECT primary_key FROM single_table WHERE some_expr)
  ```

  `unique_subquery` is just an index lookup function that replaces the subquery completely for better efficiency.

- `index_subquery`

  This join type is similar to `unique_subquery`. It replaces `IN` subqueries, but it works for nonunique indexes in subqueries of the following form:

  ```
  value IN (SELECT key_column FROM single_table WHERE some_expr)
  ```

- `range`

  Only rows that are in a given range are retrieved, using an index to select the rows. The `key` column in the output row indicates which index is used. The `key_len` contains the longest key part that was used. The `ref` column is `NULL` for this type.

  `range` can be used when a key column is compared to a constant using any of the `=`, `<>`, `>`, `>=`, `<`, `<=`, `IS NULL`, `<=>`, `BETWEEN`, or `IN()` operators:

  ```
  SELECT * FROM tbl_name
    WHERE key_column = 10;

  SELECT * FROM tbl_name
    WHERE key_column BETWEEN 10 and 20;

  SELECT * FROM tbl_name
    WHERE key_column IN (10,20,30);

  SELECT * FROM tbl_name
    WHERE key_part1 = 10 AND key_part2 IN (10,20,30);
  ```

- `index`

  This join type is the same as `ALL`, except that only the index tree is scanned. This usually is faster than `ALL` because the index file usually is smaller than the data file.

  MySQL can use this join type when the query uses only columns that are part of a single index.

- `ALL`

  A full table scan is done for each combination of rows from the previous tables. This is normally not good if the table is the first table not marked `const`, and usually *very* bad in all other cases. Normally, you can avoid `ALL` by adding indexes that enable row retrieval from the table based on constant values or column values from earlier tables.

- `possible_keys`

  The `possible_keys` column indicates which indexes MySQL can choose from use to find the rows in this table. Note that this column is totally independent of the order of the tables as displayed in the output from `EXPLAIN`. That means that some of the keys in `possible_keys` might not be usable in practice with the generated table order.

  If this column is `NULL`, there are no relevant indexes. In this case, you may be able to improve the performance of your query by examining the `WHERE` clause to check whether it refers to some column or columns that would be suitable for indexing. If so, create an appropriate index and check the query with `EXPLAIN` again. See Section 12.1.6, “`ALTER TABLE` Syntax”.

  To see what indexes a table has, use `SHOW INDEX FROM tbl_name`.

- `key`

  The `key` column indicates the key (index) that MySQL actually decided to use. If MySQL decides to use one of the `possible_keys` indexes to look up rows, that index is listed as the key value.

  It is possible that `key` will name an index that is not present in the `possible_keys` value. This can happen if none of the `possible_keys` indexes are suitable for looking up rows, but all the columns selected by the query are columns of some other index. That is, the named index covers the selected columns, so although it is not used to determine which rows to retrieve, an index scan is more efficient than a data row scan.

  For `InnoDB`, a secondary index might cover the selected columns even if the query also selects the primary key because `InnoDB` stores the primary key value with each secondary index. If `key` is `NULL`, MySQL found no index to use for executing the query more efficiently.

  To force MySQL to use or ignore an index listed in the `possible_keys` column, use `FORCE INDEX`, `USE INDEX`, or `IGNORE INDEX` in your query. See Section 12.2.9.2, "Index Hint Syntax".

  For `MyISAM` tables, running `ANALYZE TABLE` helps the optimizer choose better indexes. For `MyISAM` tables, `myisamchk --analyze` does the same. See Section 12.4.2.1, "`ANALYZE TABLE` Syntax", and Section 6.6, "`MyISAM` Table Maintenance and Crash Recovery".

- `key_len`

  The `key_len` column indicates the length of the key that MySQL decided to use. The length is `NULL` if the `key` column says `NULL`. Note that the value of `key_len` enables you to determine how many parts of a multiple-part key MySQL actually uses.

- `ref`

  The `ref` column shows which columns or constants are compared to the index named in the `key` column to select rows from the table.

- `rows`

  The `rows` column indicates the number of rows MySQL believes it must examine to execute the query.

  For `InnoDB` tables, this number is an estimate, and may not always be exact.

- `filtered`

  The `filtered` column indicates an estimated percentage of table rows that will be filtered by the table condition. That is, `rows` shows the estimated number of rows examined and `rows` × `filtered` / `100` shows the number of rows that will be joined with previous tables. This column is displayed if you use `EXPLAIN EXTENDED`.

- `Extra`

  This column contains additional information about how MySQL resolves the query. The following list explains the values that can appear in this column. If you want to make your queries as fast as possible, look out for `Extra` values of `Using filesort` and `Using temporary`.

  - `const row not found`

    For a query such as `SELECT ... FROM` *`tbl_name`*, the table was empty.

  - `Distinct`

    MySQL is looking for distinct values, so it stops searching for more rows for the current row combination after it has found the first matching row.

  - `Full scan on NULL key`

    This occurs for subquery optimization as a fallback strategy when the optimizer cannot use an index-lookup access method.

  - `Impossible HAVING`

    The `HAVING` clause is always false and cannot select any rows.

  - `Impossible WHERE`

    The `WHERE` clause is always false and cannot select any rows.

  - `Impossible WHERE noticed after reading const tables`

MySQL has read all `const` (and `system`) tables and notice that the `WHERE` clause is always false.

- `No matching min/max row`

  No row satisfies the condition for a query such as `SELECT MIN(...) FROM ... WHERE condition`.

- `no matching row in const table`

  For a query with a join, there was an empty table or a table with no rows satisfying a unique index condition.

- `No tables used`

  The query has no `FROM` clause, or has a `FROM DUAL` clause.

- `Not exists`

  MySQL was able to do a `LEFT JOIN` optimization on the query and does not examine more rows in this table for the previous row combination after it finds one row that matches the `LEFT JOIN` criteria. Here is an example of the type of query that can be optimized this way:

  ```
  SELECT * FROM t1 LEFT JOIN t2 ON t1.id=t2.id
    WHERE t2.id IS NULL;
  ```

  Assume that `t2.id` is defined as `NOT NULL`. In this case, MySQL scans `t1` and looks up the rows in `t2` using the values of `t1.id`. If MySQL finds a matching row in `t2`, it knows that `t2.id` can never be `NULL`, and does not scan through the rest of the rows in `t2` that have the same `id` value. In other words, for each row in `t1`, MySQL needs to do only a single lookup in `t2`, regardless of how many rows actually match in `t2`.

- `Range checked for each record (index map: N)`

  MySQL found no good index to use, but found that some of indexes might be used after column values from preceding tables are known. For each row combination in the preceding tables, MySQL checks whether it is possible to use a `range` or `index_merge` access method to retrieve rows. This is not very fast, but is faster than performing a join with no index at all. The applicability criteria are as described in Section 7.13.1, “Range Optimization”, and Section 7.13.2, “Index Merge Optimization”, with the exception that all column values for the preceding table are known and considered to be constants.

  Indexes are numbered beginning with 1, in the same order as shown by `SHOW INDEX` for the table. The index map value *`N`* is a bitmask value that indicates which indexes are candidates. For example, a value of `0x19` (binary 11001) means that indexes 1, 4, and 5 will be considered.

- `Scanned N databases`

  This indicates how many directory scans the server performs when processing a query for `INFORMATION_SCHEMA` tables, as described in Section 7.2.4, “Optimizing `INFORMATION_SCHEMA` Queries”. The value of *`N`* can be 0, 1, or `all`.

- `Select tables optimized away`

  The query contained only aggregate functions (`MIN()`, `MAX()`) that were all resolved using an index, or `COUNT(*)` for `MyISAM`, and no `GROUP BY` clause. The optimizer determined that only one row should be returned.

- `Skip_open_table`, `Open_frm_only`, `Open_trigger_only`, `Open_full_table`

  These values indicate file-opening optimizations that apply to queries for `INFORMATION_SCHEMA` tables, as described in Section 7.2.4, “Optimizing `INFORMATION_SCHEMA` Queries”.

  - `Skip_open_table`: Table files do not need to be opened. The information has already become available within the query by scanning the database directory.
  - `Open_frm_only`: Only the table's `.frm` file need be opened.
  - `Open_trigger_only`: Only the table's `.TRG` file need be opened.
  - `Open_full_table`: The unoptimized information lookup. The `.frm`, `.MYD`, and `.MYI` files must be opened.

- `unique row not found`

  For a query such as `SELECT ... FROM tbl_name`, no rows satisfy the condition for a `UNIQUE` index or `PRIMARY KEY` on the table.

- `Using filesort`

  MySQL must do an extra pass to find out how to retrieve the rows in sorted order. The sort is done by going through all rows according to the join type and storing the sort key and pointer to the row for all rows that match the `WHERE` clause. The keys then are sorted and the rows are retrieved in sorted order. See Section 7.13.9, “`ORDER BY` Optimization”.

- `Using index`

  The column information is retrieved from the table using only information in the index tree without having to do an additional seek to read the actual row. This strategy can be used when the query uses only columns that are part of a single index.

  For `InnoDB` tables that have a user-defined clustered index, that index can be used even when `Using index` is absent from the `Extra` column. This is the case if `type` is `index` and `key` is `PRIMARY`.

- `Using index for group-by`

  Similar to the `Using index` table access method, `Using index for group-by` indicates that MySQL found an index that can be used to retrieve all columns of a `GROUP BY` or `DISTINCT` query without any extra disk access to the actual table. Additionally, the index is used in the most efficient way so that for each group, only a few index entries are read. For details, see Section 7.13.10, “`GROUP BY` Optimization”.

- `Using join buffer`

  Tables from earlier joins are read in portions into the join buffer, and then their rows are used from the buffer to perform the join with the current table.

- `Using sort_union(...)`, `Using union(...)`, `Using intersect(...)`

  These indicate how index scans are merged for the `index_merge` join type. See Section 7.13.2, “Index Merge Optimization”.

- `Using temporary`

  To resolve the query, MySQL needs to create a temporary table to hold the result. This typically happens if the query contains `GROUP BY` and `ORDER BY` clauses that list columns differently.

- `Using where`

  A `WHERE` clause is used to restrict which rows to match against the next table or send to the client. Unless you specifically intend to fetch or examine all rows from the table, you may have something wrong in your query if the `Extra` value is not `Using where` and the table join type is `ALL` or `index`. Even if you are using an index for all parts of a `WHERE` clause, you may see `Using where` if the column can be `NULL`.

- `Using where with pushed condition`

  This item applies to `NDBCLUSTER` tables *only*. It means that MySQL Cluster is using the Condition Pushdown optimization to improve the efficiency of a direct comparison between a nonindexed column and a constant. In such cases, the condition is “pushed down” to the cluster's data nodes and is evaluated on all data nodes simultaneously. This eliminates the need to send nonmatching rows over the network, and can speed up such queries by a factor of 5 to 10 times over cases where Condition Pushdown could be but is not used. For more information, see Section 7.13.3, “Engine Condition Pushdown Optimization”.

You can get a good indication of how good a join is by taking the product of the values in the `rows` column of the `EXPLAIN` output. This should tell you roughly how many rows MySQL must examine to execute the query. If you restrict queries with the `max_join_size` system variable, this row product also is used to determine which multiple-table `SELECT` statements to execute and which to abort. See Section 7.11.2, “Tuning Server Parameters”.

The following example shows how a multiple-table join can be optimized progressively based on the information provided by `EXPLAIN`.

Suppose that you have the `SELECT` statement shown here and that you plan to examine it using `EXPLAIN`:

```
EXPLAIN SELECT tt.TicketNumber, tt.TimeIn,
               tt.ProjectReference, tt.EstimatedShipDate,
               tt.ActualShipDate, tt.ClientID,
               tt.ServiceCodes, tt.RepetitiveID,
               tt.CurrentProcess, tt.CurrentDPPerson,
               tt.RecordVolume, tt.DPPrinted, et.COUNTRY,
               et_1.COUNTRY, do.CUSTNAME
        FROM tt, et, et AS et_1, do
        WHERE tt.SubmitTime IS NULL
```

```
          AND tt.ActualPC = et.EMPLOYID
          AND tt.AssignedPC = et_1.EMPLOYID
          AND tt.ClientID = do.CUSTNMBR;
```

For this example, make the following assumptions:

- The columns being compared have been declared as follows.

Table	Column	Data Type
`tt`	`ActualPC`	`CHAR(10)`
`tt`	`AssignedPC`	`CHAR(10)`
`tt`	`ClientID`	`CHAR(10)`
`et`	`EMPLOYID`	`CHAR(15)`
`do`	`CUSTNMBR`	`CHAR(15)`

- The tables have the following indexes.

Table	Index
`tt`	`ActualPC`
`tt`	`AssignedPC`
`tt`	`ClientID`
`et`	`EMPLOYID` (primary key)
`do`	`CUSTNMBR` (primary key)

- The `tt.ActualPC` values are not evenly distributed.

Initially, before any optimizations have been performed, the `EXPLAIN` statement produces the following information:

```
table type possible_keys key  key_len ref  rows  Extra
et    ALL  PRIMARY       NULL NULL    NULL 74
do    ALL  PRIMARY       NULL NULL    NULL 2135
et_1  ALL  PRIMARY       NULL NULL    NULL 74
tt    ALL  AssignedPC,   NULL NULL    NULL 3872
           ClientID,
           ActualPC
      Range checked for each record (index map: 0x23)
```

Because `type` is `ALL` for each table, this output indicates that MySQL is generating a Cartesian product of all the tables; that is, every combination of rows. This takes quite a long time, because the product of the number of rows in each table must be examined. For the case at hand, this product is 74 × 2135 × 74 × 3872 = 45,268,558,720 rows. If the tables were bigger, you can only imagine how long it would take.

One problem here is that MySQL can use indexes on columns more efficiently if they are declared as the same type and size. In this context, `VARCHAR` and `CHAR` are considered the same if they are declared as the same size. `tt.ActualPC` is declared as `CHAR(10)` and `et.EMPLOYID` is `CHAR(15)`, so there is a length mismatch.

To fix this disparity between column lengths, use `ALTER TABLE` to lengthen `ActualPC` from 10 characters to 15 characters:

```
mysql> ALTER TABLE tt MODIFY ActualPC VARCHAR(15);
```

Now `tt.ActualPC` and `et.EMPLOYID` are both `VARCHAR(15)`. Executing the `EXPLAIN` statement again produces this result:

```
table type   possible_keys key     key_len ref         rows    Extra
tt    ALL    AssignedPC,   NULL    NULL    NULL        3872    Using
             ClientID,                                         where
             ActualPC
do    ALL    PRIMARY       NULL    NULL    NULL        2135
      Range checked for each record (index map: 0x1)
et_1  ALL    PRIMARY       NULL    NULL    NULL        74
      Range checked for each record (index map: 0x1)
et    eq_ref PRIMARY       PRIMARY 15      tt.ActualPC 1
```

This is not perfect, but is much better: The product of the `rows` values is less by a factor of 74. This version executes in a couple of seconds.

A second alteration can be made to eliminate the column length mismatches for the `tt.AssignedPC = et_1.EMPLOYID` and `tt.ClientID = do.CUSTNMBR` comparisons:

```
mysql> ALTER TABLE tt MODIFY AssignedPC VARCHAR(15),
    ->                MODIFY ClientID   VARCHAR(15);
```

After that modification, `EXPLAIN` produces the output shown here:

```
table type   possible_keys key      key_len ref           rows Extra
et    ALL    PRIMARY       NULL     NULL    NULL          74
tt    ref    AssignedPC,   ActualPC 15      et.EMPLOYID   52   Using
             ClientID,                                         where
             ActualPC
et_1  eq_ref PRIMARY       PRIMARY  15      tt.AssignedPC 1
do    eq_ref PRIMARY       PRIMARY  15      tt.ClientID   1
```

At this point, the query is optimized almost as well as possible. The remaining problem is that, by default, MySQL assumes that values in the `tt.ActualPC` column are evenly distributed, and that is not the case for the `tt` table. Fortunately, it is easy to tell MySQL to analyze the key distribution:

```
mysql> ANALYZE TABLE tt;
```

With the additional index information, the join is perfect and `EXPLAIN` produces this result:

```
table type   possible_keys key     key_len ref           rows Extra
tt    ALL    AssignedPC    NULL    NULL    NULL          3872 Using
             ClientID,                                        where
             ActualPC
et    eq_ref PRIMARY       PRIMARY 15      tt.ActualPC   1
et_1  eq_ref PRIMARY       PRIMARY 15      tt.AssignedPC 1
do    eq_ref PRIMARY       PRIMARY 15      tt.ClientID   1
```

Note that the `rows` column in the output from `EXPLAIN` is an educated guess from the MySQL join optimizer. Check whether the numbers are even close to the truth by comparing the `rows` product with the actual number of rows that the query returns. If the numbers are quite different, you might get better performance by using `STRAIGHT_JOIN` in your `SELECT` statement and trying to list the tables in a different order in the `FROM` clause.

It is possible in some cases to execute statements that modify data when `EXPLAIN SELECT` is used with a subquery; for more information, see Section 12.2.10.8, “Subqueries in the `FROM` Clause”.

7.8.3. Estimating Query Performance

In most cases, you can estimate query performance by counting disk seeks. For small tables, you can usually find a row in one disk seek (because the index is probably cached). For bigger tables, you can estimate that, using B-tree indexes, you need this many seeks to find a row: `log(`*`row_count`*`) / log(`*`index_block_length`*` / 3 * 2 / (`*`index_length`*` + `*`data_pointer_length`*`)) + 1`.

In MySQL, an index block is usually 1,024 bytes and the data pointer is usually four bytes. For a 500,000-row table with a key value length of three bytes (the size of `MEDIUMINT`), the formula indicates `log(500,000)/log(1024/3*2/(3+4)) + 1` = `4` seeks.

This index would require storage of about 500,000 * 7 * 3/2 = 5.2MB (assuming a typical index buffer fill ratio of 2/3), so you probably have much of the index in memory and so need only one or two calls to read data to find the row.

For writes, however, you need four seek requests to find where to place a new index value and normally two seeks to update the index and write the row.

Note that the preceding discussion does not mean that your application performance slowly degenerates by log *`N`*. As long as everything is cached by the OS or the MySQL server, things become only marginally slower as the table gets bigger. After the data gets too big to be cached, things start to go much slower until your applications are bound only by disk seeks (which increase by log *`N`*). To avoid this, increase the key cache size as the data grows. For `MyISAM` tables, the key cache size is controlled by the `key_buffer_size` system variable. See Section 7.11.2, “Tuning Server Parameters”.

7.8.4. Controlling the Query Optimizer

MySQL provides optimizer control through system variables that affect how query plans are evaluated and which switchable optimizations are enabled.

7.8.4.1. Controlling Query Plan Evaluation

The task of the query optimizer is to find an optimal plan for executing an SQL query. Because the difference in performance between “good” and “bad” plans can be orders of magnitude (that is, seconds versus hours or even days), most query optimizers, including that of MySQL, perform a more or less exhaustive search for an optimal plan among all possible query evaluation plans. For join queries, the number of possible plans investigated by the MySQL optimizer grows exponentially with the number of tables referenced in a query. For small numbers of tables (typically less than 7 to 10) this is not a problem. However, when larger queries are submitted, the time spent in query optimization may easily become the major bottleneck in the server's performance.

A more flexible method for query optimization enables the user to control how exhaustive the optimizer is in its search for an optimal query evaluation plan. The general idea is that the fewer plans that are investigated by the optimizer, the less time it spends in compiling a query. On the other hand, because the optimizer skips some plans, it may miss finding an optimal plan.

The behavior of the optimizer with respect to the number of plans it evaluates can be controlled using two system variables:

- The `optimizer_prune_level` variable tells the optimizer to skip certain plans based on estimates of the number of rows accessed for each table. Our experience shows that this kind of “educated guess” rarely misses optimal plans, and may dramatically reduce query compilation times. That is why this option is on (`optimizer_prune_level=1`) by default. However, if you believe that the optimizer missed a better query plan, this option can be switched off (`optimizer_prune_level=0`) with the risk that query compilation may take much longer. Note that, even with the use of this heuristic, the optimizer still explores a roughly exponential number of plans.

- The `optimizer_search_depth` variable tells how far into the “future” of each incomplete plan the optimizer should look to evaluate whether it should be expanded further. Smaller values of `optimizer_search_depth` may result in orders of magnitude smaller query compilation times. For example, queries with 12, 13, or more tables may easily require hours and even days to compile if `optimizer_search_depth` is close to the number of tables in the query. At the same time, if compiled with `optimizer_search_depth` equal to 3 or 4, the optimizer may compile in less than a minute for the same query. If you are unsure of what a reasonable value is for `optimizer_search_depth`, this variable can be set to 0 to tell the optimizer to determine the value automatically.

7.8.4.2. Controlling Switchable Optimizations

The `optimizer_switch` system variable enables control over optimizer behavior. Its value is a set of flags, each of which has a value of `on` or `off` to indicate whether the corresponding optimizer behavior is enabled or disabled. This variable has global and session values and can be changed at runtime. The global default can be set at server startup.

To see the current set of optimizer flags, select the variable value:

```
mysql> SELECT @@optimizer_switch\G
*************************** 1. row ***************************
@@optimizer_switch: index_merge=on,index_merge_union=on,
                    index_merge_sort_union=on,
                    index_merge_intersection=on,
                    engine_condition_pushdown=on
```

To change the value of `optimizer_switch`, assign a value consisting of a comma-separated list of one or more commands:

```
SET [GLOBAL|SESSION] optimizer_switch='command[,command]...';
```

Each *`command`* value should have one of the forms shown in the following table.

Command Syntax	Meaning
`default`	Reset every optimization to its default value
`opt_name``=default`	Set the named optimization to its default value
`opt_name``=off`	Disable the named optimization
`opt_name``=on`	Enable the named optimization

The order of the commands in the value does not matter, although the `default` command is executed first if present. Setting an *`opt_name`* flag to `default` sets it to whichever of `on` or `off` is its default value. Specifying any given *`opt_name`* more than once in the value is not permitted and causes an error. Any errors in the value cause the assignment to fail with an error and the value of `optimizer_switch` remains unchanged.

The following table lists the permissible *`opt_name`* flag names, grouped by optimization strategy.

Optimization	Flag Name	Meaning
Index Merge	`index_merge`	Controls all Index Merge optimizations
	`index_merge_intersection`	Controls the Index Merge Intersection Access op-

Optimization	Flag Name	Meaning
		timization
	`index_merge_sort_union`	Controls the Index Merge Sort-Union Access optimization
	`index_merge_union`	Controls the Index Merge Union Access optimization
Condition Pushdown	`engine_condition_pushdown`	Controls engine condition pushdown

The flag for condition pushdown was added in MySQL 5.5.3.

For information about Index Merge, see Section 7.13.2, “Index Merge Optimization”. For information about engine condition pushdown, see Section 7.13.3, “Engine Condition Pushdown Optimization”.

When you assign a value to `optimizer_switch`, flags that are not mentioned keep their current values. This makes it possible to enable or disable specific optimizer behaviors in a single statement without affecting other behaviors. The statement does not depend on what other optimizer flags exist and what their values are. Suppose that all Index Merge optimizations are enabled:

```
mysql> SELECT @@optimizer_switch\G
*************************** 1. row ***************************
@@optimizer_switch: index_merge=on,index_merge_union=on,
                    index_merge_sort_union=on,
                    index_merge_intersection=on,
                    engine_condition_pushdown=on
```

If the server is using the Index Merge Union or Index Merge Sort-Union access methods for certain queries and you want to check whether the optimizer will perform better without them, set the variable value like this:

```
mysql> SET optimizer_switch='index_merge_union=off,index_merge_sort_union=off';

mysql> SELECT @@optimizer_switch\G
*************************** 1. row ***************************
@@optimizer_switch: index_merge=on,index_merge_union=off,
                    index_merge_sort_union=off,
                    index_merge_intersection=on,
                    engine_condition_pushdown=on
```

7.9. Buffering and Caching

MySQL uses several strategies that cache information in memory buffers to increase performance. Depending on your database architecture, you balance the size and layout of these areas, to provide the most performance benefit without wasting memory or exceeding available memory. When you set up or resize these memory areas, test the resulting performance using the techniques from Section 7.12, “Measuring Performance (Benchmarking)”.

7.9.1. The `InnoDB` Buffer Pool

`InnoDB` maintains a storage area called the buffer pool for caching data and indexes in memory. Knowing how the `InnoDB` buffer pool works, and taking advantage of it to keep frequently accessed data in memory, is an important aspect of MySQL tuning.

Guidelines

Ideally, you set the size of the buffer pool to as large a value as practical, leaving enough memory for other processes on the server to run without excessive paging. The larger the buffer pool, the more `InnoDB` acts like an in-memory database, reading data from disk once and then accessing the data from memory during subsequent reads. The buffer pool even caches data changed by insert and update operations, so that disk writes can be grouped together for better performance.

Depending on the typical workload on your system, you might adjust the proportions of the parts within the buffer pool. You can tune the way the buffer pool chooses which blocks to cache once it fills up, to keep frequently accessed data in memory despite sudden spikes of activity for operations such as backups or reporting.

With 64-bit systems with large memory sizes, you can split the buffer pool into multiple parts, to minimize contention for the memory structures among concurrent operations. For details, see Section 13.4.7.18, “Improvements to Performance from Multiple Buffer Pools”.

Internal Details

`InnoDB` manages the pool as a list, using a variation of the least recently used (LRU) algorithm. midpoint insertion strategy. When room is needed to add a new block to the pool, `InnoDB` evicts the least recently used block and adds the new block to the middle of the list. This “midpoint insertion strategy” treats the list as two sublists:

- At the head, a sublist of “new” (or “young”) blocks that were accessed recently.
- At the tail, a sublist of “old” blocks that were accessed less recently.

This algorithm keeps blocks that are heavily used by queries in the new sublist. The old sublist contains less-used blocks; these blocks are candidates for eviction.

The LRU algorithm operates as follows by default:

- 3/8 of the buffer pool is devoted to the old sublist.
- The midpoint of the list is the boundary where the tail of the new sublist meets the head of the old sublist.
- When `InnoDB` reads a block into the buffer pool, it initially inserts it at the midpoint (the head of the old sublist). A block can be read in because it is required for a user-specified operation such as an SQL query, or as part of a read-ahead operation performed automatically by `InnoDB`.
- Accessing to a block in the old sublist makes it “young”, moving it to the head of the buffer pool (the head of the new sublist). If the block was read in because it was required, the first access occurs immediately and the block is made young. If the block was read in due to read-ahead, the first access does not occur immediately (and might not occur at all before the block is evicted).
- As the database operates, blocks in the buffer pool that are not accessed “age” by moving toward the tail of the list. Blocks in both the new and old sublists age as other blocks are made new. Blocks in the old sublist also age as blocks are inserted at the midpoint. Eventually, a block that remains unused for long enough reaches the tail of the old sublist and is evicted.

By default, blocks read by queries immediately move into the new sublist, meaning they will stay in the buffer pool for a long time. A table scan (such as performed for a `mysqldump` operation, or a `SELECT` statement with no `WHERE` clause) can bring a large amount of data into the buffer pool and evict an equivalent amount of older data, even if the new data is never used again. Similarly, blocks that are loaded by the read-ahead background thread and then accessed only once move to the head of the new list. These situations can push frequently used blocks to the old sublist, where they become subject to eviction.

Configuration Options

Several `InnoDB` system variables control the size of the buffer pool and let you tune the LRU algorithm:

- `innodb_buffer_pool_size`

  Specifies the size of the buffer pool. If your buffer pool is small and you have sufficient memory, making the pool larger can improve performance by reducing the amount of disk I/O needed as queries access `InnoDB` tables.

- `innodb_buffer_pool_instances`

  Divides the buffer pool into a user-specified number of separate regions, each with its own LRU list and related data structures, to reduce contention during concurrent memory read and write operations. The size specified by `innodb_buffer_pool_size` is divided among all the buffer pool instances. For best efficiency, specify a combination of `innodb_buffer_pool_instances` and `innodb_buffer_pool_size` so that each buffer pool instance is at least 1 gigabyte.

- `innodb_old_blocks_pct`

  Specifies the approximate percentage of the buffer pool that `InnoDB` uses for the old block sublist. The range of values is 5 to 95. The default value is 37 (that is, 3/8 of the pool).

- `innodb_old_blocks_time`

  Specifies how long in milliseconds (ms) a block inserted into the old sublist must stay there after its first access before it can be moved to the new sublist. The default value is 0: A block inserted into the old sublist moves immediately to the new sublist the first time it is accessed, no matter how soon after insertion the access occurs. If the value is greater than 0, blocks remain in the old sublist until an access occurs at least that many ms after the first access. For example, a value of 1000 causes blocks to stay in the old sublist for 1 second after the first access before they become eligible to move to the new sublist.

Setting `innodb_old_blocks_time` greater than 0 prevents one-time table scans from flooding the new sublist with blocks used only for the scan. Rows in a block read in for a scan are accessed many times in rapid succession, but the block is unused after that. If `innodb_old_blocks_time` is set to a value greater than time to process the block, the block remains in the “old” sublist and ages to the tail of the list to be evicted quickly. This way, blocks used only for a one-time scan do not act to the detriment of heavily used blocks in the new sublist.

`innodb_old_blocks_time` can be set at runtime, so you can change it temporarily while performing operations such as table scans and dumps:

```
SET GLOBAL innodb_old_blocks_time = 1000;
... perform queries that scan tables ...
SET GLOBAL innodb_old_blocks_time = 0;
```

This strategy does not apply if your intent is to “warm up” the buffer pool by filling it with a table's content. For example, benchmark tests often perform a table or index scan at server startup, because that data would normally be in the buffer pool after a period of normal use. In this case, leave `innodb_old_blocks_time` set to 0, at least until the warmup phase is complete.

Monitoring the Buffer Pool

The output from the InnoDB Standard Monitor contains several new fields in the `BUFFER POOL AND MEMORY` section that pertain to operation of the buffer pool LRU algorithm:

- `Old database pages`: The number of pages in the old sublist of the buffer pool.
- `Pages made young, not young`: The number of old pages that were moved to the head of the buffer pool (the new sublist), and the number of pages that have remained in the old sublist without being made new.
- `youngs/s non-youngs/s`: The number of accesses to old pages that have resulted in making them young or not. This metric differs from that of the previous item in two ways. First, it relates only to old pages. Second, it is based on number of accesses to pages and not the number of pages. (There can be multiple accesses to a given page, all of which are counted.)
- `young-making rate`: Hits that cause blocks to move to the head of the buffer pool.
- `not`: Hits that do not cause blocks to move to the head of the buffer pool (due to the delay not being met).

The `young-making` rate and `not` rate will not normally add up to the overall buffer pool hit rate. Hits for blocks in the old sublist cause them to move to the new sublist, but hits to blocks in the new sublist cause them to move to the head of the list only if they are a certain distance from the head.

The preceding information from the Monitor can help you make LRU tuning decisions:

- If you see very low `youngs/s` values when you do not have large scans going on, that indicates that you might need to either reduce the delay time, or increase the percentage of the buffer pool used for the old sublist. Increasing the percentage makes the old sublist larger, so blocks in that sublist take longer to move to the tail and be evicted. This increases the likelihood that they will be accessed again and be made young.
- If you do not see a lot of `non-youngs/s` when you are doing large table scans (and lots of `youngs/s`), to tune your delay value to be larger.

For more information about InnoDB Monitors, see Section 13.3.14.2, “`SHOW ENGINE INNODB STATUS` and the `InnoDB` Monitors”.

7.9.2. The `MyISAM` Key Cache

To minimize disk I/O, the `MyISAM` storage engine exploits a strategy that is used by many database management systems. It employs a cache mechanism to keep the most frequently accessed table blocks in memory:

- For index blocks, a special structure called the *key cache* (or *key buffer*) is maintained. The structure contains a number of block buffers where the most-used index blocks are placed.
- For data blocks, MySQL uses no special cache. Instead it relies on the native operating system file system cache.

This section first describes the basic operation of the `MyISAM` key cache. Then it discusses features that improve key cache performance and that enable you to better control cache operation:

- Multiple sessions can access the cache concurrently.
- You can set up multiple key caches and assign table indexes to specific caches.

To control the size of the key cache, use the `key_buffer_size` system variable. If this variable is set equal to zero, no key cache is used. The key cache also is not used if the `key_buffer_size` value is too small to allocate the minimal number of block buffers (8).

When the key cache is not operational, index files are accessed using only the native file system buffering provided by the operating system. (In other words, table index blocks are accessed using the same strategy as that employed for table data blocks.)

An index block is a contiguous unit of access to the `MyISAM` index files. Usually the size of an index block is equal to the size of nodes of the index B-tree. (Indexes are represented on disk using a B-tree data structure. Nodes at the bottom of the tree are leaf nodes. Nodes above the leaf nodes are nonleaf nodes.)

All block buffers in a key cache structure are the same size. This size can be equal to, greater than, or less than the size of a table index block. Usually one these two values is a multiple of the other.

When data from any table index block must be accessed, the server first checks whether it is available in some block buffer of the key cache. If it is, the server accesses data in the key cache rather than on disk. That is, it reads from the cache or writes into it rather than reading from or writing to disk. Otherwise, the server chooses a cache block buffer containing a different table index block (or blocks) and replaces the data there by a copy of required table index block. As soon as the new index block is in the cache, the index data can be accessed.

If it happens that a block selected for replacement has been modified, the block is considered “dirty.” In this case, prior to being replaced, its contents are flushed to the table index from which it came.

Usually the server follows an *LRU (Least Recently Used)* strategy: When choosing a block for replacement, it selects the least recently used index block. To make this choice easier, the key cache module maintains all used blocks in a special list (*LRU chain*) ordered by time of use. When a block is accessed, it is the most recently used and is placed at the end of the list. When blocks need to be replaced, blocks at the beginning of the list are the least recently used and become the first candidates for eviction.

The `InnoDB` storage engine also uses an LRU algorithm, to manage its buffer pool. See Section 7.9.1, “The `InnoDB` Buffer Pool”.

7.9.2.1. Shared Key Cache Access

Threads can access key cache buffers simultaneously, subject to the following conditions:

- A buffer that is not being updated can be accessed by multiple sessions.
- A buffer that is being updated causes sessions that need to use it to wait until the update is complete.
- Multiple sessions can initiate requests that result in cache block replacements, as long as they do not interfere with each other (that is, as long as they need different index blocks, and thus cause different cache blocks to be replaced).

Shared access to the key cache enables the server to improve throughput significantly.

7.9.2.2. Multiple Key Caches

Shared access to the key cache improves performance but does not eliminate contention among sessions entirely. They still compete for control structures that manage access to the key cache buffers. To reduce key cache access contention further, MySQL also provides multiple key caches. This feature enables you to assign different table indexes to different key caches.

Where there are multiple key caches, the server must know which cache to use when processing queries for a given `MyISAM` table. By default, all `MyISAM` table indexes are cached in the default key cache. To assign table indexes to a specific key cache, use the `CACHE INDEX` statement (see Section 12.4.6.2, “`CACHE INDEX` Syntax”). For example, the following statement assigns indexes from the tables `t1`, `t2`, and `t3` to the key cache named `hot_cache`:

```
mysql> CACHE INDEX t1, t2, t3 IN hot_cache;
+---------+--------------------+----------+----------+
| Table   | Op                 | Msg_type | Msg_text |
+---------+--------------------+----------+----------+
| test.t1 | assign_to_keycache | status   | OK       |
| test.t2 | assign_to_keycache | status   | OK       |
| test.t3 | assign_to_keycache | status   | OK       |
+---------+--------------------+----------+----------+
```

The key cache referred to in a `CACHE INDEX` statement can be created by setting its size with a `SET GLOBAL` parameter setting statement or by using server startup options. For example:

```
mysql> SET GLOBAL keycache1.key_buffer_size=128*1024;
```

To destroy a key cache, set its size to zero:

```
mysql> SET GLOBAL keycache1.key_buffer_size=0;
```

Note that you cannot destroy the default key cache. Any attempt to do this will be ignored:

```
mysql> SET GLOBAL key_buffer_size = 0;

mysql> SHOW VARIABLES LIKE 'key_buffer_size';
+-----------------+---------+
| Variable_name   | Value   |
+-----------------+---------+
| key_buffer_size | 8384512 |
+-----------------+---------+
```

Key cache variables are structured system variables that have a name and components. For `keycache1.key_buffer_size`, `keycache1` is the cache variable name and `key_buffer_size` is the cache component. See Section 5.1.4.1, "Structured System Variables", for a description of the syntax used for referring to structured key cache system variables.

By default, table indexes are assigned to the main (default) key cache created at the server startup. When a key cache is destroyed, all indexes assigned to it are reassigned to the default key cache.

For a busy server, you can use a strategy that involves three key caches:

- A "hot" key cache that takes up 20% of the space allocated for all key caches. Use this for tables that are heavily used for searches but that are not updated.
- A "cold" key cache that takes up 20% of the space allocated for all key caches. Use this cache for medium-sized, intensively modified tables, such as temporary tables.
- A "warm" key cache that takes up 60% of the key cache space. Employ this as the default key cache, to be used by default for all other tables.

One reason the use of three key caches is beneficial is that access to one key cache structure does not block access to the others. Statements that access tables assigned to one cache do not compete with statements that access tables assigned to another cache. Performance gains occur for other reasons as well:

- The hot cache is used only for retrieval queries, so its contents are never modified. Consequently, whenever an index block needs to be pulled in from disk, the contents of the cache block chosen for replacement need not be flushed first.
- For an index assigned to the hot cache, if there are no queries requiring an index scan, there is a high probability that the index blocks corresponding to nonleaf nodes of the index B-tree remain in the cache.
- An update operation most frequently executed for temporary tables is performed much faster when the updated node is in the cache and need not be read in from disk first. If the size of the indexes of the temporary tables are comparable with the size of cold key cache, the probability is very high that the updated node is in the cache.

The `CACHE INDEX` statement sets up an association between a table and a key cache, but the association is lost each time the server restarts. If you want the association to take effect each time the server starts, one way to accomplish this is to use an option file: Include variable settings that configure your key caches, and an `init-file` option that names a file containing `CACHE INDEX` statements to be executed. For example:

```
key_buffer_size = 4G
hot_cache.key_buffer_size = 2G
cold_cache.key_buffer_size = 2G
init_file=/path/to/data-directory/mysqld_init.sql
```

The statements in `mysqld_init.sql` are executed each time the server starts. The file should contain one SQL statement per line. The following example assigns several tables each to `hot_cache` and `cold_cache`:

```
CACHE INDEX db1.t1, db1.t2, db2.t3 IN hot_cache
CACHE INDEX db1.t4, db2.t5, db2.t6 IN cold_cache
```

7.9.2.3. Midpoint Insertion Strategy

By default, the key cache management system uses a simple LRU strategy for choosing key cache blocks to be evicted, but it also supports a more sophisticated method called the *midpoint insertion strategy*.

When using the midpoint insertion strategy, the LRU chain is divided into two parts: a hot sublist and a warm sublist. The division point between two parts is not fixed, but the key cache management system takes care that the warm part is not “too short,” always containing at least `key_cache_division_limit` percent of the key cache blocks. `key_cache_division_limit` is a component of structured key cache variables, so its value is a parameter that can be set per cache.

When an index block is read from a table into the key cache, it is placed at the end of the warm sublist. After a certain number of hits (accesses of the block), it is promoted to the hot sublist. At present, the number of hits required to promote a block (3) is the same for all index blocks.

A block promoted into the hot sublist is placed at the end of the list. The block then circulates within this sublist. If the block stays at the beginning of the sublist for a long enough time, it is demoted to the warm sublist. This time is determined by the value of the `key_cache_age_threshold` component of the key cache.

The threshold value prescribes that, for a key cache containing *`N`* blocks, the block at the beginning of the hot sublist not accessed within the last `N * key_cache_age_threshold / 100` hits is to be moved to the beginning of the warm sublist. It then becomes the first candidate for eviction, because blocks for replacement always are taken from the beginning of the warm sublist.

The midpoint insertion strategy enables you to keep more-valued blocks always in the cache. If you prefer to use the plain LRU strategy, leave the `key_cache_division_limit` value set to its default of 100.

The midpoint insertion strategy helps to improve performance when execution of a query that requires an index scan effectively pushes out of the cache all the index blocks corresponding to valuable high-level B-tree nodes. To avoid this, you must use a midpoint insertion strategy with the `key_cache_division_limit` set to much less than 100. Then valuable frequently hit nodes are preserved in the hot sublist during an index scan operation as well.

7.9.2.4. Index Preloading

If there are enough blocks in a key cache to hold blocks of an entire index, or at least the blocks corresponding to its nonleaf nodes, it makes sense to preload the key cache with index blocks before starting to use it. Preloading enables you to put the table index blocks into a key cache buffer in the most efficient way: by reading the index blocks from disk sequentially.

Without preloading, the blocks are still placed into the key cache as needed by queries. Although the blocks will stay in the cache, because there are enough buffers for all of them, they are fetched from disk in random order, and not sequentially.

To preload an index into a cache, use the `LOAD INDEX INTO CACHE` statement. For example, the following statement preloads nodes (index blocks) of indexes of the tables `t1` and `t2`:

```
mysql> LOAD INDEX INTO CACHE t1, t2 IGNORE LEAVES;
+---------+--------------+----------+----------+
| Table   | Op           | Msg_type | Msg_text |
+---------+--------------+----------+----------+
| test.t1 | preload_keys | status   | OK       |
| test.t2 | preload_keys | status   | OK       |
+---------+--------------+----------+----------+
```

The `IGNORE LEAVES` modifier causes only blocks for the nonleaf nodes of the index to be preloaded. Thus, the statement shown preloads all index blocks from `t1`, but only blocks for the nonleaf nodes from `t2`.

If an index has been assigned to a key cache using a `CACHE INDEX` statement, preloading places index blocks into that cache. Otherwise, the index is loaded into the default key cache.

7.9.2.5. Key Cache Block Size

It is possible to specify the size of the block buffers for an individual key cache using the `key_cache_block_size` variable. This permits tuning of the performance of I/O operations for index files.

The best performance for I/O operations is achieved when the size of read buffers is equal to the size of the native operating system I/O buffers. But setting the size of key nodes equal to the size of the I/O buffer does not always ensure the best overall performance. When reading the big leaf nodes, the server pulls in a lot of unnecessary data, effectively preventing reading other leaf nodes.

To control the size of blocks in the `.MYI` index file of `MyISAM` tables, use the `--myisam-block-size` option at server startup.

7.9.2.6. Restructuring a Key Cache

A key cache can be restructured at any time by updating its parameter values. For example:

```
mysql> SET GLOBAL cold_cache.key_buffer_size=4*1024*1024;
```

If you assign to either the `key_buffer_size` or `key_cache_block_size` key cache component a value that differs from the component's current value, the server destroys the cache's old structure and creates a new one based on the new values. If the cache contains any dirty blocks, the server saves them to disk before destroying and re-creating the cache. Restructuring does not occur if you change other key cache parameters.

When restructuring a key cache, the server first flushes the contents of any dirty buffers to disk. After that, the cache contents become unavailable. However, restructuring does not block queries that need to use indexes assigned to the cache. Instead, the server directly accesses the table indexes using native file system caching. File system caching is not as efficient as using a key cache, so although queries execute, a slowdown can be anticipated. After the cache has been restructured, it becomes available again for caching indexes assigned to it, and the use of file system caching for the indexes ceases.

7.9.3. The MySQL Query Cache

The query cache stores the text of a `SELECT` statement together with the corresponding result that was sent to the client. If an identical statement is received later, the server retrieves the results from the query cache rather than parsing and executing the statement again. The query cache is shared among sessions, so a result set generated by one client can be sent in response to the same query issued by another client.

The query cache can be useful in an environment where you have tables that do not change very often and for which the server receives many identical queries. This is a typical situation for many Web servers that generate many dynamic pages based on database content. For example, when an order form queries a table to display the lists of all US states or all countries in the world, those values can be retrieved from the query cache. Although the values would probably be retrieved from memory in any case (from the `InnoDB` buffer pool or `MyISAM` key cache), using the query cache avoids the overhead of processing the query, deciding whether to use a table scan, and locating the data block for each row.

The query cache always contains current and reliable data. Any insert, update, delete, or other modification to a table causes any relevant entries in the query cache to be flushed.

> **Note**
>
> The query cache does not work in an environment where you have multiple `mysqld` servers updating the same `MyISAM` tables.

The query cache is used for prepared statements under the conditions described in Section 7.9.3.1, “How the Query Cache Operates”.

Some performance data for the query cache follows. These results were generated by running the MySQL benchmark suite on a Linux Alpha 2×500MHz system with 2GB RAM and a 64MB query cache.

- If all the queries you are performing are simple (such as selecting a row from a table with one row), but still differ so that the queries cannot be cached, the overhead for having the query cache active is 13%. This could be regarded as the worst case scenario. In real life, queries tend to be much more complicated, so the overhead normally is significantly lower.
- Searches for a single row in a single-row table are 238% faster with the query cache than without it. This can be regarded as close to the minimum speedup to be expected for a query that is cached.

To disable the query cache at server startup, set the `query_cache_size` system variable to 0. By disabling the query cache code, there is no noticeable overhead.

The query cache offers the potential for substantial performance improvement, but do not assume that it will do so under all circumstances. With some query cache configurations or server workloads, you might actually see a performance decrease:

- Be cautious about sizing the query cache excessively large, which increases the overhead required to maintain the cache, possibly beyond the benefit of enabling it. Sizes in tens of megabytes are usually beneficial. Sizes in the hundreds of megabytes might not be.
- Server workload has a significant effect on query cache efficiency. A query mix consisting almost entirely of a fixed set of `SELECT` statements is much more likely to benefit from enabling the cache than a mix in which frequent `INSERT` statements cause continual invalidation of results in the cache. In some cases, a workaround is to use the `SQL_NO_CACHE` option to prevent results from even entering the cache for `SELECT` statements that use frequently modified tables. (See Section 7.9.3.2, “Query Cache `SELECT` Options”.)

To verify that enabling the query cache is beneficial, test the operation of your MySQL server with the cache enabled and disabled. Then retest periodically because query cache efficiency may change as server workload changes.

7.9.3.1. How the Query Cache Operates

This section describes how the query cache works when it is operational. Section 7.9.3.3, “Query Cache Configuration”, describes how to control whether it is operational.

Incoming queries are compared to those in the query cache before parsing, so the following two queries are regarded as different by the query cache:

```
SELECT * FROM tbl_name
Select * from tbl_name
```

Queries must be *exactly* the same (byte for byte) to be seen as identical. In addition, query strings that are identical may be treated as different for other reasons. Queries that use different databases, different protocol versions, or different default character sets are considered different queries and are cached separately.

The cache is not used for queries of the following types:

- Queries that are a subquery of an outer query
- Queries executed within the body of a stored function, trigger, or event

Before a query result is fetched from the query cache, MySQL checks whether the user has `SELECT` privilege for all databases and tables involved. If this is not the case, the cached result is not used.

If a query result is returned from query cache, the server increments the `Qcache_hits` status variable, not `Com_select`. See Section 7.9.3.4, "Query Cache Status and Maintenance".

If a table changes, all cached queries that use the table become invalid and are removed from the cache. This includes queries that use `MERGE` tables that map to the changed table. A table can be changed by many types of statements, such as `INSERT`, `UPDATE`, `DELETE`, `TRUNCATE TABLE`, `ALTER TABLE`, `DROP TABLE`, or `DROP DATABASE`.

The query cache also works within transactions when using `InnoDB` tables.

In MySQL 5.5, the result from a `SELECT` query on a view is cached.

The query cache works for `SELECT SQL_CALC_FOUND_ROWS ...` queries and stores a value that is returned by a following `SELECT FOUND_ROWS()` query. `FOUND_ROWS()` returns the correct value even if the preceding query was fetched from the cache because the number of found rows is also stored in the cache. The `SELECT FOUND_ROWS()` query itself cannot be cached.

Prepared statements that are issued using the binary protocol using `mysql_stmt_prepare()` and `mysql_stmt_execute()` (see Section 20.9.4, "C API Prepared Statements"), are subject to limitations on caching. Comparison with statements in the query cache is based on the text of the statement after expansion of `?` parameter markers. The statement is compared only with other cached statements that were executed using the binary protocol. That is, for query cache purposes, prepared statements issued using the binary protocol are distinct from prepared statements issued using the text protocol (see Section 12.6, "SQL Syntax for Prepared Statements").

A query cannot be cached if it contains any of the functions shown in the following table.

`BENCHMARK()`	`CONNECTION_ID()`	`CONVERT_TZ()`
`CURDATE()`	`CURRENT_DATE()`	`CURRENT_TIME()`
`CURRENT_TIMESTAMP()`	`CURTIME()`	`DATABASE()`
`ENCRYPT()` with one parameter	`FOUND_ROWS()`	`GET_LOCK()`
`LAST_INSERT_ID()`	`LOAD_FILE()`	`MASTER_POS_WAIT()`
`NOW()`	`RAND()`	`RELEASE_LOCK()`
`SLEEP()`	`SYSDATE()`	`UNIX_TIMESTAMP()` with no parameters
`USER()`	`UUID()`	`UUID_SHORT()`

A query also is not cached under these conditions:

- It refers to user-defined functions (UDFs) or stored functions.
- It refers to user variables or local stored program variables.
- It refers to tables in the `mysql`, `INFORMATION_SCHEMA`, or `performance_schema` database.
- It is of any of the following forms:

  ```
  SELECT ... LOCK IN SHARE MODE
  ```

```
SELECT ... FOR UPDATE
SELECT ... INTO OUTFILE ...
SELECT ... INTO DUMPFILE ...
SELECT * FROM ... WHERE autoincrement_col IS NULL
```

The last form is not cached because it is used as the ODBC workaround for obtaining the last insert ID value. See the MyODBC section of Chapter 20, *Connectors and APIs*.

Statements within transactions that use `SERIALIZABLE` isolation level also cannot be cached because they use `LOCK IN SHARE MODE` locking.

- It uses `TEMPORARY` tables.
- It does not use any tables.
- It generates warnings.
- The user has a column-level privilege for any of the involved tables.

7.9.3.2. Query Cache `SELECT` Options

Two query cache-related options may be specified in `SELECT` statements:

- `SQL_CACHE`

  The query result is cached if it is cacheable and the value of the `query_cache_type` system variable is `ON` or `DEMAND`.

- `SQL_NO_CACHE`

  The query result is not cached.

Examples:

```
SELECT SQL_CACHE id, name FROM customer;
SELECT SQL_NO_CACHE id, name FROM customer;
```

7.9.3.3. Query Cache Configuration

The `have_query_cache` server system variable indicates whether the query cache is available:

```
mysql> SHOW VARIABLES LIKE 'have_query_cache';
+------------------+-------+
| Variable_name    | Value |
+------------------+-------+
| have_query_cache | YES   |
+------------------+-------+
```

When using a standard MySQL binary, this value is always `YES`, even if query caching is disabled.

Several other system variables control query cache operation. These can be set in an option file or on the command line when starting `mysqld`. The query cache system variables all have names that begin with `query_cache_`. They are described briefly in Section 5.1.3, “Server System Variables”, with additional configuration information given here.

To set the size of the query cache, set the `query_cache_size` system variable. Setting it to 0 disables the query cache. The default size is 0, so the query cache is disabled by default. To reduce overhead significantly, also start the server with `query_cache_type=0` if you will not be using the query cache.

> **Note**
>
> When using the Windows Configuration Wizard to install or configure MySQL, the default value for `query_cache_size` will be configured automatically for you based on the different configuration types available. When using the Windows Configuration Wizard, the query cache may be enabled (that is, set to a nonzero value) due to the selected configuration. The query cache is also controlled by the setting of the `query_cache_type` variable. Check the values of these variables as set in your `my.ini` file after configuration has taken place.

When you set `query_cache_size` to a nonzero value, keep in mind that the query cache needs a minimum size of about 40KB to allocate its structures. (The exact size depends on system architecture.) If you set the value too small, you'll get a warning, as in this example:

```
mysql> SET GLOBAL query_cache_size = 40000;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> SHOW WARNINGS\G
*************************** 1. row ***************************
  Level: Warning
   Code: 1282
Message: Query cache failed to set size 39936;
         new query cache size is 0

mysql> SET GLOBAL query_cache_size = 41984;
Query OK, 0 rows affected (0.00 sec)

mysql> SHOW VARIABLES LIKE 'query_cache_size';
+------------------+-------+
| Variable_name    | Value |
+------------------+-------+
| query_cache_size | 41984 |
+------------------+-------+
```

For the query cache to actually be able to hold any query results, its size must be set larger:

```
mysql> SET GLOBAL query_cache_size = 1000000;
Query OK, 0 rows affected (0.04 sec)

mysql> SHOW VARIABLES LIKE 'query_cache_size';
+------------------+--------+
| Variable_name    | Value  |
+------------------+--------+
| query_cache_size | 999424 |
+------------------+--------+
1 row in set (0.00 sec)
```

The `query_cache_size` value is aligned to the nearest 1024 byte block. The value reported may therefore be different from the value that you assign.

If the query cache size is greater than 0, the `query_cache_type` variable influences how it works. This variable can be set to the following values:

- A value of `0` or `OFF` prevents caching or retrieval of cached results.
- A value of `1` or `ON` enables caching except of those statements that begin with `SELECT SQL_NO_CACHE`.
- A value of `2` or `DEMAND` causes caching of only those statements that begin with `SELECT SQL_CACHE`.

If `query_cache_size` is 0, you should also set `query_cache_type` variable to 0. In this case, the server does not acquire the query cache mutex at all, which means that the query cache cannot be enabled at runtime and there is reduced overhead in query execution.

Setting the `GLOBAL` `query_cache_type` value determines query cache behavior for all clients that connect after the change is made. Individual clients can control cache behavior for their own connection by setting the `SESSION` `query_cache_type` value. For example, a client can disable use of the query cache for its own queries like this:

```
mysql> SET SESSION query_cache_type = OFF;
```

If you set `query_cache_type` at server startup (rather than at runtime with a `SET` statement), only the numeric values are permitted.

To control the maximum size of individual query results that can be cached, set the `query_cache_limit` system variable. The default value is 1MB.

Be careful not to set the size of the cache too large. Due to the need for threads to lock the cache during updates, you may see lock contention issues with a very large cache.

> **Note**
>
> You can set the maximum size that can be specified for the query cache at run time with the `SET` statement by using the `--maximum-query_cache_size=32M` option on the command line or in the configuration file.

When a query is to be cached, its result (the data sent to the client) is stored in the query cache during result retrieval. Therefore the data usually is not handled in one big chunk. The query cache allocates blocks for storing this data on demand, so when one block is filled, a new block is allocated. Because memory allocation operation is costly (timewise), the query cache allocates blocks with a minimum size given by the `query_cache_min_res_unit` system variable. When a query is executed, the last result block is trimmed to the actual data size so that unused memory is freed. Depending on the types of queries your server executes, you might find it helpful to tune the value of `query_cache_min_res_unit`:

- The default value of `query_cache_min_res_unit` is 4KB. This should be adequate for most cases.
- If you have a lot of queries with small results, the default block size may lead to memory fragmentation, as indicated by a large number of free blocks. Fragmentation can force the query cache to prune (delete) queries from the cache due to lack of memory. In this case, decrease the value of `query_cache_min_res_unit`. The number of free blocks and queries removed due to pruning are given by the values of the `Qcache_free_blocks` and `Qcache_lowmem_prunes` status variables.
- If most of your queries have large results (check the `Qcache_total_blocks` and `Qcache_queries_in_cache` status variables), you can increase performance by increasing `query_cache_min_res_unit`. However, be careful to not make it too large (see the previous item).

7.9.3.4. Query Cache Status and Maintenance

To check whether the query cache is present in your MySQL server, use the following statement:

```
mysql> SHOW VARIABLES LIKE 'have_query_cache';
+------------------+-------+
| Variable_name    | Value |
+------------------+-------+
| have_query_cache | YES   |
+------------------+-------+
```

You can defragment the query cache to better utilize its memory with the `FLUSH QUERY CACHE` statement. The statement does not remove any queries from the cache.

The `RESET QUERY CACHE` statement removes all query results from the query cache. The `FLUSH TABLES` statement also does this.

To monitor query cache performance, use `SHOW STATUS` to view the cache status variables:

```
mysql> SHOW STATUS LIKE 'Qcache%';
+-------------------------+--------+
| Variable_name           | Value  |
+-------------------------+--------+
| Qcache_free_blocks      | 36     |
| Qcache_free_memory      | 138488 |
| Qcache_hits             | 79570  |
| Qcache_inserts          | 27087  |
| Qcache_lowmem_prunes    | 3114   |
| Qcache_not_cached       | 22989  |
| Qcache_queries_in_cache | 415    |
| Qcache_total_blocks     | 912    |
+-------------------------+--------+
```

Descriptions of each of these variables are given in Section 5.1.5, “Server Status Variables”. Some uses for them are described here.

The total number of `SELECT` queries is given by this formula:

```
  Com_select
+ Qcache_hits
+ queries with errors found by parser
```

The `Com_select` value is given by this formula:

```
  Qcache_inserts
+ Qcache_not_cached
+ queries with errors found during the column-privileges check
```

The query cache uses variable-length blocks, so `Qcache_total_blocks` and `Qcache_free_blocks` may indicate query cache memory fragmentation. After `FLUSH QUERY CACHE`, only a single free block remains.

Every cached query requires a minimum of two blocks (one for the query text and one or more for the query results). Also, every table that is used by a query requires one block. However, if two or more queries use the same table, only one table block needs to be allocated.

The information provided by the `Qcache_lowmem_prunes` status variable can help you tune the query cache size. It counts the number of queries that have been removed from the cache to free up memory for caching new queries. The query cache uses a least recently used (LRU) strategy to decide which queries to remove from the cache. Tuning information is given in Section 7.9.3.3, “Query Cache Configuration”.

7.10. Optimizing Locking Operations

When your database is busy with multiple sessions reading and writing data, the mechanism that controls access to data files and memory areas can become a consideration for performance tuning. Otherwise, sessions can spend time waiting for access to resources when they could be running concurrently.

MySQL manages contention for table contents using locking:

- Internal locking is performed within the MySQL server itself to manage contention for table contents by multiple threads. This type of locking is internal because it is performed entirely by the server and involves no other programs. See Section 7.10.1, “Internal Locking Methods”.
- External locking occurs when the server and other programs lock `MyISAM` table files to coordinate among themselves which program can access the tables at which time. See Section 7.10.5, “External Locking”.

7.10.1. Internal Locking Methods

This section discusses internal locking; that is, locking performed within the MySQL server to manage contention for table contents by multiple sessions.

MySQL uses row-level locking for `InnoDB` tables, and table-level locking for `MyISAM`, `MEMORY`, and `MERGE` tables.

Which lock type works better for your application depends on the application and its workload, especially whether the data is modified frequently and how many concurrent sessions need to read or write the same tables. Different parts of an application may require different lock types.

To decide whether you want to use a storage engine with row-level locking, look at what your application does and what mix of select and update statements it uses. For example, the `InnoDB` storage engine is targeted towards a wide variety of application workloads, especially those with heavy write activity or high concurrent usage. The `MyISAM` storage engine is targeted towards Web applications that perform many selects, relatively few deletes, updates based mainly on key values, and inserts into a few specific tables.

Considerations for Row Locking

Advantages of row-level locking:

- Fewer lock conflicts when different sessions access different rows.
- Fewer changes for rollbacks.
- Possible to lock a single row for a long time.

Disadvantages of row-level locking:

- Requires more memory than table-level locks.
- Slower than table-level locks when used on a large part of the table because you must acquire many more locks.
- Slower than other locks if you often do `GROUP BY` operations on a large part of the data or if you must scan the entire table frequently.

Considerations for Table Locking

Table locking in MySQL is deadlock-free for storage engines that use table-level locking. Deadlock avoidance is managed by always requesting all needed locks at once at the beginning of a query and always locking the tables in the same order.

MySQL grants table write locks as follows:

1. If there are no locks on the table, put a write lock on it.
2. Otherwise, put the lock request in the write lock queue.

MySQL grants table read locks as follows:

1. If there are no write locks on the table, put a read lock on it.
2. Otherwise, put the lock request in the read lock queue.

Table updates are given higher priority than table retrievals. Therefore, when a lock is released, the lock is made available to the requests in the write lock queue and then to the requests in the read lock queue. This ensures that updates to a table are not “starved” even if there is heavy `SELECT` activity for the table. However, if you have many updates for a table, `SELECT` statements wait until there are no more updates.

For information on altering the priority of reads and writes, see Section 7.10.2, “Table Locking Issues”.

You can analyze the table lock contention on your system by checking the `Table_locks_immediate` and `Table_locks_waited` status variables, which indicate the number of times that requests for table locks could be granted immediately and the number that had to wait, respectively:

```
mysql> SHOW STATUS LIKE 'Table%';
+-----------------------+---------+
| Variable_name         | Value   |
+-----------------------+---------+
| Table_locks_immediate | 1151552 |
| Table_locks_waited    | 15324   |
+-----------------------+---------+
```

The `MyISAM` storage engine supports concurrent inserts to reduce contention between readers and writers for a given table: If a `MyISAM` table has no free blocks in the middle of the data file, rows are always inserted at the end of the data file. In this case, you can freely mix concurrent `INSERT` and `SELECT` statements for a `MyISAM` table without locks. That is, you can insert rows into a `MyISAM` table at the same time other clients are reading from it. Holes can result from rows having been deleted from or updated in the middle of the table. If there are holes, concurrent inserts are disabled but are enabled again automatically when all holes have been filled with new data.. This behavior is altered by the `concurrent_insert` system variable. See Section 7.10.3, “Concurrent Inserts”.

If you acquire a table lock explicitly with `LOCK TABLES`, you can request a `READ LOCAL` lock rather than a `READ` lock to enable other sessions to perform concurrent inserts while you have the table locked.

To perform many `INSERT` and `SELECT` operations on a table `real_table` when concurrent inserts are not possible, you can insert rows into a temporary table `temp_table` and update the real table with the rows from the temporary table periodically. This can be done with the following code:

```
mysql> LOCK TABLES real_table WRITE, temp_table WRITE;
mysql> INSERT INTO real_table SELECT * FROM temp_table;
mysql> DELETE FROM temp_table;
mysql> UNLOCK TABLES;
```

`InnoDB` uses row locks. Deadlocks are possible for `InnoDB` because it automatically acquires locks during the processing of SQL statements, not at the start of the transaction.

Choosing the Type of Locking

Generally, table locks are superior to row-level locks in the following cases:

- Most statements for the table are reads.
- Statements for the table are a mix of reads and writes, where writes are updates or deletes for a single row that can be fetched with one key read:

  ```
  UPDATE tbl_name SET column=value WHERE unique_key_col=key_value;
  DELETE FROM tbl_name WHERE unique_key_col=key_value;
  ```

- `SELECT` combined with concurrent `INSERT` statements, and very few `UPDATE` or `DELETE` statements.
- Many scans or `GROUP BY` operations on the entire table without any writers.

With higher-level locks, you can more easily tune applications by supporting locks of different types, because the lock overhead is less than for row-level locks.

Options other than row-level locking:

- Versioning (such as that used in MySQL for concurrent inserts) where it is possible to have one writer at the same time as many readers. This means that the database or table supports different views for the data depending on when access begins. Other common terms for this are “time travel,” “copy on write,” or “copy on demand.”

- Copy on demand is in many cases superior to row-level locking. However, in the worst case, it can use much more memory than using normal locks.
- Instead of using row-level locks, you can employ application-level locks, such as those provided by `GET_LOCK()` and `RELEASE_LOCK()` in MySQL. These are advisory locks, so they work only with applications that cooperate with each other. See Section 11.15, “Miscellaneous Functions”.

7.10.2. Table Locking Issues

`InnoDB` tables use row-level locking so that multiple sessions and applications can read from and write to the same table simultaneously, without making each other wait or producing inconsistent results. For this storage engine, avoid using the `LOCK TABLES` statement, because it does not offer any extra protection, but instead reduces concurrency. The automatic row-level locking makes these tables suitable for your busiest databases with your most important data, while also simplifying application logic since you do not need to lock and unlock tables. Consequently, the `InnoDB` storage engine in the default in MySQL 5.5 and higher.

MySQL uses table locking (instead of page, row, or column locking) for all storage engines except `InnoDB`. The locking operations themselves do not have much overhead. But because only one session can write to a table at any one time, for best performance with these other storage engines, use them primarily for tables that are queried often and rarely inserted into or updated.

Performance Considerations Favoring `InnoDB`

When choosing whether to create a table using `InnoDB` or a different storage engine, keep in mind the following disadvantages of table locking:

- Table locking enables many sessions to read from a table at the same time, but if a session wants to write to a table, it must first get exclusive access, meaning it might have to wait for other sessions to finish with the table first. During the update, all other sessions that want to access this particular table must wait until the update is done.
- Table locking causes problems when a session is waiting because the disk is full and free space needs to become available before the session can proceed. In this case, all sessions that want to access the problem table are also put in a waiting state until more disk space is made available.
- A `SELECT` statement that takes a long time to run prevents other sessions from updating the table in the meantime, making the other sessions appear slow or unresponsive. While a session is waiting to get exclusive access to the table for updates, other sessions that issue `SELECT` statements will queue up behind it, reducing concurrency even for read-only sessions.

Workarounds for Locking Performance Issues

The following items describe some ways to avoid or reduce contention caused by table locking:

- Consider switching the table to the `InnoDB` storage engine, either using `CREATE TABLE ... ENGINE=INNODB` during setup, or using `ALTER TABLE ... ENGINE=INNODB` for an existing table. See Section 13.3, “The `InnoDB` Storage Engine” for more details about this storage engine.
- Optimize `SELECT` statements to run faster so that they lock tables for a shorter time. You might have to create some summary tables to do this.
- Start `mysqld` with `--low-priority-updates`. For storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`), this gives all statements that update (modify) a table lower priority than `SELECT` statements. In this case, the second `SELECT` statement in the preceding scenario would execute before the `UPDATE` statement, and would not wait for the first `SELECT` to finish.
- To specify that all updates issued in a specific connection should be done with low priority, set the `low_priority_updates` server system variable equal to 1.
- To give a specific `INSERT`, `UPDATE`, or `DELETE` statement lower priority, use the `LOW_PRIORITY` attribute.
- To give a specific `SELECT` statement higher priority, use the `HIGH_PRIORITY` attribute. See Section 12.2.9, “`SELECT` Syntax”.
- Start `mysqld` with a low value for the `max_write_lock_count` system variable to force MySQL to temporarily elevate the priority of all `SELECT` statements that are waiting for a table after a specific number of inserts to the table occur. This permits `READ` locks after a certain number of `WRITE` locks.

- If you have problems with `INSERT` combined with `SELECT`, consider switching to `MyISAM` tables, which support concurrent `SELECT` and `INSERT` statements. (See Section 7.10.3, “Concurrent Inserts”.)
- If you mix inserts and deletes on the same table, `INSERT DELAYED` may be of great help. See Section 12.2.5.2, “`INSERT DELAYED` Syntax”.
- If you have problems with mixed `SELECT` and `DELETE` statements, the `LIMIT` option to `DELETE` may help. See Section 12.2.2, “`DELETE` Syntax”.
- Using `SQL_BUFFER_RESULT` with `SELECT` statements can help to make the duration of table locks shorter. See Section 12.2.9, “`SELECT` Syntax”.
- Splitting table contents into separate tables may help, by allowing queries to run against columns in one table, while updates are confined to columns in a different table.
- You could change the locking code in `mysys/thr_lock.c` to use a single queue. In this case, write locks and read locks would have the same priority, which might help some applications.

7.10.3. Concurrent Inserts

The `MyISAM` storage engine supports concurrent inserts to reduce contention between readers and writers for a given table: If a `MyISAM` table has no holes in the data file (deleted rows in the middle), an `INSERT` statement can be executed to add rows to the end of the table at the same time that `SELECT` statements are reading rows from the table. If there are multiple `INSERT` statements, they are queued and performed in sequence, concurrently with the `SELECT` statements. The results of a concurrent `INSERT` may not be visible immediately.

The `concurrent_insert` system variable can be set to modify the concurrent-insert processing. By default, the variable is set to `AUTO` (or 1) and concurrent inserts are handled as just described. If `concurrent_insert` is set to `NEVER` (or 0), concurrent inserts are disabled. If the variable is set to `ALWAYS` (or 2), concurrent inserts at the end of the table are permitted even for tables that have deleted rows. See also the description of the `concurrent_insert` system variable.

Under circumstances where concurrent inserts can be used, there is seldom any need to use the `DELAYED` modifier for `INSERT` statements. See Section 12.2.5.2, “`INSERT DELAYED` Syntax”.

If you are using the binary log, concurrent inserts are converted to normal inserts for `CREATE ... SELECT` or `INSERT ... SELECT` statements. This is done to ensure that you can re-create an exact copy of your tables by applying the log during a backup operation. See Section 5.2.4, “The Binary Log”. In addition, for those statements a read lock is placed on the selected-from table such that inserts into that table are blocked. The effect is that concurrent inserts for that table must wait as well.

With `LOAD DATA INFILE`, if you specify `CONCURRENT` with a `MyISAM` table that satisfies the condition for concurrent inserts (that is, it contains no free blocks in the middle), other sessions can retrieve data from the table while `LOAD DATA` is executing. Use of the `CONCURRENT` option affects the performance of `LOAD DATA` a bit, even if no other session is using the table at the same time.

If you specify `HIGH_PRIORITY`, it overrides the effect of the `--low-priority-updates` option if the server was started with that option. It also causes concurrent inserts not to be used.

For `LOCK TABLE`, the difference between `READ LOCAL` and `READ` is that `READ LOCAL` permits nonconflicting `INSERT` statements (concurrent inserts) to execute while the lock is held. However, this cannot be used if you are going to manipulate the database using processes external to the server while you hold the lock.

7.10.4. Metadata Locking Within Transactions

To ensure transaction serializability, the server must not permit one session to perform a data definition language (DDL) statement on a table that is used in an uncompleted transaction in another session.

As of MySQL 5.5.3, the server achieves this by acquiring metadata locks on tables used within a transaction and deferring release of those locks until the transaction ends. A metadata lock on a table prevents changes to the table's structure. This locking approach has the implication that a table that is being used by a transaction within one session cannot be used in DDL statements by other sessions until the transaction ends. For example, if a table `t1` is in use by a transaction, another session that attempts to execute `DROP TABLE t1` will block until the transaction ends.

If the server acquires metadata locks for a statement that is syntactically valid but fails during execution, it does not release the locks early. Lock release is still deferred to the end of the transaction because the failed statement is written to the binary log and the locks protect log consistency.

Metadata locks acquired during a `PREPARE` statement are released once the statement has been prepared, even if preparation occurs within a multiple-statement transaction.

Before MySQL 5.5.3, when a transaction acquired a metadata lock for a table used within a statement, it released the lock at the end of the statement. This approach had the disadvantage that if a DDL statement occurred for a table that was being used by another session in an active transaction, statements could be written to the binary log in the wrong order.

7.10.5. External Locking

External locking is the use of file system locking to manage contention for `MyISAM` database tables by multiple processes. External locking is used in situations where a single process such as the MySQL server cannot be assumed to be the only process that requires access to tables. Here are some examples:

- If you run multiple servers that use the same database directory (not recommended), each server must have external locking enabled.
- If you use `myisamchk` to perform table maintenance operations on `MyISAM` tables, you must either ensure that the server is not running, or that the server has external locking enabled so that it locks table files as necessary to coordinate with `myisamchk` for access to the tables. The same is true for use of `myisampack` to pack `MyISAM` tables.

  If the server is run with external locking enabled, you can use `myisamchk` at any time for read operations such a checking tables. In this case, if the server tries to update a table that `myisamchk` is using, the server will wait for `myisamchk` to finish before it continues.

  If you use `myisamchk` for write operations such as repairing or optimizing tables, or if you use `myisampack` to pack tables, you *must* always ensure that the `mysqld` server is not using the table. If you don't stop `mysqld`, at least do a `mysqladmin flush-tables` before you run `myisamchk`. Your tables *may become corrupted* if the server and `myisamchk` access the tables simultaneously.

With external locking in effect, each process that requires access to a table acquires a file system lock for the table files before proceeding to access the table. If all necessary locks cannot be acquired, the process is blocked from accessing the table until the locks can be obtained (after the process that currently holds the locks releases them).

External locking affects server performance because the server must sometimes wait for other processes before it can access tables.

External locking is unnecessary if you run a single server to access a given data directory (which is the usual case) and if no other programs such as `myisamchk` need to modify tables while the server is running. If you only *read* tables with other programs, external locking is not required, although `myisamchk` might report warnings if the server changes tables while `myisamchk` is reading them.

With external locking disabled, to use `myisamchk`, you must either stop the server while `myisamchk` executes or else lock and flush the tables before running `myisamchk`. (See Section 7.11.1, “System Factors and Startup Parameter Tuning”.) To avoid this requirement, use the `CHECK TABLE` and `REPAIR TABLE` statements to check and repair `MyISAM` tables.

For `mysqld`, external locking is controlled by the value of the `skip_external_locking` system variable. When this variable is enabled, external locking is disabled, and vice versa. From MySQL 4.0 on, external locking is disabled by default.

Use of external locking can be controlled at server startup by using the `--external-locking` or `--skip-external-locking` option.

If you do use external locking option to enable updates to `MyISAM` tables from many MySQL processes, you must ensure that the following conditions are satisfied:

- Do not use the query cache for queries that use tables that are updated by another process.
- Do not start the server with the `--delay-key-write=ALL` option or use the `DELAY_KEY_WRITE=1` table option for any shared tables. Otherwise, index corruption can occur.

The easiest way to satisfy these conditions is to always use `--external-locking` together with `--delay-key-write=OFF` and `--query-cache-size=0`. (This is not done by default because in many setups it is useful to have a mixture of the preceding options.)

7.11. Optimizing the MySQL Server

This section discusses optimization techniques for the database server, primarily dealing with system configuration rather than tuning SQL statements. The information in this section is appropriate for DBAs who want to ensure performance and scalability across the servers they manage; for developers constructing installation scripts that include setting up the database; and people running MySQL themselves for development, testing, and so on who want to maximize their own productivity.

7.11.1. System Factors and Startup Parameter Tuning

We start with system-level factors, because some of these decisions must be made very early to achieve large performance gains. In other cases, a quick look at this section may suffice. However, it is always nice to have a sense of how much can be gained by changing factors that apply at this level.

The operating system to use is very important. To get the best use of multiple-CPU machines, you should use Solaris (because its threads implementation works well) or Linux (because the 2.4 and later kernels have good SMP support). Note that older Linux kernels have a 2GB filesize limit by default. If you have such a kernel and a need for files larger than 2GB, get the Large File Support (LFS) patch for the ext2 file system. Other file systems such as ReiserFS and XFS do not have this 2GB limitation.

Before using MySQL in production, test it on your intended platform.

Other tips:

- If you have enough RAM, you could remove all swap devices. Some operating systems use a swap device in some contexts even if you have free memory.
- Avoid external locking for `MyISAM` tables. Since MySQL 4.0, the default has been for external locking to be disabled on all systems. The `--external-locking` and `--skip-external-locking` options explicitly enable and disable external locking.

  Note that disabling external locking does not affect MySQL's functionality as long as you run only one server. Just remember to take down the server (or lock and flush the relevant tables) before you run `myisamchk`. On some systems it is mandatory to disable external locking because it does not work, anyway.

  The only case in which you cannot disable external locking is when you run multiple MySQL *servers* (not clients) on the same data, or if you run `myisamchk` to check (not repair) a table without telling the server to flush and lock the tables first. Note that using multiple MySQL servers to access the same data concurrently is generally *not* recommended, except when using MySQL Cluster.

  > **Note**
  >
  > MySQL Cluster is currently not supported in MySQL 5.5. Users wishing to upgrade a MySQL Cluster from MySQL 5.0 or 5.1 should instead migrate to MySQL Cluster NDB 7.0 or 7.1; these are based on MySQL 5.1 but contain the latest improvements and fixes for `NDBCLUSTER`.

  The `LOCK TABLES` and `UNLOCK TABLES` statements use internal locking, so you can use them even if external locking is disabled.

7.11.2. Tuning Server Parameters

You can determine the default buffer sizes used by the `mysqld` server using this command:

```
shell> mysqld --verbose --help
```

This command produces a list of all `mysqld` options and configurable system variables. The output includes the default variable values and looks something like this:

```
abort-slave-event-count           0
allow-suspicious-udfs             FALSE
auto-increment-increment          1
auto-increment-offset             1
automatic-sp-privileges           TRUE
back_log                          50
basedir                           /home/jon/bin/mysql-5.5/
bind-address                      (No default value)
binlog-row-event-max-size         1024
binlog_cache_size                 32768
binlog_format                     (No default value)
bulk_insert_buffer_size           8388608
character-set-client-handshake    TRUE
character-set-filesystem          binary
character-set-server              latin1
character-sets-dir                /home/jon/bin/mysql-5.5/share/mysql/charsets/
chroot                            (No default value)
collation-server                  latin1_swedish_ci
completion-type                   0
concurrent-insert                 1
connect_timeout                   10
console                           FALSE
datadir                           .
datetime_format                   %Y-%m-%d %H:%i:%s
date_format                       %Y-%m-%d
default-character-set             latin1
default-collation                 latin1_swedish_ci
```

```
default-storage-engine            MyISAM
default-time-zone                 (No default value)
default_week_format               0
delayed_insert_limit              100
delayed_insert_timeout            300
delayed_queue_size                1000
disconnect-slave-event-count      0
div_precision_increment           4
engine-condition-pushdown         TRUE
expire_logs_days                  0
external-locking                  FALSE
flush_time                        0
ft_max_word_len                   84
ft_min_word_len                   4
ft_query_expansion_limit          20
ft_stopword_file                  (No default value)
gdb                               FALSE
general_log                       FALSE
general_log_file                  (No default value)
group_concat_max_len              1024
help                              TRUE
init-connect                      (No default value)
init-file                         (No default value)
init-slave                        (No default value)
innodb                            TRUE
innodb-adaptive-hash-index        TRUE
innodb-additional-mem-pool-size   1048576
innodb-autoextend-increment       8
innodb-autoinc-lock-mode          1
innodb-buffer-pool-size           8388608
innodb-checksums                  TRUE
innodb-commit-concurrency         0
innodb-concurrency-tickets        500
innodb-data-file-path             (No default value)
innodb-data-home-dir              (No default value)
innodb-doublewrite                TRUE
innodb-fast-shutdown              1
innodb-file-io-threads            4
innodb-file-per-table             FALSE
innodb-flush-log-at-trx-commit    1
innodb-flush-method               (No default value)
innodb-force-recovery             0
innodb-lock-wait-timeout          50
innodb-locks-unsafe-for-binlog    FALSE
innodb-log-buffer-size            1048576
innodb-log-file-size              5242880
innodb-log-files-in-group         2
innodb-log-group-home-dir         (No default value)
innodb-max-dirty-pages-pct        90
innodb-max-purge-lag              0
innodb-mirrored-log-groups        1
innodb-open-files                 300
innodb-rollback-on-timeout        FALSE
innodb-stats-on-metadata          TRUE
innodb-status-file                FALSE
innodb-support-xa                 TRUE
innodb-sync-spin-loops            20
innodb-table-locks                TRUE
innodb-thread-concurrency         8
innodb-thread-sleep-delay         10000
interactive_timeout               28800
join_buffer_size                  131072
keep_files_on_create              FALSE
key_buffer_size                   8384512
key_cache_age_threshold           300
key_cache_block_size              1024
key_cache_division_limit          100
language                          /home/jon/bin/mysql-5.5/share/mysql/english/
large-pages                       FALSE
lc-time-names                     en_US
local-infile                      TRUE
log                               (No default value)
log-bin                           (No default value)
log-bin-index                     (No default value)
log-bin-trust-function-creators   FALSE
log-error
log-isam                          myisam.log
log-output                        FILE
log-queries-not-using-indexes     FALSE
log-short-format                  FALSE
log-slave-updates                 FALSE
log-slow-admin-statements         FALSE
log-slow-slave-statements         FALSE
log-tc                            tc.log
log-tc-size                       24576
log-warnings                      1
log_slow_queries                  (No default value)
long_query_time                   10
low-priority-updates              FALSE
lower_case_table_names            0
master-retry-count                86400
max-binlog-dump-events            0
max_allowed_packet                1048576
max_binlog_cache_size             18446744073709547520
max_binlog_size                   1073741824
max_connections                   151
max_connect_errors                10
```

```
max_delayed_threads               20
max_error_count                   64
max_heap_table_size               16777216
max_join_size                     18446744073709551615
max_length_for_sort_data          1024
max_prepared_stmt_count           16382
max_relay_log_size                0
max_seeks_for_key                 18446744073709551615
max_sort_length                   1024
max_sp_recursion_depth            0
max_tmp_tables                    32
max_user_connections              0
max_write_lock_count              18446744073709551615
memlock                           FALSE
min_examined_row_limit            0
multi_range_count                 256
myisam-recover-options            OFF
myisam_block_size                 1024
myisam_data_pointer_size          6
myisam_max_sort_file_size         9223372036853727232
myisam_repair_threads             1
myisam_sort_buffer_size           8388608
myisam_stats_method               nulls_unequal
myisam_use_mmap                   FALSE
ndb-autoincrement-prefetch-sz     1
ndb-cache-check-time              0
ndb-connectstring                 (No default value)
ndb-extra-logging                 0
ndb-force-send                    TRUE
ndb-index-stat-enable             FALSE
ndb-mgmd-host                     (No default value)
ndb-nodeid                        0
ndb-optimized-node-selection      TRUE
ndb-report-thresh-binlog-epoch-slip 3
ndb-report-thresh-binlog-mem-usage 10
ndb-shm                           FALSE
ndb-use-copying-alter-table       FALSE
ndb-use-exact-count               TRUE
ndb-use-transactions              TRUE
ndb_force_send                    TRUE
ndb_use_exact_count               TRUE
ndb_use_transactions              TRUE
net_buffer_length                 16384
net_read_timeout                  30
net_retry_count                   10
net_write_timeout                 60
new                               FALSE
old                               FALSE
old-alter-table                   FALSE
old-passwords                     FALSE
old-style-user-limits             FALSE
open_files_limit                  1024
optimizer_prune_level             1
optimizer_search_depth            62
pid-file                          /home/jon/bin/mysql-5.5/var/tonfisk.pid
plugin-load                       (No default value)
plugin_dir                        /home/jon/bin/mysql-5.5/lib/mysql/plugin
port                              3306
port-open-timeout                 0
preload_buffer_size               32768
profiling_history_size            15
query_alloc_block_size            8192
query_cache_limit                 1048576
query_cache_min_res_unit          4096
query_cache_size                  0
query_cache_type                  1
query_cache_wlock_invalidate      FALSE
query_prealloc_size               8192
range_alloc_block_size            4096
read_buffer_size                  131072
read_only                         FALSE
read_rnd_buffer_size              262144
relay-log                         (No default value)
relay-log-index                   (No default value)
relay-log-info-file               relay-log.info
relay_log_purge                   TRUE
relay_log_space_limit             0
replicate-same-server-id          FALSE
report-host                       (No default value)
report-password                   (No default value)
report-port                       3306
report-user                       (No default value)
rpl-recovery-rank                 0
safe-user-create                  FALSE
secure-auth                       FALSE
secure-file-priv                  (No default value)
server-id                         0
show-slave-auth-info              FALSE
skip-grant-tables                 FALSE
skip-slave-start                  FALSE
slave-exec-mode                   STRICT
slave-load-tmpdir                 /tmp
slave_compressed_protocol         FALSE
slave_net_timeout                 3600
slave_transaction_retries         10
slow-query-log                    FALSE
slow_launch_time                  2
```

```
slow_query_log_file                (No default value)
socket                             /tmp/mysql.sock
sort_buffer_size                   2097144
sporadic-binlog-dump-fail          FALSE
sql-mode                           OFF
symbolic-links                     TRUE
sync-binlog                        0
sync-frm                           TRUE
sysdate-is-now                     FALSE
table_definition_cache             256
table_open_cache                   400
tc-heuristic-recover               (No default value)
temp-pool                          TRUE
thread_cache_size                  0
thread_concurrency                 10
thread_stack                       262144
timed_mutexes                      FALSE
time_format                        %H:%i:%s
tmpdir                             (No default value)
tmp_table_size                     16777216
transaction_alloc_block_size       8192
transaction_prealloc_size          4096
updatable_views_with_limit         1
verbose                            TRUE
wait_timeout                       28800
```

For a `mysqld` server that is currently running, you can see the current values of its system variables by connecting to it and issuing this statement:

```
mysql> SHOW VARIABLES;
```

You can also see some statistical and status indicators for a running server by issuing this statement:

```
mysql> SHOW STATUS;
```

System variable and status information also can be obtained using `mysqladmin`:

```
shell> mysqladmin variables
shell> mysqladmin extended-status
```

For a full description of all system and status variables, see Section 5.1.3, “Server System Variables”, and Section 5.1.5, “Server Status Variables”.

MySQL uses algorithms that are very scalable, so you can usually run with very little memory. However, normally you get better performance by giving MySQL more memory.

When tuning a MySQL server, the two most important variables to configure are `key_buffer_size` and `table_open_cache`. You should first feel confident that you have these set appropriately before trying to change any other variables.

The following examples indicate some typical variable values for different runtime configurations.

- If you have at least 256MB of memory and many tables and want maximum performance with a moderate number of clients, use something like this:

  ```
  shell> mysqld_safe --key_buffer_size=64M --table_open_cache=256 \
             --sort_buffer_size=4M --read_buffer_size=1M &
  ```

- If you have only 128MB of memory and only a few tables, but you still do a lot of sorting, you can use something like this:

  ```
  shell> mysqld_safe --key_buffer_size=16M --sort_buffer_size=1M
  ```

  If there are very many simultaneous connections, swapping problems may occur unless `mysqld` has been configured to use very little memory for each connection. `mysqld` performs better if you have enough memory for all connections.

- With little memory and lots of connections, use something like this:

  ```
  shell> mysqld_safe --key_buffer_size=512K --sort_buffer_size=100K \
             --read_buffer_size=100K &
  ```

  Or even this:

  ```
  shell> mysqld_safe --key_buffer_size=512K --sort_buffer_size=16K \
             --table_open_cache=32 --read_buffer_size=8K \
             --net_buffer_length=1K &
  ```

If you are performing `GROUP BY` or `ORDER BY` operations on tables that are much larger than your available memory, increase the value of `read_rnd_buffer_size` to speed up the reading of rows following sorting operations.

You can make use of the example option files included with your MySQL distribution; see Section 4.2.3.3.2, “Preconfigured Option Files”.

If you specify an option on the command line for `mysqld` or `mysqld_safe`, it remains in effect only for that invocation of the server. To use the option every time the server runs, put it in an option file.

To see the effects of a parameter change, do something like this:

```
shell> mysqld --key_buffer_size=32M --verbose --help
```

The variable values are listed near the end of the output. Make sure that the `--verbose` and `--help` options are last. Otherwise, the effect of any options listed after them on the command line are not reflected in the output.

For information on tuning the `InnoDB` storage engine, see Section 13.3.14.1, “`InnoDB` Performance Tuning Tips”.

7.11.3. Optimizing Disk I/O

The `SHOW COLUMNS` and The `DESCRIBE` statements use `BLOB` as the type for some columns, thus the temporary table used for the results is an on-disk table.

The tips in Section 7.5.7, “Optimizing `InnoDB` Disk I/O” help you get more I/O performance out of your existing storage configuration. This section describes ways to configure your storage devices when you can devote more and faster storage hardware to the database server.

- Disk seeks are a huge performance bottleneck. This problem becomes more apparent when the amount of data starts to grow so large that effective caching becomes impossible. For large databases where you access data more or less randomly, you can be sure that you need at least one disk seek to read and a couple of disk seeks to write things. To minimize this problem, use disks with low seek times.

- Increase the number of available disk spindles (and thereby reduce the seek overhead) by either symlinking files to different disks or striping the disks:

    - Using symbolic links

      This means that, for `MyISAM` tables, you symlink the index file and data files from their usual location in the data directory to another disk (that may also be striped). This makes both the seek and read times better, assuming that the disk is not used for other purposes as well. See Section 7.11.3.1, “Using Symbolic Links”.

    - Striping

      Striping means that you have many disks and put the first block on the first disk, the second block on the second disk, and the *`N`*-th block on the (*`N`* `MOD` *`number_of_disks`*) disk, and so on. This means if your normal data size is less than the stripe size (or perfectly aligned), you get much better performance. Striping is very dependent on the operating system and the stripe size, so benchmark your application with different stripe sizes. See Section 7.12.3, “Using Your Own Benchmarks”.

      The speed difference for striping is *very* dependent on the parameters. Depending on how you set the striping parameters and number of disks, you may get differences measured in orders of magnitude. You have to choose to optimize for random or sequential access.

- For reliability, you may want to use RAID 0+1 (striping plus mirroring), but in this case, you need 2 × *`N`* drives to hold *`N`* drives of data. This is probably the best option if you have the money for it. However, you may also have to invest in some volume-management software to handle it efficiently.

- A good option is to vary the RAID level according to how critical a type of data is. For example, store semi-important data that can be regenerated on a RAID 0 disk, but store really important data such as host information and logs on a RAID 0+1 or RAID *`N`* disk. RAID *`N`* can be a problem if you have many writes, due to the time required to update the parity bits.

- On Linux, you can get much better performance by using `hdparm` to configure your disk's interface. (Up to 100% under load is not uncommon.) The following `hdparm` options should be quite good for MySQL, and probably for many other applications:

  ```
  hdparm -m 16 -d 1
  ```

Note that performance and reliability when using this command depend on your hardware, so we strongly suggest that you test your system thoroughly after using `hdparm`. Please consult the `hdparm` manual page for more information. If `hdparm` is not used wisely, file system corruption may result, so back up everything before experimenting!

- You can also set the parameters for the file system that the database uses:

  If you do not need to know when files were last accessed (which is not really useful on a database server), you can mount your file systems with the `-o noatime` option. That skips updates to the last access time in inodes on the file system, which avoids some disk seeks.

  On many operating systems, you can set a file system to be updated asynchronously by mounting it with the `-o async` option. If your computer is reasonably stable, this should give you better performance without sacrificing too much reliability. (This flag is on by default on Linux.)

7.11.3.1. Using Symbolic Links

You can move tables and databases from the database directory to other locations and replace them with symbolic links to the new locations. You might want to do this, for example, to move a database to a file system with more free space or increase the speed of your system by spreading your tables to different disk.

The recommended way to do this is simply to symlink databases to a different disk. Symlink tables only as a last resort.

7.11.3.1.1. Using Symbolic Links for Databases on Unix

On Unix, to symlink a database, first create a directory on some disk where you have free space and then create a symlink to it from the MySQL data directory.

```
shell> mkdir /dr1/databases/test
shell> ln -s /dr1/databases/test /path/to/datadir
```

MySQL does not support linking one directory to multiple databases. Replacing a database directory with a symbolic link works as long as you do not make a symbolic link between databases. Suppose that you have a database `db1` under the MySQL data directory, and then make a symlink `db2` that points to `db1`:

```
shell> cd /path/to/datadir
shell> ln -s db1 db2
```

The result is that, or any table `tbl_a` in `db1`, there also appears to be a table `tbl_a` in `db2`. If one client updates `db1.tbl_a` and another client updates `db2.tbl_a`, problems are likely to occur.

However, if you really need to do this, it is possible by altering the source file `mysys/my_symlink.c`. Look for the following statement:

```
if (!(MyFlags & MY_RESOLVE_LINK) ||
    (!lstat(filename,&stat_buff) && S_ISLNK(stat_buff.st_mode)))
```

Change the statement to this:

```
if (1)
```

7.11.3.1.2. Using Symbolic Links for Tables on Unix

Do not symlink tables on systems that do not have a fully operational `realpath()` call. (Linux and Solaris support `realpath()`). Check whether your system supports symbolic links by issuing a `SHOW VARIABLES LIKE 'have_symlink'` statement.

Symlinks are fully supported only for `MyISAM` tables. For files used by tables for other storage engines, you may get strange problems if you try to use symbolic links.

The handling of symbolic links for `MyISAM` tables works as follows:

- In the data directory, you always have the table format (`.frm`) file, the data (`.MYD`) file, and the index (`.MYI`) file. The data file and index file can be moved elsewhere and replaced in the data directory by symlinks. The format file cannot.
- You can symlink the data file and the index file independently to different directories.

- You can instruct a running MySQL server to perform the symlinking by using the `DATA DIRECTORY` and `INDEX DIRECTORY` options to `CREATE TABLE`. See Section 12.1.14, "`CREATE TABLE` Syntax". Alternatively, symlinking can be accomplished manually from the command line using `ln -s` if `mysqld` is not running.

  > **Note**
  >
  > The path used with either or both of the `DATA DIRECTORY` and `INDEX DIRECTORY` options may not include the MySQL `data` directory. (Bug #32167)

- `myisamchk` does not replace a symlink with the data file or index file. It works directly on the file to which the symlink points. Any temporary files are created in the directory where the data file or index file is located. The same is true for the `ALTER TABLE`, `OPTIMIZE TABLE`, and `REPAIR TABLE` statements.

- > **Note**
  >
  > When you drop a table that is using symlinks, *both the symlink and the file to which the symlink points are dropped*. This is an extremely good reason *not* to run `mysqld` as the system `root` or permit system users to have write access to MySQL database directories.

- If you rename a table with `ALTER TABLE ... RENAME` or `RENAME TABLE` and you do not move the table to another database, the symlinks in the database directory are renamed to the new names and the data file and index file are renamed accordingly.

- If you use `ALTER TABLE ... RENAME` or `RENAME TABLE` to move a table to another database, the table is moved to the other database directory. If the table name changed, the symlinks in the new database directory are renamed to the new names and the data file and index file are renamed accordingly.

- If you are not using symlinks, use the `--skip-symbolic-links` option to `mysqld` to ensure that no one can use `mysqld` to drop or rename a file outside of the data directory.

Table symlink operations that are not yet supported:

- `ALTER TABLE` ignores the `DATA DIRECTORY` and `INDEX DIRECTORY` table options.

- The `.frm` file must *never* be a symbolic link (as indicated previously, only the data and index files can be symbolic links). Attempting to do this (for example, to make synonyms) produces incorrect results. Suppose that you have a database `db1` under the MySQL data directory, a table `tbl1` in this database, and in the `db1` directory you make a symlink `tbl2` that points to `tbl1`:

  ```
  shell> cd /path/to/datadir/db1
  shell> ln -s tbl1.frm tbl2.frm
  shell> ln -s tbl1.MYD tbl2.MYD
  shell> ln -s tbl1.MYI tbl2.MYI
  ```

  Problems result if one thread reads `db1.tbl1` and another thread updates `db1.tbl2`:

  - The query cache is "fooled" (it has no way of knowing that `tbl1` has not been updated, so it returns outdated results).

  - `ALTER` statements on `tbl2` fail.

7.11.3.1.3. Using Symbolic Links for Databases on Windows

Symbolic links are enabled by default for all Windows servers. This enables you to put a database directory on a different disk by setting up a symbolic link to it. This is similar to the way that database symbolic links work on Unix, although the procedure for setting up the link is different. If you do not need symbolic links, you can disable them using the `--skip-symbolic-links` option.

On Windows, create a symbolic link to a MySQL database by creating a file in the data directory that contains the path to the destination directory. The file should be named `*db_name*.sym`, where `*db_name*` is the database name.

Suppose that the MySQL data directory is `C:\mysql\data` and you want to have database `foo` located at `D:\data\foo`. Set up a symlink using this procedure

1. Make sure that the `D:\data\foo` directory exists by creating it if necessary. If you already have a database directory named `foo` in the data directory, move it to `D:\data`. Otherwise, the symbolic link will be ineffective. To avoid problems, make sure that the server is not running when you move the database directory.

2. Create a text file `C:\mysql\data\foo.sym` that contains the path name `D:\data\foo\`.

> **Note**
>
> The path name to the new database and tables should be absolute. If you specify a relative path, the location will be relative to the `foo.sym` file.

After this, all tables created in the database `foo` are created in `D:\data\foo`.

The following limitations apply to the use of `.sym` files for database symbolic linking on Windows:

- The symbolic link is not used if a directory with the same name as the database exists in the MySQL data directory.
- The `--innodb_file_per_table` option cannot be used.
- If you run `mysqld` as a service, you cannot use a mapped drive to a remote server as the destination of the symbolic link. As a workaround, you can use the full path (`\\servername\path\`).

7.11.4. Optimizing Memory Use

7.11.4.1. How MySQL Uses Memory

The following list indicates some of the ways that the `mysqld` server uses memory. Where applicable, the name of the system variable relevant to the memory use is given:

- All threads share the `MyISAM` key buffer; its size is determined by the `key_buffer_size` variable. Other buffers used by the server are allocated as needed. See Section 7.11.2, “Tuning Server Parameters”.
- Each thread that is used to manage client connections uses some thread-specific space. The following list indicates these and which variables control their size:
  - A stack (variable `thread_stack`)
  - A connection buffer (variable `net_buffer_length`)
  - A result buffer (variable `net_buffer_length`)

  The connection buffer and result buffer each begin with a size equal to `net_buffer_length` bytes, but are dynamically enlarged up to `max_allowed_packet` bytes as needed. The result buffer shrinks to `net_buffer_length` bytes after each SQL statement. While a statement is running, a copy of the current statement string is also allocated.
- All threads share the same base memory.
- When a thread is no longer needed, the memory allocated to it is released and returned to the system unless the thread goes back into the thread cache. In that case, the memory remains allocated.
- The `myisam_use_mmap` system variable can be set to 1 to enable memory-mapping for all `MyISAM` tables.
- Each request that performs a sequential scan of a table allocates a *read buffer* (variable `read_buffer_size`).
- When reading rows in an arbitrary sequence (for example, following a sort), a *random-read buffer* (variable `read_rnd_buffer_size`) may be allocated to avoid disk seeks.
- All joins are executed in a single pass, and most joins can be done without even using a temporary table. Most temporary tables are memory-based hash tables. Temporary tables with a large row length (calculated as the sum of all column lengths) or that contain `BLOB` columns are stored on disk.

  If an internal in-memory temporary table becomes too large, MySQL handles this automatically by changing the table from in-memory to on-disk format, to be handled by the `MyISAM` storage engine. You can increase the permissible temporary table size as described in Section 7.4.3.3, “How MySQL Uses Internal Temporary Tables”.
- Most requests that perform a sort allocate a sort buffer and zero to two temporary files depending on the result set size. See Section C.5.4.4, “Where MySQL Stores Temporary Files”.
- Almost all parsing and calculating is done in thread-local and reusable memory pools. No memory overhead is needed for small items, so the normal slow memory allocation and freeing is avoided. Memory is allocated only for unexpectedly large strings.

- For each `MyISAM` table that is opened, the index file is opened once; the data file is opened once for each concurrently running thread. For each concurrent thread, a table structure, column structures for each column, and a buffer of size `3 * N` are allocated (where `N` is the maximum row length, not counting `BLOB` columns). A `BLOB` column requires five to eight bytes plus the length of the `BLOB` data. The `MyISAM` storage engine maintains one extra row buffer for internal use.

- For each table having `BLOB` columns, a buffer is enlarged dynamically to read in larger `BLOB` values. If you scan a table, a buffer as large as the largest `BLOB` value is allocated.

- Handler structures for all in-use tables are saved in a cache and managed as a FIFO. The initial cache size is taken from the value of the `table_open_cache` system variable. If a table has been used by two running threads at the same time, the cache contains two entries for the table. See Section 7.4.3.1, “How MySQL Opens and Closes Tables”.

- A `FLUSH TABLES` statement or `mysqladmin flush-tables` command closes all tables that are not in use at once and marks all in-use tables to be closed when the currently executing thread finishes. This effectively frees most in-use memory. `FLUSH TABLES` does not return until all tables have been closed.

- The server caches information in memory as a result of `GRANT`, `CREATE USER`, `CREATE SERVER`, and `INSTALL PLUGIN` statements. This memory is not released by the corresponding `REVOKE`, `DROP USER`, `DROP SERVER`, and `UNINSTALL PLUGIN` statements, so for a server that executes many instances of the statements that cause caching, there will be an increase in memory use. This cached memory can be freed with `FLUSH PRIVILEGES`.

`ps` and other system status programs may report that `mysqld` uses a lot of memory. This may be caused by thread stacks on different memory addresses. For example, the Solaris version of `ps` counts the unused memory between stacks as used memory. To verify this, check available swap with `swap -s`. We test `mysqld` with several memory-leakage detectors (both commercial and Open Source), so there should be no memory leaks.

7.11.4.2. Enabling Large Page Support

Some hardware/operating system architectures support memory pages greater than the default (usually 4KB). The actual implementation of this support depends on the underlying hardware and operating system. Applications that perform a lot of memory accesses may obtain performance improvements by using large pages due to reduced Translation Lookaside Buffer (TLB) misses.

In MySQL, large pages can be used by InnoDB, to allocate memory for its buffer pool and additional memory pool.

Standard use of large pages in MySQL attempts to use the largest size supported, up to 4MB. Under Solaris, a “super large pages” feature enables uses of pages up to 256MB. This feature is available for recent SPARC platforms. It can be enabled or disabled by using the `--super-large-pages` or `--skip-super-large-pages` option.

MySQL also supports the Linux implementation of large page support (which is called HugeTLB in Linux).

Before large pages can be used on Linux, the kernel must be enabled to support them and it is necessary to configure the HugeTLB memory pool. For reference, the HugeTBL API is documented in the `Documentation/vm/hugetlbpage.txt` file of your Linux sources.

The kernel for some recent systems such as Red Hat Enterprise Linux appear to have the large pages feature enabled by default. To check whether this is true for your kernel, use the following command and look for output lines containing “huge”:

```
shell> cat /proc/meminfo | grep -i huge
HugePages_Total:       0
HugePages_Free:        0
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       4096 kB
```

The nonempty command output indicates that large page support is present, but the zero values indicate that no pages are configured for use.

If your kernel needs to be reconfigured to support large pages, consult the `hugetlbpage.txt` file for instructions.

Assuming that your Linux kernel has large page support enabled, configure it for use by MySQL using the following commands. Normally, you put these in an `rc` file or equivalent startup file that is executed during the system boot sequence, so that the commands execute each time the system starts. The commands should execute early in the boot sequence, before the MySQL server starts. Be sure to change the allocation numbers and the group number as appropriate for your system.

```
# Set the number of pages to be used.
# Each page is normally 2MB, so a value of 20 = 40MB.
# This command actually allocates memory, so this much
# memory must be available.
echo 20 > /proc/sys/vm/nr_hugepages

# Set the group number that is permitted to access this
# memory (102 in this case). The mysql user must be a
# member of this group.
```

```
echo 102 > /proc/sys/vm/hugetlb_shm_group

# Increase the amount of shmem permitted per segment
# (12G in this case).
echo 1560281088 > /proc/sys/kernel/shmmax

# Increase total amount of shared memory.  The value
# is the number of pages. At 4KB/page, 4194304 = 16GB.
echo 4194304 > /proc/sys/kernel/shmall
```

For MySQL usage, you normally want the value of `shmmax` to be close to the value of `shmall`.

To verify the large page configuration, check `/proc/meminfo` again as described previously. Now you should see some nonzero values:

```
shell> cat /proc/meminfo | grep -i huge
HugePages_Total:      20
HugePages_Free:       20
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       4096 kB
```

The final step to make use of the `hugetlb_shm_group` is to give the `mysql` user an "unlimited" value for the memlock limit. This can by done either by editing `/etc/security/limits.conf` or by adding the following command to your `mysqld_safe` script:

```
ulimit -l unlimited
```

Adding the `ulimit` command to `mysqld_safe` causes the `root` user to set the memlock limit to `unlimited` before switching to the `mysql` user. (This assumes that `mysqld_safe` is started by `root`.)

Large page support in MySQL is disabled by default. To enable it, start the server with the `--large-pages` option. For example, you can use the following lines in your server's `my.cnf` file:

```
[mysqld]
large-pages
```

With this option, `InnoDB` uses large pages automatically for its buffer pool and additional memory pool. If `InnoDB` cannot do this, it falls back to use of traditional memory and writes a warning to the error log: WARNING: USING CONVENTIONAL MEMORY POOL

To verify that large pages are being used, check `/proc/meminfo` again:

```
shell> cat /proc/meminfo | grep -i huge
HugePages_Total:      20
HugePages_Free:       20
HugePages_Rsvd:        2
HugePages_Surp:        0
Hugepagesize:       4096 kB
```

7.11.5. Optimizing Network Use

7.11.5.1. How MySQL Uses Threads for Client Connections

Connection manager threads handle client connection requests on the network interfaces that the server listens to. On all platforms, one manager thread handles TCP/IP connection requests. On Unix, this manager thread also handles Unix socket file connection requests. On Windows, a manager thread handles shared-memory connection requests, and another handles named-pipe connection requests. The server does not create threads to handle interfaces that it does not listen to. For example, a Windows server that does not have support for named-pipe connections enabled does not create a thread to handle them.

Connection manager threads associate each client connection with a thread dedicated to it that handles authentication and request processing for that connection. Manager threads create a new thread when necessary but try to avoid doing so by consulting the thread cache first to see whether it contains a thread that can be used for the connection. When a connection ends, its thread is returned to the thread cache if the cache is not full.

In this connection thread model, there are as many threads as there are clients currently connected, which has some disadvantages when server workload must scale to handle large numbers of connections. For example, thread creation and disposal becomes expensive. Also, each thread requires server and kernel resources, such as stack space. To accommodate a large number of simultaneous connections, the stack size per thread must be kept small, leading to a situation where it is either too small or the server consumes large amounts of memory. Exhaustion of other resources can occur as well, and scheduling overhead can become significant.

To control and monitor how the server manages threads that handle client connections, several system and status variables are relevant. (See Section 5.1.3, “Server System Variables”, and Section 5.1.5, “Server Status Variables”.)

The thread cache has a size determined by the `thread_cache_size` system variable. The default value is 0 (no caching), which causes a thread to be set up for each new connection and disposed of when the connection terminates. Set `thread_cache_size` to *`N`* to enable *`N`* inactive connection threads to be cached. `thread_cache_size` can be set at server startup or changed while the server runs. A connection thread becomes inactive when the client connection with which it was associated terminates.

To monitor the number of threads in the cache and how many threads have been created because a thread could not be taken from the cache, monitor the `Threads_cached` and `Threads_created` status variables.

You can set `max_connections` at server startup or at runtime to control the maximum number of clients that can connect simultaneously.

When the thread stack is too small, this limits the complexity of the SQL statements which the server can handle, the recursion depth of stored procedures, and other memory-consuming actions. To set a stack size of *`N`* bytes for each thread, start the server with `--thread_stack=N`.

7.11.5.2. How MySQL Uses DNS

When a new client connects to `mysqld`, `mysqld` spawns a new thread to handle the request. This thread first checks whether the host name is in the host name cache. If not, the thread attempts to resolve the host name:

- The thread takes the IP address and resolves it to a host name (using `gethostbyaddr()`). It then takes that host name and resolves it back to the IP address (using `gethostbyname()`) and compares to ensure it is the original IP address.
- If the operating system supports the thread-safe `gethostbyaddr_r()` and `gethostbyname_r()` calls, the thread uses them to perform host name resolution.
- If the operating system does not support the thread-safe calls, the thread locks a mutex and calls `gethostbyaddr()` and `gethostbyname()` instead. In this case, no other thread can resolve host names that are not in the host name cache until the first thread unlocks the mutex.

You can disable DNS host name lookups by starting `mysqld` with the `--skip-name-resolve` option. However, in this case, you can use only IP addresses in the MySQL grant tables.

If you have a very slow DNS and many hosts, you can get more performance by either disabling DNS lookups with `--skip-name-resolve` or by increasing the `HOST_CACHE_SIZE` define (default value: 128) and recompiling `mysqld`.

You can disable the host name cache by starting the server with the `--skip-host-cache` option. To clear the host name cache, issue a `FLUSH HOSTS` statement or execute the `mysqladmin flush-hosts` command.

To disallow TCP/IP connections entirely, start `mysqld` with the `--skip-networking` option.

7.12. Measuring Performance (Benchmarking)

To measure performance, consider the following factors:

- Whether you are measuring the speed of a single operation on a quiet system, or how a set of operations (a “workload”) works over a period of time. With simple tests, you usually test how changing one aspect (a configuration setting, the set of indexes on a table, the SQL clauses in a query) affects performance. Benchmarks are typically long-running and elaborate performance tests, where the results could dictate high-level choices such as hardware and storage configuration, or how soon to upgrade to a new MySQL version.
- For benchmarking, sometimes you must simulate a heavy database workload to get an accurate picture.
- Performance can vary depending on so many different factors that a difference of a few percentage points might not be a decisive victory. The results might shift the opposite way when you test in a different environment.
- Certain MySQL features help or do not help performance depending on the workload. For completeness, always test performance with those features turned on and turned off. The two most important features to try with each workload are the MySQL query cache, and the adaptive hash index for `InnoDB` tables.

This section progresses from simple and direct measurement techniques that a single developer can do, to more complicated ones that require additional expertise to perform and interpret the results.

7.12.1. Measuring the Speed of Expressions and Functions

To measure the speed of a specific MySQL expression or function, invoke the `BENCHMARK()` function using the `mysql` client program. Its syntax is `BENCHMARK(loop_count,expression)`. The return value is always zero, but `mysql` prints a line displaying approximately how long the statement took to execute. For example:

```
mysql> SELECT BENCHMARK(1000000,1+1);
+------------------------+
| BENCHMARK(1000000,1+1) |
+------------------------+
|                      0 |
+------------------------+
1 row in set (0.32 sec)
```

This result was obtained on a Pentium II 400MHz system. It shows that MySQL can execute 1,000,000 simple addition expressions in 0.32 seconds on that system.

The built-in MySQL functions are typically highly optimized, but there may be some exceptions. `BENCHMARK()` is an excellent tool for finding out if some function is a problem for your queries.

7.12.2. The MySQL Benchmark Suite

This benchmark suite is meant to tell any user what operations a given SQL implementation performs well or poorly. You can get a good idea for how the benchmarks work by looking at the code and results in the `sql-bench` directory in any MySQL source distribution.

Note that this benchmark is single-threaded, so it measures the minimum time for the operations performed. We plan to add multi-threaded tests to the benchmark suite in the future.

To use the benchmark suite, the following requirements must be satisfied:

- The benchmark suite is provided with MySQL source distributions. You can either download a released distribution from http://dev.mysql.com/downloads/, or use the current development source tree. (See Section 2.9.3, “Installing MySQL from a Development Source Tree”.)
- The benchmark scripts are written in Perl and use the Perl DBI module to access database servers, so DBI must be installed. You also need the server-specific DBD drivers for each of the servers you want to test. For example, to test MySQL, PostgreSQL, and DB2, you must have the `DBD::mysql`, `DBD::Pg`, and `DBD::DB2` modules installed. See Section 2.13, “Perl Installation Notes”.

After you obtain a MySQL source distribution, you can find the benchmark suite located in its `sql-bench` directory. To run the benchmark tests, build MySQL, and then change location into the `sql-bench` directory and execute the `run-all-tests` script:

```
shell> cd sql-bench
shell> perl run-all-tests --server=server_name
```

`server_name` should be the name of one of the supported servers. To get a list of all options and supported servers, invoke this command:

```
shell> perl run-all-tests --help
```

The `crash-me` script also is located in the `sql-bench` directory. `crash-me` tries to determine what features a database system supports and what its capabilities and limitations are by actually running queries. For example, it determines:

- What data types are supported.
- How many indexes are supported.
- What functions are supported.
- How big a query can be.
- How big a `VARCHAR` column can be.

For more information about benchmark results, visit http://www.mysql.com/why-mysql/benchmarks/.

7.12.3. Using Your Own Benchmarks

Benchmark your application and database to find out where the bottlenecks are. After fixing one bottleneck (or by replacing it with a “dummy” module), you can proceed to identify the next bottleneck. Even if the overall performance for your application currently is acceptable, you should at least make a plan for each bottleneck and decide how to solve it if someday you really need the extra performance.

For examples of portable benchmark programs, look at those in the MySQL benchmark suite. See Section 7.12.2, “The MySQL Benchmark Suite”. You can take any program from this suite and modify it for your own needs. By doing this, you can try different solutions to your problem and test which really is fastest for you.

Another free benchmark suite is the Open Source Database Benchmark, available at http://osdb.sourceforge.net/.

It is very common for a problem to occur only when the system is very heavily loaded, even if other aspects of the system were tested extensively. These performance problems are typically due to issues of basic database design (for example, table scans are not good under high load) or problems with the operating system or libraries. These problems are much easier to fix if isolated during pre-production testing.

To avoid problems like this, benchmark your whole application under the worst possible load:

- The `mysqlslap` program can be helpful for simulating a high load produced by multiple clients issuing queries simultaneously. See Section 4.5.7, “`mysqlslap` — Load Emulation Client”.
- You can also try benchmarking packages such as SysBench and DBT2, available at http://sourceforge.net/projects/sysbench/, and http://osdldbt.sourceforge.net/#dbt2.

These programs or packages can bring a system to its knees, so be sure to use them only on your development systems.

7.12.4. Measuring Performance with `performance_schema`

You can query the tables in the `performance_schema` database to see real-time information about the performance characteristics of your server and the applications it is running. See Chapter 19, *MySQL Performance Schema* for details.

7.12.5. Examining Thread Information

As you monitor the performance of your MySQL server, examine the process list, which is the set of threads currently executing within the server. Process list information is available from these sources:

- The `SHOW [FULL] PROCESSLIST` statement: Section 12.4.5.30, “`SHOW PROCESSLIST` Syntax”
- The `SHOW PROFILE` statement: Section 12.4.5.32, “`SHOW PROFILES` Syntax”
- The `INFORMATION_SCHEMA` `PROCESSLIST` table: Section 18.23, “The `INFORMATION_SCHEMA PROCESSLIST` Table”
- The `mysqladmin processlist` command: Section 4.5.2, “`mysqladmin` — Client for Administering a MySQL Server”

You can always view information about your own threads. To view information about threads being executed for other accounts, you must have the `PROCESS` privilege.

Each process list entry contains several pieces of information:

- `Id` is the connection identifier for the client associated with the thread.
- `User` and `Host` indicate the account associated with the thread.
- `db` is the default database for the thread, or `NULL` if none is selected.
- `Command` and `State` indicate what the thread is doing.

  Most states correspond to very quick operations. If a thread stays in a given state for many seconds, there might be a problem that needs to be investigated.
- `Time` indicates how long the thread has been in its current state. The thread's notion of the current time may be altered in some cases: The thread can change the time with `SET TIMESTAMP = value`. For a thread running on a slave that is processing events from the master, the thread time is set to the time found in the events and thus reflects current time on the master and not

the slave.

- `Info` contains the text of the statement being executed by the thread, or `NULL` if it is not executing one. By default, this value contains only the first 100 characters of the statement. To see the complete statements, use `SHOW FULL PROCESSLIST`.

The following sections list the possible `Command` values, and `State` values grouped by category. The meaning for some of these values is self-evident. For others, additional description is provided.

7.12.5.1. Thread Command Values

A thread can have any of the following `Command` values:

- `Binlog Dump`

  This is a thread on a master server for sending binary log contents to a slave server.

- `Change user`

  The thread is executing a change-user operation.

- `Close stmt`

  The thread is closing a prepared statement.

- `Connect`

  A replication slave is connected to its master.

- `Connect Out`

  A replication slave is connecting to its master.

- `Create DB`

  The thread is executing a create-database operation.

- `Daemon`

  This thread is internal to the server, not a thread that services a client connection.

- `Debug`

  The thread is generating debugging information.

- `Delayed insert`

  The thread is a delayed-insert handler.

- `Drop DB`

  The thread is executing a drop-database operation.

- `Error`
- `Execute`

  The thread is executing a prepared statement.

- `Fetch`

  The thread is fetching the results from executing a prepared statement.

- `Field List`

  The thread is retrieving information for table columns.

- `Init DB`

  The thread is selecting a default database.

- `Kill`

  The thread is killing another thread.

- `Long Data`

  The thread is retrieving long data in the result of executing a prepared statement.

- `Ping`

  The thread is handling a server-ping request.

- `Prepare`

  The thread is preparing a prepared statement.

- `Processlist`

  The thread is producing information about server threads.

- `Query`

  The thread is executing a statement.

- `Quit`

  The thread is terminating.

- `Refresh`

  The thread is flushing table, logs, or caches, or resetting status variable or replication server information.

- `Register Slave`

  The thread is registering a slave server.

- `Reset stmt`

  The thread is resetting a prepared statement.

- `Set option`

  The thread is setting or resetting a client statement-execution option.

- `Shutdown`

  The thread is shutting down the server.

- `Sleep`

  The thread is waiting for the client to send a new statement to it.

- `Statistics`

  The thread is producing server-status information.

- `Table Dump`

  The thread is sending table contents to a slave server.

- `Time`

  Unused.

7.12.5.2. General Thread States

The following list describes thread `State` values that are associated with general query processing and not more specialized activities such as replication. Many of these are useful only for finding bugs in the server.

- `After create`

This occurs when the thread creates a table (including internal temporary tables), at the end of the function that creates the table. This state is used even if the table could not be created due to some error.

- `Analyzing`

  The thread is calculating a `MyISAM` table key distributions (for example, for `ANALYZE TABLE`).

- `checking permissions`

  The thread is checking whether the server has the required privileges to execute the statement.

- `Checking table`

  The thread is performing a table check operation.

- `cleaning up`

  The thread has processed one command and is preparing to free memory and reset certain state variables.

- `closing tables`

  The thread is flushing the changed table data to disk and closing the used tables. This should be a fast operation. If not, verify that you do not have a full disk and that the disk is not in very heavy use.

- `converting HEAP to MyISAM`

  The thread is converting an internal temporary table from a `MEMORY` table to an on-disk `MyISAM` table.

- `copy to tmp table`

  The thread is processing an `ALTER TABLE` statement. This state occurs after the table with the new structure has been created but before rows are copied into it.

- `Copying to group table`

  If a statement has different `ORDER BY` and `GROUP BY` criteria, the rows are sorted by group and copied to a temporary table.

- `Copying to tmp table`

  The server is copying to a temporary table in memory.

- `Copying to tmp table on disk`

  The server is copying to a temporary table on disk. The temporary result set has become too large (see Section 7.4.3.3, “How MySQL Uses Internal Temporary Tables”). Consequently, the thread is changing the temporary table from in-memory to disk-based format to save memory.

- `Creating index`

  The thread is processing `ALTER TABLE ... ENABLE KEYS` for a `MyISAM` table.

- `Creating sort index`

  The thread is processing a `SELECT` that is resolved using an internal temporary table.

- `creating table`

  The thread is creating a table. This includes creation of temporary tables.

- `Creating tmp table`

  The thread is creating a temporary table in memory or on disk. If the table is created in memory but later is converted to an on-disk table, the state during that operation will be `Copying to tmp table on disk`.

- `deleting from main table`

  The server is executing the first part of a multiple-table delete. It is deleting only from the first table, and saving columns and offsets to be used for deleting from the other (reference) tables.

- `deleting from reference tables`

The server is executing the second part of a multiple-table delete and deleting the matched rows from the other tables.

- `discard_or_import_tablespace`

  The thread is processing an `ALTER TABLE ... DISCARD TABLESPACE` or `ALTER TABLE ... IMPORT TABLESPACE` statement.

- `end`

  This occurs at the end but before the cleanup of `ALTER TABLE`, `CREATE VIEW`, `DELETE`, `INSERT`, `SELECT`, or `UPDATE` statements.

- `executing`

  The thread has begun executing a statement.

- `Execution of init_command`

  The thread is executing statements in the value of the `init_command` system variable.

- `freeing items`

  The thread has executed a command. Some freeing of items done during this state involves the query cache. This state is usually followed by `cleaning up`.

- `Flushing tables`

  The thread is executing `FLUSH TABLES` and is waiting for all threads to close their tables.

- `FULLTEXT initialization`

  The server is preparing to perform a natural-language full-text search.

- `init`

  This occurs before the initialization of `ALTER TABLE`, `DELETE`, `INSERT`, `SELECT`, or `UPDATE` statements. Actions taken by the server in this state include flushing the binary log, the `InnoDB` log, and some query cache cleanup operations.

  For the `end` state, the following operations could be happening:

  - Removing query cache entries after data in a table is changed
  - Writing an event to the binary log
  - Freeing memory buffers, including for blobs

- `Killed`

  Someone has sent a `KILL` statement to the thread and it should abort next time it checks the kill flag. The flag is checked in each major loop in MySQL, but in some cases it might still take a short time for the thread to die. If the thread is locked by some other thread, the kill takes effect as soon as the other thread releases its lock.

- `Locked`

  The query is locked by another query.

  As of MySQL 5.5.3, this state was removed because it was equivalent to the `Table lock` state and no longer appears in `SHOW PROCESSLIST` output.

- `logging slow query`

  The thread is writing a statement to the slow-query log.

- `NULL`

  This state is used for the `SHOW PROCESSLIST` state.

- `login`

  The initial state for a connection thread until the client has been authenticated successfully.

- `manage keys`

  The server is enabling or disabling a table index.

- `Opening tables`, `Opening table`

  The thread is trying to open a table. This is should be very fast procedure, unless something prevents opening. For example, an `ALTER TABLE` or a `LOCK TABLE` statement can prevent opening a table until the statement is finished. It is also worth checking that your `table_open_cache` value is large enough.

- `optimizing`

  The server is performing initial optimizations for a query.

- `preparing`

  This state occurs during query optimization.

- `Purging old relay logs`

  The thread is removing unneeded relay log files.

- `query end`

  This state occurs after processing a query but before the `freeing items` state.

- `Reading from net`

  The server is reading a packet from the network.

- `Removing duplicates`

  The query was using `SELECT DISTINCT` in such a way that MySQL could not optimize away the distinct operation at an early stage. Because of this, MySQL requires an extra stage to remove all duplicated rows before sending the result to the client.

- `removing tmp table`

  The thread is removing an internal temporary table after processing a `SELECT` statement. This state is not used if no temporary table was created.

- `rename`

  The thread is renaming a table.

- `rename result table`

  The thread is processing an `ALTER TABLE` statement, has created the new table, and is renaming it to replace the original table.

- `Reopen tables`

  The thread got a lock for the table, but noticed after getting the lock that the underlying table structure changed. It has freed the lock, closed the table, and is trying to reopen it.

- `Repair by sorting`

  The repair code is using a sort to create indexes.

- `Repair done`

  The thread has completed a multi-threaded repair for a `MyISAM` table.

- `Repair with keycache`

  The repair code is using creating keys one by one through the key cache. This is much slower than `Repair by sorting`.

- `Rolling back`

  The thread is rolling back a transaction.

- `Saving state`

For `MyISAM` table operations such as repair or analysis, the thread is saving the new table state to the `.MYI` file header. State includes information such as number of rows, the `AUTO_INCREMENT` counter, and key distributions.

- `Searching rows for update`

  The thread is doing a first phase to find all matching rows before updating them. This has to be done if the `UPDATE` is changing the index that is used to find the involved rows.

- `Sending data`

  The thread is reading and processing rows for a `SELECT` statement, and sending data to the client. Because operations occurring during this this state tend to perform large amounts of disk access (reads), it is often the longest-running state over the lifetime of a given query.

- `setup`

  The thread is beginning an `ALTER TABLE` operation.

- `Sorting for group`

  The thread is doing a sort to satisfy a `GROUP BY`.

- `Sorting for order`

  The thread is doing a sort to satisfy a `ORDER BY`.

- `Sorting index`

  The thread is sorting index pages for more efficient access during a `MyISAM` table optimization operation.

- `Sorting result`

  For a `SELECT` statement, this is similar to `Creating sort index`, but for nontemporary tables.

- `statistics`

  The server is calculating statistics to develop a query execution plan. If a thread is in this state for a long time, the server is probably disk-bound performing other work.

- `System lock`

  The thread is going to request or is waiting for an internal or external system lock for the table. If this state is being caused by requests for external locks and you are not using multiple `mysqld` servers that are accessing the same `MyISAM` tables, you can disable external system locks with the `--skip-external-locking` option. However, external locking is disabled by default, so it is likely that this option will have no effect. For `SHOW PROFILE`, this state means the thread is requesting the lock (not waiting for it).

- `Table lock`

  The next thread state after `System lock`. The thread has acquired an external lock and is going to request an internal table lock.

  This state was replaced in MySQL 5.5.6 with `Waiting for table level lock`.

- `Updating`

  The thread is searching for rows to update and is updating them.

- `updating main table`

  The server is executing the first part of a multiple-table update. It is updating only the first table, and saving columns and offsets to be used for updating the other (reference) tables.

- `updating reference tables`

  The server is executing the second part of a multiple-table update and updating the matched rows from the other tables.

- `User lock`

  The thread is going to request or is waiting for an advisory lock requested with a `GET_LOCK()` call. For `SHOW PROFILE`, this state means the thread is requesting the lock (not waiting for it).

- `User sleep`

  The thread has invoked a `SLEEP()` call.

- `Waiting for all running commits to finish`

  A statement that causes an explicit or implicit commit is waiting for release of a read lock. This state was removed in MySQL 5.5.8; `Waiting for commit lock` is used instead.

- `Waiting for commit lock`

  A statement that causes an explicit or implicit commit is waiting for release of a read lock or `FLUSH TABLES WITH READ LOCK`) is waiting for a commit lock. This state was added in MySQL 5.5.8.

- `Waiting for global read lock`

  `FLUSH TABLES WITH READ LOCK`) is waiting for a global read lock.

- `Waiting for release of readlock`

  The thread is waiting for a global read lock obtained by another thread (with `FLUSH TABLES WITH READ LOCK`) to be released. This state was removed in MySQL 5.5.8; `Waiting for global read lock` or `Waiting for commit lock` are used instead.

- `Waiting for tables`, `Waiting for table`, `Waiting for table flush`

  The thread got a notification that the underlying structure for a table has changed and it needs to reopen the table to get the new structure. However, to reopen the table, it must wait until all other threads have closed the table in question.

  This notification takes place if another thread has used `FLUSH TABLES` or one of the following statements on the table in question: `FLUSH TABLES` *`tbl_name`*, `ALTER TABLE`, `RENAME TABLE`, `REPAIR TABLE`, `ANALYZE TABLE`, or `OPTIMIZE TABLE`.

  In MySQL 5.5.6, `Waiting for table` was replaced with `Waiting for table flush`.

- `Waiting for` *`lock_type`* `lock`

  The server is waiting to acquire a lock, where *`lock_type`* indicates the type of lock:

  - `Waiting for event metadata lock` (added in MySQL 5.5.8)
  - `Waiting for global metadata lock` (replaced by `Waiting for global read lock` in MySQL 5.5.8)
  - `Waiting for global read lock` (added in MySQL 5.5.8)
  - `Waiting for schema metadata lock`
  - `Waiting for stored function metadata lock`
  - `Waiting for stored procedure metadata lock`
  - `Waiting for table level lock`
  - `Waiting for table metadata lock`
  - `Waiting for trigger metadata lock` (added in MySQL 5.5.8)

- `Waiting on cond`

  A generic state in which the thread is waiting for a condition to become true. No specific state information is available.

- `Waiting to get readlock`

  The thread has issued a `FLUSH TABLES WITH READ LOCK` statement to obtain a global read lock and is waiting to obtain the lock. This state was removed in MySQL 5.5.8; `Waiting for global read lock` is used instead.

- `Writing to net`

  The server is writing a packet to the network.

7.12.5.3. Delayed-Insert Thread States

These thread states are associated with processing for `DELAYED` inserts (see Section 12.2.5.2, “`INSERT DELAYED` Syntax”). Some states are associated with connection threads that process `INSERT DELAYED` statements from clients. Other states are associated with delayed-insert handler threads that insert the rows. There is a delayed-insert handler thread for each table for which `INSERT DELAYED` statements are issued.

States associated with a connection thread that processes an `INSERT DELAYED` statement from the client:

- `allocating local table`

  The thread is preparing to feed rows to the delayed-insert handler thread.

- `Creating delayed handler`

  The thread is creating a handler for `DELAYED` inserts.

- `got handler lock`

  This occurs before the `allocating local table` state and after the `waiting for handler lock` state, when the connection thread gets access to the delayed-insert handler thread.

- `got old table`

  This occurs after the `waiting for handler open` state. The delayed-insert handler thread has signaled that it has ended its initialization phase, which includes opening the table for delayed inserts.

- `storing row into queue`

  The thread is adding a new row to the list of rows that the delayed-insert handler thread must insert.

- `update`

  The thread is getting ready to start updating the table.

- `waiting for delay_list`

  This occurs during the initialization phase when the thread is trying to find the delayed-insert handler thread for the table, and before attempting to gain access to the list of delayed-insert threads.

- `waiting for handler insert`

  An `INSERT DELAYED` handler has processed all pending inserts and is waiting for new ones.

- `waiting for handler lock`

  This occurs before the `allocating local table` state when the connection thread waits for access to the delayed-insert handler thread.

- `waiting for handler open`

  This occurs after the `Creating delayed handler` state and before the `got old table` state. The delayed-insert handler thread has just been started, and the connection thread is waiting for it to initialize.

States associated with a delayed-insert handler thread that inserts the rows:

- `insert`

  The state that occurs just before inserting rows into the table.

- `reschedule`

  After inserting a number of rows, the delayed-insert thread sleeps to let other threads do work.

- `upgrading lock`

  A delayed-insert handler is trying to get a lock for the table to insert rows.

- `Waiting for INSERT`

  A delayed-insert handler is waiting for a connection thread to add rows to the queue (see `storing row into queue`).

7.12.5.4. Query Cache Thread States

These thread states are associated with the query cache (see Section 7.9.3, “The MySQL Query Cache”).

- `checking privileges on cached query`

  The server is checking whether the user has privileges to access a cached query result.

- `checking query cache for query`

  The server is checking whether the current query is present in the query cache.

- `invalidating query cache entries`

  Query cache entries are being marked invalid because the underlying tables have changed.

- `sending cached result to client`

  The server is taking the result of a query from the query cache and sending it to the client.

- `storing result in query cache`

  The server is storing the result of a query in the query cache.

- `Waiting for query cache lock`

  This state occurs while a session is waiting to take the query cache lock. This can happen for any statement that needs to perform some query cache operation, such as an `INSERT` or `DELETE` that invalidates the query cache, a `SELECT` that looks for a cached entry, `RESET QUERY CACHE`, and so forth.

7.12.5.5. Replication Master Thread States

The following list shows the most common states you may see in the `State` column for the master's `Binlog Dump` thread. If you see no `Binlog Dump` threads on a master server, this means that replication is not running—that is, that no slaves are currently connected.

- `Sending binlog event to slave`

  Binary logs consist of *events*, where an event is usually an update plus some other information. The thread has read an event from the binary log and is now sending it to the slave.

- `Finished reading one binlog; switching to next binlog`

  The thread has finished reading a binary log file and is opening the next one to send to the slave.

- `Master has sent all binlog to slave; waiting for binlog to be updated`

  The thread has read all outstanding updates from the binary logs and sent them to the slave. The thread is now idle, waiting for new events to appear in the binary log resulting from new updates occurring on the master.

- `Waiting to finalize termination`

  A very brief state that occurs as the thread is stopping.

7.12.5.6. Replication Slave I/O Thread States

The following list shows the most common states you see in the `State` column for a slave server I/O thread. This state also appears in the `Slave_IO_State` column displayed by `SHOW SLAVE STATUS`, so you can get a good view of what is happening by using that statement.

- `Waiting for master update`

  The initial state before `Connecting to master`.

- `Connecting to master`

The thread is attempting to connect to the master.

- `Checking master version`

  A state that occurs very briefly, after the connection to the master is established.

- `Registering slave on master`

  A state that occurs very briefly after the connection to the master is established.

- `Requesting binlog dump`

  A state that occurs very briefly, after the connection to the master is established. The thread sends to the master a request for the contents of its binary logs, starting from the requested binary log file name and position.

- `Waiting to reconnect after a failed binlog dump request`

  If the binary log dump request failed (due to disconnection), the thread goes into this state while it sleeps, then tries to reconnect periodically. The interval between retries can be specified using the `CHANGE MASTER TO` statement.

- `Reconnecting after a failed binlog dump request`

  The thread is trying to reconnect to the master.

- `Waiting for master to send event`

  The thread has connected to the master and is waiting for binary log events to arrive. This can last for a long time if the master is idle. If the wait lasts for `slave_net_timeout` seconds, a timeout occurs. At that point, the thread considers the connection to be broken and makes an attempt to reconnect.

- `Queueing master event to the relay log`

  The thread has read an event and is copying it to the relay log so that the SQL thread can process it.

- `Waiting to reconnect after a failed master event read`

  An error occurred while reading (due to disconnection). The thread is sleeping for the number of seconds set by the `CHANGE MASTER TO` statement (default 60) before attempting to reconnect.

- `Reconnecting after a failed master event read`

  The thread is trying to reconnect to the master. When connection is established again, the state becomes `Waiting for master to send event`.

- `Waiting for the slave SQL thread to free enough relay log space`

  You are using a nonzero `relay_log_space_limit` value, and the relay logs have grown large enough that their combined size exceeds this value. The I/O thread is waiting until the SQL thread frees enough space by processing relay log contents so that it can delete some relay log files.

- `Waiting for slave mutex on exit`

  A state that occurs briefly as the thread is stopping.

7.12.5.7. Replication Slave SQL Thread States

The following list shows the most common states you may see in the `State` column for a slave server SQL thread:

- `Waiting for the next event in relay log`

  The initial state before `Reading event from the relay log`.

- `Reading event from the relay log`

  The thread has read an event from the relay log so that the event can be processed.

- `Making temp file`

  The thread is executing a `LOAD DATA INFILE` statement and is creating a temporary file containing the data from which the slave will read rows.

- `Slave has read all relay log; waiting for the slave I/O thread to update it`

  The thread has processed all events in the relay log files, and is now waiting for the I/O thread to write new events to the relay log.

- `Waiting for slave mutex on exit`

  A very brief state that occurs as the thread is stopping.

The `State` column for the I/O thread may also show the text of a statement. This indicates that the thread has read an event from the relay log, extracted the statement from it, and is executing it.

7.12.5.8. Replication Slave Connection Thread States

These thread states occur on a replication slave but are associated with connection threads, not with the I/O or SQL threads.

- `Changing master`

  The thread is processing a `CHANGE MASTER TO` statement.

- `Killing slave`

  The thread is processing a `STOP SLAVE` statement.

- `Opening master dump table`

  This state occurs after `Creating table from master dump`.

- `Reading master dump table data`

  This state occurs after `Opening master dump table`.

- `Rebuilding the index on master dump table`

  This state occurs after `Reading master dump table data`.

7.12.5.9. Event Scheduler Thread States

These states occur for the Event Scheduler thread, threads that are created to execute scheduled events, or threads that terminate the scheduler.

- `Clearing`

  The scheduler thread or a thread that was executing an event is terminating and is about to end.

- `Initialized`

  The scheduler thread or a thread that will execute an event has been initialized.

- `Waiting for next activation`

  The scheduler has a nonempty event queue but the next activation is in the future.

- `Waiting for scheduler to stop`

  The thread issued `SET GLOBAL event_scheduler=OFF` and is waiting for the scheduler to stop.

- `Waiting on empty queue`

  The scheduler's event queue is empty and it is sleeping.

7.13. Internal Details of MySQL Optimizations

This background information helps you to understand some of the terms you see in the `EXPLAIN` plan output. If you are rewriting queries to make them more efficient, or writing your own application logic for lookups, joining, or sorting, use this information to determine which optimizations you write yourself and which you can rely on MySQL to perform.

7.13.1. Range Optimization

The `range` access method uses a single index to retrieve a subset of table rows that are contained within one or several index value intervals. It can be used for a single-part or multiple-part index. The following sections give a detailed description of how intervals are extracted from the `WHERE` clause.

7.13.1.1. The Range Access Method for Single-Part Indexes

For a single-part index, index value intervals can be conveniently represented by corresponding conditions in the `WHERE` clause, so we speak of *range conditions* rather than “intervals.”

The definition of a range condition for a single-part index is as follows:

- For both `BTREE` and `HASH` indexes, comparison of a key part with a constant value is a range condition when using the `=`, `<=>`, `IN()`, `IS NULL`, or `IS NOT NULL` operators.
- Additionally, for `BTREE` indexes, comparison of a key part with a constant value is a range condition when using the `>`, `<`, `>=`, `<=`, `BETWEEN`, `!=`, or `<>` operators, or `LIKE` comparisons if the argument to `LIKE` is a constant string that does not start with a wildcard character.
- For all types of indexes, multiple range conditions combined with `OR` or `AND` form a range condition.

“Constant value” in the preceding descriptions means one of the following:

- A constant from the query string
- A column of a `const` or `system` table from the same join
- The result of an uncorrelated subquery
- Any expression composed entirely from subexpressions of the preceding types

Here are some examples of queries with range conditions in the `WHERE` clause:

```
SELECT * FROM t1
  WHERE key_col > 1
  AND key_col < 10;

SELECT * FROM t1
  WHERE key_col = 1
  OR key_col IN (15,18,20);

SELECT * FROM t1
  WHERE key_col LIKE 'ab%'
  OR key_col BETWEEN 'bar' AND 'foo';
```

Note that some nonconstant values may be converted to constants during the constant propagation phase.

MySQL tries to extract range conditions from the `WHERE` clause for each of the possible indexes. During the extraction process, conditions that cannot be used for constructing the range condition are dropped, conditions that produce overlapping ranges are combined, and conditions that produce empty ranges are removed.

Consider the following statement, where `key1` is an indexed column and `nonkey` is not indexed:

```
SELECT * FROM t1 WHERE
  (key1 < 'abc' AND (key1 LIKE 'abcde%' OR key1 LIKE '%b')) OR
  (key1 < 'bar' AND nonkey = 4) OR
  (key1 < 'uux' AND key1 > 'z');
```

The extraction process for key `key1` is as follows:

1. Start with original `WHERE` clause:

   ```
   (key1 < 'abc' AND (key1 LIKE 'abcde%' OR key1 LIKE '%b')) OR
   (key1 < 'bar' AND nonkey = 4) OR
   (key1 < 'uux' AND key1 > 'z')
   ```

2. Remove `nonkey = 4` and `key1 LIKE '%b'` because they cannot be used for a range scan. The correct way to remove them is to replace them with `TRUE`, so that we do not miss any matching rows when doing the range scan. Having replaced them with `TRUE`, we get:

   ```
   (key1 < 'abc' AND (key1 LIKE 'abcde%' OR TRUE)) OR
   (key1 < 'bar' AND TRUE) OR
   (key1 < 'uux' AND key1 > 'z')
   ```

3. Collapse conditions that are always true or false:

   - `(key1 LIKE 'abcde%' OR TRUE)` is always true
   - `(key1 < 'uux' AND key1 > 'z')` is always false

   Replacing these conditions with constants, we get:

   ```
   (key1 < 'abc' AND TRUE) OR (key1 < 'bar' AND TRUE) OR (FALSE)
   ```

   Removing unnecessary `TRUE` and `FALSE` constants, we obtain:

   ```
   (key1 < 'abc') OR (key1 < 'bar')
   ```

4. Combining overlapping intervals into one yields the final condition to be used for the range scan:

   ```
   (key1 < 'bar')
   ```

In general (and as demonstrated by the preceding example), the condition used for a range scan is less restrictive than the `WHERE` clause. MySQL performs an additional check to filter out rows that satisfy the range condition but not the full `WHERE` clause.

The range condition extraction algorithm can handle nested `AND`/`OR` constructs of arbitrary depth, and its output does not depend on the order in which conditions appear in `WHERE` clause.

Currently, MySQL does not support merging multiple ranges for the `range` access method for spatial indexes. To work around this limitation, you can use a `UNION` with identical `SELECT` statements, except that you put each spatial predicate in a different `SELECT`.

7.13.1.2. The Range Access Method for Multiple-Part Indexes

Range conditions on a multiple-part index are an extension of range conditions for a single-part index. A range condition on a multiple-part index restricts index rows to lie within one or several key tuple intervals. Key tuple intervals are defined over a set of key tuples, using ordering from the index.

For example, consider a multiple-part index defined as `key1(key_part1, key_part2, key_part3)`, and the following set of key tuples listed in key order:

```
key_part1  key_part2  key_part3
  NULL       1          'abc'
  NULL       1          'xyz'
  NULL       2          'foo'
   1         1          'abc'
   1         1          'xyz'
   1         2          'abc'
   2         1          'aaa'
```

The condition `key_part1 = 1` defines this interval:

```
(1,-inf,-inf) <= (key_part1,key_part2,key_part3) < (1,+inf,+inf)
```

The interval covers the 4th, 5th, and 6th tuples in the preceding data set and can be used by the range access method.

By contrast, the condition `key_part3 = 'abc'` does not define a single interval and cannot be used by the range access method.

The following descriptions indicate how range conditions work for multiple-part indexes in greater detail.

- For `HASH` indexes, each interval containing identical values can be used. This means that the interval can be produced only for conditions in the following form:

  ```
      key_part1 cmp const1
  ```

```
AND key_part2 cmp const2
AND ...
AND key_partN cmp constN;
```

Here, `const1`, `const2`, … are constants, `cmp` is one of the `=`, `<=>`, or `IS NULL` comparison operators, and the conditions cover all index parts. (That is, there are `N` conditions, one for each part of an `N`-part index.) For example, the following is a range condition for a three-part `HASH` index:

```
key_part1 = 1 AND key_part2 IS NULL AND key_part3 = 'foo'
```

For the definition of what is considered to be a constant, see Section 7.13.1.1, “The Range Access Method for Single-Part Indexes”.

- For a `BTREE` index, an interval might be usable for conditions combined with `AND`, where each condition compares a key part with a constant value using `=`, `<=>`, `IS NULL`, `>`, `<`, `>=`, `<=`, `!=`, `<>`, `BETWEEN`, or `LIKE 'pattern'` (where `'pattern'` does not start with a wildcard). An interval can be used as long as it is possible to determine a single key tuple containing all rows that match the condition (or two intervals if `<>` or `!=` is used).

  The optimizer attempts to use additional key parts to determine the interval as long as the comparison operator is `=`, `<=>`, or `IS NULL`. If the operator is `>`, `<`, `>=`, `<=`, `!=`, `<>`, `BETWEEN`, or `LIKE`, the optimizer uses it but considers no more key parts. For the following expression, the optimizer uses `=` from the first comparison. It also uses `>=` from the second comparison but considers no further key parts and does not use the third comparison for interval construction:

  ```
  key_part1 = 'foo' AND key_part2 >= 10 AND key_part3 > 10
  ```

  The single interval is:

  ```
  ('foo',10,-inf) < (key_part1,key_part2,key_part3) < ('foo',+inf,+inf)
  ```

  It is possible that the created interval contains more rows than the initial condition. For example, the preceding interval includes the value `('foo', 11, 0)`, which does not satisfy the original condition.

- If conditions that cover sets of rows contained within intervals are combined with `OR`, they form a condition that covers a set of rows contained within the union of their intervals. If the conditions are combined with `AND`, they form a condition that covers a set of rows contained within the intersection of their intervals. For example, for this condition on a two-part index:

  ```
  (key_part1 = 1 AND key_part2 < 2) OR (key_part1 > 5)
  ```

  The intervals are:

  ```
  (1,-inf) < (key_part1,key_part2) < (1,2)
  (5,-inf) < (key_part1,key_part2)
  ```

  In this example, the interval on the first line uses one key part for the left bound and two key parts for the right bound. The interval on the second line uses only one key part. The `key_len` column in the `EXPLAIN` output indicates the maximum length of the key prefix used.

  In some cases, `key_len` may indicate that a key part was used, but that might be not what you would expect. Suppose that `key_part1` and `key_part2` can be `NULL`. Then the `key_len` column displays two key part lengths for the following condition:

  ```
  key_part1 >= 1 AND key_part2 < 2
  ```

  But, in fact, the condition is converted to this:

  ```
  key_part1 >= 1 AND key_part2 IS NOT NULL
  ```

Section 7.13.1.1, “The Range Access Method for Single-Part Indexes”, describes how optimizations are performed to combine or eliminate intervals for range conditions on a single-part index. Analogous steps are performed for range conditions on multiple-part indexes.

7.13.2. Index Merge Optimization

The *Index Merge* method is used to retrieve rows with several `range` scans and to merge their results into one. The merge can produce unions, intersections, or unions-of-intersections of its underlying scans. This access method merges index scans from a single table; it does not merge scans across multiple tables.

In `EXPLAIN` output, the Index Merge method appears as `index_merge` in the `type` column. In this case, the `key` column contains a list of indexes used, and `key_len` contains a list of the longest key parts for those indexes.

Examples:

```
SELECT * FROM tbl_name WHERE key1 = 10 OR key2 = 20;

SELECT * FROM tbl_name
  WHERE (key1 = 10 OR key2 = 20) AND non_key=30;

SELECT * FROM t1, t2
  WHERE (t1.key1 IN (1,2) OR t1.key2 LIKE 'value%')
  AND t2.key1=t1.some_col;

SELECT * FROM t1, t2
  WHERE t1.key1=1
  AND (t2.key1=t1.some_col OR t2.key2=t1.some_col2);
```

The Index Merge method has several access algorithms (seen in the `Extra` field of `EXPLAIN` output):

- `Using intersect(...)`
- `Using union(...)`
- `Using sort_union(...)`

The following sections describe these methods in greater detail.

> **Note**
>
> The Index Merge optimization algorithm has the following known deficiencies:

- If a range scan is possible on some key, the optimizer will not consider using Index Merge Union or Index Merge Sort-Union algorithms. For example, consider this query:

  ```
  SELECT * FROM t1 WHERE (goodkey1 < 10 OR goodkey2 < 20) AND badkey < 30;
  ```

  For this query, two plans are possible:

  - An Index Merge scan using the `(goodkey1 < 10 OR goodkey2 < 20)` condition.
  - A range scan using the `badkey < 30` condition.

  However, the optimizer considers only the second plan.

- If your query has a complex `WHERE` clause with deep `AND`/`OR` nesting and MySQL doesn't choose the optimal plan, try distributing terms using the following identity laws:

  ```
  (x AND y) OR z = (x OR z) AND (y OR z)
  (x OR y) AND z = (x AND z) OR (y AND z)
  ```

- Index Merge is not applicable to full-text indexes. We plan to extend it to cover these in a future MySQL release.

The choice between different possible variants of the Index Merge access method and other access methods is based on cost estimates of various available options.

7.13.2.1. The Index Merge Intersection Access Algorithm

This access algorithm can be employed when a `WHERE` clause was converted to several range conditions on different keys combined with `AND`, and each condition is one of the following:

- In this form, where the index has exactly *`N`* parts (that is, all index parts are covered):

  ```
  key_part1=const1 AND key_part2=const2 ... AND key_partN=constN
  ```

- Any range condition over a primary key of an `InnoDB` table.

Examples:

```
SELECT * FROM innodb_table WHERE primary_key < 10 AND key_col1=20;

SELECT * FROM tbl_name
  WHERE (key1_part1=1 AND key1_part2=2) AND key2=2;
```

The Index Merge intersection algorithm performs simultaneous scans on all used indexes and produces the intersection of row sequences that it receives from the merged index scans.

If all columns used in the query are covered by the used indexes, full table rows are not retrieved (`EXPLAIN` output contains `Using index` in `Extra` field in this case). Here is an example of such a query:

```
SELECT COUNT(*) FROM t1 WHERE key1=1 AND key2=1;
```

If the used indexes don't cover all columns used in the query, full rows are retrieved only when the range conditions for all used keys are satisfied.

If one of the merged conditions is a condition over a primary key of an `InnoDB` table, it is not used for row retrieval, but is used to filter out rows retrieved using other conditions.

7.13.2.2. The Index Merge Union Access Algorithm

The applicability criteria for this algorithm are similar to those for the Index Merge method intersection algorithm. The algorithm can be employed when the table's `WHERE` clause was converted to several range conditions on different keys combined with `OR`, and each condition is one of the following:

- In this form, where the index has exactly *`N`* parts (that is, all index parts are covered):

  ```
  key_part1=const1 AND key_part2=const2 ... AND key_partN=constN
  ```

- Any range condition over a primary key of an `InnoDB` table.
- A condition for which the Index Merge method intersection algorithm is applicable.

Examples:

```
SELECT * FROM t1 WHERE key1=1 OR key2=2 OR key3=3;

SELECT * FROM innodb_table WHERE (key1=1 AND key2=2) OR
  (key3='foo' AND key4='bar') AND key5=5;
```

7.13.2.3. The Index Merge Sort-Union Access Algorithm

This access algorithm is employed when the `WHERE` clause was converted to several range conditions combined by `OR`, but for which the Index Merge method union algorithm is not applicable.

Examples:

```
SELECT * FROM tbl_name WHERE key_col1 < 10 OR key_col2 < 20;

SELECT * FROM tbl_name
  WHERE (key_col1 > 10 OR key_col2 = 20) AND nonkey_col=30;
```

The difference between the sort-union algorithm and the union algorithm is that the sort-union algorithm must first fetch row IDs for all rows and sort them before returning any rows.

7.13.3. Engine Condition Pushdown Optimization

This optimization improves the efficiency of direct comparisons between a nonindexed column and a constant. In such cases, the condition is “pushed down” to the storage engine for evaluation. This optimization can be used only by the `NDBCLUSTER` storage engine.

> **Note**
>
> The `NDBCLUSTER` storage engine is currently not available in MySQL 5.5. If you are interested in using MySQL Cluster, see MySQL Cluster NDB 6.X/7.X, which provides information about MySQL Cluster NDB 7.0 and 7.1, which are based on MySQL 5.1 but contain the latest improvements and fixes for `NDBCLUSTER`.

For MySQL Cluster, this optimization can eliminate the need to send nonmatching rows over the network between the cluster's data nodes and the MySQL Server that issued the query, and can speed up queries where it is used by a factor of 5 to 10 times over cases where condition pushdown could be but is not used.

Suppose that a MySQL Cluster table is defined as follows:

```
CREATE TABLE t1 (
    a INT,
    b INT,
    KEY(a)
) ENGINE=NDBCLUSTER;
```

Condition pushdown can be used with queries such as the one shown here, which includes a comparison between a nonindexed column and a constant:

```
SELECT a, b FROM t1 WHERE b = 10;
```

The use of condition pushdown can be seen in the output of `EXPLAIN`:

```
mysql> EXPLAIN SELECT a,b FROM t1 WHERE b = 10\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: t1
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 10
        Extra: Using where with pushed condition
```

However, condition pushdown *cannot* be used with either of these two queries:

```
SELECT a,b FROM t1 WHERE a = 10;
SELECT a,b FROM t1 WHERE b + 1 = 10;
```

Condition pushdown is not applicable to the first query because an index exists on column `a`. (An index access method would be more efficient and so would be chosen in preference to condition pushdown.) Condition pushdown cannot be employed for the second query because the comparison involving the nonindexed column `b` is indirect. (However, condition pushdown could be applied if you were to reduce `b + 1 = 10` to `b = 9` in the `WHERE` clause.)

Condition pushdown may also be employed when an indexed column is compared with a constant using a `>` or `<` operator:

```
mysql> EXPLAIN SELECT a, b FROM t1 WHERE a < 2\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: t1
         type: range
possible_keys: a
          key: a
      key_len: 5
          ref: NULL
         rows: 2
        Extra: Using where with pushed condition
```

Other supported comparisons for condition pushdown include the following:

- `column [NOT] LIKE pattern`

  `pattern` must be a string literal containing the pattern to be matched; for syntax, see Section 11.5.1, “String Comparison Functions”.

- `column IS [NOT] NULL`

- `column IN (value_list)`

  Each item in the `value_list` must be a constant, literal value.

- `column BETWEEN constant1 AND constant2`

  `constant1` and `constant2` must each be a constant, literal value.

In all of the cases in the preceding list, it is possible for the condition to be converted into the form of one or more direct comparisons between a column and a constant.

Engine condition pushdown is enabled by default. To disable it at server startup, set the `optimizer_switch` system variable. For example, in a `my.cnf` file, use these lines:

```
[mysqld]
optimizer_switch=engine_condition_pushdown=off
```

At runtime, disable condition pushdown like this:

```
SET optimizer_switch='engine_condition_pushdown=off';
```

Before MySQL 5.5.3, disable condition pushdown using the `engine_condition_pushdown` system variable. At server startup:

```
[mysqld]
engine_condition_pushdown=0
```

At runtime, use either of these statements:

```
SET engine_condition_pushdown=OFF;
```

```
SET engine_condition_pushdown=0;
```

Limitations. Condition pushdown is subject to the following limitations:

- Condition pushdown is supported only by the `NDBCLUSTER` storage engine.
- Columns may be compared with constants only; however, this includes expressions which evaluate to constant values.
- Columns used in comparisons cannot be of any of the `BLOB` or `TEXT` types.
- A string value to be compared with a column must use the same collation as the column.
- Joins are not directly supported; conditions involving multiple tables are pushed separately where possible. Use `EXPLAIN EXTENDED` to determine which conditions are actually pushed down.

7.13.4. `IS NULL` Optimization

MySQL can perform the same optimization on *`col_name`* `IS NULL` that it can use for *`col_name`* `=` *`constant_value`*. For example, MySQL can use indexes and ranges to search for `NULL` with `IS NULL`.

Examples:

```
SELECT * FROM tbl_name WHERE key_col IS NULL;

SELECT * FROM tbl_name WHERE key_col <=> NULL;

SELECT * FROM tbl_name
  WHERE key_col=const1 OR key_col=const2 OR key_col IS NULL;
```

If a `WHERE` clause includes a *`col_name`* `IS NULL` condition for a column that is declared as `NOT NULL`, that expression is optimized away. This optimization does not occur in cases when the column might produce `NULL` anyway; for example, if it comes from a table on the right side of a `LEFT JOIN`.

MySQL can also optimize the combination `col_name = expr OR col_name IS NULL`, a form that is common in resolved subqueries. `EXPLAIN` shows `ref_or_null` when this optimization is used.

This optimization can handle one `IS NULL` for any key part.

Some examples of queries that are optimized, assuming that there is an index on columns `a` and `b` of table `t2`:

```
SELECT * FROM t1 WHERE t1.a=expr OR t1.a IS NULL;

SELECT * FROM t1, t2 WHERE t1.a=t2.a OR t2.a IS NULL;

SELECT * FROM t1, t2
  WHERE (t1.a=t2.a OR t2.a IS NULL) AND t2.b=t1.b;
```

```
SELECT * FROM t1, t2
  WHERE t1.a=t2.a AND (t2.b=t1.b OR t2.b IS NULL);

SELECT * FROM t1, t2
  WHERE (t1.a=t2.a AND t2.a IS NULL AND ...)
  OR (t1.a=t2.a AND t2.a IS NULL AND ...);
```

`ref_or_null` works by first doing a read on the reference key, and then a separate search for rows with a `NULL` key value.

Note that the optimization can handle only one `IS NULL` level. In the following query, MySQL uses key lookups only on the expression `(t1.a=t2.a AND t2.a IS NULL)` and is not able to use the key part on `b`:

```
SELECT * FROM t1, t2
  WHERE (t1.a=t2.a AND t2.a IS NULL)
  OR (t1.b=t2.b AND t2.b IS NULL);
```

7.13.5. `LEFT JOIN` and `RIGHT JOIN` Optimization

MySQL implements an `A LEFT JOIN B join_condition` as follows:

- Table `B` is set to depend on table `A` and all tables on which `A` depends.
- Table `A` is set to depend on all tables (except `B`) that are used in the `LEFT JOIN` condition.
- The `LEFT JOIN` condition is used to decide how to retrieve rows from table `B`. (In other words, any condition in the `WHERE` clause is not used.)
- All standard join optimizations are performed, with the exception that a table is always read after all tables on which it depends. If there is a circular dependence, MySQL issues an error.
- All standard `WHERE` optimizations are performed.
- If there is a row in `A` that matches the `WHERE` clause, but there is no row in `B` that matches the `ON` condition, an extra `B` row is generated with all columns set to `NULL`.
- If you use `LEFT JOIN` to find rows that do not exist in some table and you have the following test: `col_name IS NULL` in the `WHERE` part, where `col_name` is a column that is declared as `NOT NULL`, MySQL stops searching for more rows (for a particular key combination) after it has found one row that matches the `LEFT JOIN` condition.

The implementation of `RIGHT JOIN` is analogous to that of `LEFT JOIN` with the roles of the tables reversed.

The join optimizer calculates the order in which tables should be joined. The table read order forced by `LEFT JOIN` or `STRAIGHT_JOIN` helps the join optimizer do its work much more quickly, because there are fewer table permutations to check. Note that this means that if you do a query of the following type, MySQL does a full scan on `b` because the `LEFT JOIN` forces it to be read before `d`:

```
SELECT *
  FROM a JOIN b LEFT JOIN c ON (c.key=a.key)
  LEFT JOIN d ON (d.key=a.key)
  WHERE b.key=d.key;
```

The fix in this case is reverse the order in which `a` and `b` are listed in the `FROM` clause:

```
SELECT *
  FROM b JOIN a LEFT JOIN c ON (c.key=a.key)
  LEFT JOIN d ON (d.key=a.key)
  WHERE b.key=d.key;
```

For a `LEFT JOIN`, if the `WHERE` condition is always false for the generated `NULL` row, the `LEFT JOIN` is changed to a normal join. For example, the `WHERE` clause would be false in the following query if `t2.column1` were `NULL`:

```
SELECT * FROM t1 LEFT JOIN t2 ON (column1) WHERE t2.column2=5;
```

Therefore, it is safe to convert the query to a normal join:

```
SELECT * FROM t1, t2 WHERE t2.column2=5 AND t1.column1=t2.column1;
```

This can be made faster because MySQL can use table `t2` before table `t1` if doing so would result in a better query plan. To provide a hint about the table join order, use `STRAIGHT_JOIN`. (See Section 12.2.9, “`SELECT` Syntax”.)

7.13.6. Nested-Loop Join Algorithms

MySQL executes joins between tables using a nested-loop algorithm or variations on it.

Nested-Loop Join Algorithm

A simple nested-loop join (NLJ) algorithm reads rows from the first table in a loop one at a time, passing each row to a nested loop that processes the next table in the join. This process is repeated as many times as there remain tables to be joined.

Assume that a join between three tables `t1`, `t2`, and `t3` is to be executed using the following join types:

```
Table   Join Type
t1      range
t2      ref
t3      ALL
```

If a simple NLJ algorithm is used, the join is processed like this:

```
for each row in t1 matching range {
  for each row in t2 matching reference key {
    for each row in t3 {
      if row satisfies join conditions,
      send to client
    }
  }
}
```

Because the NLJ algorithm passes rows one at a time from outer loops to inner loops, it typically reads tables processed in the inner loops many times.

Block Nested-Loop Join Algorithm

A Block Nested-Loop (BNL) Join algorithm uses buffering of rows read in outer loops to reduce the number of times that tables in inner loops must be read. For example, if 10 rows are read into a buffer and the buffer is passed to the next inner loop, each row read in the inner loop can be compared against all 10 rows in the buffer. The reduces the number of times the inner table must be read by an order of magnitude.

MySQL uses join buffering under these conditions:

- The `join_buffer_size` system variable determines the size of each join buffer.
- Join buffering can be used when the join is of type `ALL` or `index` (in other words, when no possible keys can be used, and a full scan is done, of either the data or index rows, respectively), or `range`.
- One buffer is allocated for each join that can be buffered, so a given query might be processed using multiple join buffers.
- A join buffer is never allocated for the first nonconst table, even if it would be of type `ALL` or `index`.
- A join buffer is allocated prior to executing the join and freed after the query is done.
- Only columns of interest to the join are stored in the join buffer, not whole rows.

For the example join described previously for the NLJ algorithm (without buffering), the join is done as follow using join buffering:

```
for each row in t1 matching range {
  for each row in t2 matching reference key {
    store used columns from t1, t2 in join buffer
    if buffer is full {
      for each row in t3 {
        for each t1, t2 combination in join buffer {
          if row satisfies join conditions,
          send to client
        }
      }
      empty buffer
    }
  }
}

if buffer is not empty {
  for each row in t3 {
    for each t1, t2 combination in join buffer {
      if row satisfies join conditions,
      send to client
    }
  }
}
```

If *`S`* is the size of each stored `t1`, `t2` combination is the join buffer and *`C`* is the number of combinations in the buffer, the number of times table `t3` is scanned is:

```
(S * C)/join_buffer_size + 1
```

The number of `t3` scans decreases as the value of `join_buffer_size` increases, up to the point when `join_buffer_size` is large enough to hold all previous row combinations. At that point, there is no speed to be gained by making it larger.

7.13.7. Nested Join Optimization

The syntax for expressing joins permits nested joins. The following discussion refers to the join syntax described in Section 12.2.9.1, "`JOIN` Syntax".

The syntax of *`table_factor`* is extended in comparison with the SQL Standard. The latter accepts only *`table_reference`*, not a list of them inside a pair of parentheses. This is a conservative extension if we consider each comma in a list of *`table_reference`* items as equivalent to an inner join. For example:

```
SELECT * FROM t1 LEFT JOIN (t2, t3, t4)
                 ON (t2.a=t1.a AND t3.b=t1.b AND t4.c=t1.c)
```

is equivalent to:

```
SELECT * FROM t1 LEFT JOIN (t2 CROSS JOIN t3 CROSS JOIN t4)
                 ON (t2.a=t1.a AND t3.b=t1.b AND t4.c=t1.c)
```

In MySQL, `CROSS JOIN` is a syntactic equivalent to `INNER JOIN` (they can replace each other). In standard SQL, they are not equivalent. `INNER JOIN` is used with an `ON` clause; `CROSS JOIN` is used otherwise.

In general, parentheses can be ignored in join expressions containing only inner join operations. After removing parentheses and grouping operations to the left, the join expression:

```
t1 LEFT JOIN (t2 LEFT JOIN t3 ON t2.b=t3.b OR t2.b IS NULL)
   ON t1.a=t2.a
```

transforms into the expression:

```
(t1 LEFT JOIN t2 ON t1.a=t2.a) LEFT JOIN t3
    ON t2.b=t3.b OR t2.b IS NULL
```

Yet, the two expressions are not equivalent. To see this, suppose that the tables `t1`, `t2`, and `t3` have the following state:

- Table `t1` contains rows `(1)`, `(2)`
- Table `t2` contains row `(1,101)`
- Table `t3` contains row `(101)`

In this case, the first expression returns a result set including the rows `(1,1,101,101)`, `(2,NULL,NULL,NULL)`, whereas the second expression returns the rows `(1,1,101,101)`, `(2,NULL,NULL,101)`:

```
mysql> SELECT *
    -> FROM t1
    ->      LEFT JOIN
    ->      (t2 LEFT JOIN t3 ON t2.b=t3.b OR t2.b IS NULL)
    ->      ON t1.a=t2.a;
+------+------+------+------+
| a    | a    | b    | b    |
+------+------+------+------+
|    1 |    1 |  101 |  101 |
|    2 | NULL | NULL | NULL |
+------+------+------+------+

mysql> SELECT *
    -> FROM (t1 LEFT JOIN t2 ON t1.a=t2.a)
    ->      LEFT JOIN t3
    ->      ON t2.b=t3.b OR t2.b IS NULL;
+------+------+------+------+
| a    | a    | b    | b    |
+------+------+------+------+
|    1 |    1 |  101 |  101 |
|    2 | NULL | NULL |  101 |
+------+------+------+------+
```

In the following example, an outer join operation is used together with an inner join operation:

```
t1 LEFT JOIN (t2, t3) ON t1.a=t2.a
```

That expression cannot be transformed into the following expression:

```
t1 LEFT JOIN t2 ON t1.a=t2.a, t3.
```

For the given table states, the two expressions return different sets of rows:

```
mysql> SELECT *
    -> FROM t1 LEFT JOIN (t2, t3) ON t1.a=t2.a;
+------+------+------+------+
| a    | a    | b    | b    |
+------+------+------+------+
|    1 |    1 |  101 |  101 |
|    2 | NULL | NULL | NULL |
+------+------+------+------+

mysql> SELECT *
    -> FROM t1 LEFT JOIN t2 ON t1.a=t2.a, t3;
+------+------+------+------+
| a    | a    | b    | b    |
+------+------+------+------+
|    1 |    1 |  101 |  101 |
|    2 | NULL | NULL |  101 |
+------+------+------+------+
```

Therefore, if we omit parentheses in a join expression with outer join operators, we might change the result set for the original expression.

More exactly, we cannot ignore parentheses in the right operand of the left outer join operation and in the left operand of a right join operation. In other words, we cannot ignore parentheses for the inner table expressions of outer join operations. Parentheses for the other operand (operand for the outer table) can be ignored.

The following expression:

```
(t1,t2) LEFT JOIN t3 ON P(t2.b,t3.b)
```

is equivalent to this expression:

```
t1, t2 LEFT JOIN t3 ON P(t2.b,t3.b)
```

for any tables `t1,t2,t3` and any condition `P` over attributes `t2.b` and `t3.b`.

Whenever the order of execution of the join operations in a join expression (*`join_table`*) is not from left to right, we talk about nested joins. Consider the following queries:

```
SELECT * FROM t1 LEFT JOIN (t2 LEFT JOIN t3 ON t2.b=t3.b) ON t1.a=t2.a
  WHERE t1.a > 1

SELECT * FROM t1 LEFT JOIN (t2, t3) ON t1.a=t2.a
  WHERE (t2.b=t3.b OR t2.b IS NULL) AND t1.a > 1
```

Those queries are considered to contain these nested joins:

```
t2 LEFT JOIN t3 ON t2.b=t3.b
t2, t3
```

The nested join is formed in the first query with a left join operation, whereas in the second query it is formed with an inner join operation.

In the first query, the parentheses can be omitted: The grammatical structure of the join expression will dictate the same order of execution for join operations. For the second query, the parentheses cannot be omitted, although the join expression here can be interpreted unambiguously without them. (In our extended syntax the parentheses in `(t2, t3)` of the second query are required, although theoretically the query could be parsed without them: We still would have unambiguous syntactical structure for the query because `LEFT JOIN` and `ON` would play the role of the left and right delimiters for the expression `(t2,t3)`.)

The preceding examples demonstrate these points:

- For join expressions involving only inner joins (and not outer joins), parentheses can be removed. You can remove parentheses and evaluate left to right (or, in fact, you can evaluate the tables in any order).

- The same is not true, in general, for outer joins or for outer joins mixed with inner joins. Removal of parentheses may change the result.

Queries with nested outer joins are executed in the same pipeline manner as queries with inner joins. More exactly, a variation of the nested-loop join algorithm is exploited. Recall by what algorithmic schema the nested-loop join executes a query. Suppose that we have a join query over 3 tables `T1,T2,T3` of the form:

```
SELECT * FROM T1 INNER JOIN T2 ON P1(T1,T2)
                 INNER JOIN T3 ON P2(T2,T3)
  WHERE P(T1,T2,T3).
```

Here, `P1(T1,T2)` and `P2(T3,T3)` are some join conditions (on expressions), whereas `P(t1,t2,t3)` is a condition over columns of tables `T1,T2,T3`.

The nested-loop join algorithm would execute this query in the following manner:

```
FOR each row t1 in T1 {
  FOR each row t2 in T2 such that P1(t1,t2) {
    FOR each row t3 in T3 such that P2(t2,t3) {
      IF P(t1,t2,t3) {
         t:=t1||t2||t3; OUTPUT t;
      }
    }
  }
}
```

The notation `t1||t2||t3` means “a row constructed by concatenating the columns of rows `t1`, `t2`, and `t3`.” In some of the following examples, `NULL` where a row name appears means that `NULL` is used for each column of that row. For example, `t1||t2||NULL` means “a row constructed by concatenating the columns of rows `t1` and `t2`, and `NULL` for each column of `t3`.”

Now let's consider a query with nested outer joins:

```
SELECT * FROM T1 LEFT JOIN
              (T2 LEFT JOIN T3 ON P2(T2,T3))
              ON P1(T1,T2)
  WHERE P(T1,T2,T3).
```

For this query, we modify the nested-loop pattern to get:

```
FOR each row t1 in T1 {
  BOOL f1:=FALSE;
  FOR each row t2 in T2 such that P1(t1,t2) {
    BOOL f2:=FALSE;
    FOR each row t3 in T3 such that P2(t2,t3) {
      IF P(t1,t2,t3) {
        t:=t1||t2||t3; OUTPUT t;
      }
      f2=TRUE;
      f1=TRUE;
    }
    IF (!f2) {
      IF P(t1,t2,NULL) {
        t:=t1||t2||NULL; OUTPUT t;
      }
      f1=TRUE;
    }
  }
  IF (!f1) {
    IF P(t1,NULL,NULL) {
      t:=t1||NULL||NULL; OUTPUT t;
    }
  }
}
```

In general, for any nested loop for the first inner table in an outer join operation, a flag is introduced that is turned off before the loop and is checked after the loop. The flag is turned on when for the current row from the outer table a match from the table representing the inner operand is found. If at the end of the loop cycle the flag is still off, no match has been found for the current row of the outer table. In this case, the row is complemented by `NULL` values for the columns of the inner tables. The result row is passed to the final check for the output or into the next nested loop, but only if the row satisfies the join condition of all embedded outer joins.

In our example, the outer join table expressed by the following expression is embedded:

```
(T2 LEFT JOIN T3 ON P2(T2,T3))
```

Note that for the query with inner joins, the optimizer could choose a different order of nested loops, such as this one:

```
FOR each row t3 in T3 {
  FOR each row t2 in T2 such that P2(t2,t3) {
    FOR each row t1 in T1 such that P1(t1,t2) {
      IF P(t1,t2,t3) {
         t:=t1||t2||t3; OUTPUT t;
      }
    }
  }
}
```

For the queries with outer joins, the optimizer can choose only such an order where loops for outer tables precede loops for inner tables. Thus, for our query with outer joins, only one nesting order is possible. For the following query, the optimizer will evaluate two different nestings:

```
SELECT * T1 LEFT JOIN (T2,T3) ON P1(T1,T2) AND P2(T1,T3)
  WHERE P(T1,T2,T3)
```

The nestings are these:

```
FOR each row t1 in T1 {
  BOOL f1:=FALSE;
  FOR each row t2 in T2 such that P1(t1,t2) {
    FOR each row t3 in T3 such that P2(t1,t3) {
      IF P(t1,t2,t3) {
        t:=t1||t2||t3; OUTPUT t;
      }
      f1:=TRUE
    }
  }
  IF (!f1) {
    IF P(t1,NULL,NULL) {
      t:=t1||NULL||NULL; OUTPUT t;
    }
  }
}
```

and:

```
FOR each row t1 in T1 {
  BOOL f1:=FALSE;
  FOR each row t3 in T3 such that P2(t1,t3) {
    FOR each row t2 in T2 such that P1(t1,t2) {
      IF P(t1,t2,t3) {
        t:=t1||t2||t3; OUTPUT t;
      }
      f1:=TRUE
    }
  }
  IF (!f1) {
    IF P(t1,NULL,NULL) {
      t:=t1||NULL||NULL; OUTPUT t;
    }
  }
}
```

In both nestings, `T1` must be processed in the outer loop because it is used in an outer join. `T2` and `T3` are used in an inner join, so that join must be processed in the inner loop. However, because the join is an inner join, `T2` and `T3` can be processed in either order.

When discussing the nested-loop algorithm for inner joins, we omitted some details whose impact on the performance of query execution may be huge. We did not mention so-called “pushed-down” conditions. Suppose that our `WHERE` condition `P(T1,T2,T3)` can be represented by a conjunctive formula:

```
P(T1,T2,T2) = C1(T1) AND C2(T2) AND C3(T3).
```

In this case, MySQL actually uses the following nested-loop schema for the execution of the query with inner joins:

```
FOR each row t1 in T1 such that C1(t1) {
  FOR each row t2 in T2 such that P1(t1,t2) AND C2(t2)  {
    FOR each row t3 in T3 such that P2(t2,t3) AND C3(t3) {
      IF P(t1,t2,t3) {
         t:=t1||t2||t3; OUTPUT t;
      }
    }
  }
}
```

You see that each of the conjuncts `C1(T1)`, `C2(T2)`, `C3(T3)` are pushed out of the most inner loop to the most outer loop where it can be evaluated. If `C1(T1)` is a very restrictive condition, this condition pushdown may greatly reduce the number of rows from table `T1` passed to the inner loops. As a result, the execution time for the query may improve immensely.

For a query with outer joins, the `WHERE` condition is to be checked only after it has been found that the current row from the outer table has a match in the inner tables. Thus, the optimization of pushing conditions out of the inner nested loops cannot be applied directly to queries with outer joins. Here we have to introduce conditional pushed-down predicates guarded by the flags that are turned on when a match has been encountered.

For our example with outer joins with:

```
P(T1,T2,T3)=C1(T1) AND C(T2) AND C3(T3)
```

the nested-loop schema using guarded pushed-down conditions looks like this:

```
FOR each row t1 in T1 such that C1(t1) {
  BOOL f1:=FALSE;
  FOR each row t2 in T2
      such that P1(t1,t2) AND (f1?C2(t2):TRUE) {
    BOOL f2:=FALSE;
    FOR each row t3 in T3
        such that P2(t2,t3) AND (f1&&f2?C3(t3):TRUE) {
      IF (f1&&f2?TRUE:(C2(t2) AND C3(t3))) {
        t:=t1||t2||t3; OUTPUT t;
      }
      f2=TRUE;
      f1=TRUE;
    }
    IF (!f2) {
      IF (f1?TRUE:C2(t2) && P(t1,t2,NULL)) {
        t:=t1||t2||NULL; OUTPUT t;
      }
      f1=TRUE;
    }
  }
  IF (!f1 && P(t1,NULL,NULL)) {
      t:=t1||NULL||NULL; OUTPUT t;
  }
}
```

In general, pushed-down predicates can be extracted from join conditions such as `P1(T1,T2)` and `P(T2,T3)`. In this case, a pushed-down predicate is guarded also by a flag that prevents checking the predicate for the `NULL`-complemented row generated by the corresponding outer join operation.

Note that access by key from one inner table to another in the same nested join is prohibited if it is induced by a predicate from the `WHERE` condition. (We could use conditional key access in this case, but this technique is not employed yet in MySQL 5.5.)

7.13.8. Outer Join Simplification

Table expressions in the `FROM` clause of a query are simplified in many cases.

At the parser stage, queries with right outer joins operations are converted to equivalent queries containing only left join operations. In the general case, the conversion is performed according to the following rule:

```
(T1, ...) RIGHT JOIN (T2,...) ON P(T1,...,T2,...) =
(T2, ...) LEFT JOIN (T1,...) ON P(T1,...,T2,...)
```

All inner join expressions of the form `T1 INNER JOIN T2 ON P(T1,T2)` are replaced by the list `T1,T2`, `P(T1,T2)` being joined as a conjunct to the `WHERE` condition (or to the join condition of the embedding join, if there is any).

When the optimizer evaluates plans for join queries with outer join operation, it takes into consideration only the plans where, for each such operation, the outer tables are accessed before the inner tables. The optimizer options are limited because only such plans enables us to execute queries with outer joins operations by the nested loop schema.

Suppose that we have a query of the form:

```
SELECT * T1 LEFT JOIN T2 ON P1(T1,T2)
  WHERE P(T1,T2) AND R(T2)
```

with `R(T2)` narrowing greatly the number of matching rows from table `T2`. If we executed the query as it is, the optimizer would have no other choice besides to access table `T1` before table `T2` that may lead to a very inefficient execution plan.

Fortunately, MySQL converts such a query into a query without an outer join operation if the `WHERE` condition is null-rejected. A condition is called null-rejected for an outer join operation if it evaluates to `FALSE` or to `UNKNOWN` for any `NULL`-complemented row built for the operation.

Thus, for this outer join:

```
T1 LEFT JOIN T2 ON T1.A=T2.A
```

Conditions such as these are null-rejected:

```
T2.B IS NOT NULL,
T2.B > 3,
T2.C <= T1.C,
T2.B < 2 OR T2.C > 1
```

Conditions such as these are not null-rejected:

```
T2.B IS NULL,
T1.B < 3 OR T2.B IS NOT NULL,
T1.B < 3 OR T2.B > 3
```

The general rules for checking whether a condition is null-rejected for an outer join operation are simple. A condition is null-rejected in the following cases:

- If it is of the form `A IS NOT NULL`, where `A` is an attribute of any of the inner tables
- If it is a predicate containing a reference to an inner table that evaluates to `UNKNOWN` when one of its arguments is `NULL`
- If it is a conjunction containing a null-rejected condition as a conjunct
- If it is a disjunction of null-rejected conditions

A condition can be null-rejected for one outer join operation in a query and not null-rejected for another. In the query:

```
SELECT * FROM T1 LEFT JOIN T2 ON T2.A=T1.A
                 LEFT JOIN T3 ON T3.B=T1.B
  WHERE T3.C > 0
```

the `WHERE` condition is null-rejected for the second outer join operation but is not null-rejected for the first one.

If the `WHERE` condition is null-rejected for an outer join operation in a query, the outer join operation is replaced by an inner join operation.

For example, the preceding query is replaced with the query:

```
SELECT * FROM T1 LEFT JOIN T2 ON T2.A=T1.A
                 INNER JOIN T3 ON T3.B=T1.B
  WHERE T3.C > 0
```

For the original query, the optimizer would evaluate plans compatible with only one access order `T1,T2,T3`. For the replacing query, it additionally considers the access sequence `T3,T1,T2`.

A conversion of one outer join operation may trigger a conversion of another. Thus, the query:

```
SELECT * FROM T1 LEFT JOIN T2 ON T2.A=T1.A
                 LEFT JOIN T3 ON T3.B=T2.B
  WHERE T3.C > 0
```

will be first converted to the query:

```
SELECT * FROM T1 LEFT JOIN T2 ON T2.A=T1.A
                 INNER JOIN T3 ON T3.B=T2.B
  WHERE T3.C > 0
```

which is equivalent to the query:

```
SELECT * FROM (T1 LEFT JOIN T2 ON T2.A=T1.A), T3
  WHERE T3.C > 0 AND T3.B=T2.B
```

Now the remaining outer join operation can be replaced by an inner join, too, because the condition `T3.B=T2.B` is null-rejected and we get a query without outer joins at all:

```
SELECT * FROM (T1 INNER JOIN T2 ON T2.A=T1.A), T3
  WHERE T3.C > 0 AND T3.B=T2.B
```

Sometimes we succeed in replacing an embedded outer join operation, but cannot convert the embedding outer join. The following query:

```
SELECT * FROM T1 LEFT JOIN
              (T2 LEFT JOIN T3 ON T3.B=T2.B)
              ON T2.A=T1.A
  WHERE T3.C > 0
```

is converted to:

```
SELECT * FROM T1 LEFT JOIN
              (T2 INNER JOIN T3 ON T3.B=T2.B)
              ON T2.A=T1.A
  WHERE T3.C > 0,
```

That can be rewritten only to the form still containing the embedding outer join operation:

```
SELECT * FROM T1 LEFT JOIN
              (T2,T3)
              ON (T2.A=T1.A AND T3.B=T2.B)
  WHERE T3.C > 0.
```

When trying to convert an embedded outer join operation in a query, we must take into account the join condition for the embedding outer join together with the `WHERE` condition. In the query:

```
SELECT * FROM T1 LEFT JOIN
              (T2 LEFT JOIN T3 ON T3.B=T2.B)
              ON T2.A=T1.A AND T3.C=T1.C
  WHERE T3.D > 0 OR T1.D > 0
```

the `WHERE` condition is not null-rejected for the embedded outer join, but the join condition of the embedding outer join `T2.A=T1.A AND T3.C=T1.C` is null-rejected. So the query can be converted to:

```
SELECT * FROM T1 LEFT JOIN
              (T2, T3)
              ON T2.A=T1.A AND T3.C=T1.C AND T3.B=T2.B
  WHERE T3.D > 0 OR T1.D > 0
```

7.13.9. `ORDER BY` Optimization

In some cases, MySQL can use an index to satisfy an `ORDER BY` clause without doing any extra sorting.

The index can also be used even if the `ORDER BY` does not match the index exactly, as long as all of the unused portions of the index and all the extra `ORDER BY` columns are constants in the `WHERE` clause. The following queries use the index to resolve the `ORDER BY` part:

```
SELECT * FROM t1
  ORDER BY key_part1,key_part2,... ;

SELECT * FROM t1
  WHERE key_part1=constant
  ORDER BY key_part2;

SELECT * FROM t1
  ORDER BY key_part1 DESC, key_part2 DESC;

SELECT * FROM t1
  WHERE key_part1=1
  ORDER BY key_part1 DESC, key_part2 DESC;
```

In some cases, MySQL *cannot* use indexes to resolve the `ORDER BY`, although it still uses indexes to find the rows that match the `WHERE` clause. These cases include the following:

- You use `ORDER BY` on different keys:

  ```
  SELECT * FROM t1 ORDER BY key1, key2;
  ```

- You use `ORDER BY` on nonconsecutive parts of a key:

  ```
  SELECT * FROM t1 WHERE key2=constant ORDER BY key_part2;
  ```

- You mix `ASC` and `DESC`:

  ```
  SELECT * FROM t1 ORDER BY key_part1 DESC, key_part2 ASC;
  ```

- The key used to fetch the rows is not the same as the one used in the `ORDER BY`:

```
SELECT * FROM t1 WHERE key2=constant ORDER BY key1;
```

- You use `ORDER BY` with an expression that includes terms other than the key column name:

  ```
  SELECT * FROM t1 ORDER BY ABS(key);
  SELECT * FROM t1 ORDER BY -key;
  ```

- You are joining many tables, and the columns in the `ORDER BY` are not all from the first nonconstant table that is used to retrieve rows. (This is the first table in the `EXPLAIN` output that does not have a `const` join type.)
- You have different `ORDER BY` and `GROUP BY` expressions.
- You index only a prefix of a column named in the `ORDER BY` clause. In this case, the index cannot be used to fully resolve the sort order. For example, if you have a `CHAR(20)` column, but index only the first 10 bytes, the index cannot distinguish values past the 10th byte and a `filesort` will be needed.
- The type of table index used does not store rows in order. For example, this is true for a `HASH` index in a `MEMORY` table.

Availability of an index for sorting may be affected by the use of column aliases. Suppose that the column `t1.a` is indexed. In this statement, the name of the column in the select list is `a`. It refers to `t1.a`, so for the reference to `a` in the `ORDER BY`, the index can be used:

```
SELECT a FROM t1 ORDER BY a;
```

In this statement, the name of the column in the select list is also `a`, but it is the alias name. It refers to `ABS(a)`, so for the reference to `a` in the `ORDER BY`, the index cannot be used:

```
SELECT ABS(a) AS a FROM t1 ORDER BY a;
```

In the following statement, the `ORDER BY` refers to a name that is not the name of a column in the select list. But there is a column in `t1` named `a`, so the `ORDER BY` uses that, and the index can be used. (The resulting sort order may be completely different from the order for `ABS(a)`, of course.)

```
SELECT ABS(a) AS b FROM t1 ORDER BY a;
```

By default, MySQL sorts all `GROUP BY col1, col2, ...` queries as if you specified `ORDER BY col1, col2, ...` in the query as well. If you include an `ORDER BY` clause explicitly that contains the same column list, MySQL optimizes it away without any speed penalty, although the sorting still occurs. If a query includes `GROUP BY` but you want to avoid the overhead of sorting the result, you can suppress sorting by specifying `ORDER BY NULL`. For example:

```
INSERT INTO foo
SELECT a, COUNT(*) FROM bar GROUP BY a ORDER BY NULL;
```

With `EXPLAIN SELECT ... ORDER BY`, you can check whether MySQL can use indexes to resolve the query. It cannot if you see `Using filesort` in the `Extra` column. See Section 7.8.1, “Optimizing Queries with `EXPLAIN`”. Filesort uses a fixed-length row-storage format similar to that used by the `MEMORY` storage engine. Variable-length types such as `VARCHAR` are stored using a fixed length.

MySQL has two `filesort` algorithms for sorting and retrieving results. The original method uses only the `ORDER BY` columns. The modified method uses not just the `ORDER BY` columns, but all the columns used in the query.

The optimizer selects which `filesort` algorithm to use. It normally uses the modified algorithm except when `BLOB` or `TEXT` columns are involved, in which case it uses the original algorithm.

The original `filesort` algorithm works as follows:

1. Read all rows according to key or by table scanning. Rows that do not match the `WHERE` clause are skipped.
2. For each row, store a pair of values in a buffer (the sort key and the row pointer). The size of the buffer is the value of the `sort_buffer_size` system variable.
3. When the buffer gets full, run a qsort (quicksort) on it and store the result in a temporary file. Save a pointer to the sorted block. (If all pairs fit into the sort buffer, no temporary file is created.)
4. Repeat the preceding steps until all rows have been read.

5. Do a multi-merge of up to `MERGEBUFF` (7) regions to one block in another temporary file. Repeat until all blocks from the first file are in the second file.
6. Repeat the following until there are fewer than `MERGEBUFF2` (15) blocks left.
7. On the last multi-merge, only the pointer to the row (the last part of the sort key) is written to a result file.
8. Read the rows in sorted order by using the row pointers in the result file. To optimize this, we read in a big block of row pointers, sort them, and use them to read the rows in sorted order into a row buffer. The size of the buffer is the value of the `read_rnd_buffer_size` system variable. The code for this step is in the `sql/records.cc` source file.

One problem with this approach is that it reads rows twice: One time when evaluating the `WHERE` clause, and again after sorting the pair values. And even if the rows were accessed successively the first time (for example, if a table scan is done), the second time they are accessed randomly. (The sort keys are ordered, but the row positions are not.)

The modified `filesort` algorithm incorporates an optimization such that it records not only the sort key value and row position, but also the columns required for the query. This avoids reading the rows twice. The modified `filesort` algorithm works like this:

1. Read the rows that match the `WHERE` clause.
2. For each row, record a tuple of values consisting of the sort key value and row position, and also the columns required for the query.
3. Sort the tuples by sort key value
4. Retrieve the rows in sorted order, but read the required columns directly from the sorted tuples rather than by accessing the table a second time.

Using the modified `filesort` algorithm, the tuples are longer than the pairs used in the original method, and fewer of them fit in the sort buffer (the size of which is given by `sort_buffer_size`). As a result, it is possible for the extra I/O to make the modified approach slower, not faster. To avoid a slowdown, the optimization is used only if the total size of the extra columns in the sort tuple does not exceed the value of the `max_length_for_sort_data` system variable. (A symptom of setting the value of this variable too high is a combination of high disk activity and low CPU activity.)

For slow queries for which `filesort` is not used, try lowering `max_length_for_sort_data` to a value that is appropriate to trigger a `filesort`.

If you want to increase `ORDER BY` speed, check whether you can get MySQL to use indexes rather than an extra sorting phase. If this is not possible, you can try the following strategies:

- Increase the size of the `sort_buffer_size` variable.
- Increase the size of the `read_rnd_buffer_size` variable.
- Use less RAM per row by declaring columns only as large as they need to be to hold the values stored in them. For example, `CHAR(16)` is better than `CHAR(200)` if values never exceed 16 characters.
- Change `tmpdir` to point to a dedicated file system with large amounts of free space. Also, this option accepts several paths that are used in round-robin fashion, so you can use this feature to spread the load across several directories. Paths should be separated by colon characters (“`:`”) on Unix and semicolon characters (“`;`”) on Windows. The paths should be for directories in file systems that are located on different *physical* disks, not different partitions on the same disk.

7.13.10. `GROUP BY` Optimization

The most general way to satisfy a `GROUP BY` clause is to scan the whole table and create a new temporary table where all rows from each group are consecutive, and then use this temporary table to discover groups and apply aggregate functions (if any). In some cases, MySQL is able to do much better than that and to avoid creation of temporary tables by using index access.

The most important preconditions for using indexes for `GROUP BY` are that all `GROUP BY` columns reference attributes from the same index, and that the index stores its keys in order (for example, this is a `BTREE` index and not a `HASH` index). Whether use of temporary tables can be replaced by index access also depends on which parts of an index are used in a query, the conditions specified for these parts, and the selected aggregate functions.

There are two ways to execute a `GROUP BY` query through index access, as detailed in the following sections. In the first method, the grouping operation is applied together with all range predicates (if any). The second method first performs a range scan, and then groups the resulting tuples.

In MySQL, `GROUP BY` is used for sorting, so the server may also apply `ORDER BY` optimizations to grouping. See Section 7.13.9, "`ORDER BY` Optimization".

7.13.10.1. Loose Index Scan

The most efficient way to process `GROUP BY` is when an index is used to directly retrieve the grouping columns. With this access method, MySQL uses the property of some index types that the keys are ordered (for example, `BTREE`). This property enables use of lookup groups in an index without having to consider all keys in the index that satisfy all `WHERE` conditions. This access method considers only a fraction of the keys in an index, so it is called a *loose index scan*. When there is no `WHERE` clause, a loose index scan reads as many keys as the number of groups, which may be a much smaller number than that of all keys. If the `WHERE` clause contains range predicates (see the discussion of the `range` join type in Section 7.8.1, "Optimizing Queries with `EXPLAIN`"), a loose index scan looks up the first key of each group that satisfies the range conditions, and again reads the least possible number of keys. This is possible under the following conditions:

- The query is over a single table.
- The `GROUP BY` names only columns that form a leftmost prefix of the index and no other columns. (If, instead of `GROUP BY`, the query has a `DISTINCT` clause, all distinct attributes refer to columns that form a leftmost prefix of the index.) For example, if a table `t1` has an index on `(c1,c2,c3)`, loose index scan is applicable if the query has `GROUP BY c1, c2,`. It is not applicable if the query has `GROUP BY c2, c3` (the columns are not a leftmost prefix) or `GROUP BY c1, c2, c4` (`c4` is not in the index).
- The only aggregate functions used in the select list (if any) are `MIN()` and `MAX()`, and all of them refer to the same column. The column must be in the index and must follow the columns in the `GROUP BY`.
- Any other parts of the index than those from the `GROUP BY` referenced in the query must be constants (that is, they must be referenced in equalities with constants), except for the argument of `MIN()` or `MAX()` functions.
- For columns in the index, full column values must be indexed, not just a prefix. For example, with `c1 VARCHAR(20), INDEX (c1(10))`, the index cannot be used for loose index scan.

If loose index scan is applicable to a query, the `EXPLAIN` output shows `Using index for group-by` in the `Extra` column.

Assume that there is an index `idx(c1,c2,c3)` on table `t1(c1,c2,c3,c4)`. The loose index scan access method can be used for the following queries:

```
SELECT c1, c2 FROM t1 GROUP BY c1, c2;
SELECT DISTINCT c1, c2 FROM t1;
SELECT c1, MIN(c2) FROM t1 GROUP BY c1;
SELECT c1, c2 FROM t1 WHERE c1 < const GROUP BY c1, c2;
SELECT MAX(c3), MIN(c3), c1, c2 FROM t1 WHERE c2 > const GROUP BY c1, c2;
SELECT c2 FROM t1 WHERE c1 < const GROUP BY c1, c2;
SELECT c1, c2 FROM t1 WHERE c3 = const GROUP BY c1, c2;
```

The following queries cannot be executed with this quick select method, for the reasons given:

- There are aggregate functions other than `MIN()` or `MAX()`:

  ```
  SELECT c1, SUM(c2) FROM t1 GROUP BY c1;
  ```

- The columns in the `GROUP BY` clause do not form a leftmost prefix of the index:

  ```
  SELECT c1, c2 FROM t1 GROUP BY c2, c3;
  ```

- The query refers to a part of a key that comes after the `GROUP BY` part, and for which there is no equality with a constant:

  ```
  SELECT c1, c3 FROM t1 GROUP BY c1, c2;
  ```

  Were the query to include `WHERE c3 = const`, loose index scan could be used.

As of MySQL 5.5, the loose index scan access method can be applied to other forms of aggregate function references in the select list, in addition to the `MIN()` and `MAX()` references already supported:

- `AVG(DISTINCT)`, `SUM(DISTINCT)`, and `COUNT(DISTINCT)` are supported. `AVG(DISTINCT)` and `SUM(DISTINCT)` take a single argument. `COUNT(DISTINCT)` can have more than one column argument.

- There must be no `GROUP BY` or `DISTINCT` clause in the query.
- The loose scan limitations described earlier still apply.

Assume that there is an index `idx(c1,c2,c3)` on table `t1(c1,c2,c3,c4)`. The loose index scan access method can be used for the following queries:

```
SELECT COUNT(DISTINCT c1), SUM(DISTINCT c1) FROM t1;

SELECT COUNT(DISTINCT c1, c2), COUNT(DISTINCT c2, c1) FROM t1;
```

Loose index scan is not applicable for the following queries:

```
SELECT DISTINCT COUNT(DISTINCT c1) FROM t1;

SELECT COUNT(DISTINCT c1) FROM t1 GROUP BY c1;
```

7.13.10.2. Tight Index Scan

A tight index scan may be either a full index scan or a range index scan, depending on the query conditions.

When the conditions for a loose index scan are not met, it still may be possible to avoid creation of temporary tables for `GROUP BY` queries. If there are range conditions in the `WHERE` clause, this method reads only the keys that satisfy these conditions. Otherwise, it performs an index scan. Because this method reads all keys in each range defined by the `WHERE` clause, or scans the whole index if there are no range conditions, we term it a *tight index scan*. With a tight index scan, the grouping operation is performed only after all keys that satisfy the range conditions have been found.

For this method to work, it is sufficient that there is a constant equality condition for all columns in a query referring to parts of the key coming before or in between parts of the `GROUP BY` key. The constants from the equality conditions fill in any “gaps” in the search keys so that it is possible to form complete prefixes of the index. These index prefixes then can be used for index lookups. If we require sorting of the `GROUP BY` result, and it is possible to form search keys that are prefixes of the index, MySQL also avoids extra sorting operations because searching with prefixes in an ordered index already retrieves all the keys in order.

Assume that there is an index `idx(c1,c2,c3)` on table `t1(c1,c2,c3,c4)`. The following queries do not work with the loose index scan access method described earlier, but still work with the tight index scan access method.

- There is a gap in the `GROUP BY`, but it is covered by the condition `c2 = 'a'`:

  ```
  SELECT c1, c2, c3 FROM t1 WHERE c2 = 'a' GROUP BY c1, c3;
  ```

- The `GROUP BY` does not begin with the first part of the key, but there is a condition that provides a constant for that part:

  ```
  SELECT c1, c2, c3 FROM t1 WHERE c1 = 'a' GROUP BY c2, c3;
  ```

7.13.11. `DISTINCT` Optimization

`DISTINCT` combined with `ORDER BY` needs a temporary table in many cases.

Because `DISTINCT` may use `GROUP BY`, learn how MySQL works with columns in `ORDER BY` or `HAVING` clauses that are not part of the selected columns. See Section 11.16.3, “`GROUP BY` and `HAVING` with Hidden Columns”.

In most cases, a `DISTINCT` clause can be considered as a special case of `GROUP BY`. For example, the following two queries are equivalent:

```
SELECT DISTINCT c1, c2, c3 FROM t1
WHERE c1 > const;

SELECT c1, c2, c3 FROM t1
WHERE c1 > const GROUP BY c1, c2, c3;
```

Due to this equivalence, the optimizations applicable to `GROUP BY` queries can be also applied to queries with a `DISTINCT` clause. Thus, for more details on the optimization possibilities for `DISTINCT` queries, see Section 7.13.10, “`GROUP BY` Optimization”.

When combining `LIMIT` *`row_count`* with `DISTINCT`, MySQL stops as soon as it finds *`row_count`* unique rows.

If you do not use columns from all tables named in a query, MySQL stops scanning any unused tables as soon as it finds the first match. In the following case, assuming that `t1` is used before `t2` (which you can check with `EXPLAIN`), MySQL stops reading from `t2` (for any particular row in `t1`) when it finds the first row in `t2`:

```
SELECT DISTINCT t1.a FROM t1, t2 where t1.a=t2.a;
```

7.13.12. Optimizing `IN`/`=ANY` Subqueries

Certain optimizations are applicable to comparisons that use the `IN` operator to test subquery results (or that use `=ANY`, which is equivalent). This section discusses these optimizations, particularly with regard to the challenges that `NULL` values present. Suggestions on what you can do to help the optimizer are given at the end of the discussion.

To help the query optimizer better execute your queries, use these tips:

- A column must be declared as `NOT NULL` if it really is. (This also helps other aspects of the optimizer.)
- If you don't need to distinguish a `NULL` from `FALSE` subquery result, you can easily avoid the slow execution path. Replace a comparison that looks like this:

  ```
  outer_expr IN (SELECT inner_expr FROM ...)
  ```

  with this expression:

  ```
  (outer_expr IS NOT NULL) AND (outer_expr IN (SELECT inner_expr FROM ...))
  ```

  Then `NULL IN (SELECT ...)` will never be evaluated because MySQL stops evaluating `AND` parts as soon as the expression result is clear.

Consider the following subquery comparison:

```
outer_expr IN (SELECT inner_expr FROM ... WHERE subquery_where)
```

MySQL evaluates queries “from outside to inside.” That is, it first obtains the value of the outer expression *`outer_expr`*, and then runs the subquery and captures the rows that it produces.

A very useful optimization is to “inform” the subquery that the only rows of interest are those where the inner expression *`inner_expr`* is equal to *`outer_expr`*. This is done by pushing down an appropriate equality into the subquery's `WHERE` clause. That is, the comparison is converted to this:

```
EXISTS (SELECT 1 FROM ... WHERE subquery_where AND outer_expr=inner_expr)
```

After the conversion, MySQL can use the pushed-down equality to limit the number of rows that it must examine when evaluating the subquery.

More generally, a comparison of *`N`* values to a subquery that returns *`N`*-value rows is subject to the same conversion. If *`oe_i`* and *`ie_i`* represent corresponding outer and inner expression values, this subquery comparison:

```
(oe_1, ..., oe_N) IN
  (SELECT ie_1, ..., ie_N FROM ... WHERE subquery_where)
```

Becomes:

```
EXISTS (SELECT 1 FROM ... WHERE subquery_where
                          AND oe_1 = ie_1
                          AND ...
                          AND oe_N = ie_N)
```

The following discussion assumes a single pair of outer and inner expression values for simplicity.

The conversion just described has its limitations. It is valid only if we ignore possible `NULL` values. That is, the “pushdown” strategy works as long as both of these two conditions are true:

- *`outer_expr`* and *`inner_expr`* cannot be `NULL`.
- You do not need to distinguish `NULL` from `FALSE` subquery results. (If the subquery is a part of an `OR` or `AND` expression in the `WHERE` clause, MySQL assumes that you don't care.)

When either or both of those conditions do not hold, optimization is more complex.

Suppose that *`outer_expr`* is known to be a non-`NULL` value but the subquery does not produce a row such that *`outer_expr`* = *`inner_expr`*. Then *`outer_expr`* `IN (SELECT ...)` evaluates as follows:

- `NULL`, if the `SELECT` produces any row where *`inner_expr`* is `NULL`
- `FALSE`, if the `SELECT` produces only non-`NULL` values or produces nothing

In this situation, the approach of looking for rows with *`outer_expr`* `=` *`inner_expr`* is no longer valid. It is necessary to look for such rows, but if none are found, also look for rows where *`inner_expr`* is `NULL`. Roughly speaking, the subquery can be converted to:

```
EXISTS (SELECT 1 FROM ... WHERE subquery_where AND
        (outer_expr=inner_expr OR inner_expr IS NULL))
```

The need to evaluate the extra `IS NULL` condition is why MySQL has the `ref_or_null` access method:

```
mysql> EXPLAIN
    -> SELECT outer_expr IN (SELECT t2.maybe_null_key
    ->                       FROM t2, t3 WHERE ...)
    -> FROM t1;
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: t1
...
*************************** 2. row ***************************
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: t2
         type: ref_or_null
possible_keys: maybe_null_key
          key: maybe_null_key
      key_len: 5
          ref: func
         rows: 2
        Extra: Using where; Using index
...
```

The `unique_subquery` and `index_subquery` subquery-specific access methods also have or-null variants. However, they are not visible in `EXPLAIN` output, so you must use `EXPLAIN EXTENDED` followed by `SHOW WARNINGS` (note the `checking NULL` in the warning message):

```
mysql> EXPLAIN EXTENDED
    -> SELECT outer_expr IN (SELECT maybe_null_key FROM t2) FROM t1\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: t1
...
*************************** 2. row ***************************
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: t2
         type: index_subquery
possible_keys: maybe_null_key
          key: maybe_null_key
      key_len: 5
          ref: func
         rows: 2
        Extra: Using index

mysql> SHOW WARNINGS\G
*************************** 1. row ***************************
  Level: Note
   Code: 1003
Message: select (`test`.`t1`.`outer_expr`,
         (((`test`.`t1`.`outer_expr`) in t2 on
         maybe_null_key checking NULL))) AS `outer_expr IN (SELECT
         maybe_null_key FROM t2)` from `test`.`t1`
```

The additional `OR ... IS NULL` condition makes query execution slightly more complicated (and some optimizations within the subquery become inapplicable), but generally this is tolerable.

The situation is much worse when *`outer_expr`* can be `NULL`. According to the SQL interpretation of `NULL` as “unknown value,” `NULL IN (SELECT` *`inner_expr`* `...)` should evaluate to:

- `NULL`, if the `SELECT` produces any rows

- `FALSE`, if the `SELECT` produces no rows

For proper evaluation, it is necessary to be able to check whether the `SELECT` has produced any rows at all, so *`outer_expr = inner_expr`* cannot be pushed down into the subquery. This is a problem, because many real world subqueries become very slow unless the equality can be pushed down.

Essentially, there must be different ways to execute the subquery depending on the value of *`outer_expr`*.

The optimizer chooses SQL compliance over speed, so it accounts for the possibility that *`outer_expr`* might be `NULL`.

If *`outer_expr`* is `NULL`, to evaluate the following expression, it is necessary to run the `SELECT` to determine whether it produces any rows:

```
NULL IN (SELECT inner_expr FROM ... WHERE subquery_where)
```

It is necessary to run the original `SELECT` here, without any pushed-down equalities of the kind mentioned earlier.

On the other hand, when *`outer_expr`* is not `NULL`, it is absolutely essential that this comparison:

```
outer_expr IN (SELECT inner_expr FROM ... WHERE subquery_where)
```

be converted to this expression that uses a pushed-down condition:

```
EXISTS (SELECT 1 FROM ... WHERE subquery_where AND outer_expr=inner_expr)
```

Without this conversion, subqueries will be slow. To solve the dilemma of whether to push down or not push down conditions into the subquery, the conditions are wrapped in “trigger” functions. Thus, an expression of the following form:

```
outer_expr IN (SELECT inner_expr FROM ... WHERE subquery_where)
```

is converted into:

```
EXISTS (SELECT 1 FROM ... WHERE subquery_where
                          AND trigcond(outer_expr=inner_expr))
```

More generally, if the subquery comparison is based on several pairs of outer and inner expressions, the conversion takes this comparison:

```
(oe_1, ..., oe_N) IN (SELECT ie_1, ..., ie_N FROM ... WHERE subquery_where)
```

and converts it to this expression:

```
EXISTS (SELECT 1 FROM ... WHERE subquery_where
                          AND trigcond(oe_1=ie_1)
                          AND ...
                          AND trigcond(oe_N=ie_N)
       )
```

Each `trigcond(X)` is a special function that evaluates to the following values:

- *`X`* when the “linked” outer expression *`oe_i`* is not `NULL`
- `TRUE` when the “linked” outer expression *`oe_i`* is `NULL`

Note that trigger functions are *not* triggers of the kind that you create with `CREATE TRIGGER`.

Equalities that are wrapped into `trigcond()` functions are not first class predicates for the query optimizer. Most optimizations cannot deal with predicates that may be turned on and off at query execution time, so they assume any `trigcond(X)` to be an unknown function and ignore it. At the moment, triggered equalities can be used by those optimizations:

- Reference optimizations: `trigcond(X=Y [OR Y IS NULL])` can be used to construct `ref`, `eq_ref`, or `ref_or_null` table accesses.
- Index lookup-based subquery execution engines: `trigcond(X=Y)` can be used to construct `unique_subquery` or `index_subquery` accesses.

- Table-condition generator: If the subquery is a join of several tables, the triggered condition will be checked as soon as possible.

When the optimizer uses a triggered condition to create some kind of index lookup-based access (as for the first two items of the preceding list), it must have a fallback strategy for the case when the condition is turned off. This fallback strategy is always the same: Do a full table scan. In `EXPLAIN` output, the fallback shows up as `Full scan on NULL key` in the `Extra` column:

```
mysql> EXPLAIN SELECT t1.col1,
    -> t1.col1 IN (SELECT t2.key1 FROM t2 WHERE t2.col2=t1.col2) FROM t1\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: t1
        ...
*************************** 2. row ***************************
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: t2
         type: index_subquery
possible_keys: key1
          key: key1
      key_len: 5
          ref: func
         rows: 2
        Extra: Using where; Full scan on NULL key
```

If you run `EXPLAIN EXTENDED` followed by `SHOW WARNINGS`, you can see the triggered condition:

```
*************************** 1. row ***************************
  Level: Note
   Code: 1003
Message: select `test`.`t1`.`col1` AS `col1`,
         <in_optimizer>(`test`.`t1`.`col1`,
         <exists>(<index_lookup>(<cache>(`test`.`t1`.`col1`) in t2
         on key1 checking NULL
         where (`test`.`t2`.`col2` = `test`.`t1`.`col2`) having
         trigcond(<is_not_null_test>(`test`.`t2`.`key1`))))) AS
         `t1.col1 IN (select t2.key1 from t2 where t2.col2=t1.col2)`
         from `test`.`t1`
```

The use of triggered conditions has some performance implications. A `NULL IN (SELECT ...)` expression now may cause a full table scan (which is slow) when it previously did not. This is the price paid for correct results (the goal of the trigger-condition strategy was to improve compliance and not speed).

For multiple-table subqueries, execution of `NULL IN (SELECT ...)` will be particularly slow because the join optimizer doesn't optimize for the case where the outer expression is `NULL`. It assumes that subquery evaluations with `NULL` on the left side are very rare, even if there are statistics that indicate otherwise. On the other hand, if the outer expression might be `NULL` but never actually is, there is no performance penalty.

Chapter 8. Language Structure

This chapter discusses the rules for writing the following elements of SQL statements when using MySQL:

- Literal values such as strings and numbers
- Identifiers such as database, table, and column names
- Reserved words
- User-defined and system variables
- Comments

8.1. Literal Values

This section describes how to write literal values in MySQL. These include strings, numbers, hexadecimal values, boolean values, and `NULL`. The section also covers the various nuances and “gotchas” that you may run into when dealing with these basic types in MySQL.

8.1.1. Strings

A string is a sequence of bytes or characters, enclosed within either single quote (“`'`”) or double quote (“`"`”) characters. Examples:

```
'a string'
"another string"
```

Quoted strings placed next to each other are concatenated to a single string. The following lines are equivalent:

```
'a string'
'a' ' ' 'string'
```

If the `ANSI_QUOTES` SQL mode is enabled, string literals can be quoted only within single quotation marks because a string quoted within double quotation marks is interpreted as an identifier.

A *binary string* is a string of bytes that has no character set or collation. A *nonbinary string* is a string of characters that has a character set and collation. For both types of strings, comparisons are based on the numeric values of the string unit. For binary strings, the unit is the byte. For nonbinary strings the unit is the character and some character sets support multi-byte characters. Character value ordering is a function of the string collation.

String literals may have an optional character set introducer and `COLLATE` clause:

```
[_charset_name]'string' [COLLATE collation_name]
```

Examples:

```
SELECT _latin1'string';
SELECT _latin1'string' COLLATE latin1_danish_ci;
```

You can use `N'literal'` (or `n'literal'`) to create a string in the national character set. These statements are equivalent:

```
SELECT N'some text';
SELECT n'some text';
SELECT _utf8'some text';
```

For more information about these forms of string syntax, see Section 9.1.3.5, “Character String Literal Character Set and Collation”, and Section 9.1.3.6, “National Character Set”.

Within a string, certain sequences have special meaning unless the `NO_BACKSLASH_ESCAPES` SQL mode is enabled. Each of these sequences begins with a backslash (“`\`”), known as the *escape character*. MySQL recognizes the escape sequences shown in Table 8.1, “Special Character Escape Sequences”. For all other escape sequences, backslash is ignored. That is, the escaped character is interpreted as if it was not escaped. For example, “`\x`” is just “`x`”. These sequences are case sensitive. For example, “`\b`” is interpreted as a backspace, but “`\B`” is interpreted as “`B`”. Escape processing is done according to the character set indicated by the `character_set_connection` system variable. This is true even for strings that are preceded by an introducer that indicates a different character set, as discussed in Section 9.1.3.5, “Character String Literal Character Set and Collation”.

Table 8.1. Special Character Escape Sequences

Escape Sequence	Character Represented by Sequence
`\0`	An ASCII NUL (`0x00`) character.
`\'`	A single quote (“`'`”) character.
`\"`	A double quote (“`"`”) character.
`\b`	A backspace character.
`\n`	A newline (linefeed) character.
`\r`	A carriage return character.
`\t`	A tab character.
`\Z`	ASCII 26 (Control+Z). See note following the table.
`\\`	A backslash (“`\`”) character.
`\%`	A “`%`” character. See note following the table.
`\_`	A “`_`” character. See note following the table.

The ASCII 26 character can be encoded as “`\Z`” to enable you to work around the problem that ASCII 26 stands for END-OF-FILE on Windows. ASCII 26 within a file causes problems if you try to use `mysql db_name < file_name`.

The “`\%`” and “`\_`” sequences are used to search for literal instances of “`%`” and “`_`” in pattern-matching contexts where they would otherwise be interpreted as wildcard characters. See the description of the `LIKE` operator in Section 11.5.1, “String Comparison Functions”. If you use “`\%`” or “`\_`” outside of pattern-matching contexts, they evaluate to the strings “`\%`” and “`\_`”, not to “`%`” and “`_`”.

There are several ways to include quote characters within a string:

- A “`'`” inside a string quoted with “`'`” may be written as “`''`”.
- A “`"`” inside a string quoted with “`"`” may be written as “`""`”.
- Precede the quote character by an escape character (“`\`”).
- A “`'`” inside a string quoted with “`"`” needs no special treatment and need not be doubled or escaped. In the same way, “`"`” inside a string quoted with “`'`” needs no special treatment.

The following `SELECT` statements demonstrate how quoting and escaping work:

```
mysql> SELECT 'hello', '"hello"', '""hello""', 'hel''lo', '\'hello';
+-------+---------+-----------+--------+--------+
| hello | "hello" | ""hello"" | hel'lo | 'hello |
+-------+---------+-----------+--------+--------+

mysql> SELECT "hello", "'hello'", "''hello''", "hel""lo", "\"hello";
+-------+---------+-----------+--------+--------+
| hello | 'hello' | ''hello'' | hel"lo | "hello |
+-------+---------+-----------+--------+--------+

mysql> SELECT 'This\nIs\nFour\nLines';
+--------------------+
| This
Is
Four
Lines |
+--------------------+

mysql> SELECT 'disappearing\ backslash';
+------------------------+
| disappearing backslash |
+------------------------+
```

If you want to insert binary data into a string column (such as a `BLOB` column), you should represent certain characters by escape sequences. Backslash (“`\`”) and the quote character used to quote the string must be escaped. In certain client environments, it may also be necessary to escape `NUL` or Control+Z. The `mysql` client truncates quoted strings containing `NUL` characters if they are not escaped, and Control+Z may be taken for END-OF-FILE on Windows if not escaped. For the escape sequences that represent each of these characters, see Table 8.1, “Special Character Escape Sequences”.

When writing application programs, any string that might contain any of these special characters must be properly escaped before the string is used as a data value in an SQL statement that is sent to the MySQL server. You can do this in two ways:

- Process the string with a function that escapes the special characters. In a C program, you can use the `mysql_real_escape_string()` C API function to escape characters. See Section 20.9.3.53, “`mysql_real_escape_string()`”. Within SQL statements that construct other SQL statements, you can use the `QUOTE()` function. The Perl DBI interface provides a `quote` method to convert special characters to the proper escape sequences. See Section 20.11, “MySQL Perl API”. Other language interfaces may provide a similar capability.
- As an alternative to explicitly escaping special characters, many MySQL APIs provide a placeholder capability that enables you to insert special markers into a statement string, and then bind data values to them when you issue the statement. In this case, the API takes care of escaping special characters in the values for you.

8.1.2. Numbers

Integers are represented as a sequence of digits. Floats use “`.`” as a decimal separator. Either type of number may be preceded by “`-`” or “`+`” to indicate a negative or positive value, respectively

Examples of valid integers:

```
1221
0
-32
```

Examples of valid floating-point numbers:

```
294.42
-32032.6809e+10
148.00
```

An integer may be used in a floating-point context; it is interpreted as the equivalent floating-point number.

8.1.3. Date and Time Values

Date and time values can be represented as quoted strings or as numbers, depending on the exact type of the value and other factors.

For specific information about the formats used to represent `DATE`, `DATETIME`, and `TIMESTAMP` values, see Section 10.3.1, “The `DATETIME`, `DATE`, and `TIMESTAMP` Types”.

For specific information about the formats used to represent `TIME` values, see Section 10.3.2, “The `TIME` Type”.

For specific information about the formats used to represent `YEAR` values, see Section 10.3.3, “The `YEAR` Type”.

8.1.4. Hexadecimal Values

MySQL supports hexadecimal values, written using `X'val'`, `x'val'`, or `0xval` format, where *`val`* contains hexadecimal digits (`0..9`, `A..F`). Lettercase of the digits does not matter. For values written using `X'val'` or `x'val'` format, *`val`* must contain an even number of digits. For values written using `0xval syntax`, values that contain an odd number of digits are treated as having an extra leading `0`. For example, `0x0a` and `0xaaa` are interpreted as `0x0a` and `0x0aaa`.

In numeric contexts, hexadecimal values act like integers (64-bit precision). In string contexts, they act like binary strings, where each pair of hex digits is converted to a character:

```
mysql> SELECT X'4D7953514C';
        -> 'MySQL'
mysql> SELECT 0x0a+0;
        -> 10
mysql> SELECT 0x5061756c;
        -> 'Paul'
```

The default type of a hexadecimal value is a string. If you want to ensure that the value is treated as a number, you can use `CAST(... AS UNSIGNED)`:

```
mysql> SELECT 0x41, CAST(0x41 AS UNSIGNED);
        -> 'A', 65
```

The `X'hexstring'` syntax is based on standard SQL. The `0x` syntax is based on ODBC. Hexadecimal strings are often used by ODBC to supply values for `BLOB` columns.

You can convert a string or a number to a string in hexadecimal format with the `HEX()` function:

```
mysql> SELECT HEX('cat');
```

```
        -> '636174'
mysql> SELECT 0x636174;
        -> 'cat'
```

8.1.5. Boolean Values

The constants `TRUE` and `FALSE` evaluate to `1` and `0`, respectively. The constant names can be written in any lettercase.

```
mysql> SELECT TRUE, true, FALSE, false;
        -> 1, 1, 0, 0
```

8.1.6. Bit-Field Values

Bit-field values can be written using `b'value'` or `0bvalue` notation. `value` is a binary value written using zeros and ones.

Bit-field notation is convenient for specifying values to be assigned to `BIT` columns:

```
mysql> CREATE TABLE t (b BIT(8));
mysql> INSERT INTO t SET b = b'11111111';
mysql> INSERT INTO t SET b = b'1010';
mysql> INSERT INTO t SET b = b'0101';
```

Bit values are returned as binary values. To display them in printable form, add 0 or use a conversion function such as `BIN()`. High-order 0 bits are not displayed in the converted value.

```
mysql> SELECT b+0, BIN(b+0), OCT(b+0), HEX(b+0) FROM t;
+------+----------+----------+----------+
| b+0  | BIN(b+0) | OCT(b+0) | HEX(b+0) |
+------+----------+----------+----------+
|  255 | 11111111 | 377      | FF       |
|   10 | 1010     | 12       | A        |
|    5 | 101      | 5        | 5        |
+------+----------+----------+----------+
```

Bit values assigned to user variables are treated as binary strings. To assign a bit value as a number to a user variable, use `CAST()` or `+0`:

```
mysql> SET @v1 = 0b1000001;
mysql> SET @v2 = CAST(0b1000001 AS UNSIGNED), @v3 = 0b1000001+0;
mysql> SELECT @v1, @v2, @v3;
+------+------+------+
| @v1  | @v2  | @v3  |
+------+------+------+
| A    |   65 |   65 |
+------+------+------+
```

8.1.7. `NULL` Values

The `NULL` value means “no data.” `NULL` can be written in any lettercase. A synonym is `\N` (case sensitive).

For text file import or export operations performed with `LOAD DATA INFILE` or `SELECT ... INTO OUTFILE`, `NULL` is represented by the `\N` sequence. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”.

Be aware that the `NULL` value is different from values such as `0` for numeric types or the empty string for string types. For more information, see Section C.5.5.3, “Problems with `NULL` Values”.

8.2. Schema Object Names

Certain objects within MySQL, including database, table, index, column, alias, view, stored procedure, partition, tablespace, and other object names are known as identifiers. This section describes the permissible syntax for identifiers in MySQL. Section 8.2.2, “Identifier Case Sensitivity”, describes which types of identifiers are case sensitive and under what conditions.

An identifier may be quoted or unquoted. If an identifier contains special characters or is a reserved word, you *must* quote it whenever you refer to it. (Exception: A reserved word that follows a period in a qualified name must be an identifier, so it need not be quoted.) Reserved words are listed at Section 8.3, “Reserved Words”.

Identifiers are converted to Unicode internally. They may contain these characters:

- Permitted characters in unquoted identifiers:
  - ASCII: [0-9,a-z,A-Z$_] (basic Latin letters, digits 0-9, dollar, underscore)

  - Extended: U+0080 .. U+FFFF

- Permitted characters in quoted identifiers include the full Unicode Basic Multilingual Plane (BMP), except U+0000:
  - ASCII: U+0001 .. U+007F
  - Extended: U+0080 .. U+FFFF
- ASCII NUL (U+0000) and supplementary characters (U+10000 and higher) are not permitted in quoted or unquoted identifiers.
- Identifiers may begin with a digit but unless quoted may not consist solely of digits.
- Database, table, and column names cannot end with space characters.

The identifier quote character is the backtick ("`"):

```
mysql> SELECT * FROM `select` WHERE `select`.id > 100;
```

If the `ANSI_QUOTES` SQL mode is enabled, it is also permissible to quote identifiers within double quotation marks:

```
mysql> CREATE TABLE "test" (col INT);
ERROR 1064: You have an error in your SQL syntax...
mysql> SET sql_mode='ANSI_QUOTES';
mysql> CREATE TABLE "test" (col INT);
Query OK, 0 rows affected (0.00 sec)
```

The `ANSI_QUOTES` mode causes the server to interpret double-quoted strings as identifiers. Consequently, when this mode is enabled, string literals must be enclosed within single quotation marks. They cannot be enclosed within double quotation marks. The server SQL mode is controlled as described in Section 5.1.6, "Server SQL Modes".

Identifier quote characters can be included within an identifier if you quote the identifier. If the character to be included within the identifier is the same as that used to quote the identifier itself, then you need to double the character. The following statement creates a table named `` a`b `` that contains a column named `c"d`:

```
mysql> CREATE TABLE `a``b` (`c"d` INT);
```

In the select list of a query, a quoted column alias can be specified using identifier or string quoting characters:

```
mysql> SELECT 1 AS `one`, 2 AS 'two';
+-----+-----+
| one | two |
+-----+-----+
|   1 |   2 |
+-----+-----+
```

Elsewhere in the statement, quoted references to the alias must use identifier quoting or the reference is treated as a string literal.

It is recommended that you do not use names that begin with `Me` or `MeN`, where `M` and `N` are integers. For example, avoid using `1e` as an identifier, because an expression such as `1e+3` is ambiguous. Depending on context, it might be interpreted as the expression `1e + 3` or as the number `1e+3`.

Be careful when using `MD5()` to produce table names because it can produce names in illegal or ambiguous formats such as those just described.

A user variable cannot be used directly in an SQL statement as an identifier or as part of an identifier. See Section 8.4, "User-Defined Variables", for more information and examples of workarounds.

Special characters in database and table names are encoded in the corresponding file system names as described in Section 8.2.3, "Mapping of Identifiers to File Names". If you have databases or tables from an older version of MySQL that contain special characters and for which the underlying directory names or file names have not been updated to use the new encoding, the server displays their names with a prefix of `#mysql50#`. For information about referring to such names or converting them to the newer encoding, see that section.

The following table describes the maximum length for each type of identifier.

Identifier	**Maximum Length (characters)**
Database	64
Table	64
Column	64

Identifier	**Maximum Length (characters)**
Index	64
Constraint	64
Stored Procedure or Function	64
Trigger	64
View	64
Event	64
Tablespace	64
Server	64
Log File Group	64
Alias	256 (see exception following table)
Compound Statement Label	16

Aliases for column names in `CREATE VIEW` statements are checked against the maximum column length of 64 characters (not the maximum alias length of 256 characters).

Identifiers are stored using Unicode (UTF-8). This applies to identifiers in table definitions that are stored in `.frm` files and to identifiers stored in the grant tables in the `mysql` database. The sizes of the identifier string columns in the grant tables are measured in characters. You can use multi-byte characters without reducing the number of characters permitted for values stored in these columns, something not true prior to MySQL 4.1. As indicated earlier, the permissible Unicode characters are those in the Basic Multilingual Plane (BMP). Supplementary characters are not permitted.

8.2.1. Identifier Qualifiers

MySQL permits names that consist of a single identifier or multiple identifiers. The components of a multiple-part name must be separated by period (“`.`”) characters. The initial parts of a multiple-part name act as qualifiers that affect the context within which the final identifier is interpreted.

In MySQL, you can refer to a table column using any of the following forms.

Column Reference	**Meaning**
`col_name`	The column *`col_name`* from whichever table used in the statement contains a column of that name.
`tbl_name.col_name`	The column *`col_name`* from table *`tbl_name`* of the default database.
`db_name.tbl_name.col_name`	The column *`col_name`* from table *`tbl_name`* of the database *`db_name`*.

If any components of a multiple-part name require quoting, quote them individually rather than quoting the name as a whole. For example, write ``` `my-table`.`my-column` ```, not ``` `my-table.my-column` ```.

A reserved word that follows a period in a qualified name must be an identifier, so in that context it need not be quoted.

You need not specify a *`tbl_name`* or *`db_name.tbl_name`* prefix for a column reference in a statement unless the reference would be ambiguous. Suppose that tables `t1` and `t2` each contain a column `c`, and you retrieve `c` in a `SELECT` statement that uses both `t1` and `t2`. In this case, `c` is ambiguous because it is not unique among the tables used in the statement. You must qualify it with a table name as `t1.c` or `t2.c` to indicate which table you mean. Similarly, to retrieve from a table `t` in database `db1` and from a table `t` in database `db2` in the same statement, you must refer to columns in those tables as `db1.t.col_name` and `db2.t.col_name`.

The syntax *`.tbl_name`* means the table *`tbl_name`* in the default database. This syntax is accepted for ODBC compatibility because some ODBC programs prefix table names with a “`.`” character.

8.2.2. Identifier Case Sensitivity

In MySQL, databases correspond to directories within the data directory. Each table within a database corresponds to at least one file within the database directory (and possibly more, depending on the storage engine). Triggers also correspond to files. Consequently, the case sensitivity of the underlying operating system plays a part in the case sensitivity of database, table, and trigger names. This means such names are not case sensitive in Windows, but are case sensitive in most varieties of Unix. One notable exception is Mac OS X, which is Unix-based but uses a default file system type (HFS+) that is not case sensitive. However, Mac OS X also supports UFS volumes, which are case sensitive just as on any Unix. See Section 1.8.4, “MySQL Extensions to Standard SQL”. The `lower_case_table_names` system variable also affects how the server handles identifier case sensitivity, as described later in this section.

> **Note**
>
> Although database, table, and trigger names are not case sensitive on some platforms, you should not refer to one of these using different cases within the same statement. The following statement would not work because it refers to a table both as `my_table` and as `MY_TABLE`:
>
> ```
> mysql> SELECT * FROM my_table WHERE MY_TABLE.col=1;
> ```

Column, index, stored routine, and event names are not case sensitive on any platform, nor are column aliases.

However, names of logfile groups are case sensitive. This differs from standard SQL.

By default, table aliases are case sensitive on Unix, but not so on Windows or Mac OS X. The following statement would not work on Unix, because it refers to the alias both as `a` and as `A`:

```
mysql> SELECT col_name FROM tbl_name AS a
    -> WHERE a.col_name = 1 OR A.col_name = 2;
```

However, this same statement is permitted on Windows. To avoid problems caused by such differences, it is best to adopt a consistent convention, such as always creating and referring to databases and tables using lowercase names. This convention is recommended for maximum portability and ease of use.

How table and database names are stored on disk and used in MySQL is affected by the `lower_case_table_names` system variable, which you can set when starting `mysqld`. `lower_case_table_names` can take the values shown in the following table. This variable does *not* affect case sensitivity of trigger identifiers. On Unix, the default value of `lower_case_table_names` is 0. On Windows the default value is 1. On Mac OS X, the default value is 2.

Value	**Meaning**
`0`	Table and database names are stored on disk using the lettercase specified in the `CREATE TABLE` or `CREATE DATABASE` statement. Name comparisons are case sensitive. You should *not* set this variable to 0 if you are running MySQL on a system that has case-insensitive file names (such as Windows or Mac OS X). If you force this variable to 0 with `--lower-case-table-names=0` on a case-insensitive file system and access `MyISAM` tablenames using different lettercases, index corruption may result.
`1`	Table names are stored in lowercase on disk and name comparisons are not case sensitive. MySQL converts all table names to lowercase on storage and lookup. This behavior also applies to database names and table aliases.
`2`	Table and database names are stored on disk using the lettercase specified in the `CREATE TABLE` or `CREATE DATABASE` statement, but MySQL converts them to lowercase on lookup. Name comparisons are not case sensitive. This works *only* on file systems that are not case sensitive! `InnoDB` table names are stored in lowercase, as for `lower_case_table_names=1`.

If you are using MySQL on only one platform, you do not normally have to change the `lower_case_table_names` variable from its default value. However, you may encounter difficulties if you want to transfer tables between platforms that differ in file system case sensitivity. For example, on Unix, you can have two different tables named `my_table` and `MY_TABLE`, but on Windows these two names are considered identical. To avoid data transfer problems arising from lettercase of database or table names, you have two options:

- Use `lower_case_table_names=1` on all systems. The main disadvantage with this is that when you use `SHOW TABLES` or `SHOW DATABASES`, you do not see the names in their original lettercase.

- Use `lower_case_table_names=0` on Unix and `lower_case_table_names=2` on Windows. This preserves the lettercase of database and table names. The disadvantage of this is that you must ensure that your statements always refer to your database and table names with the correct lettercase on Windows. If you transfer your statements to Unix, where lettercase is significant, they do not work if the lettercase is incorrect.

  Exception: If you are using `InnoDB` tables and you are trying to avoid these data transfer problems, you should set `lower_case_table_names` to 1 on all platforms to force names to be converted to lowercase.

If you plan to set the `lower_case_table_names` system variable to 1 on Unix, you must first convert your old database and table names to lowercase before stopping `mysqld` and restarting it with the new variable setting.

Object names may be considered duplicates if their uppercase forms are equal according to a binary collation. That is true for names of cursors, conditions, procedures, functions, savepoints, stored routine parameters, stored program local variables, and plugins. It is not true for names of columns, constraints, databases, partitions, statements prepared with `PREPARE`, tables, triggers, users, and user-defined variables.

File system case sensitivity can affect searches in string columns of `INFORMATION_SCHEMA` tables. For more information, see Section 9.1.7.9, “Collation and `INFORMATION_SCHEMA` Searches”.

8.2.3. Mapping of Identifiers to File Names

There is a correspondence between database and table identifiers and names in the file system. For the basic structure, MySQL represents each database as a directory in the data directory, and each table by one or more files in the appropriate database directory. For the table format files (`.FRM`), the data is always stored in this structure and location.

For the data and index files, the exact representation on disk is storage engine specific. These files may be stored in the same location as the `FRM` files, or the information may be stored separate file. `InnoDB` data is stored in the InnoDB data files. If you are using tablespaces with `InnoDB`, then the specific tablespace files you create are used instead.

Any character is legal in database or table identifiers except ASCII NUL (`0x00`). MySQL encodes any characters that are problematic in the corresponding file system objects when it creates database directories or table files:

- Basic Latin letters (`a..zA..Z`) and digits (`0..9`) are encoded as is. Consequently, their case sensitivity directly depends on file system features.

- All other national letters from alphabets that have uppercase/lowercase mapping are encoded as follows:

  ```
  Code range Pattern            Number   Used Unused  Blocks
  -----------------------------------------------------------------------------
  00C0..017F [@][0..4][g..z] 5*20= 100   97     3  Latin1 Supplement + Ext A
  0370..03FF [@][5..9][g..z] 5*20= 100   88    12  Greek + Coptic
  0400..052F [@][g..z][0..6] 20*7= 140  137     3  Cyrillic
  0530..058F [@][g..z][7..8] 20*2=  40   38     2  Armenian
  2160..217F [@][g..z][9]    20*1=  20   16     4  Number Forms
  0180..02AF [@][g..z][a..k] 28*11=220  203    17  Latin Ext B + IPA
  1E00..1EFF [@][g..z][l..r] 20*7= 140  136     4  Latin Additional Extended
  1F00..1FFF [@][g..z][s..z] 20*8= 160  144    16  Greek Extended
  ....  .... [@][a..f][g..z] 6*20= 120    0   120  RESERVED
  24B6..24E9 [@][@][a..z]            26   26     0  Enclosed Alphanumerics
  FF21..FF5A [@][a..z][@]            26   26     0  Full Width forms
  ```

  One of the bytes in the sequence encodes lettercase. For example: `LATIN CAPITAL LETTER A WITH GRAVE` is encoded as `@0G`, whereas `LATIN SMALL LETTER A WITH GRAVE` is encoded as `@0g`. Here the third byte (`G` or `g`) indicates lettercase. (On a case-insensitive file system, both letters will be treated as the same.)

  For some blocks, such as Cyrillic, the second byte determines lettercase. For other blocks, such as Latin1 Supplement, the third byte determines lettercase. If two bytes in the sequence are letters (as in Greek Extended), the leftmost letter character stands for lettercase. All other letter bytes must be in lowercase.

- All nonletter characters, as well as letters from alphabets that do not have uppercase/lowercase mapping (such as Hebrew) are encoded using hexadecimal representation using lowercase letters for hex digits `a..f`:

  ```
  0x003F -> @003f
  0xFFFF -> @ffff
  ```

  The hexadecimal values correspond to character values in the `ucs2` double-byte character set.

On Windows, some names such as `nul`, `prn`, and `aux` are encoded by appending `@@@` to the name when the server creates the corresponding file or directory. This occurs on all platforms for portability of the corresponding database object between platforms.

If you have databases or tables from a version of MySQL older than 5.1.6 that contain special characters and for which the underlying directory names or file names have not been updated to use the new encoding, the server displays their names with a prefix of `#mysql50#` in the output from `INFORMATION_SCHEMA` tables or `SHOW` statements. For example, if you have a table named `a@b` and its name encoding has not been updated, `SHOW TABLES` displays it like this:

```
mysql> SHOW TABLES;
+----------------+
| Tables_in_test |
+----------------+
| #mysql50#a@b   |
+----------------+
```

To refer to such a name for which the encoding has not been updated, you must supply the `#mysql50#` prefix:

```
mysql> SHOW COLUMNS FROM `a@b`;
ERROR 1146 (42S02): Table 'test.a@b' doesn't exist

mysql> SHOW COLUMNS FROM `#mysql50#a@b`;
+-------+---------+------+-----+---------+-------+
| Field | Type    | Null | Key | Default | Extra |
```

```
+-------+---------+------+-----+---------+-------+
| i     | int(11) | YES  |     | NULL    |       |
+-------+---------+------+-----+---------+-------+
```

To update old names to eliminate the need to use the special prefix to refer to them, re-encode them with `mysqlcheck`. The following command updates all names to the new encoding:

```
shell> mysqlcheck --check-upgrade --fix-db-names --fix-table-names --all-databases
```

To check only specific databases or tables, omit `--all-databases` and provide the appropriate database or table arguments. For information about `mysqlcheck` invocation syntax, see Section 4.5.3, “`mysqlcheck` — A Table Maintenance Program”.

> **Note**
>
> The `#mysql50#` prefix is intended only to be used internally by the server. You should not create databases or tables with names that use this prefix.
>
> Also, `mysqlcheck` cannot fix names that contain literal instances of the `@` character that is used for encoding special characters. If you have databases or tables that contain this character, use `mysqldump` to dump them before upgrading to MySQL 5.1.6 or later, and then reload the dump file after upgrading.

8.2.4. Function Name Parsing and Resolution

MySQL 5.5 supports built-in (native) functions, user-defined functions (UDFs), and stored functions. This section describes how the server recognizes whether the name of a built-in function is used as a function call or as an identifier, and how the server determines which function to use in cases when functions of different types exist with a given name.

Built-In Function Name Parsing

The parser uses default rules for parsing names of built-in functions. These rules can be changed by enabling the `IGNORE_SPACE` SQL mode.

When the parser encounters a word that is the name of a built-in function, it must determine whether the name signifies a function call or is instead a nonexpression reference to an identifier such as a table or column name. For example, in the following statements, the first reference to `count` is a function call, whereas the second reference is a table name:

```
SELECT COUNT(*) FROM mytable;
CREATE TABLE count (i INT);
```

The parser should recognize the name of a built-in function as indicating a function call only when parsing what is expected to be an expression. That is, in nonexpression context, function names are permitted as identifiers.

However, some built-in functions have special parsing or implementation considerations, so the parser uses the following rules by default to distinguish whether their names are being used as function calls or as identifiers in nonexpression context:

- To use the name as a function call in an expression, there must be no whitespace between the name and the following “`(`” parenthesis character.
- Conversely, to use the function name as an identifier, it must not be followed immediately by a parenthesis.

The requirement that function calls be written with no whitespace between the name and the parenthesis applies only to the built-in functions that have special considerations. `COUNT` is one such name. The exact list of function names for which following whitespace determines their interpretation are those listed in the `sql_functions[]` array of the `sql/lex.h` source file. Before MySQL 5.1, these are rather numerous (about 200), so you may find it easiest to treat the no-whitespace requirement as applying to all function calls. In MySQL 5.1 and later, parser improvements reduce to about 30 the number of affected function names.

For functions not listed in the `sql_functions[]`) array, whitespace does not matter. They are interpreted as function calls only when used in expression context and may be used freely as identifiers otherwise. `ASCII` is one such name. However, for these nonaffected function names, interpretation may vary in expression context: *`func_name`* `()` is interpreted as a built-in function if there is one with the given name; if not, *`func_name`* `()` is interpreted as a user-defined function or stored function if one exists with that name.

The `IGNORE_SPACE` SQL mode can be used to modify how the parser treats function names that are whitespace-sensitive:

- With `IGNORE_SPACE` disabled, the parser interprets the name as a function call when there is no whitespace between the name and the following parenthesis. This occurs even when the function name is used in nonexpression context:

  ```
  mysql> CREATE TABLE count(i INT);
  ```

```
ERROR 1064 (42000): You have an error in your SQL syntax ...
near 'count(i INT)'
```

To eliminate the error and cause the name to be treated as an identifier, either use whitespace following the name or write it as a quoted identifier (or both):

```
CREATE TABLE count (i INT);
CREATE TABLE `count`(i INT);
CREATE TABLE `count` (i INT);
```

- With `IGNORE_SPACE` enabled, the parser loosens the requirement that there be no whitespace between the function name and the following parenthesis. This provides more flexibility in writing function calls. For example, either of the following function calls are legal:

  ```
  SELECT COUNT(*) FROM mytable;
  SELECT COUNT (*) FROM mytable;
  ```

  However, enabling `IGNORE_SPACE` also has the side effect that the parser treats the affected function names as reserved words (see Section 8.3, “Reserved Words”). This means that a space following the name no longer signifies its use as an identifier. The name can be used in function calls with or without following whitespace, but causes a syntax error in nonexpression context unless it is quoted. For example, with `IGNORE_SPACE` enabled, both of the following statements fail with a syntax error because the parser interprets `count` as a reserved word:

  ```
  CREATE TABLE count(i INT);
  CREATE TABLE count (i INT);
  ```

  To use the function name in nonexpression context, write it as a quoted identifier:

  ```
  CREATE TABLE `count`(i INT);
  CREATE TABLE `count` (i INT);
  ```

To enable the `IGNORE_SPACE` SQL mode, use this statement:

```
SET sql_mode = 'IGNORE_SPACE';
```

`IGNORE_SPACE` is also enabled by certain other composite modes such as `ANSI` that include it in their value:

```
SET sql_mode = 'ANSI';
```

Check Section 5.1.6, “Server SQL Modes”, to see which composite modes enable `IGNORE_SPACE`.

To minimize the dependency of SQL code on the `IGNORE_SPACE` setting, use these guidelines:

- Avoid creating UDFs or stored functions that have the same name as a built-in function.
- Avoid using function names in nonexpression context. For example, these statements use `count` (one of the affected function names affected by `IGNORE_SPACE`), so they fail with or without whitespace following the name if `IGNORE_SPACE` is enabled:

  ```
  CREATE TABLE count(i INT);
  CREATE TABLE count (i INT);
  ```

  If you must use a function name in nonexpression context, write it as a quoted identifier:

  ```
  CREATE TABLE `count`(i INT);
  CREATE TABLE `count` (i INT);
  ```

The number of function names affected by `IGNORE_SPACE` was reduced significantly in MySQL 5.1.13, from about 200 to about 30. As of MySQL 5.1.13, only the following functions are still affected by the `IGNORE_SPACE` setting.

`ADDDATE`	`BIT_AND`	`BIT_OR`	`BIT_XOR`
`CAST`	`COUNT`	`CURDATE`	`CURTIME`
`DATE_ADD`	`DATE_SUB`	`EXTRACT`	`GROUP_CONCAT`
`MAX`	`MID`	`MIN`	`NOW`

`POSITION`	`SESSION_USER`	`STD`	`STDDEV`
`STDDEV_POP`	`STDDEV_SAMP`	`SUBDATE`	`SUBSTR`
`SUBSTRING`	`SUM`	`SYSDATE`	`SYSTEM_USER`
`TRIM`	`VARIANCE`	`VAR_POP`	`VAR_SAMP`

For earlier versions of MySQL, check the contents of the `sql_functions[]` array in the `sql/lex.h` source file to see which functions are affected by `IGNORE_SPACE`.

Incompatibility warning: The change in MySQL 5.1.13 that reduces the number of function names affected by `IGNORE_SPACE` improves the consistency of parser operation. However, it also introduces the possibility of incompatibility for old SQL code that relies on the following conditions:

- `IGNORE_SPACE` is disabled.
- The presence or absence of whitespace following a function name is used to distinguish between a built-in function and stored function that have the same name, such as `PI()` versus `PI ()`.

For functions that are no longer affected by `IGNORE_SPACE` as of MySQL 5.1.13, that strategy no longer works. Either of the following approaches can be used if you have code that is subject to the preceding incompatibility:

- If a stored function has a name that conflicts with a built-in function, refer to the stored function with a schema name qualifier, regardless of whether whitespace is present. For example, write *`schema_name`*`.PI()` or *`schema_name`*`.PI ()`.
- Alternatively, rename the stored function to use a nonconflicting name and change invocations of the function to use the new name.

Function Name Resolution

The following rules describe how the server resolves references to function names for function creation and invocation:

- Built-in functions and user-defined functions

  An error occurs if you try to create a UDF with the same name as a built-in function.
- Built-in functions and stored functions

  It is possible to create a stored function with the same name as a built-in function, but to invoke the stored function it is necessary to qualify it with a schema name. For example, if you create a stored function named `PI` in the `test` schema, you invoke it as `test.PI()` because the server resolves `PI()` as a reference to the built-in function. The server creates a warning if the stored function name collides with a built-in function name. The warning can be displayed with `SHOW WARNINGS`.
- User-defined functions and stored functions

  User-defined functions and stored functions share the same namespace, so you cannot create a UDF and a stored function with the same name.

The preceding function name resolution rules have implications for upgrading to versions of MySQL that implement new built-in functions:

- If you have already created a user-defined function with a given name and upgrade MySQL to a version that implements a new built-in function with the same name, the UDF becomes inaccessible. To correct this, use `DROP FUNCTION` to drop the UDF, and then use `CREATE FUNCTION` to re-create the UDF with a different nonconflicting name.
- If a new version of MySQL implements a built-in function with the same name as an existing stored function, you have two choices: Rename the stored function to use a nonconflicting name, or change calls to the function so that they use a schema qualifier (that is, use *`schema_name`*`.`*`func_name`*`()` syntax).

8.3. Reserved Words

Certain words such as `SELECT`, `DELETE`, or `BIGINT` are reserved and require special treatment for use as identifiers such as table and column names. This may also be true for the names of built-in functions.

Reserved words are permitted as identifiers if you quote them as described in Section 8.2, “Schema Object Names”:

```
mysql> CREATE TABLE interval (begin INT, end INT);
ERROR 1064 (42000): You have an error in your SQL syntax ...
near 'interval (begin INT, end INT)'

mysql> CREATE TABLE `interval` (begin INT, end INT);
Query OK, 0 rows affected (0.01 sec)
```

Exception: A word that follows a period in a qualified name must be an identifier, so it need not be quoted even if it is reserved:

```
mysql> CREATE TABLE mydb.interval (begin INT, end INT);
Query OK, 0 rows affected (0.01 sec)
```

Names of built-in functions are permitted as identifiers but may require care to be used as such. For example, `COUNT` is acceptable as a column name. However, by default, no whitespace is permitted in function invocations between the function name and the following “`(`” character. This requirement enables the parser to distinguish whether the name is used in a function call or in nonfunction context. For further detail on recognition of function names, see Section 8.2.4, “Function Name Parsing and Resolution”.

The words in the following table are explicitly reserved in MySQL 5.5. In addition, `_FILENAME` is reserved. At some point, you might upgrade to a higher version, so it is a good idea to have a look at future reserved words, too. You can find these in the manuals that cover higher versions of MySQL. Most of the words in the table are forbidden by standard SQL as column or table names (for example, `GROUP`). A few are reserved because MySQL needs them and uses a `yacc` parser. A reserved word can be used as an identifier if you quote it.

For a more detailed list of reserved words, including differences between versions, see Reserved Words in MySQL 5.5.

`ACCESSIBLE`	`ADD`	`ALL`
`ALTER`	`ANALYZE`	`AND`
`AS`	`ASC`	`ASENSITIVE`
`BEFORE`	`BETWEEN`	`BIGINT`
`BINARY`	`BLOB`	`BOTH`
`BY`	`CALL`	`CASCADE`
`CASE`	`CHANGE`	`CHAR`
`CHARACTER`	`CHECK`	`COLLATE`
`COLUMN`	`CONDITION`	`CONSTRAINT`
`CONTINUE`	`CONVERT`	`CREATE`
`CROSS`	`CURRENT_DATE`	`CURRENT_TIME`
`CURRENT_TIMESTAMP`	`CURRENT_USER`	`CURSOR`
`DATABASE`	`DATABASES`	`DAY_HOUR`
`DAY_MICROSECOND`	`DAY_MINUTE`	`DAY_SECOND`
`DEC`	`DECIMAL`	`DECLARE`
`DEFAULT`	`DELAYED`	`DELETE`
`DESC`	`DESCRIBE`	`DETERMINISTIC`
`DISTINCT`	`DISTINCTROW`	`DIV`
`DOUBLE`	`DROP`	`DUAL`
`EACH`	`ELSE`	`ELSEIF`
`ENCLOSED`	`ESCAPED`	`EXISTS`
`EXIT`	`EXPLAIN`	`FALSE`
`FETCH`	`FLOAT`	`FLOAT4`
`FLOAT8`	`FOR`	`FORCE`
`FOREIGN`	`FROM`	`FULLTEXT`
`GRANT`	`GROUP`	`HAVING`
`HIGH_PRIORITY`	`HOUR_MICROSECOND`	`HOUR_MINUTE`
`HOUR_SECOND`	`IF`	`IGNORE`
`IN`	`INDEX`	`INFILE`
`INNER`	`INOUT`	`INSENSITIVE`

INSERT	INT	INT1
INT2	INT3	INT4
INT8	INTEGER	INTERVAL
INTO	IS	ITERATE
JOIN	KEY	KEYS
KILL	LEADING	LEAVE
LEFT	LIKE	LIMIT
LINEAR	LINES	LOAD
LOCALTIME	LOCALTIMESTAMP	LOCK
LONG	LONGBLOB	LONGTEXT
LOOP	LOW_PRIORITY	MASTER_SSL_VERIFY_SERVER_CERT
MATCH	MAXVALUE	MEDIUMBLOB
MEDIUMINT	MEDIUMTEXT	MIDDLEINT
MINUTE_MICROSECOND	MINUTE_SECOND	MOD
MODIFIES	NATURAL	NOT
NO_WRITE_TO_BINLOG	NULL	NUMERIC
ON	OPTIMIZE	OPTION
OPTIONALLY	OR	ORDER
OUT	OUTER	OUTFILE
PRECISION	PRIMARY	PROCEDURE
PURGE	RANGE	READ
READS	READ_WRITE	REAL
REFERENCES	REGEXP	RELEASE
RENAME	REPEAT	REPLACE
REQUIRE	RESIGNAL	RESTRICT
RETURN	REVOKE	RIGHT
RLIKE	SCHEMA	SCHEMAS
SECOND_MICROSECOND	SELECT	SENSITIVE
SEPARATOR	SET	SHOW
SIGNAL	SMALLINT	SPATIAL
SPECIFIC	SQL	SQLEXCEPTION
SQLSTATE	SQLWARNING	SQL_BIG_RESULT
SQL_CALC_FOUND_ROWS	SQL_SMALL_RESULT	SSL
STARTING	STRAIGHT_JOIN	TABLE
TERMINATED	THEN	TINYBLOB
TINYINT	TINYTEXT	TO
TRAILING	TRIGGER	TRUE
UNDO	UNION	UNIQUE
UNLOCK	UNSIGNED	UPDATE
USAGE	USE	USING
UTC_DATE	UTC_TIME	UTC_TIMESTAMP
VALUES	VARBINARY	VARCHAR
VARCHARACTER	VARYING	WHEN
WHERE	WHILE	WITH
WRITE	XOR	YEAR_MONTH
ZEROFILL		

The following are new reserved words in MySQL 5.5:

`GENERAL`	`IGNORE_SERVER_IDS`	`MASTER_HEARTBEAT_PERIOD`
`MAXVALUE`	`RESIGNAL`	`SIGNAL`
`SLOW`		

MySQL permits some keywords to be used as unquoted identifiers because many people previously used them. Examples are those in the following list:

- `ACTION`
- `BIT`
- `DATE`
- `ENUM`
- `NO`
- `TEXT`
- `TIME`
- `TIMESTAMP`

8.4. User-Defined Variables

You can store a value in a user-defined variable in one statement and then refer to it later in another statement. This enables you to pass values from one statement to another. *User-defined variables are connection-specific*. That is, a user variable defined by one client cannot be seen or used by other clients. All variables for a given client connection are automatically freed when that client exits.

User variables are written as `@var_name`, where the variable name `var_name` consists of alphanumeric characters, “`.`”, “`_`”, and “`$`”. A user variable name can contain other characters if you quote it as a string or identifier (for example, `@'my-var'`, `@"my-var"`, or ``@`my-var` ``).

User variable names are not case sensitive in MySQL 5.0 and up.

One way to set a user-defined variable is by issuing a `SET` statement:

```
SET @var_name = expr [, @var_name = expr] ...
```

For `SET`, either `=` or `:=` can be used as the assignment operator.

You can also assign a value to a user variable in statements other than `SET`. In this case, the assignment operator must be `:=` and not `=` because the latter is treated as the comparison operator `=` in non-`SET` statements:

```
mysql> SET @t1=1, @t2=2, @t3:=4;
mysql> SELECT @t1, @t2, @t3, @t4 := @t1+@t2+@t3;
+------+------+------+--------------------+
| @t1  | @t2  | @t3  | @t4 := @t1+@t2+@t3 |
+------+------+------+--------------------+
|    1 |    2 |    4 |                  7 |
+------+------+------+--------------------+
```

User variables can be assigned a value from a limited set of data types: integer, decimal, floating-point, binary or nonbinary string, or `NULL` value. Assignment of decimal and real values does not preserve the precision or scale of the value. A value of a type other than one of the permissible types is converted to a permissible type. For example, a value having a temporal or spatial data type is converted to a binary string.

If a user variable is assigned a nonbinary (character) string value, it has the same character set and collation as the string. The coercibility of user variables is implicit. (This is the same coercibility as for table column values.)

Bit values assigned to user variables are treated as binary strings. To assign a bit value as a number to a user variable, use `CAST()` or `+0`:

```
mysql> SET @v1 = b'1000001';
mysql> SET @v2 = CAST(b'1000001' AS UNSIGNED), @v3 = b'1000001'+0;
mysql> SELECT @v1, @v2, @v3;
+------+------+------+
| @v1  | @v2  | @v3  |
+------+------+------+
| A    |   65 |   65 |
+------+------+------+
```

If the value of a user variable is selected in a result set, it is returned to the client as a string.

If you refer to a variable that has not been initialized, it has a value of `NULL` and a type of string.

User variables may be used in most contexts where expressions are permitted. This does not currently include contexts that explicitly require a literal value, such as in the `LIMIT` clause of a `SELECT` statement, or the `IGNORE N LINES` clause of a `LOAD DATA` statement.

As a general rule, you should never assign a value to a user variable and read the value within the same statement. You might get the results you expect, but this is not guaranteed. The order of evaluation for expressions involving user variables is undefined and may change based on the elements contained within a given statement. In `SELECT @a, @a:=@a+1, ...`, you might think that MySQL will evaluate `@a` first and then do an assignment second. However, changing the statement (for example, by adding a `GROUP BY`, `HAVING`, or `ORDER BY` clause) may cause MySQL to select an execution plan with a different order of evaluation.

Another issue with assigning a value to a variable and reading the value within the same statement is that the default result type of a variable is based on its type at the start of the statement. The following example illustrates this:

```
mysql> SET @a='test';
mysql> SELECT @a,(@a:=20) FROM tbl_name;
```

For this `SELECT` statement, MySQL reports to the client that column one is a string and converts all accesses of `@a` to strings, even though @a is set to a number for the second row. After the `SELECT` statement executes, `@a` is regarded as a number for the next statement.

To avoid problems with this behavior, either do not assign a value to and read the value of the same variable within a single statement, or else set the variable to `0`, `0.0`, or `''` to define its type before you use it.

In a `SELECT` statement, each select expression is evaluated only when sent to the client. This means that in a `HAVING`, `GROUP BY`, or `ORDER BY` clause, referring to a variable that is assigned a value in the select expression list does *not* work as expected:

```
mysql> SELECT (@aa:=id) AS a, (@aa+3) AS b FROM tbl_name HAVING b=5;
```

The reference to `b` in the `HAVING` clause refers to an alias for an expression in the select list that uses `@aa`. This does not work as expected: `@aa` contains the value of `id` from the previous selected row, not from the current row.

User variables are intended to provide data values. They cannot be used directly in an SQL statement as an identifier or as part of an identifier, such as in contexts where a table or database name is expected, or as a reserved word such as `SELECT`. This is true even if the variable is quoted, as shown in the following example:

```
mysql> SELECT c1 FROM t;
+----+
| c1 |
+----+
|  0 |
+----+
|  1 |
+----+
2 rows in set (0.00 sec)

mysql> SET @col = "c1";
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @col FROM t;
+------+
| @col |
+------+
| c1   |
+------+
1 row in set (0.00 sec)

mysql> SELECT `@col` FROM t;
ERROR 1054 (42S22): Unknown column '@col' in 'field list'

mysql> SET @col = "`c1`";
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @col FROM t;
+------+
| @col |
+------+
| `c1` |
+------+
1 row in set (0.00 sec)
```

An exception to this principle that user variables cannot be used to provide identifiers is that if you are constructing a string for use as a prepared statement to be executed later. In this case, user variables can be used to provide any part of the statement. The following example illustrates how this can be done:

```
mysql> SET @c = "c1";
Query OK, 0 rows affected (0.00 sec)

mysql> SET @s = CONCAT("SELECT ", @c, " FROM t");
Query OK, 0 rows affected (0.00 sec)

mysql> PREPARE stmt FROM @s;
Query OK, 0 rows affected (0.04 sec)
Statement prepared

mysql> EXECUTE stmt;
+----+
| c1 |
+----+
|  0 |
+----+
|  1 |
+----+
2 rows in set (0.00 sec)

mysql> DEALLOCATE PREPARE stmt;
Query OK, 0 rows affected (0.00 sec)
```

See Section 12.6, “SQL Syntax for Prepared Statements”, for more information.

A similar technique can be used in application programs to construct SQL statements using program variables, as shown here using PHP 5:

```
<?php
  $mysqli = new mysqli("localhost", "user", "pass", "test");

  if( mysqli_connect_errno() )
    die("Connection failed: %s\n", mysqli_connect_error());

  $col = "c1";

  $query = "SELECT $col FROM t";

  $result = $mysqli->query($query);

  while($row = $result->fetch_assoc())
  {
    echo "<p>" . $row["$col"] . "</p>\n";
  }

  $result->close();

  $mysqli->close();
?>
```

Assembling an SQL statement in this fashion is sometimes known as “Dynamic SQL”.

8.5. Expression Syntax

The following rules define expression syntax in MySQL. The grammar shown here is based on that given in the `sql/sql_yacc.yy` file of MySQL source distributions. See the notes after the grammar for additional information about some of the terms. Operator precedence is given in Section 11.3.1, “Operator Precedence”.

```
expr:
    expr OR expr
  | expr || expr
  | expr XOR expr
  | expr AND expr
  | expr && expr
  | NOT expr
  | ! expr
  | boolean_primary IS [NOT] {TRUE | FALSE | UNKNOWN}
  | boolean_primary

boolean_primary:
    boolean_primary IS [NOT] NULL
  | boolean_primary <=> predicate
  | boolean_primary comparison_operator predicate
  | boolean_primary comparison_operator {ALL | ANY} (subquery)
  | predicate

comparison_operator: = | >= | > | <= | < | <> | !=

predicate:
    bit_expr [NOT] IN (subquery)
  | bit_expr [NOT] IN (expr [, expr] ...)
  | bit_expr [NOT] BETWEEN bit_expr AND predicate
  | bit_expr SOUNDS LIKE bit_expr
  | bit_expr [NOT] LIKE simple_expr [ESCAPE simple_expr]
  | bit_expr [NOT] REGEXP bit_expr
  | bit_expr

bit_expr:
    bit_expr | bit_expr
  | bit_expr & bit_expr
  | bit_expr << bit_expr
  | bit_expr >> bit_expr
  | bit_expr + bit_expr
  | bit_expr - bit_expr
  | bit_expr * bit_expr
  | bit_expr / bit_expr
  | bit_expr DIV bit_expr
  | bit_expr MOD bit_expr
  | bit_expr % bit_expr
  | bit_expr ^ bit_expr
  | bit_expr + interval_expr
  | bit_expr - interval_expr
  | simple_expr

simple_expr:
    literal
  | identifier
  | function_call
  | simple_expr COLLATE collation_name
  | param_marker
  | variable
  | simple_expr || simple_expr
  | + simple_expr
  | - simple_expr
  | ~ simple_expr
  | ! simple_expr
  | BINARY simple_expr
  | (expr [, expr] ...)
  | ROW (expr, expr [, expr] ...)
  | (subquery)
  | EXISTS (subquery)
  | {identifier expr}
  | match_expr
  | case_expr
  | interval_expr
```

Notes:

For literal value syntax, see Section 8.1, “Literal Values”.

For identifier syntax, see Section 8.2, “Schema Object Names”.

Variables can be user variables, system variables, or stored program local variables or parameters:

- User variables: Section 8.4, “User-Defined Variables”
- System variables: Section 5.1.4, “Using System Variables”
- Local variables: Section 12.7.3.1, “`DECLARE` for Local Variables”
- Parameters: Section 12.1.12, “`CREATE PROCEDURE` and `CREATE FUNCTION` Syntax”

`param_marker` is `'?'` as used in prepared statements for placeholders. See Section 12.6.1, “`PREPARE` Syntax”.

`(`*`subquery`*`)` indicates a subquery that returns a single value; that is, a scalar subquery. See Section 12.2.10.1, “The Subquery as Scalar Operand”.

`{`*`identifier expr`*`}` is ODBC escape syntax and is accepted for ODBC compatibility. The value is *`expr`*. The curly braces in the syntax should be written literally; they are not metasyntax as used elsewhere in syntax descriptions.

`match_expr` indicates a `MATCH` expression. See Section 11.9, “Full-Text Search Functions”.

`case_expr` indicates a `CASE` expression. See Section 11.4, “Control Flow Functions”.

`interval_expr` represents a time interval. The syntax is `INTERVAL` *`expr unit`*, where *`unit`* is a specifier such as `HOUR`, `DAY`, or `WEEK`. For the full list of *`unit`* specifiers, see the description of the `DATE_ADD()` function in Section 11.7, “Date and Time Functions”.

The meaning of some operators depends on the SQL mode:

- By default, `||` is a logical `OR` operator. With `PIPES_AS_CONCAT` enabled, `||` is string concatenation, with a precedence between `^` and the unary operators.

- By default, `!` has a higher precedence than `NOT`. With `HIGH_NOT_PRECEDENCE` enabled, `!` and `NOT` have the same precedence.

See Section 5.1.6, “Server SQL Modes”.

8.6. Comment Syntax

MySQL Server supports three comment styles:

- From a “`#`” character to the end of the line.
- From a “`-- `” sequence to the end of the line. In MySQL, the “`-- `” (double-dash) comment style requires the second dash to be followed by at least one whitespace or control character (such as a space, tab, newline, and so on). This syntax differs slightly from standard SQL comment syntax, as discussed in Section 1.8.5.5, “'`--`' as the Start of a Comment”.
- From a `/*` sequence to the following `*/` sequence, as in the C programming language. This syntax enables a comment to extend over multiple lines because the beginning and closing sequences need not be on the same line.

The following example demonstrates all three comment styles:

```
mysql> SELECT 1+1;     # This comment continues to the end of line
mysql> SELECT 1+1;     -- This comment continues to the end of line
mysql> SELECT 1 /* this is an in-line comment */ + 1;
mysql> SELECT 1+
/*
this is a
multiple-line comment
*/
1;
```

Nested comments are not supported. (Under some conditions, nested comments might be permitted, but usually are not, and users should avoid them.)

MySQL Server supports some variants of C-style comments. These enable you to write code that includes MySQL extensions, but is still portable, by using comments of the following form:

```
/*! MySQL-specific code */
```

In this case, MySQL Server parses and executes the code within the comment as it would any other SQL statement, but other SQL servers will ignore the extensions. For example, MySQL Server recognizes the `STRAIGHT_JOIN` keyword in the following statement, but other servers will not:

```
SELECT /*! STRAIGHT_JOIN */ col1 FROM table1,table2 WHERE ...
```

If you add a version number after the “`!`” character, the syntax within the comment is executed only if the MySQL version is greater than or equal to the specified version number. The `TEMPORARY` keyword in the following comment is executed only by servers from MySQL 3.23.02 or higher:

```
CREATE /*!32302 TEMPORARY */ TABLE t (a INT);
```

The comment syntax just described applies to how the `mysqld` server parses SQL statements. The `mysql` client program also performs some parsing of statements before sending them to the server. (It does this to determine statement boundaries within a multiple-statement input line.)

Comments in this format, `/*!12345 ... */`, are not stored on the server. If this format is used to comment stored routines, the comments will not be retained on the server.

The use of short-form `mysql` commands such as `\C` within multi-line `/* ... */` comments is not supported.

Chapter 9. Globalization

This chapter covers issues of globalization, which includes internationalization (MySQL's capabilities for adapting to local use) and localization (selecting particular local conventions):

- MySQL support for character sets in SQL statements.
- How to configure the server to support different character sets.
- Selecting the language for error messages.
- How to set the server's time zone and enable per-connection time zone support.
- Selecting the locale for day and month names.

9.1. Character Set Support

MySQL includes character set support that enables you to store data using a variety of character sets and perform comparisons according to a variety of collations. You can specify character sets at the server, database, table, and column level. MySQL supports the use of character sets for the `MyISAM`, `MEMORY`, and `InnoDB` storage engines.

This chapter discusses the following topics:

- What are character sets and collations?
- The multiple-level default system for character set assignment
- Syntax for specifying character sets and collations
- Affected functions and operations
- Unicode support
- The character sets and collations that are available, with notes

Character set issues affect not only data storage, but also communication between client programs and the MySQL server. If you want the client program to communicate with the server using a character set different from the default, you'll need to indicate which one. For example, to use the `utf8` Unicode character set, issue this statement after connecting to the server:

```
SET NAMES 'utf8';
```

For more information about configuring character sets for application use and character set-related issues in client/server communication, see Section 9.1.5, “Configuring the Character Set and Collation for Applications”, and Section 9.1.4, “Connection Character Sets and Collations”.

9.1.1. Character Sets and Collations in General

A *character set* is a set of symbols and encodings. A *collation* is a set of rules for comparing characters in a character set. Let's make the distinction clear with an example of an imaginary character set.

Suppose that we have an alphabet with four letters: “`A`”, “`B`”, “`a`”, “`b`”. We give each letter a number: “`A`” = 0, “`B`” = 1, “`a`” = 2, “`b`” = 3. The letter “`A`” is a symbol, the number 0 is the **encoding** for “`A`”, and the combination of all four letters and their encodings is a **character set**.

Suppose that we want to compare two string values, “`A`” and “`B`”. The simplest way to do this is to look at the encodings: 0 for “`A`” and 1 for “`B`”. Because 0 is less than 1, we say “`A`” is less than “`B`”. What we've just done is apply a collation to our character set. The collation is a set of rules (only one rule in this case): “compare the encodings.” We call this simplest of all possible collations a *binary* collation.

But what if we want to say that the lowercase and uppercase letters are equivalent? Then we would have at least two rules: (1) treat the lowercase letters “`a`” and “`b`” as equivalent to “`A`” and “`B`”; (2) then compare the encodings. We call this a *case-insensitive* collation. It is a little more complex than a binary collation.

In real life, most character sets have many characters: not just “`A`” and “`B`” but whole alphabets, sometimes multiple alphabets or eastern writing systems with thousands of characters, along with many special symbols and punctuation marks. Also in real life, most collations have many rules, not just for whether to distinguish lettercase, but also for whether to distinguish accents (an “accent” is a mark attached to a character as in German “`Ö`”), and for multiple-character mappings (such as the rule that “`Ö`” = “`OE`” in one of the two German collations).

MySQL can do these things for you:

- Store strings using a variety of character sets
- Compare strings using a variety of collations
- Mix strings with different character sets or collations in the same server, the same database, or even the same table
- Enable specification of character set and collation at any level

In these respects, MySQL is far ahead of most other database management systems. However, to use these features effectively, you need to know what character sets and collations are available, how to change the defaults, and how they affect the behavior of string operators and functions.

9.1.2. Character Sets and Collations in MySQL

The MySQL server can support multiple character sets. To list the available character sets, use the `SHOW CHARACTER SET` statement. A partial listing follows. For more complete information, see Section 9.1.14, “Character Sets and Collations That MySQL Supports”.

```
mysql> SHOW CHARACTER SET;
+----------+-----------------------------+---------------------+--------+
| Charset  | Description                 | Default collation   | Maxlen |
+----------+-----------------------------+---------------------+--------+
| big5     | Big5 Traditional Chinese    | big5_chinese_ci     |      2 |
| dec8     | DEC West European           | dec8_swedish_ci     |      1 |
| cp850    | DOS West European           | cp850_general_ci    |      1 |
| hp8      | HP West European            | hp8_english_ci      |      1 |
| koi8r    | KOI8-R Relcom Russian       | koi8r_general_ci    |      1 |
| latin1   | cp1252 West European        | latin1_swedish_ci   |      1 |
| latin2   | ISO 8859-2 Central European | latin2_general_ci   |      1 |
| swe7     | 7bit Swedish                | swe7_swedish_ci     |      1 |
| ascii    | US ASCII                    | ascii_general_ci    |      1 |
| ujis     | EUC-JP Japanese             | ujis_japanese_ci    |      3 |
| sjis     | Shift-JIS Japanese          | sjis_japanese_ci    |      2 |
| hebrew   | ISO 8859-8 Hebrew           | hebrew_general_ci   |      1 |
| tis620   | TIS620 Thai                 | tis620_thai_ci      |      1 |
| euckr    | EUC-KR Korean               | euckr_korean_ci     |      2 |
| koi8u    | KOI8-U Ukrainian            | koi8u_general_ci    |      1 |
| gb2312   | GB2312 Simplified Chinese   | gb2312_chinese_ci   |      2 |
| greek    | ISO 8859-7 Greek            | greek_general_ci    |      1 |
| cp1250   | Windows Central European    | cp1250_general_ci   |      1 |
| gbk      | GBK Simplified Chinese      | gbk_chinese_ci      |      2 |
| latin5   | ISO 8859-9 Turkish          | latin5_turkish_ci   |      1 |
...
```

Any given character set always has at least one collation. It may have several collations. To list the collations for a character set, use the `SHOW COLLATION` statement. For example, to see the collations for the `latin1` (cp1252 West European) character set, use this statement to find those collation names that begin with `latin1`:

```
mysql> SHOW COLLATION LIKE 'latin1%';
+---------------------+---------+----+---------+----------+---------+
| Collation           | Charset | Id | Default | Compiled | Sortlen |
+---------------------+---------+----+---------+----------+---------+
| latin1_german1_ci   | latin1  |  5 |         |          |       0 |
| latin1_swedish_ci   | latin1  |  8 | Yes     | Yes      |       1 |
| latin1_danish_ci    | latin1  | 15 |         |          |       0 |
| latin1_german2_ci   | latin1  | 31 |         | Yes      |       2 |
| latin1_bin          | latin1  | 47 |         | Yes      |       1 |
| latin1_general_ci   | latin1  | 48 |         |          |       0 |
| latin1_general_cs   | latin1  | 49 |         |          |       0 |
| latin1_spanish_ci   | latin1  | 94 |         |          |       0 |
+---------------------+---------+----+---------+----------+---------+
```

The `latin1` collations have the following meanings.

Collation	Meaning
`latin1_german1_ci`	German DIN-1
`latin1_swedish_ci`	Swedish/Finnish
`latin1_danish_ci`	Danish/Norwegian
`latin1_german2_ci`	German DIN-2
`latin1_bin`	Binary according to `latin1` encoding

Collation	Meaning
`latin1_general_ci`	Multilingual (Western European)
`latin1_general_cs`	Multilingual (ISO Western European), case sensitive
`latin1_spanish_ci`	Modern Spanish

Collations have these general characteristics:

- Two different character sets cannot have the same collation.
- Each character set has one collation that is the *default collation*. For example, the default collation for `latin1` is `latin1_swedish_ci`. The output for `SHOW CHARACTER SET` indicates which collation is the default for each displayed character set.
- There is a convention for collation names: They start with the name of the character set with which they are associated, they usually include a language name, and they end with `_ci` (case insensitive), `_cs` (case sensitive), or `_bin` (binary).

In cases where a character set has multiple collations, it might not be clear which collation is most suitable for a given application. To avoid choosing the wrong collation, it can be helpful to perform some comparisons with representative data values to make sure that a given collation sorts values the way you expect.

Collation-Charts.Org is a useful site for information that shows how one collation compares to another.

9.1.3. Specifying Character Sets and Collations

There are default settings for character sets and collations at four levels: server, database, table, and column. The description in the following sections may appear complex, but it has been found in practice that multiple-level defaulting leads to natural and obvious results.

`CHARACTER SET` is used in clauses that specify a character set. `CHARSET` can be used as a synonym for `CHARACTER SET`.

Character set issues affect not only data storage, but also communication between client programs and the MySQL server. If you want the client program to communicate with the server using a character set different from the default, you'll need to indicate which one. For example, to use the `utf8` Unicode character set, issue this statement after connecting to the server:

```
SET NAMES 'utf8';
```

For more information about character set-related issues in client/server communication, see Section 9.1.4, “Connection Character Sets and Collations”.

9.1.3.1. Server Character Set and Collation

MySQL Server has a server character set and a server collation. These can be set at server startup on the command line or in an option file and changed at runtime.

Initially, the server character set and collation depend on the options that you use when you start `mysqld`. You can use `--character-set-server` for the character set. Along with it, you can add `--collation-server` for the collation. If you don't specify a character set, that is the same as saying `--character-set-server=latin1`. If you specify only a character set (for example, `latin1`) but not a collation, that is the same as saying `--character-set-server=latin1 --collation-server=latin1_swedish_ci` because `latin1_swedish_ci` is the default collation for `latin1`. Therefore, the following three commands all have the same effect:

```
shell> mysqld
shell> mysqld --character-set-server=latin1
shell> mysqld --character-set-server=latin1 \
           --collation-server=latin1_swedish_ci
```

One way to change the settings is by recompiling. To change the default server character set and collation when building from sources, use the `DEFAULT_CHARSET` and `DEFAULT_COLLATION` options for `CMake`. For example:

```
shell> cmake . -DDEFAULT_CHARSET=latin1
```

Or:

```
shell> cmake . -DDEFAULT_CHARSET=latin1 \
           -DDEFAULT_COLLATION=latin1_german1_ci
```

Both `mysqld` and `CMake` verify that the character set/collation combination is valid. If not, each program displays an error message and terminates.

The server character set and collation are used as default values if the database character set and collation are not specified in `CREATE DATABASE` statements. They have no other purpose.

The current server character set and collation can be determined from the values of the `character_set_server` and `collation_server` system variables. These variables can be changed at runtime.

9.1.3.2. Database Character Set and Collation

Every database has a database character set and a database collation. The `CREATE DATABASE` and `ALTER DATABASE` statements have optional clauses for specifying the database character set and collation:

```
CREATE DATABASE db_name
    [[DEFAULT] CHARACTER SET charset_name]
    [[DEFAULT] COLLATE collation_name]

ALTER DATABASE db_name
    [[DEFAULT] CHARACTER SET charset_name]
    [[DEFAULT] COLLATE collation_name]
```

The keyword `SCHEMA` can be used instead of `DATABASE`.

All database options are stored in a text file named `db.opt` that can be found in the database directory.

The `CHARACTER SET` and `COLLATE` clauses make it possible to create databases with different character sets and collations on the same MySQL server.

Example:

```
CREATE DATABASE db_name CHARACTER SET latin1 COLLATE latin1_swedish_ci;
```

MySQL chooses the database character set and database collation in the following manner:

- If both `CHARACTER SET X` and `COLLATE Y` are specified, character set *X* and collation *Y* are used.
- If `CHARACTER SET X` is specified without `COLLATE`, character set *X* and its default collation are used. To see the default collation for each character set, use the `SHOW COLLATION` statement.
- If `COLLATE Y` is specified without `CHARACTER SET`, the character set associated with *Y* and collation *Y* are used.
- Otherwise, the server character set and server collation are used.

The database character set and collation are used as default values for table definitions if the table character set and collation are not specified in `CREATE TABLE` statements. The database character set also is used by `LOAD DATA INFILE`. The character set and collation have no other purposes.

The character set and collation for the default database can be determined from the values of the `character_set_database` and `collation_database` system variables. The server sets these variables whenever the default database changes. If there is no default database, the variables have the same value as the corresponding server-level system variables, `character_set_server` and `collation_server`.

9.1.3.3. Table Character Set and Collation

Every table has a table character set and a table collation. The `CREATE TABLE` and `ALTER TABLE` statements have optional clauses for specifying the table character set and collation:

```
CREATE TABLE tbl_name (column_list)
    [[DEFAULT] CHARACTER SET charset_name]
    [COLLATE collation_name]]

ALTER TABLE tbl_name
    [[DEFAULT] CHARACTER SET charset_name]
    [COLLATE collation_name]
```

Example:

```
CREATE TABLE t1 ( ... )
CHARACTER SET latin1 COLLATE latin1_danish_ci;
```

MySQL chooses the table character set and collation in the following manner:

- If both `CHARACTER SET X` and `COLLATE Y` are specified, character set *X* and collation *Y* are used.
- If `CHARACTER SET X` is specified without `COLLATE`, character set *X* and its default collation are used. To see the default collation for each character set, use the `SHOW COLLATION` statement.
- If `COLLATE Y` is specified without `CHARACTER SET`, the character set associated with *Y* and collation *Y* are used.
- Otherwise, the database character set and collation are used.

The table character set and collation are used as default values for column definitions if the column character set and collation are not specified in individual column definitions. The table character set and collation are MySQL extensions; there are no such things in standard SQL.

9.1.3.4. Column Character Set and Collation

Every “character” column (that is, a column of type `CHAR`, `VARCHAR`, or `TEXT`) has a column character set and a column collation. Column definition syntax for `CREATE TABLE` and `ALTER TABLE` has optional clauses for specifying the column character set and collation:

```
col_name {CHAR | VARCHAR | TEXT} (col_length)
    [CHARACTER SET charset_name]
    [COLLATE collation_name]
```

These clauses can also be used for `ENUM` and `SET` columns:

```
col_name {ENUM | SET} (val_list)
    [CHARACTER SET charset_name]
    [COLLATE collation_name]
```

Examples:

```
CREATE TABLE t1
(
    col1 VARCHAR(5)
      CHARACTER SET latin1
      COLLATE latin1_german1_ci
);

ALTER TABLE t1 MODIFY
    col1 VARCHAR(5)
      CHARACTER SET latin1
      COLLATE latin1_swedish_ci;
```

MySQL chooses the column character set and collation in the following manner:

- If both `CHARACTER SET X` and `COLLATE Y` are specified, character set *X* and collation *Y* are used.

  ```
  CREATE TABLE t1
  (
      col1 CHAR(10) CHARACTER SET utf8 COLLATE utf8_unicode_ci
  ) CHARACTER SET latin1 COLLATE latin1_bin;
  ```

  The character set and collation are specified for the column, so they are used. The column has character set `utf8` and collation `utf8_unicode_ci`.

- If `CHARACTER SET X` is specified without `COLLATE`, character set *X* and its default collation are used.

  ```
  CREATE TABLE t1
  (
      col1 CHAR(10) CHARACTER SET utf8
  ) CHARACTER SET latin1 COLLATE latin1_bin;
  ```

  The character set is specified for the column, but the collation is not. The column has character set `utf8` and the default collation for `utf8`, which is `utf8_general_ci`. To see the default collation for each character set, use the `SHOW COLLATION` statement.

- If `COLLATE Y` is specified without `CHARACTER SET`, the character set associated with *Y* and collation *Y* are used.

  ```
  CREATE TABLE t1
  (
  ```

```
    col1 CHAR(10) COLLATE utf8_polish_ci
) CHARACTER SET latin1 COLLATE latin1_bin;
```

The collation is specified for the column, but the character set is not. The column has collation `utf8_polish_ci` and the character set is the one associated with the collation, which is `utf8`.

- Otherwise, the table character set and collation are used.

```
CREATE TABLE t1
(
    col1 CHAR(10)
) CHARACTER SET latin1 COLLATE latin1_bin;
```

Neither the character set nor collation are specified for the column, so the table defaults are used. The column has character set `latin1` and collation `latin1_bin`.

The `CHARACTER SET` and `COLLATE` clauses are standard SQL.

If you use `ALTER TABLE` to convert a column from one character set to another, MySQL attempts to map the data values, but if the character sets are incompatible, there may be data loss.

9.1.3.5. Character String Literal Character Set and Collation

Every character string literal has a character set and a collation.

A character string literal may have an optional character set introducer and `COLLATE` clause:

```
[_charset_name]'string' [COLLATE collation_name]
```

Examples:

```
SELECT 'string';
SELECT _latin1'string';
SELECT _latin1'string' COLLATE latin1_danish_ci;
```

For the simple statement `SELECT 'string'`, the string has the character set and collation defined by the `character_set_connection` and `collation_connection` system variables.

The `_charset_name` expression is formally called an *introducer*. It tells the parser, “the string that is about to follow uses character set *X*.” Because this has confused people in the past, we emphasize that an introducer does not change the string to the introducer character set like `CONVERT()` would do. It does not change the string's value, although padding may occur. The introducer is just a signal. An introducer is also legal before standard hex literal and numeric hex literal notation (`x'literal'` and `0xnnnn`), or before bit-field literal notation (`b'literal'` and `0bnnnn`).

Examples:

```
SELECT _latin1 x'AABBCC';
SELECT _latin1 0xAABBCC;
SELECT _latin1 b'1100011';
SELECT _latin1 0b1100011;
```

MySQL determines a literal's character set and collation in the following manner:

- If both `_X` and `COLLATE Y` are specified, character set *X* and collation *Y* are used.
- If `_X` is specified but `COLLATE` is not specified, character set *X* and its default collation are used. To see the default collation for each character set, use the `SHOW COLLATION` statement.
- Otherwise, the character set and collation given by the `character_set_connection` and `collation_connection` system variables are used.

Examples:

- A string with `latin1` character set and `latin1_german1_ci` collation:

```
SELECT _latin1'Müller' COLLATE latin1_german1_ci;
```

- A string with `latin1` character set and its default collation (that is, `latin1_swedish_ci`):

  ```
  SELECT _latin1'Müller';
  ```

- A string with the connection default character set and collation:

  ```
  SELECT 'Müller';
  ```

Character set introducers and the `COLLATE` clause are implemented according to standard SQL specifications.

An introducer indicates the character set for the following string, but does not change now how the parser performs escape processing within the string. Escapes are always interpreted by the parser according to the character set given by `character_set_connection`.

The following examples show that escape processing occurs using `character_set_connection` even in the presence of an introducer. The examples use `SET NAMES` (which changes `character_set_connection`, as discussed in Section 9.1.4, “Connection Character Sets and Collations”), and display the resulting strings using the `HEX()` function so that the exact string contents can be seen.

Example 1:

```
mysql> SET NAMES latin1;
Query OK, 0 rows affected (0.01 sec)

mysql> SELECT HEX('à\n'), HEX(_sjis'à\n');
+------------+-----------------+
| HEX('à\n') | HEX(_sjis'à\n') |
+------------+-----------------+
| E00A       | E00A            |
+------------+-----------------+
1 row in set (0.00 sec)
```

Here, “`à`” (hex value `E0`) is followed by “`\n`”, the escape sequence for newline. The escape sequence is interpreted using the `character_set_connection` value of `latin1` to produce a literal newline (hex value `0A`). This happens even for the second string. That is, the introducer of `_sjis` does not affect the parser's escape processing.

Example 2:

```
mysql> SET NAMES sjis;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT HEX('à\n'), HEX(_latin1'à\n');
+------------+-------------------+
| HEX('à\n') | HEX(_latin1'à\n') |
+------------+-------------------+
| E05C6E     | E05C6E            |
+------------+-------------------+
1 row in set (0.04 sec)
```

Here, `character_set_connection` is `sjis`, a character set in which the sequence of “`à`” followed by “`\`” (hex values `05` and `5C`) is a valid multi-byte character. Hence, the first two bytes of the string are interpreted as a single `sjis` character, and the “`\`” is not interpreted as an escape character. The following “`n`” (hex value `6E`) is not interpreted as part of an escape sequence. This is true even for the second string; the introducer of `_latin1` does not affect escape processing.

9.1.3.6. National Character Set

Standard SQL defines `NCHAR` or `NATIONAL CHAR` as a way to indicate that a `CHAR` column should use some predefined character set. MySQL 5.5 uses `utf8` as this predefined character set. For example, these data type declarations are equivalent:

```
CHAR(10) CHARACTER SET utf8
NATIONAL CHARACTER(10)
NCHAR(10)
```

As are these:

```
VARCHAR(10) CHARACTER SET utf8
NATIONAL VARCHAR(10)
NCHAR VARCHAR(10)
NATIONAL CHARACTER VARYING(10)
NATIONAL CHAR VARYING(10)
```

You can use `N'`*`literal`*`'` (or `n'`*`literal`*`'`) to create a string in the national character set. These statements are equivalent:

```
SELECT N'some text';
```

```
SELECT n'some text';
SELECT _utf8'some text';
```

For information on upgrading character sets to MySQL 5.5 from versions prior to 4.1, see the *MySQL 3.23, 4.0, 4.1 Reference Manual*.

9.1.3.7. Examples of Character Set and Collation Assignment

The following examples show how MySQL determines default character set and collation values.

Example 1: Table and Column Definition

```
CREATE TABLE t1
(
    c1 CHAR(10) CHARACTER SET latin1 COLLATE latin1_german1_ci
) DEFAULT CHARACTER SET latin2 COLLATE latin2_bin;
```

Here we have a column with a `latin1` character set and a `latin1_german1_ci` collation. The definition is explicit, so that is straightforward. Notice that there is no problem with storing a `latin1` column in a `latin2` table.

Example 2: Table and Column Definition

```
CREATE TABLE t1
(
    c1 CHAR(10) CHARACTER SET latin1
) DEFAULT CHARACTER SET latin1 COLLATE latin1_danish_ci;
```

This time we have a column with a `latin1` character set and a default collation. Although it might seem natural, the default collation is not taken from the table level. Instead, because the default collation for `latin1` is always `latin1_swedish_ci`, column `c1` has a collation of `latin1_swedish_ci` (not `latin1_danish_ci`).

Example 3: Table and Column Definition

```
CREATE TABLE t1
(
    c1 CHAR(10)
) DEFAULT CHARACTER SET latin1 COLLATE latin1_danish_ci;
```

We have a column with a default character set and a default collation. In this circumstance, MySQL checks the table level to determine the column character set and collation. Consequently, the character set for column `c1` is `latin1` and its collation is `latin1_danish_ci`.

Example 4: Database, Table, and Column Definition

```
CREATE DATABASE d1
    DEFAULT CHARACTER SET latin2 COLLATE latin2_czech_ci;
USE d1;
CREATE TABLE t1
(
    c1 CHAR(10)
);
```

We create a column without specifying its character set and collation. We're also not specifying a character set and a collation at the table level. In this circumstance, MySQL checks the database level to determine the table settings, which thereafter become the column settings.) Consequently, the character set for column `c1` is `latin2` and its collation is `latin2_czech_ci`.

9.1.3.8. Compatibility with Other DBMSs

For MaxDB compatibility these two statements are the same:

```
CREATE TABLE t1 (f1 CHAR(N) UNICODE);
CREATE TABLE t1 (f1 CHAR(N) CHARACTER SET ucs2);
```

9.1.4. Connection Character Sets and Collations

Several character set and collation system variables relate to a client's interaction with the server. Some of these have been mentioned in earlier sections:

- The server character set and collation are the values of the `character_set_server` and `collation_server` system variables.

- The character set and collation of the default database are the values of the `character_set_database` and `collation_database` system variables.

Additional character set and collation system variables are involved in handling traffic for the connection between a client and the server. Every client has connection-related character set and collation system variables.

A “connection” is what you make when you connect to the server. The client sends SQL statements, such as queries, over the connection to the server. The server sends responses, such as result sets or error messages, over the connection back to the client. This leads to several questions about character set and collation handling for client connections, each of which can be answered in terms of system variables:

- What character set is the statement in when it leaves the client?

  The server takes the `character_set_client` system variable to be the character set in which statements are sent by the client.

- What character set should the server translate a statement to after receiving it?

  For this, the server uses the `character_set_connection` and `collation_connection` system variables. It converts statements sent by the client from `character_set_client` to `character_set_connection` (except for string literals that have an introducer such as `_latin1` or `_utf8`). `collation_connection` is important for comparisons of literal strings. For comparisons of strings with column values, `collation_connection` does not matter because columns have their own collation, which has a higher collation precedence.

- What character set should the server translate to before shipping result sets or error messages back to the client?

  The `character_set_results` system variable indicates the character set in which the server returns query results to the client. This includes result data such as column values, and result metadata such as column names and error messages.

Clients can fine-tune the settings for these variables, or depend on the defaults (in which case, you can skip the rest of this section). If you do not use the defaults, you must change the character settings *for each connection to the server.*

Two statements affect the connection-related character set variables as a group:

- `SET NAMES 'charset_name' [COLLATE 'collation_name']`

  `SET NAMES` indicates what character set the client will use to send SQL statements to the server. Thus, `SET NAMES 'cp1251'` tells the server, “future incoming messages from this client are in character set `cp1251`.” It also specifies the character set that the server should use for sending results back to the client. (For example, it indicates what character set to use for column values if you use a `SELECT` statement.)

  A `SET NAMES 'x'` statement is equivalent to these three statements:

  ```
  SET character_set_client = x;
  SET character_set_results = x;
  SET character_set_connection = x;
  ```

  Setting `character_set_connection` to `x` also implicitly sets `collation_connection` to the default collation for `x`. It is unnecessary to set that collation explicitly. To specify a particular collation, use the optional `COLLATE` clause:

  ```
  SET NAMES 'charset_name' COLLATE 'collation_name'
  ```

- `SET CHARACTER SET charset_name`

  `SET CHARACTER SET` is similar to `SET NAMES` but sets `character_set_connection` and `collation_connection` to `character_set_database` and `collation_database`. A `SET CHARACTER SET x` statement is equivalent to these three statements:

  ```
  SET character_set_client = x;
  SET character_set_results = x;
  SET collation_connection = @@collation_database;
  ```

  Setting `collation_connection` also implicitly sets `character_set_connection` to the character set associated with the collation (equivalent to executing `SET character_set_connection = @@character_set_database`). It is unnecessary to set `character_set_connection` explicitly.

> **Note**
>
> `ucs2`, `utf16`, and `utf32` cannot be used as a client character set, which means that they do not work for `SET NAMES` or `SET CHARACTER SET`.

The MySQL client programs `mysql`, `mysqladmin`, `mysqlcheck`, `mysqlimport`, and `mysqlshow` determine the default character set to use as follows:

- In the absence of other information, the programs use the compiled-in default character set, usually `latin1`.
- The programs can autodetect which character set to use based on the operating system setting, such as the value of the `LANG` or `LC_ALL` locale environment variable on Unix systems or the code page setting on Windows systems. For systems on which the locale is available from the OS, the client uses it to set the default character set rather than using the compiled-in default. For example, setting `LANG` to `ru_RU.KOI8-R` causes the `koi8r` character set to be used. Thus, users can configure the locale in their environment for use by MySQL clients.

  The OS character set is mapped to the closest MySQL character set if there is no exact match. If the client does not support the matching character set, it uses the compiled-in default. For example, `ucs2` is not supported as a connection character set.

  C applications that wish to use character set autodetection based on the OS setting can invoke the following `mysql_options()` call before connecting to the server:

  ```
  mysql_options(mysql,
                MYSQL_SET_CHARSET_NAME,
                MYSQL_AUTODETECT_CHARSET_NAME);
  ```

- The programs support a `--default-character-set` option, which enables users to specify the character set explicitly to override whatever default the client otherwise determines.

> **Note**
>
> Before MySQL 5.5, in the absence of other information, the MySQL client programs used the compiled-in default character set, usually `latin1`. An implication of this difference is that if your environment is configured to use a non-`latin1` locale, MySQL client programs will use a different connection character set than previously, as though you had issued an implicit `SET NAMES` statement. If the previous behavior is required, start the client with the `--default-character-set=latin1` option.

When a client connects to the server, it sends the name of the character set that it wants to use. The server uses the name to set the `character_set_client`, `character_set_results`, and `character_set_connection` system variables. In effect, the server performs a `SET NAMES` operation using the character set name.

With the `mysql` client, if you want to use a character set different from the default, you could explicitly execute `SET NAMES` every time you start up. However, to accomplish the same result more easily, you can add the `--default-character-set` option setting to your `mysql` command line or in your option file. For example, the following option file setting changes the three connection-related character set variables set to `koi8r` each time you invoke `mysql`:

```
[mysql]
default-character-set=koi8r
```

If you are using the `mysql` client with auto-reconnect enabled (which is not recommended), it is preferable to use the `charset` command rather than `SET NAMES`. For example:

```
mysql> charset utf8
Charset changed
```

The `charset` command issues a `SET NAMES` statement, and also changes the default character set that `mysql` uses when it reconnects after the connection has dropped.

Example: Suppose that `column1` is defined as `CHAR(5) CHARACTER SET latin2`. If you do not say `SET NAMES` or `SET CHARACTER SET`, then for `SELECT column1 FROM t`, the server sends back all the values for `column1` using the character set that the client specified when it connected. On the other hand, if you say `SET NAMES 'latin1'` or `SET CHARACTER SET latin1` before issuing the `SELECT` statement, the server converts the `latin2` values to `latin1` just before sending results back. Conversion may be lossy if there are characters that are not in both character sets.

If you do not want the server to perform any conversion of result sets or error messages, set `character_set_results` to `NULL` or `binary`:

```
SET character_set_results = NULL;
```

To see the values of the character set and collation system variables that apply to your connection, use these statements:

```
SHOW VARIABLES LIKE 'character_set%';
SHOW VARIABLES LIKE 'collation%';
```

You must also consider the environment within which your MySQL applications execute. See Section 9.1.5, “Configuring the Character Set and Collation for Applications”.

For more information about character sets and error messages, see Section 9.1.6, “Character Set for Error Messages”.

9.1.5. Configuring the Character Set and Collation for Applications

For applications that store data using the default MySQL character set and collation (`latin1`, `latin1_swedish_ci`), no special configuration should be needed. If applications require data storage using a different character set or collation, you can configure character set information several ways:

- Specify character settings per database. For example, applications that use one database might require `utf8`, whereas applications that use another database might require `sjis`.
- Specify character settings at server startup. This causes the server to use the given settings for all applications that do not make other arrangements.
- Specify character settings at configuration time, if you build MySQL from source. This causes the server to use the given settings for all applications, without having to specify them at server startup.

When different applications require different character settings, the per-database technique provides a good deal of flexibility. If most or all applications use the same character set, specifying character settings at server startup or configuration time may be most convenient.

For the per-database or server-startup techniques, the settings control the character set for data storage. Applications must also tell the server which character set to use for client/server communications, as described in the following instructions.

The examples shown here assume use of the `utf8` character set and `utf8_general_ci` collation.

Specify character settings per database. To create a database such that its tables will use a given default character set and collation for data storage, use a `CREATE DATABASE` statement like this:

```
CREATE DATABASE mydb
  DEFAULT CHARACTER SET utf8
  DEFAULT COLLATE utf8_general_ci;
```

Tables created in the database will use `utf8` and `utf8_general_ci` by default for any character columns.

Applications that use the database should also configure their connection to the server each time they connect. This can be done by executing a `SET NAMES 'utf8'` statement after connecting. The statement can be used regardless of connection method: The `mysql` client, PHP scripts, and so forth.

In some cases, it may be possible to configure the connection to use the desired character set some other way. For example, for connections made using `mysql`, you can specify the `--default-character-set=utf8` command-line option to achieve the same effect as `SET NAMES 'utf8'`.

For more information about configuring client connections, see Section 9.1.4, “Connection Character Sets and Collations”.

Specify character settings at server startup. To select a character set and collation at server startup, use the `--character-set-server` and `--collation-server` options. For example, to specify the options in an option file, include these lines:

```
[mysqld]
character-set-server=utf8
collation-server=utf8_general_ci
```

These settings apply server-wide and apply as the defaults for databases created by any application, and for tables created in those databases.

It is still necessary for applications to configure their connection using `SET NAMES` or equivalent after they connect, as described previously. You might be tempted to start the server with the `--init_connect="SET NAMES 'utf8'"` option to cause `SET NAMES` to be executed automatically for each client that connects. However, this will yield inconsistent results because the `init_connect` value is not executed for users who have the `SUPER` privilege.

Specify character settings at MySQL configuration time. To select a character set and collation when you configure and build MySQL from source, use the `DEFAULT_CHARSET` and `DEFAULT_COLLATION` options for `CMake`:

```
shell> cmake . -DDEFAULT_CHARSET=utf8 \
           -DDEFAULT_COLLATION=utf8_general_ci
```

The resulting server uses `utf8` and `utf8_general_ci` as the default for databases and tables and for client connections. It is unnecessary to use `--character-set-server` and `--collation-server` to specify those defaults at server startup. It is also unnecessary for applications to configure their connection using `SET NAMES` or equivalent after they connect to the server.

Regardless of how you configure the MySQL character set for application use, you must also consider the environment within which those applications execute. If you will send statements using UTF-8 text taken from a file that you create in an editor, you should edit the file with the locale of your environment set to UTF-8 so that the file encoding is correct and so that the operating system handles it correctly. If you use the `mysql` client from within a terminal window, the window must be configured to use UTF-8 or characters may not display properly. For a script that executes in a Web environment, the script must handle character encoding properly for its interaction with the MySQL server, and it must generate pages that correctly indicate the encoding so that browsers know how to display the content of the pages. For example, you can include this `<meta>` tag within your `<head>` element:

```
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
```

9.1.6. Character Set for Error Messages

This section describes how the server uses character sets for constructing error messages and returning them to clients. For information about the language of error messages (rather than the character set), see Section 9.2, “Setting the Error Message Language”.

As of MySQL 5.5, the server constructs error messages using UTF-8 and returns them to clients in the character set specified by the `character_set_results` system variable.

The server constructs error messages as follows:

- The message template uses UTF-8.
- Parameters in the message template are replaced with values that apply to a specific error occurrence:
  - Identifiers such as table or column names use UTF-8 internally so they are copied as is.
  - Character (nonbinary) string values are converted from their character set to UTF-8.
  - Binary string values are copied as is for bytes in the range `0x20` to `0x7E`, and using `\x` hex encoding for bytes outside that range. For example, if a duplicate-key error occurs for an attempt to insert `0x41CF9F` into a `VARBINARY` unique column, the resulting error message uses UTF-8 with some bytes hex encoded:

    ```
    Duplicate entry 'A\xC3\x9F' for key 1
    ```

To return a message to the client after it has been constructed, the server converts it from UTF-8 to the character set specified by the `character_set_results` system variable. If `character_set_results` has a value of `NULL` or `binary`, no conversion occurs. No conversion occurs if the variable value is `utf8`, either, because that matches the original error message character set.

For characters that cannot be represented in `character_set_results`, some encoding may occur during the conversion. The encoding uses Unicode code point values:

- Characters in the Basic Multilingual Plane (BMP) range (`0x0000` to `0xFFFF`) are written using `\nnnn` notation.
- Characters outside the BMP range (`0x01000` to `0x10FFFF`) are written using `\+nnnnnn` notation.

Clients can set `character_set_results` to control the character set in which they receive error messages. The variable can be set directly, or indirectly by means such as `SET NAMES`. For more information about `character_set_results`, see Section 9.1.4, “Connection Character Sets and Collations”.

Prior to MySQL 5.5, the server constructs error messages and returns them to clients as follows:

- The message template has the character set associated with the error message language. For example, English, Korean, and Russian messages use `latin1`, `euckr`, and `koi8r`, respectively.

- Parameters in the message template are replaced with values that apply to a specific error occurrence. These parameters use their own character set. Identifiers such as table or column names use UTF-8. Data values retain their character set. For example, in the following duplicate-key message, `'xxx'` has the character set of the table column associated with key 1:

  ```
  Duplicate entry 'xxx' for key1
  ```

The preceding method of error-message construction can result in messages that contain a mix of character sets unless all items involved contain only ASCII characters.

For MySQL 5.5 and higher, the encoding that occurs during the conversion to `character_set_results` before returning error messages to clients can result in different message content compared to earlier versions. For example, if an error occurs for an attempt to drop a table named ペ (KATAKANA LETTER PE) and `character_set_results` is a character set such as `latin1` that does not contain that character, the resulting message sent to the client has an encoded table name:

```
ERROR 1051 (42S02): Unknown table '\30DA'
```

Before MySQL 5.5, the name is not encoded:

```
ERROR 1051 (42S02): Unknown table 'ペ'
```

9.1.7. Collation Issues

The following sections discuss various aspects of character set collations.

9.1.7.1. Collation Names

MySQL collation names follow these rules:

- A name ending in `_ci` indicates a case-insensitive collation.
- A name ending in `_cs` indicates a case-sensitive collation.
- A name ending in `_bin` indicates a binary collation. Character comparisons are based on character binary code values.

9.1.7.2. Using `COLLATE` in SQL Statements

With the `COLLATE` clause, you can override whatever the default collation is for a comparison. `COLLATE` may be used in various parts of SQL statements. Here are some examples:

- With `ORDER BY`:

  ```
  SELECT k
  FROM t1
  ORDER BY k COLLATE latin1_german2_ci;
  ```

- With `AS`:

  ```
  SELECT k COLLATE latin1_german2_ci AS k1
  FROM t1
  ORDER BY k1;
  ```

- With `GROUP BY`:

  ```
  SELECT k
  FROM t1
  GROUP BY k COLLATE latin1_german2_ci;
  ```

- With aggregate functions:

  ```
  SELECT MAX(k COLLATE latin1_german2_ci)
  FROM t1;
  ```

- With `DISTINCT`:

  ```
  SELECT DISTINCT k COLLATE latin1_german2_ci
  FROM t1;
  ```

- With `WHERE`:

  ```
      SELECT *
      FROM t1
      WHERE _latin1 'Müller' COLLATE latin1_german2_ci = k;
  ```

  ```
      SELECT *
      FROM t1
      WHERE k LIKE _latin1 'Müller' COLLATE latin1_german2_ci;
  ```

- With `HAVING`:

  ```
  SELECT k
  FROM t1
  GROUP BY k
  HAVING k = _latin1 'Müller' COLLATE latin1_german2_ci;
  ```

9.1.7.3. `COLLATE` Clause Precedence

The `COLLATE` clause has high precedence (higher than `||`), so the following two expressions are equivalent:

```
x || y COLLATE z
x || (y COLLATE z)
```

9.1.7.4. Collations Must Be for the Right Character Set

Each character set has one or more collations, but each collation is associated with one and only one character set. Therefore, the following statement causes an error message because the `latin2_bin` collation is not legal with the `latin1` character set:

```
mysql> SELECT _latin1 'x' COLLATE latin2_bin;
ERROR 1253 (42000): COLLATION 'latin2_bin' is not valid
for CHARACTER SET 'latin1'
```

9.1.7.5. Collation of Expressions

In the great majority of statements, it is obvious what collation MySQL uses to resolve a comparison operation. For example, in the following cases, it should be clear that the collation is the collation of column `x`:

```
SELECT x FROM T ORDER BY x;
SELECT x FROM T WHERE x = x;
SELECT DISTINCT x FROM T;
```

However, with multiple operands, there can be ambiguity. For example:

```
SELECT x FROM T WHERE x = 'Y';
```

Should the comparison use the collation of the column `x`, or of the string literal `'Y'`? Both `x` and `'Y'` have collations, so which collation takes precedence?

Standard SQL resolves such questions using what used to be called “coercibility” rules. MySQL assigns coercibility values as follows:

- An explicit `COLLATE` clause has a coercibility of 0. (Not coercible at all.)
- The concatenation of two strings with different collations has a coercibility of 1.
- The collation of a column or a stored routine parameter or local variable has a coercibility of 2.
- A “system constant” (the string returned by functions such as `USER()` or `VERSION()`) has a coercibility of 3.
- The collation of a literal has a coercibility of 4.
- `NULL` or an expression that is derived from `NULL` has a coercibility of 5.

MySQL uses coercibility values with the following rules to resolve ambiguities:

- Use the collation with the lowest coercibility value.
- If both sides have the same coercibility, then:
    - If both sides are Unicode, or both sides are not Unicode, it is an error.
    - If one of the sides has a Unicode character set, and another side has a non-Unicode character set, the side with Unicode character set wins, and automatic character set conversion is applied to the non-Unicode side. For example, the following statement does not return an error:

      ```
      SELECT CONCAT(utf8_column, latin1_column) FROM t1;
      ```

      It returns a result that has a character set of `utf8` and the same collation as `utf8_column`. Values of `latin1_column` are automatically converted to `utf8` before concatenating.
    - For an operation with operands from the same character set but that mix a `_bin` collation and a `_ci` or `_cs` collation, the `_bin` collation is used. This is similar to how operations that mix nonbinary and binary strings evaluate the operands as binary strings, except that it is for collations rather than data types.

Although automatic conversion is not in the SQL standard, the SQL standard document does say that every character set is (in terms of supported characters) a “subset” of Unicode. Because it is a well-known principle that “what applies to a superset can apply to a subset,” we believe that a collation for Unicode can apply for comparisons with non-Unicode strings.

Examples:

Comparison	**Collation Used**
`column1 = 'A'`	Use collation of `column1`
`column1 = 'A' COLLATE x`	Use collation of `'A' COLLATE x`
`column1 COLLATE x = 'A' COLLATE y`	Error

The `COERCIBILITY()` function can be used to determine the coercibility of a string expression:

```
mysql> SELECT COERCIBILITY('A' COLLATE latin1_swedish_ci);
        -> 0
mysql> SELECT COERCIBILITY(VERSION());
        -> 3
mysql> SELECT COERCIBILITY('A');
        -> 4
```

See Section 11.14, “Information Functions”.

For implicit conversion of a numeric or temporal value to a string, such as occurs for the argument `1` in the expression `CONCAT(1, 'abc')`, the result is a character (nonbinary) string that has a character set and collation determined by the `character_set_connection` and `collation_connection` system variables. (Before MySQL 5.5.3, the result is a binary string for which the character set and collation are `binary`). See Section 11.2, “Type Conversion in Expression Evaluation”.

9.1.7.6. The `_bin` and `binary` Collations

This section describes how `_bin` collations for nonbinary strings differ from the `binary` “collation” for binary strings.

Nonbinary strings (as stored in the `CHAR`, `VARCHAR`, and `TEXT` data types) have a character set and collation. A given character set can have several collations, each of which defines a particular sorting and comparison order for the characters in the set. One of these is the binary collation for the character set, indicated by a `_bin` suffix in the collation name. For example, `latin1` and `utf8` have binary collations named `latin1_bin` and `utf8_bin`.

Binary strings (as stored in the `BINARY`, `VARBINARY`, and `BLOB` data types) have no character set or collation in the sense that nonbinary strings do. (Applied to a binary string, the `CHARSET()` and `COLLATION()` functions both return a value of `binary`.) Binary strings are sequences of bytes and the numeric values of those bytes determine sort order.

The `_bin` collations differ from the `binary` collation in several respects.

The unit for sorting and comparison. Binary strings are sequences of bytes. Sorting and comparison is always based on numeric byte values. Nonbinary strings are sequences of characters, which might be multi-byte. Collations for nonbinary strings define an ordering of the character values for sorting and comparison. For the `_bin` collation, this ordering is based solely on binary code values of the characters (which is similar to ordering for binary strings except that a `_bin` collation must take into account that a character might contain multiple bytes). For other collations, character ordering might take additional factors such as lettercase into account.

Character set conversion. A nonbinary string has a character set and is converted to another character set in many cases, even when the string has a `_bin` collation:

- When assigning column values from another column that has a different character set:

```
UPDATE t1 SET utf8_bin_column=latin1_column;
INSERT INTO t1 (latin1_column) SELECT utf8_bin_column FROM t2;
```

- When assigning column values for `INSERT` or `UPDATE` using a string literal:

```
SET NAMES latin1;
INSERT INTO t1 (utf8_bin_column) VALUES ('string-in-latin1');
```

- When sending results from the server to a client:

```
SET NAMES latin1;
SELECT utf8_bin_column FROM t2;
```

For binary string columns, no conversion occurs. For the preceding cases, the string value is copied byte-wise.

Lettercase conversion. Collations provide information about lettercase of characters, so characters in a nonbinary string can be converted from one lettercase to another, even for `_bin` collations that ignore lettercase for ordering:

```
mysql> SET NAMES latin1 COLLATE latin1_bin;
Query OK, 0 rows affected (0.02 sec)

mysql> SELECT LOWER('aA'), UPPER('zZ');
+-------------+-------------+
| LOWER('aA') | UPPER('zZ') |
+-------------+-------------+
| aa          | ZZ          |
+-------------+-------------+
1 row in set (0.13 sec)
```

The concept of lettercase does not apply to bytes in a binary string. To perform lettercase conversion, the string must be converted to a nonbinary string:

```
mysql> SET NAMES binary;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT LOWER('aA'), LOWER(CONVERT('aA' USING latin1));
+-------------+-----------------------------------+
| LOWER('aA') | LOWER(CONVERT('aA' USING latin1)) |
+-------------+-----------------------------------+
| aA          | aa                                |
+-------------+-----------------------------------+
1 row in set (0.00 sec)
```

Trailing space handling in comparisons. Nonbinary strings have `PADSPACE` behavior for all collations, including `_bin` collations. Trailing spaces are insignificant in comparisons:

```
mysql> SET NAMES utf8 COLLATE utf8_bin;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT 'a ' = 'a';
+------------+
| 'a ' = 'a' |
+------------+
|          1 |
+------------+
1 row in set (0.00 sec)
```

For binary strings, all characters are significant in comparisons, including trailing spaces:

```
mysql> SET NAMES binary;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT 'a ' = 'a';
+------------+
| 'a ' = 'a' |
+------------+
|          0 |
+------------+
1 row in set (0.00 sec)
```

Trailing space handling for inserts and retrievals. `CHAR(N)` columns store nonbinary strings. Values shorter than *`N`* characters are extended with spaces on insertion. For retrieval, trailing spaces are removed.

`BINARY(N)` columns store binary strings. Values shorter than *N* bytes are extended with `0x00` bytes on insertion. For retrieval, nothing is removed; a value of the declared length is always returned.

```
mysql> CREATE TABLE t1 (
    ->   a CHAR(10) CHARACTER SET utf8 COLLATE utf8_bin,
    ->   b BINARY(10)
    -> );
Query OK, 0 rows affected (0.09 sec)

mysql> INSERT INTO t1 VALUES ('a','a');
Query OK, 1 row affected (0.01 sec)

mysql> SELECT HEX(a), HEX(b) FROM t1;
+--------+----------------------+
| HEX(a) | HEX(b)               |
+--------+----------------------+
| 61     | 61000000000000000000 |
+--------+----------------------+
1 row in set (0.04 sec)
```

9.1.7.7. The `BINARY` Operator

The `BINARY` operator casts the string following it to a binary string. This is an easy way to force a comparison to be done byte by byte rather than character by character. `BINARY` also causes trailing spaces to be significant.

```
mysql> SELECT 'a' = 'A';
        -> 1
mysql> SELECT BINARY 'a' = 'A';
        -> 0
mysql> SELECT 'a' = 'a ';
        -> 1
mysql> SELECT BINARY 'a' = 'a ';
        -> 0
```

`BINARY str` is shorthand for `CAST(str AS BINARY)`.

The `BINARY` attribute in character column definitions has a different effect. A character column defined with the `BINARY` attribute is assigned the binary collation of the column character set. Every character set has a binary collation. For example, the binary collation for the `latin1` character set is `latin1_bin`, so if the table default character set is `latin1`, these two column definitions are equivalent:

```
CHAR(10) BINARY
CHAR(10) CHARACTER SET latin1 COLLATE latin1_bin
```

The effect of `BINARY` as a column attribute differs from its effect prior to MySQL 4.1. Formerly, `BINARY` resulted in a column that was treated as a binary string. A binary string is a string of bytes that has no character set or collation, which differs from a nonbinary character string that has a binary collation. For both types of strings, comparisons are based on the numeric values of the string unit, but for nonbinary strings the unit is the character and some character sets support multi-byte characters. Section 10.4.2, "The `BINARY` and `VARBINARY` Types".

The use of `CHARACTER SET binary` in the definition of a `CHAR`, `VARCHAR`, or `TEXT` column causes the column to be treated as a binary data type. For example, the following pairs of definitions are equivalent:

```
CHAR(10) CHARACTER SET binary
BINARY(10)

VARCHAR(10) CHARACTER SET binary
VARBINARY(10)

TEXT CHARACTER SET binary
BLOB
```

9.1.7.8. Examples of the Effect of Collation

Example 1: Sorting German Umlauts

Suppose that column `X` in table `T` has these `latin1` column values:

```
Muffler
Müller
MX Systems
MySQL
```

Suppose also that the column values are retrieved using the following statement:

```
SELECT X FROM T ORDER BY X COLLATE collation_name;
```

The following table shows the resulting order of the values if we use `ORDER BY` with different collations.

`latin1_swedish_ci`	`latin1_german1_ci`	`latin1_german2_ci`
Muffler	Muffler	Müller
MX Systems	Müller	Muffler
Müller	MX Systems	MX Systems
MySQL	MySQL	MySQL

The character that causes the different sort orders in this example is the U with two dots over it (`ü`), which the Germans call “U-umlaut.”

- The first column shows the result of the `SELECT` using the Swedish/Finnish collating rule, which says that U-umlaut sorts with Y.
- The second column shows the result of the `SELECT` using the German DIN-1 rule, which says that U-umlaut sorts with U.
- The third column shows the result of the `SELECT` using the German DIN-2 rule, which says that U-umlaut sorts with UE.

Example 2: Searching for German Umlauts

Suppose that you have three tables that differ only by the character set and collation used:

```
mysql> SET NAMES utf8;
mysql> CREATE TABLE german1 (
    ->   c CHAR(10)
    -> ) CHARACTER SET latin1 COLLATE latin1_german1_ci;
mysql> CREATE TABLE german2 (
    ->   c CHAR(10)
    -> ) CHARACTER SET latin1 COLLATE latin1_german2_ci;
mysql> CREATE TABLE germanutf8 (
    ->   c CHAR(10)
    -> ) CHARACTER SET utf8 COLLATE utf8_unicode_ci;
```

Each table contains two records:

```
mysql> INSERT INTO german1 VALUES ('Bar'), ('Bär');
mysql> INSERT INTO german2 VALUES ('Bar'), ('Bär');
mysql> INSERT INTO germanutf8 VALUES ('Bar'), ('Bär');
```

Two of the above collations have an `A = Ä` equality, and one has no such equality (`latin1_german2_ci`). For that reason, you'll get these results in comparisons:

```
mysql> SELECT * FROM german1 WHERE c = 'Bär';
+------+
| c    |
+------+
| Bar  |
| Bär  |
+------+
mysql> SELECT * FROM german2 WHERE c = 'Bär';
+------+
| c    |
+------+
| Bär  |
+------+
mysql> SELECT * FROM germanutf8 WHERE c = 'Bär';
+------+
| c    |
+------+
| Bar  |
| Bär  |
+------+
```

This is not a bug but rather a consequence of the sorting properties of `latin1_german1_ci` and `utf8_unicode_ci` (the sorting shown is done according to the German DIN 5007 standard).

9.1.7.9. Collation and `INFORMATION_SCHEMA` Searches

String columns in `INFORMATION_SCHEMA` tables have a collation of `utf8_general_ci`, which is case insensitive. However, searches in `INFORMATION_SCHEMA` string columns are also affected by file system case sensitivity. For values that correspond to objects that are represented in the file system, such as names of databases and tables, searches may be case sensitive if the file system is case sensitive. This section describes how to work around this issue if necessary; see also Bug #34921.

Suppose that a query searches the `SCHEMATA.SCHEMA_NAME` column for the `test` database. On Linux, file systems are case sensitive, so comparisons of `SCHEMATA.SCHEMA_NAME` with `'test'` match, but comparisons with `'TEST'` do not:

```
mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME = 'test';
+-------------+
| SCHEMA_NAME |
+-------------+
| test        |
+-------------+
1 row in set (0.01 sec)

mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME = 'TEST';
Empty set (0.00 sec)
```

On Windows or Mac OS X where file systems are not case sensitive, comparisons match both `'test'` and `'TEST'`:

```
mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME = 'test';
+-------------+
| SCHEMA_NAME |
+-------------+
| test        |
+-------------+
1 row in set (0.00 sec)

mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME = 'TEST';
+-------------+
| SCHEMA_NAME |
+-------------+
| TEST        |
+-------------+
1 row in set (0.00 sec)
```

The value of the `lower_case_table_names` system variable makes no difference in this context.

This behavior occurs because the `utf8_general_ci` collation is not used for `INFORMATION_SCHEMA` queries when searching the file system for database objects. It is a result of optimizations implemented for `INFORMATION_SCHEMA` searches in MySQL. For information about these optimizations, see Section 7.2.4, “Optimizing `INFORMATION_SCHEMA` Queries”.

Searches in `INFORMATION_SCHEMA` string columns for values that refer to `INFORMATION_SCHEMA` itself do use the `utf8_general_ci` collation because `INFORMATION_SCHEMA` is a “virtual” database and is not represented in the file system. For example, comparisons with `SCHEMATA.SCHEMA_NAME` match `'information_schema'` or `'INFORMATION_SCHEMA'` regardless of platform:

```
mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME = 'information_schema';
+--------------------+
| SCHEMA_NAME        |
+--------------------+
| information_schema |
+--------------------+
1 row in set (0.00 sec)

mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME = 'INFORMATION_SCHEMA';
+--------------------+
| SCHEMA_NAME        |
+--------------------+
| information_schema |
+--------------------+
1 row in set (0.00 sec)
```

If the result of a string operation on an `INFORMATION_SCHEMA` column differs from expectations, a workaround is to use an explicit `COLLATE` clause to force a suitable collation (Section 9.1.7.2, “Using `COLLATE` in SQL Statements”). For example, to perform a case-insensitive search, use `COLLATE` with the `INFORMATION_SCHEMA` column name:

```
mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME COLLATE utf8_general_ci = 'test';
+-------------+
| SCHEMA_NAME |
+-------------+
| test        |
+-------------+
1 row in set (0.00 sec)

mysql> SELECT SCHEMA_NAME FROM INFORMATION_SCHEMA.SCHEMATA
    -> WHERE SCHEMA_NAME COLLATE utf8_general_ci = 'TEST';
| SCHEMA_NAME |
+-------------+
| test        |
+-------------+
1 row in set (0.00 sec)
```

You can also use the `UPPER()` or `LOWER()` function:

```
WHERE UPPER(SCHEMA_NAME) = 'TEST'
WHERE LOWER(SCHEMA_NAME) = 'test'
```

Although a case-insensitive comparison can be performed even on platforms with case-sensitive file systems, as just shown, it is not necessarily always the right thing to do. On such platforms, it is possible to have multiple objects with names that differ only in lettercase. For example, tables named `city`, `CITY`, and `City` can all exist simultaneously. Consider whether a search should match all such names or just one and write queries accordingly:

```
WHERE TABLE_NAME COLLATE utf8_bin = 'City'
WHERE TABLE_NAME COLLATE utf8_general_ci = 'city'
WHERE UPPER(TABLE_NAME) = 'CITY'
WHERE LOWER(TABLE_NAME) = 'city'
```

The first of those comparisons (with `utf8_bin`) is case sensitive; the others are not.

9.1.8. String Repertoire

The *repertoire* of a character set is the collection of characters in the set.

String expressions have a repertoire attribute, which can have two values:

- `ASCII`: The expression can contain only characters in the Unicode range `U+0000` to `U+007F`.
- `UNICODE`: The expression can contain characters in the Unicode range `U+0000` to `U+FFFF`.

The `ASCII` range is a subset of `UNICODE` range, so a string with `ASCII` repertoire can be converted safely without loss of information to the character set of any string with `UNICODE` repertoire or to a character set that is a superset of `ASCII`. (All MySQL character sets are supersets of `ASCII` with the exception of `swe7`, which reuses some punctuation characters for Swedish accented characters.) The use of repertoire enables character set conversion in expressions for many cases where MySQL would otherwise return an “illegal mix of collations” error.

The following discussion provides examples of expressions and their repertoires, and describes how the use of repertoire changes string expression evaluation:

- The repertoire for string constants depends on string content:

  ```
  SET NAMES utf8; SELECT 'abc';
  SELECT _utf8'def';
  SELECT N'MySQL';
  ```

  Although the character set is `utf8` in each of the preceding cases, the strings do not actually contain any characters outside the ASCII range, so their repertoire is `ASCII` rather than `UNICODE`.

- Columns having the `ascii` character set have `ASCII` repertoire because of their character set. In the following table, `c1` has `ASCII` repertoire:

  ```
  CREATE TABLE t1 (c1 CHAR(1) CHARACTER SET ascii);
  ```

  The following example illustrates how repertoire enables a result to be determined in a case where an error occurs without repertoire:

  ```
  CREATE TABLE t1 (
    c1 CHAR(1) CHARACTER SET latin1,
    c2 CHAR(1) CHARACTER SET ascii
  );
  INSERT INTO t1 VALUES ('a','b');
  SELECT CONCAT(c1,c2) FROM t1;
  ```

  Without repertoire, this error occurs:

  ```
  ERROR 1267 (HY000): Illegal mix of collations (latin1_swedish_ci,IMPLICIT)
  and (ascii_general_ci,IMPLICIT) for operation 'concat'
  ```

  Using repertoire, subset to superset (`ascii` to `latin1`) conversion can occur and a result is returned:

```
+---------------+
| CONCAT(c1,c2) |
+---------------+
| ab            |
+---------------+
```

- Functions with one string argument inherit the repertoire of their argument. The result of `UPPER(_utf8'abc')` has `ASCII` repertoire because its argument has `ASCII` repertoire.
- For functions that return a string but do not have string arguments and use `character_set_connection` as the result character set, the result repertoire is `ASCII` if `character_set_connection` is `ascii`, and `UNICODE` otherwise:

  ```
  FORMAT(numeric_column, 4);
  ```

  Use of repertoire changes how MySQL evaluates the following example:

  ```
  SET NAMES ascii;
  CREATE TABLE t1 (a INT, b VARCHAR(10) CHARACTER SET latin1);
  INSERT INTO t1 VALUES (1,'b');
  SELECT CONCAT(FORMAT(a, 4), b) FROM t1;
  ```

  Without repertoire, this error occurs:

  ```
  ERROR 1267 (HY000): Illegal mix of collations (ascii_general_ci,COERCIBLE)
  and (latin1_swedish_ci,IMPLICIT) for operation 'concat'
  ```

  With repertoire, a result is returned:

  ```
  +-------------------------+
  | CONCAT(FORMAT(a, 4), b) |
  +-------------------------+
  | 1.0000b                 |
  +-------------------------+
  ```

- Functions with two or more string arguments use the “widest” argument repertoire for the result repertoire (`UNICODE` is wider than `ASCII`). Consider the following `CONCAT()` calls:

  ```
  CONCAT(_ucs2 0x0041, _ucs2 0x0042)
  CONCAT(_ucs2 0x0041, _ucs2 0x00C2)
  ```

  For the first call, the repertoire is `ASCII` because both arguments are within the range of the `ascii` character set. For the second call, the repertoire is `UNICODE` because the second argument is outside the `ascii` character set range.

- The repertoire for function return values is determined based only on the repertoire of the arguments that affect the result's character set and collation.

  ```
  IF(column1 < column2, 'smaller', 'greater')
  ```

  The result repertoire is `ASCII` because the two string arguments (the second argument and the third argument) both have `ASCII` repertoire. The first argument does not matter for the result repertoire, even if the expression uses string values.

9.1.9. Operations Affected by Character Set Support

This section describes operations that take character set information into account.

9.1.9.1. Result Strings

MySQL has many operators and functions that return a string. This section answers the question: What is the character set and collation of such a string?

For simple functions that take string input and return a string result as output, the output's character set and collation are the same as those of the principal input value. For example, `UPPER(X)` returns a string whose character string and collation are the same as that of *X*. The same applies for `INSTR()`, `LCASE()`, `LOWER()`, `LTRIM()`, `MID()`, `REPEAT()`, `REPLACE()`, `REVERSE()`, `RIGHT()`, `RPAD()`, `RTRIM()`, `SOUNDEX()`, `SUBSTRING()`, `TRIM()`, `UCASE()`, and `UPPER()`.

Note: The `REPLACE()` function, unlike all other functions, always ignores the collation of the string input and performs a case-sensitive comparison.

If a string input or function result is a binary string, the string has no character set or collation. This can be checked by using the

`CHARSET()` and `COLLATION()` functions, both of which return `binary` to indicate that their argument is a binary string:

```
mysql> SELECT CHARSET(BINARY 'a'), COLLATION(BINARY 'a');
+---------------------+-----------------------+
| CHARSET(BINARY 'a') | COLLATION(BINARY 'a') |
+---------------------+-----------------------+
| binary              | binary                |
+---------------------+-----------------------+
```

For operations that combine multiple string inputs and return a single string output, the “aggregation rules” of standard SQL apply for determining the collation of the result:

- If an explicit `COLLATE X` occurs, use *X*.
- If explicit `COLLATE X` and `COLLATE Y` occur, raise an error.
- Otherwise, if all collations are *X*, use *X*.
- Otherwise, the result has no collation.

For example, with `CASE ... WHEN a THEN b WHEN b THEN c COLLATE X END`, the resulting collation is *X*. The same applies for `UNION`, `||`, `CONCAT()`, `ELT()`, `GREATEST()`, `IF()`, and `LEAST()`.

For operations that convert to character data, the character set and collation of the strings that result from the operations are defined by the `character_set_connection` and `collation_connection` system variables. This applies only to `CAST()`, `CONV()`, `FORMAT()`, `HEX()`, and `SPACE()`.

If you are uncertain about the character set or collation of the result returned by a string function, you can use the `CHARSET()` or `COLLATION()` function to find out:

```
mysql> SELECT USER(), CHARSET(USER()), COLLATION(USER());
+----------------+-----------------+-------------------+
| USER()         | CHARSET(USER()) | COLLATION(USER()) |
+----------------+-----------------+-------------------+
| test@localhost | utf8            | utf8_general_ci   |
+----------------+-----------------+-------------------+
```

9.1.9.2. `CONVERT()` and `CAST()`

`CONVERT()` provides a way to convert data between different character sets. The syntax is:

```
CONVERT(expr USING transcoding_name)
```

In MySQL, transcoding names are the same as the corresponding character set names.

Examples:

```
SELECT CONVERT(_latin1'Müller' USING utf8);
INSERT INTO utf8table (utf8column)
    SELECT CONVERT(latin1field USING utf8) FROM latin1table;
```

`CONVERT(... USING ...)` is implemented according to the standard SQL specification.

You may also use `CAST()` to convert a string to a different character set. The syntax is:

```
CAST(character_string AS character_data_type CHARACTER SET charset_name)
```

Example:

```
SELECT CAST(_latin1'test' AS CHAR CHARACTER SET utf8);
```

If you use `CAST()` without specifying `CHARACTER SET`, the resulting character set and collation are defined by the `character_set_connection` and `collation_connection` system variables. If you use `CAST()` with `CHARACTER SET X`, the resulting character set and collation are `X` and the default collation of `X`.

You may not use a `COLLATE` clause inside a `CONVERT()` or `CAST()` call, but you may use it outside. For example, `CAST(... COLLATE ...)` is illegal, but `CAST(...) COLLATE ...` is legal:

```
SELECT CAST(_latin1'test' AS CHAR CHARACTER SET utf8) COLLATE utf8_bin;
```

9.1.9.3. `SHOW` Statements and `INFORMATION_SCHEMA`

Several `SHOW` statements provide additional character set information. These include `SHOW CHARACTER SET`, `SHOW COLLATION`, `SHOW CREATE DATABASE`, `SHOW CREATE TABLE` and `SHOW COLUMNS`. These statements are described here briefly. For more information, see Section 12.4.5, “SHOW Syntax”.

`INFORMATION_SCHEMA` has several tables that contain information similar to that displayed by the `SHOW` statements. For example, the `CHARACTER_SETS` and `COLLATIONS` tables contain the information displayed by `SHOW CHARACTER SET` and `SHOW COLLATION`. See Chapter 18, *`INFORMATION_SCHEMA` Tables*.

The `SHOW CHARACTER SET` statement shows all available character sets. It takes an optional `LIKE` clause that indicates which character set names to match. For example:

```
mysql> SHOW CHARACTER SET LIKE 'latin%';
+---------+-----------------------------+-------------------+--------+
| Charset | Description                 | Default collation | Maxlen |
+---------+-----------------------------+-------------------+--------+
| latin1  | cp1252 West European        | latin1_swedish_ci |      1 |
| latin2  | ISO 8859-2 Central European | latin2_general_ci |      1 |
| latin5  | ISO 8859-9 Turkish          | latin5_turkish_ci |      1 |
| latin7  | ISO 8859-13 Baltic          | latin7_general_ci |      1 |
+---------+-----------------------------+-------------------+--------+
```

The output from `SHOW COLLATION` includes all available character sets. It takes an optional `LIKE` clause that indicates which collation names to match. For example:

```
mysql> SHOW COLLATION LIKE 'latin1%';
+-------------------+---------+----+---------+----------+---------+
| Collation         | Charset | Id | Default | Compiled | Sortlen |
+-------------------+---------+----+---------+----------+---------+
| latin1_german1_ci | latin1  |  5 |         |          |       0 |
| latin1_swedish_ci | latin1  |  8 | Yes     | Yes      |       0 |
| latin1_danish_ci  | latin1  | 15 |         |          |       0 |
| latin1_german2_ci | latin1  | 31 |         | Yes      |       2 |
| latin1_bin        | latin1  | 47 |         | Yes      |       0 |
| latin1_general_ci | latin1  | 48 |         |          |       0 |
| latin1_general_cs | latin1  | 49 |         |          |       0 |
| latin1_spanish_ci | latin1  | 94 |         |          |       0 |
+-------------------+---------+----+---------+----------+---------+
```

`SHOW CREATE DATABASE` displays the `CREATE DATABASE` statement that creates a given database:

```
mysql> SHOW CREATE DATABASE test;
+----------+-----------------------------------------------------------------+
| Database | Create Database                                                 |
+----------+-----------------------------------------------------------------+
| test     | CREATE DATABASE `test` /*!40100 DEFAULT CHARACTER SET latin1 */ |
+----------+-----------------------------------------------------------------+
```

If no `COLLATE` clause is shown, the default collation for the character set applies.

`SHOW CREATE TABLE` is similar, but displays the `CREATE TABLE` statement to create a given table. The column definitions indicate any character set specifications, and the table options include character set information.

The `SHOW COLUMNS` statement displays the collations of a table's columns when invoked as `SHOW FULL COLUMNS`. Columns with `CHAR`, `VARCHAR`, or `TEXT` data types have collations. Numeric and other noncharacter types have no collation (indicated by `NULL` as the `Collation` value). For example:

```
mysql> SHOW FULL COLUMNS FROM person\G
*************************** 1. row ***************************
     Field: id
      Type: smallint(5) unsigned
 Collation: NULL
      Null: NO
       Key: PRI
   Default: NULL
     Extra: auto_increment
Privileges: select,insert,update,references
   Comment:
*************************** 2. row ***************************
     Field: name
      Type: char(60)
 Collation: latin1_swedish_ci
      Null: NO
       Key:
   Default:
     Extra:
Privileges: select,insert,update,references
   Comment:
```

The character set is not part of the display but is implied by the collation name.

9.1.10. Unicode Support

The initial implementation of Unicode support (in MySQL 4.1) included two character sets for storing Unicode data:

- `ucs2`, the UCS-2 encoding of the Unicode character set using 16 bits per character
- `utf8`, a UTF-8 encoding of the Unicode character set using one to three bytes per character

These two character sets support the characters from the Basic Multilingual Plane (BMP) of Unicode Version 3.0. BMP characters have these characteristics:

- Their code values are between 0 and 65535 (or `U+0000` .. `U+FFFF`)
- They can be encoded with a fixed 16-bit word, as in `ucs2`
- They can be encoded with 8, 16, or 24 bits, as in `utf8`
- They are sufficient for almost all characters in major languages

Characters not supported by the aforementioned character sets include supplementary characters that lie outside the BMP. Characters outside the BMP compare as REPLACEMENT CHARACTER and convert to `'?'` when converted to a Unicode character set.

As of MySQL 5.5.3, Unicode support includes supplementary characters, which requires new character sets that have a broader range and therefore take more space. The following table shows a brief feature comparison of previous and current Unicode support.

Before MySQL 5.5	**MySQL 5.5 and up**
All Unicode 3.0 characters	All Unicode 5.0 characters
No supplementary characters	With supplementary characters
`ucs2` character set, BMP only	No change
`utf8` character set for up to three bytes, BMP only	No change
	New `utf8mb4` character set for up to four bytes, BMP or supplemental
	New `utf16` character set, BMP or supplemental
	New `utf32` character set, BMP or supplemental

These changes are upward compatible. If you want to use the new character sets, there are potential incompatibility issues for your applications; see Section 9.1.11, “Upgrading from Previous to Current Unicode Support”. That section also describes how to convert tables from `utf8` to the (four-byte) `utf8mb4` character set, and what constraints may apply in doing so.

MySQL 5.5 supports these Unicode character sets:

- `ucs2`, the UCS-2 encoding of the Unicode character set using 16 bits per character
- `utf16`, the UTF-16 encoding for the Unicode character set; like `ucs2` but with an extension for supplementary characters
- `utf32`, the UTF-32 encoding for the Unicode character set using 32 bits per character
- `utf8`, a UTF-8 encoding of the Unicode character set using one to three bytes per character
- `utf8mb4`, a UTF-8 encoding of the Unicode character set using one to four bytes per character

`ucs2` and `utf8` support BMP characters. `utf8mb4`, `utf16`, and `utf32` support BMP and supplementary characters.

A similar set of collations is available for each Unicode character set. For example, each has a Danish collation, the names of which are `ucs2_danish_ci`, `utf16_danish_ci`, `utf32_danish_ci`, `utf8_danish_ci`, and `utf8mb4_danish_ci`. All Unicode collations are listed at Section 9.1.14.1, “Unicode Character Sets”, which also describes collation properties for supplementary characters.

Note that although many of the supplementary characters come from East Asian languages, what MySQL 5.5 adds is support for more Japanese and Chinese characters in Unicode character sets, not support for new Japanese and Chinese character sets.

The MySQL implementation of UCS-2, UTF-16, and UTF-32 stores characters in big-endian byte order and does not use a byte order mark (BOM) at the beginning of values. Other database systems might use little-endian byte order or a BOM. In such cases, conversion of values will need to be performed when transferring data between those systems and MySQL.

MySQL uses no BOM for UTF-8 values.

Client applications that need to communicate with the server using Unicode should set the client character set accordingly; for example, by issuing a `SET NAMES 'utf8'` statement. `ucs2`, `utf16`, and `utf32` cannot be used as a client character set, which means that they do not work for `SET NAMES` or `SET CHARACTER SET`. (See Section 9.1.4, “Connection Character Sets and Collations”.)

The following sections provide additional detail on the Unicode character sets in MySQL.

9.1.10.1. The `ucs2` Character Set (UCS-2 Unicode Encoding)

In UCS-2, every character is represented by a two-byte Unicode code with the most significant byte first. For example: `LATIN CAPITAL LETTER A` has the code `0x0041` and it is stored as a two-byte sequence: `0x00 0x41`. `CYRILLIC SMALL LETTER YERU` (Unicode `0x044B`) is stored as a two-byte sequence: `0x04 0x4B`. For Unicode characters and their codes, please refer to the Unicode Home Page.

In MySQL, the `ucs2` character set is a fixed-length 16-bit encoding for Unicode BMP characters.

9.1.10.2. The `utf16` Character Set (UTF-16 Unicode Encoding)

The `utf16` character set is the `ucs2` character set with an extension that enables encoding of supplementary characters:

- For a BMP character, `utf16` and `ucs2` have identical storage characteristics: same code values, same encoding, same length.
- For a supplementary character, `utf16` has a special sequence for representing the character using 32 bits. This is called the “surrogate” mechanism: For a number greater than `0xffff`, take 10 bits and add them to `0xd800` and put them in the first 16-bit word, take 10 more bits and add them to `0xdc00` and put them in the next 16-bit word. Consequently, all supplementary characters require 32 bits, where the first 16 bits are a number between `0xd800` and `0xdbff`, and the last 16 bits are a number between `0xdc00` and `0xdfff`. Examples are in Section 15.5 Surrogates Area of the Unicode 4.0 document.

Because `utf16` supports surrogates and `ucs2` does not, there is a validity check that applies only in `utf16`: You cannot insert a top surrogate without a bottom surrogate, or vice versa. For example:

```
INSERT INTO t (ucs2_column) VALUES (0xd800); /* legal */
INSERT INTO t (utf16_column)VALUES (0xd800); /* illegal */
```

There is no validity check for characters that are technically valid but are not true Unicode (that is, characters that Unicode considers to be “unassigned code points” or “private use” characters or even “illegals” like `0xffff`). For example, since `U+F8FF` is the Apple Logo, this is legal:

```
INSERT INTO t (utf16_column)VALUES (0xf8ff); /* legal */
```

Such characters cannot be expected to mean the same thing to everyone.

Because MySQL must allow for the worst case (that one character requires four bytes) the maximum length of a `utf16` column or index is only half of the maximum length for a `ucs2` column or index. For example, in MySQL 5.5, the maximum length of a `MEMORY` table index key is 3072 bytes, so these statements create tables with the longest permitted indexes for `ucs2` and `utf16` columns:

```
CREATE TABLE tf (s1 VARCHAR(1536) CHARACTER SET ucs2) ENGINE=MEMORY;
CREATE INDEX i ON tf (s1);
CREATE TABLE tg (s1 VARCHAR(768) CHARACTER SET utf16) ENGINE=MEMORY;
CREATE INDEX i ON tg (s1);
```

9.1.10.3. The `utf32` Character Set (UTF-32 Unicode Encoding)

The `utf32` character set is fixed length (like `ucs2` and unlike `utf16`). `utf32` uses 32 bits for every character, unlike `ucs2` (which uses 16 bits for every character), and unlike `utf16` (which uses 16 bits for some characters and 32 bits for others).

`utf32` takes twice as much space as `ucs2` and more space than `utf16`, but `utf32` has the same advantage as `ucs2` that it is predictable for storage: The required number of bytes for `utf32` equals the number of characters times 4. Also, unlike `utf16`, there are no tricks for encoding in `utf32`, so the stored value equals the code value.

To demonstrate how the latter advantage is useful, here is an example that shows how to determine a `utf8mb4` value given the `utf32` code value:

```
/* Assume code value = 100cc LINEAR B WHEELED CHARIOT */
CREATE TABLE tmp (utf32_col CHAR(1) CHARACTER SET utf32,
                  utf8mb4_col CHAR(1) CHARACTER SET utf8mb4);
INSERT INTO tmp VALUES (0x000100cc,NULL);
UPDATE tmp SET utf8mb4_col = utf32_col;
SELECT HEX(utf32_col),HEX(utf8mb4_col) FROM tmp;
```

MySQL is very forgiving about additions of unassigned Unicode characters or private-use-area characters. There is in fact only one validity check for `utf32`: No code value may be greater than `0x10ffff`. For example, this is illegal:

```
INSERT INTO t (utf32_column) VALUES (0x110000); /* illegal */
```

9.1.10.4. The `utf8` Character Set (Three-Byte UTF-8 Unicode Encoding)

UTF-8 (Unicode Transformation Format with 8-bit units) is an alternative way to store Unicode data. It is implemented according to RFC 3629, which describes encoding sequences that take from one to four bytes. (An older standard for UTF-8 encoding, RFC 2279, describes UTF-8 sequences that take from one to six bytes. RFC 3629 renders RFC 2279 obsolete; for this reason, sequences with five and six bytes are no longer used.)

The idea of UTF-8 is that various Unicode characters are encoded using byte sequences of different lengths:

- Basic Latin letters, digits, and punctuation signs use one byte.
- Most European and Middle East script letters fit into a two-byte sequence: extended Latin letters (with tilde, macron, acute, grave and other accents), Cyrillic, Greek, Armenian, Hebrew, Arabic, Syriac, and others.
- Korean, Chinese, and Japanese ideographs use three-byte or four-byte sequences.

The `utf8` character set is the same in MySQL 5.5 as before 5.5 and has exactly the same characteristics:

- No support for supplementary characters (BMP characters only)
- A maximum of three bytes per multi-byte character

Exactly the same set of characters is available in `utf8` as in `ucs2`. That is, they have the same repertoire.

9.1.10.5. The `utf8mb3` “Character Set” (Alias for `utf8`)

In a future version of MySQL, it is possible that `utf8` will become the 4-byte `utf8`, and that users who want to indicate 3-byte `utf8` will have to say `utf8mb3`. To avoid some future problems which might occur with replication when master and slave servers have different MySQL versions, it is possible as of MySQL 5.5.3 for users to specify `utf8mb3` in `CHARACTER SET` clauses, and `utf8mb3_collation_substring` in `COLLATE` clauses, where `collation_substring` is `bin`, `czech_ci`, `danish_ci`, `esperanto_ci`, `estonian_ci`, and so forth. For example:

```
CREATE TABLE t (s1 CHAR(1) CHARACTER SET utf8mb3;
SELECT * FROM t WHERE s1 COLLATE utf8mb3_general_ci = 'x';
DECLARE x VARCHAR(5) CHARACTER SET utf8mb3 COLLATE utf8mb3_danish_ci;
SELECT CAST('a' AS CHAR CHARACTER SET utf8) COLLATE utf8_czech_ci;
```

MySQL immediately converts instances of `utf8mb3` in an alias to `utf8`, so in statements such as `SHOW CREATE TABLE` or `SELECT CHARACTER_SET_NAME FROM INFORMATION_SCHEMA.COLUMNS` or `SELECT COLLATION_NAME FROM INFORMATION_SCHEMA.COLUMNS`, users will see the true name, `utf8` or `utf8_collation_substring`.

The `utf8mb3` alias is valid only in `CHARACTER SET` clauses, and in certain other places. For example, these are legal:

```
mysqld --character-set-server=utf8mb3
SET NAMES 'utf8mb3'; /* and other SET statements that have similar effect */
SELECT _utf8mb3 'a';
```

9.1.10.6. The `utf8mb4` Character Set (Four-Byte UTF-8 Unicode Encoding)

The character set named `utf8` uses a maximum of three bytes per character and contains only BMP characters. As of MySQL 5.5.3, the `utf8mb4` character set uses a maximum of four bytes per character supports supplemental characters:

- For a BMP character, `utf8` and `utf8mb4` have identical storage characteristics: same code values, same encoding, same length.
- For a supplementary character, `utf8` cannot store the character at all, while `utf8mb4` requires four bytes to store it. Since `utf8` cannot store the character at all, you do not have any supplementary characters in `utf8` columns and you need not worry about converting characters or losing data when upgrading `utf8` data from older versions of MySQL.

`utf8mb4` is a superset of `utf8`, so for an operation such as the following concatenation, the result has character set `utf8mb4` and the collation of `utf8mb4_col`:

```
SELECT CONCAT(utf8_col, utf8mb4_col);
```

Similarly, the following comparison in the `WHERE` clause works according to the collation of `utf8mb_col`:

```
SELECT * FROM utf8_tbl, utf8mb4_tbl
WHERE utf8_tbl.utf8_col = utf8mb4_tbl.utf8mb4_col;
```

> **Tip**
>
> To save space with UTF-8, use `VARCHAR` instead of `CHAR`. Otherwise, MySQL must reserve three (or four) bytes for each character in a `CHAR CHARACTER SET utf8` (or `utf8mb4`) column because that is the maximum possible length. For example, MySQL must reserve 40 bytes for a `CHAR(10) CHARACTER SET utf8mb4` column.

9.1.11. Upgrading from Previous to Current Unicode Support

This section describes issues pertaining to Unicode support that you may face when upgrading to MySQL 5.5 from an older MySQL release. It also provides guidelines for downgrading from MySQL 5.5 to an older release.

In most respects, upgrading to MySQL 5.5 should present few problems with regard to Unicode usage, although there are some potential areas of incompatibility. These are the primary areas of concern:

- For the variable-length character data types (`VARCHAR` and the `TEXT` types), the maximum length in characters is less for `utf8mb4` columns than for `utf8` columns.
- For all character data types (`CHAR`, `VARCHAR`, and the `TEXT` types), the maximum number of characters that can be indexed is less for `utf8mb4` columns than for `utf8` columns.

Consequently, if you want to upgrade tables from `utf8` to `utf8mb4` to take advantage of supplementary-character support, it may be necessary to change some column or index definitions.

Tables can be converted from `utf8` to `utf8mb4` by using `ALTER TABLE`. Suppose that a table was originally defined as follows:

```
CREATE TABLE t1 (
  col1 CHAR(10) CHARACTER SET utf8 COLLATE utf8_unicode_ci NOT NULL,
  col2 CHAR(10) CHARACTER SET utf8 COLLATE utf8_bin NOT NULL
) CHARACTER SET utf8;
```

The following statement converts `t1` to use `utf8mb4`:

```
ALTER TABLE t1
  DEFAULT CHARACTER SET utf8mb4,
  MODIFY col1 CHAR(10)
    CHARACTER SET utf8mb4 COLLATE utf8mb4_unicode_ci NOT NULL,
  MODIFY col2 CHAR(10)
    CHARACTER SET utf8mb4 COLLATE utf8mb4_bin NOT NULL;
```

In terms of table content, conversion from `utf8` to `utf8mb4` presents no problems:

- For a BMP character, `utf8` and `utf8mb4` have identical storage characteristics: same code values, same encoding, same length.
- For a supplementary character, `utf8` cannot store the character at all, while `utf8mb4` requires four bytes to store it. Since `utf8` cannot store the character at all, you do not have any supplementary characters in `utf8` columns and you need not worry about converting characters or losing data when upgrading `utf8` data from older versions of MySQL.

In terms of table structure, the catch when converting from `utf8` to `utf8mb4` is that the maximum length of a column or index key is unchanged in terms of *bytes*. Therefore, it is smaller in terms of *characters* because the maximum length of a character is four bytes instead of three. For the `CHAR`, `VARCHAR`, and `TEXT` data types, watch for these things when converting your MySQL tables:

- Check all definitions of `utf8` columns and make sure they will not exceed the maximum length for the storage engine.
- Check all indexes on `utf8` columns and make sure they will not exceed the maximum length for the storage engine. Sometimes the maximum can change due to storage engine enhancements.

If the preceding conditions apply, you must either reduce the defined length of columns or indexes, or continue to use `utf8` rather than `utf8mb4`.

Here are some examples where structural changes may be needed:

- A `TINYTEXT` column can hold up to 255 bytes, so it can hold up to 85 three-byte or 63 four-byte characters. Suppose that you have a `TINYTEXT` column that uses `utf8` but must be able to contain more than 63 characters. You cannot convert it to `utf8mb4` unless you also change the data type to a longer type such as `TEXT`.

  Similarly, a very long `VARCHAR` column may need to be changed to one of the longer `TEXT` types if you want to convert it from `utf8` to `utf8mb4`.

- `InnoDB` has a maximum index length of 767 bytes, so for `utf8` or `utf8mb4` columns, you can index a maximum of 255 or 191 characters, respectively. If you currently have `utf8` columns with indexes longer than 191 characters, you will need to index a smaller number of characters. In an `InnoDB` table, these column and index definitions are legal:

  ```
  col1 VARCHAR(500) CHARACTER SET utf8, INDEX (col1(255))
  ```

  To use `utf8mb4` instead, the index must be smaller:

  ```
  col1 VARCHAR(500) CHARACTER SET utf8mb4, INDEX (col1(191))
  ```

The preceding types of changes are most likely to be required only if you have very long columns or indexes. Otherwise, you should be able to convert your tables from `utf8` to `utf8mb4` without problems. You can do this by using `ALTER TABLE` as described earlier in this section after upgrading in place to 5.5.

The following items summarize other potential areas of incompatibility:

- Performance of four-byte UTF-8 (`utf8mb4`) is slower than for three-byte UTF-8 (`utf8`). If you do not want to incur this penalty, continue to use `utf8`.
- `SET NAMES 'utf8mb4'` causes use of the four-byte character set for connection character sets. As long as no four-byte characters are sent from the server, there should be no problems. Otherwise, applications that expect to receive a maximum of three bytes per character may have problems. Conversely, applications that expect to send four-byte characters must ensure that the server understands them.
- Applications cannot send `utf16` or `utf32` character data to an older server that does not understand them.
- For replication, if the character sets that support supplementary characters are going to be used on the master, all slaves must understand them as well. If you attempt to replicate from a MySQL 5.5 master to an older slave, `utf8` data will be seen as `utf8` by the slave and should replicate correctly. But you cannot send `utf8mb4`, `utf16`, or `utf32` data.

  Also, keep in mind the general principle that if a table has different definitions on the master and slave, this can lead to unexpected results. For example, the differences in limitations on index key length makes it risky to use `utf8` on the master and `utf8mb4` on the slave.

If you have upgraded to MySQL 5.5, and then decide to downgrade back to an older release, these considerations apply:

- `ucs2` and `utf8` data should present no problems.
- Any definitions that refer to the `utf8mb4`, `utf16`, or `utf32` character sets will not be recognized by the older server.
- For object definitions that refer to the `utf8mb4` character set, you can dump them with `mysqldump` in MySQL 5.5, edit the dump file to change instances of `utf8mb4` to `utf8`, and reload the file in the older server, as long as there are no four-byte

characters in the data. The older server will see `utf8` in the dump file object definitions and create new objects that use the (three-byte) `utf8` character set.

9.1.12. UTF-8 for Metadata

Metadata is “the data about the data.” Anything that *describes* the database—as opposed to being the *contents* of the database—is metadata. Thus column names, database names, user names, version names, and most of the string results from `SHOW` are metadata. This is also true of the contents of tables in `INFORMATION_SCHEMA` because those tables by definition contain information about database objects.

Representation of metadata must satisfy these requirements:

- All metadata must be in the same character set. Otherwise, neither the `SHOW` statements nor `SELECT` statements for tables in `INFORMATION_SCHEMA` would work properly because different rows in the same column of the results of these operations would be in different character sets.
- Metadata must include all characters in all languages. Otherwise, users would not be able to name columns and tables using their own languages.

To satisfy both requirements, MySQL stores metadata in a Unicode character set, namely UTF-8. This does not cause any disruption if you never use accented or non-Latin characters. But if you do, you should be aware that metadata is in UTF-8.

The metadata requirements mean that the return values of the `USER()`, `CURRENT_USER()`, `SESSION_USER()`, `SYSTEM_USER()`, `DATABASE()`, and `VERSION()` functions have the UTF-8 character set by default.

The server sets the `character_set_system` system variable to the name of the metadata character set:

```
mysql> SHOW VARIABLES LIKE 'character_set_system';
+----------------------+-------+
| Variable_name        | Value |
+----------------------+-------+
| character_set_system | utf8  |
+----------------------+-------+
```

Storage of metadata using Unicode does *not* mean that the server returns headers of columns and the results of `DESCRIBE` functions in the `character_set_system` character set by default. When you use `SELECT column1 FROM t`, the name `column1` itself is returned from the server to the client in the character set determined by the value of the `character_set_results` system variable, which has a default value of `latin1`. If you want the server to pass metadata results back in a different character set, use the `SET NAMES` statement to force the server to perform character set conversion. `SET NAMES` sets the `character_set_results` and other related system variables. (See Section 9.1.4, “Connection Character Sets and Collations”.) Alternatively, a client program can perform the conversion after receiving the result from the server. It is more efficient for the client perform the conversion, but this option is not always available for all clients.

If `character_set_results` is set to `NULL`, no conversion is performed and the server returns metadata using its original character set (the set indicated by `character_set_system`).

Error messages returned from the server to the client are converted to the client character set automatically, as with metadata.

If you are using (for example) the `USER()` function for comparison or assignment within a single statement, don't worry. MySQL performs some automatic conversion for you.

```
SELECT * FROM t1 WHERE USER() = latin1_column;
```

This works because the contents of `latin1_column` are automatically converted to UTF-8 before the comparison.

```
INSERT INTO t1 (latin1_column) SELECT USER();
```

This works because the contents of `USER()` are automatically converted to `latin1` before the assignment.

Although automatic conversion is not in the SQL standard, the SQL standard document does say that every character set is (in terms of supported characters) a “subset” of Unicode. Because it is a well-known principle that “what applies to a superset can apply to a subset,” we believe that a collation for Unicode can apply for comparisons with non-Unicode strings. For more information about coercion of strings, see Section 9.1.7.5, “Collation of Expressions”.

9.1.13. Column Character Set Conversion

To convert a binary or nonbinary string column to use a particular character set, use `ALTER TABLE`. For successful conversion to occur, one of the following conditions must apply:

- If the column has a binary data type (`BINARY`, `VARBINARY`, `BLOB`), all the values that it contains must be encoded using a single character set (the character set you're converting the column to). If you use a binary column to store information in multiple character sets, MySQL has no way to know which values use which character set and cannot convert the data properly.
- If the column has a nonbinary data type (`CHAR`, `VARCHAR`, `TEXT`), its contents should be encoded in the column character set, not some other character set. If the contents are encoded in a different character set, you can convert the column to use a binary data type first, and then to a nonbinary column with the desired character set.

Suppose that a table `t` has a binary column named `col1` defined as `VARBINARY(50)`. Assuming that the information in the column is encoded using a single character set, you can convert it to a nonbinary column that has that character set. For example, if `col1` contains binary data representing characters in the `greek` character set, you can convert it as follows:

```
ALTER TABLE t MODIFY col1 VARCHAR(50) CHARACTER SET greek;
```

If your original column has a type of `BINARY(50)`, you could convert it to `CHAR(50)`, but the resulting values will be padded with `0x00` bytes at the end, which may be undesirable. To remove these bytes, use the `TRIM()` function:

```
UPDATE t SET col1 = TRIM(TRAILING 0x00 FROM col1);
```

Suppose that table `t` has a nonbinary column named `col1` defined as `CHAR(50) CHARACTER SET latin1` but you want to convert it to use `utf8` so that you can store values from many languages. The following statement accomplishes this:

```
ALTER TABLE t MODIFY col1 CHAR(50) CHARACTER SET utf8;
```

Conversion may be lossy if the column contains characters that are not in both character sets.

A special case occurs if you have old tables from before MySQL 4.1 where a nonbinary column contains values that actually are encoded in a character set different from the server's default character set. For example, an application might have stored `sjis` values in a column, even though MySQL's default character set was `latin1`. It is possible to convert the column to use the proper character set but an additional step is required. Suppose that the server's default character set was `latin1` and `col1` is defined as `CHAR(50)` but its contents are `sjis` values. The first step is to convert the column to a binary data type, which removes the existing character set information without performing any character conversion:

```
ALTER TABLE t MODIFY col1 BLOB;
```

The next step is to convert the column to a nonbinary data type with the proper character set:

```
ALTER TABLE t MODIFY col1 CHAR(50) CHARACTER SET sjis;
```

This procedure requires that the table not have been modified already with statements such as `INSERT` or `UPDATE` after an upgrade to MySQL 4.1 or later. In that case, MySQL would store new values in the column using `latin1`, and the column will contain a mix of `sjis` and `latin1` values and cannot be converted properly.

If you specified attributes when creating a column initially, you should also specify them when altering the table with `ALTER TABLE`. For example, if you specified `NOT NULL` and an explicit `DEFAULT` value, you should also provide them in the `ALTER TABLE` statement. Otherwise, the resulting column definition will not include those attributes.

9.1.14. Character Sets and Collations That MySQL Supports

MySQL supports 70+ collations for 30+ character sets. This section indicates which character sets MySQL supports. There is one subsection for each group of related character sets. For each character set, the permissible collations are listed.

You can always list the available character sets and their default collations with the `SHOW CHARACTER SET` statement:

```
mysql> SHOW CHARACTER SET;
+----------+-----------------------------+---------------------+
| Charset  | Description                 | Default collation   |
+----------+-----------------------------+---------------------+
| big5     | Big5 Traditional Chinese    | big5_chinese_ci     |
| dec8     | DEC West European           | dec8_swedish_ci     |
| cp850    | DOS West European           | cp850_general_ci    |
| hp8      | HP West European            | hp8_english_ci      |
| koi8r    | KOI8-R Relcom Russian       | koi8r_general_ci    |
| latin1   | cp1252 West European        | latin1_swedish_ci   |
| latin2   | ISO 8859-2 Central European | latin2_general_ci   |
| swe7     | 7bit Swedish                | swe7_swedish_ci     |
| ascii    | US ASCII                    | ascii_general_ci    |
| ujis     | EUC-JP Japanese             | ujis_japanese_ci    |
| sjis     | Shift-JIS Japanese          | sjis_japanese_ci    |
| hebrew   | ISO 8859-8 Hebrew           | hebrew_general_ci   |
| tis620   | TIS620 Thai                 | tis620_thai_ci      |
| euckr    | EUC-KR Korean               | euckr_korean_ci     |
| koi8u    | KOI8-U Ukrainian            | koi8u_general_ci    |
| gb2312   | GB2312 Simplified Chinese   | gb2312_chinese_ci   |
| greek    | ISO 8859-7 Greek            | greek_general_ci    |
| cp1250   | Windows Central European    | cp1250_general_ci   |
| gbk      | GBK Simplified Chinese      | gbk_chinese_ci      |
| latin5   | ISO 8859-9 Turkish          | latin5_turkish_ci   |
| armscii8 | ARMSCII-8 Armenian          | armscii8_general_ci |
| utf8     | UTF-8 Unicode               | utf8_general_ci     |
| ucs2     | UCS-2 Unicode               | ucs2_general_ci     |
| cp866    | DOS Russian                 | cp866_general_ci    |
| keybcs2  | DOS Kamenicky Czech-Slovak  | keybcs2_general_ci  |
| macce    | Mac Central European        | macce_general_ci    |
| macroman | Mac West European           | macroman_general_ci |
| cp852    | DOS Central European        | cp852_general_ci    |
| latin7   | ISO 8859-13 Baltic          | latin7_general_ci   |
| utf8mb4  | UTF-8 Unicode               | utf8mb4_general_ci  |
| cp1251   | Windows Cyrillic            | cp1251_general_ci   |
| utf16    | UTF-16 Unicode              | utf16_general_ci    |
| cp1256   | Windows Arabic              | cp1256_general_ci   |
| cp1257   | Windows Baltic              | cp1257_general_ci   |
| utf32    | UTF-32 Unicode              | utf32_general_ci    |
| binary   | Binary pseudo charset       | binary              |
| geostd8  | GEOSTD8 Georgian            | geostd8_general_ci  |
| cp932    | SJIS for Windows Japanese   | cp932_japanese_ci   |
| eucjpms  | UJIS for Windows Japanese   | eucjpms_japanese_ci |
+----------+-----------------------------+---------------------+
```

The `utf8mb4`, `utf16`, and `utf32` character sets were added in MySQL 5.5.3.

In cases where a character set has multiple collations, it might not be clear which collation is most suitable for a given application. To avoid choosing the wrong collation, it can be helpful to perform some comparisons with representative data values to make sure that a given collation sorts values the way you expect.

Collation-Charts.Org is a useful site for information that shows how one collation compares to another.

9.1.14.1. Unicode Character Sets

MySQL 5.5 supports these Unicode character sets:

- `ucs2`, the UCS-2 encoding of the Unicode character set using 16 bits per character
- `utf16`, the UTF-16 encoding for the Unicode character set; like `ucs2` but with an extension for supplementary characters
- `utf32`, the UTF-32 encoding for the Unicode character set using 32 bits per character
- `utf8`, a UTF-8 encoding of the Unicode character set using one to three bytes per character
- `utf8mb4`, a UTF-8 encoding of the Unicode character set using one to four bytes per character

`ucs2` and `utf8` support Basic Multilingual Plane (BMP) characters. `utf8mb4`, `utf16`, and `utf32` support BMP and supplementary characters. The `utf8mb4`, `utf16`, and `utf32` character sets were added in MySQL 5.5.3.

You can store text in about 650 languages using these character sets. This section lists the collations available for each Unicode character set and describes their differentiating properties. For general information about the character sets, see Section 9.1.10, “Unicode Support”.

A similar set of collations is available for each Unicode character set. These are shown in the following list, where *`xxx`* represents the character set name. For example, *`xxx`*`_danish_ci` represents the Danish collations, the specific names of which are `ucs2_danish_ci`, `utf16_danish_ci`, `utf32_danish_ci`, `utf8_danish_ci`, and `utf8mb4_danish_ci`.

- *`xxx`*`_bin`
- *`xxx`*`_czech_ci`
- *`xxx`*`_danish_ci`
- *`xxx`*`_esperanto_ci`
- *`xxx`*`_estonian_ci`
- *`xxx`*`_general_ci` (default)
- *`xxx`*`_hungarian_ci`

- `xxx_icelandic_ci`
- `xxx_latvian_ci`
- `xxx_lithuanian_ci`
- `xxx_persian_ci`
- `xxx_polish_ci`
- `xxx_roman_ci`
- `xxx_romanian_ci`
- `xxx_sinhala_ci`
- `xxx_slovak_ci`
- `xxx_slovenian_ci`
- `xxx_spanish_ci`
- `xxx_spanish2_ci`
- `xxx_swedish_ci`
- `xxx_turkish_ci`
- `xxx_unicode_ci`

MySQL implements the `xxx_unicode_ci` collations according to the Unicode Collation Algorithm (UCA) described at http://www.unicode.org/reports/tr10/. The collation uses the version-4.0.0 UCA weight keys: http://www.unicode.org/Public/UCA/4.0.0/allkeys-4.0.0.txt. Currently, the `xxx_unicode_ci` collations have only partial support for the Unicode Collation Algorithm. Some characters are not supported yet. Also, combining marks are not fully supported. This affects primarily Vietnamese, Yoruba, and some smaller languages such as Navajo.

MySQL implements language-specific Unicode collations only if the ordering with `xxx_unicode_ci` does not work well for a language. Language-specific collations are UCA-based. They are derived from `xxx_unicode_ci` with additional language tailoring rules.

For any Unicode character set, operations performed using the `xxx_general_ci` collation are faster than those for the `xxx_unicode_ci` collation. For example, comparisons for the `utf8_general_ci` collation are faster, but slightly less correct, than comparisons for `utf8_unicode_ci`. The reason for this is that `utf8_unicode_ci` supports mappings such as expansions; that is, when one character compares as equal to combinations of other characters. For example, in German and some other languages “ß” is equal to “`ss`”. `utf8_unicode_ci` also supports contractions and ignorable characters. `utf8_general_ci` is a legacy collation that does not support expansions, contractions, or ignorable characters. It can make only one-to-one comparisons between characters.

To further illustrate, the following equalities hold in both `utf8_general_ci` and `utf8_unicode_ci` (for the effect this has in comparisons or when doing searches, see Section 9.1.7.8, “Examples of the Effect of Collation”):

```
Ä = A
Ö = O
Ü = U
```

A difference between the collations is that this is true for `utf8_general_ci`:

```
ß = s
```

Whereas this is true for `utf8_unicode_ci`, which supports the German DIN-1 ordering (also known as dictionary order):

```
ß = ss
```

MySQL implements language-specific collations for the `utf8` character set only if the ordering with `utf8_unicode_ci` does not work well for a language. For example, `utf8_unicode_ci` works fine for German dictionary order and French, so there is no need to create special `utf8` collations.

`utf8_general_ci` also is satisfactory for both German and French, except that “ß” is equal to “`s`”, and not to “`ss`”. If this is acceptable for your application, you should use `utf8_general_ci` because it is faster. Otherwise, use `utf8_unicode_ci` because it is more accurate.

`xxx_swedish_ci` includes Swedish rules. For example, in Swedish, the following relationship holds, which is not something expected by a German or French speaker:

```
Ü = Y < Ö
```

The `xxx_spanish_ci` and `xxx_spanish2_ci` collations correspond to modern Spanish and traditional Spanish, respectively. In both collations, "`ñ`" (n-tilde) is a separate letter between "`n`" and "`o`". In addition, for traditional Spanish, "`ch`" is a separate letter between "`c`" and "`d`", and "`ll`" is a separate letter between "`l`" and "`m`"

In the `xxx_roman_ci` collations, `I` and `J` compare as equal, and `U` and `V` compare as equal.

For all Unicode collations except the "binary" (`xxx_bin`) collations, MySQL performs a table lookup to find a character's collating weight. If a character is not in the table (for example, because it is a "new" character), collating weight determination becomes more complex:

- For BMP characters in general collations (`xxx_general_ci`), weight = code point.
- For BMP characters in UCA collations (for example, `xxx_unicode_ci` and language-specific collations), the following algorithm applies:

  ```
  if (code >= 0x3400 && code <= 0x4DB5)
    base= 0xFB80; /* CJK Ideograph Extension */
  else if (code >= 0x4E00 && code <= 0x9FA5)
    base= 0xFB40; /* CJK Ideograph */
  else
    base= 0xFBC0; /* All other characters */
  aaaa= base +  (code >> 15);
  bbbb= (code & 0x7FFF) | 0x8000;
  ```

  The result is a sequence of two collating elements, `aaaa` followed by `bbbb`.

  Thus, `U+04cf CYRILLIC SMALL LETTER PALOCHKA` currently is, with all UCA collations, greater than `U+04c0 CYRILLIC LETTER PALOCHKA`. Eventually, after further collation tuning, all palochkas will sort together.

- For supplementary characters in general collations, the weight is the weight for `0xfffd REPLACEMENT CHARACTER`. For supplementary characters in UCA collations, their collating weight is `0xfffd`. That is, to MySQL, all supplementary characters are equal to each other, and greater than almost all BMP characters.

  An example with Deseret characters and `COUNT(DISTINCT)`:

  ```
  CREATE TABLE t (s1 VARCHAR(5) CHARACTER SET utf32 COLLATE utf32_unicode_ci);
  INSERT INTO t VALUES (0xfffd);   /* REPLACEMENT CHARACTER */
  INSERT INTO t VALUES (0x010412); /* DESERET CAPITAL LETTER BEE */
  INSERT INTO t VALUES (0x010413); /* DESERET CAPITAL LETTER TEE */
  SELECT COUNT(DISTINCT s1) FROM t;
  ```

  The result is 2 because in the MySQL `xxx_unicode_ci` collations, the replacement character has a weight of `0x0dc6`, whereas Deseret Bee and Deseret Tee both have a weight of `0xfffd`. (Were the `utf32_general_ci` collation used instead, the result would be 1 because all three characters have a weight of `0xfffd` in that collation.)

The current rule that all supplementary characters are equal to each other is nonoptimal but is not expected to cause trouble. These characters are very rare, so it will be very rare that a multi-character string consists entirely of supplementary characters. In Japan, since the supplementary characters are obscure Kanji ideographs, the typical user does not care what order they are in, anyway. If you really want rows sorted by MySQL's rule and secondarily by code point value, it is easy:

```
ORDER BY s1 COLLATE utf32_unicode_ci, s1 COLLATE utf32_bin
```

The `utf16_bin` Collation

There is a difference between "ordering by the character's code value" and "ordering by the character's binary representation," a difference that appears only with `utf16_bin`, because of surrogates.

Suppose that `utf16_bin` (the binary collation for `utf16`) was a binary comparison "byte by byte" rather than "character by character." If that were so, the order of characters in `utf16_bin` would differ from the order in `utf8_bin`. For example, the following chart shows two rare characters. The first character is in the range `E000`-`FFFF`, so it is greater than a surrogate but less than a supplementary. The second character is a supplementary.

```
Code point  Character                    utf8         utf16
----------  ---------                    ----         -----
0FF9D       HALFWIDTH KATAKANA LETTER N  EF BE 9D     FF 9D
10384       UGARITIC LETTER DELTA        F0 90 8E 84  D8 00 DF 84
```

The two characters in the chart are in order by code point value because `0xff9d` < `0x10384`. And they are in order by `utf8` value because `0xef` < `0xf0`. But they are not in order by `utf16` value, if we use byte-by-byte comparison, because `0xff` > `0xd8`.

So MySQL's `utf16_bin` collation is not “byte by byte.” It is “by code point.” When MySQL sees a supplementary-character encoding in `utf16`, it converts to the character's code-point value, and then compares. Therefore, `utf8_bin` and `utf16_bin` are the same ordering. This is consistent with the SQL:2008 standard requirement for a UCS_BASIC collation: “UCS_BASIC is a collation in which the ordering is determined entirely by the Unicode scalar values of the characters in the strings being sorted. It is applicable to the UCS character repertoire. Since every character repertoire is a subset of the UCS repertoire, the UCS_BASIC collation is potentially applicable to every character set. NOTE 11: The Unicode scalar value of a character is its code point treated as an unsigned integer.”

If the character set is `ucs2`, comparison is byte-by-byte, but `ucs2` strings should not contain surrogates, anyway.

For additional information about Unicode collations in MySQL, see Collation-Charts.Org (utf8).

9.1.14.2. West European Character Sets

Western European character sets cover most West European languages, such as French, Spanish, Catalan, Basque, Portuguese, Italian, Albanian, Dutch, German, Danish, Swedish, Norwegian, Finnish, Faroese, Icelandic, Irish, Scottish, and English.

- `ascii` (US ASCII) collations:
  - `ascii_bin`
  - `ascii_general_ci` (default)
- `cp850` (DOS West European) collations:
  - `cp850_bin`
  - `cp850_general_ci` (default)
- `dec8` (DEC Western European) collations:
  - `dec8_bin`
  - `dec8_swedish_ci` (default)
- `hp8` (HP Western European) collations:
  - `hp8_bin`
  - `hp8_english_ci` (default)
- `latin1` (cp1252 West European) collations:
  - `latin1_bin`
  - `latin1_danish_ci`
  - `latin1_general_ci`
  - `latin1_general_cs`
  - `latin1_german1_ci`
  - `latin1_german2_ci`
  - `latin1_spanish_ci`
  - `latin1_swedish_ci` (default)

  `latin1` is the default character set. MySQL's `latin1` is the same as the Windows `cp1252` character set. This means it is the same as the official `ISO 8859-1` or IANA (Internet Assigned Numbers Authority) `latin1`, except that IANA `latin1` treats the code points between `0x80` and `0x9f` as “undefined,” whereas `cp1252`, and therefore MySQL's `latin1`, assign characters for those positions. For example, `0x80` is the Euro sign. For the “undefined” entries in `cp1252`, MySQL translates `0x81` to Unicode `0x0081`, `0x8d` to `0x008d`, `0x8f` to `0x008f`, `0x90` to `0x0090`, and `0x9d` to `0x009d`.

  The `latin1_swedish_ci` collation is the default that probably is used by the majority of MySQL customers. Although it is frequently said that it is based on the Swedish/Finnish collation rules, there are Swedes and Finns who disagree with this statement.

The `latin1_german1_ci` and `latin1_german2_ci` collations are based on the DIN-1 and DIN-2 standards, where DIN stands for *Deutsches Institut für Normung* (the German equivalent of ANSI). DIN-1 is called the “dictionary collation” and DIN-2 is called the “phone book collation.” For an example of the effect this has in comparisons or when doing searches, see Section 9.1.7.8, “Examples of the Effect of Collation”.

- `latin1_german1_ci` (dictionary) rules:

  ```
  Ä = A
  Ö = O
  Ü = U
  ß = s
  ```

- `latin1_german2_ci` (phone-book) rules:

  ```
  Ä = AE
  Ö = OE
  Ü = UE
  ß = ss
  ```

In the `latin1_spanish_ci` collation, “`ñ`” (n-tilde) is a separate letter between “`n`” and “`o`”.

- `macroman` (Mac West European) collations:
  - `macroman_bin`
  - `macroman_general_ci` (default)
- `swe7` (7bit Swedish) collations:
  - `swe7_bin`
  - `swe7_swedish_ci` (default)

For additional information about Western European collations in MySQL, see Collation-Charts.Org (ascii, cp850, dec8, hp8, latin1, macroman, swe7).

9.1.14.3. Central European Character Sets

MySQL provides some support for character sets used in the Czech Republic, Slovakia, Hungary, Romania, Slovenia, Croatia, Poland, and Serbia (Latin).

- `cp1250` (Windows Central European) collations:
  - `cp1250_bin`
  - `cp1250_croatian_ci`
  - `cp1250_czech_cs`
  - `cp1250_general_ci` (default)
  - `cp1250_polish_ci`
- `cp852` (DOS Central European) collations:
  - `cp852_bin`
  - `cp852_general_ci` (default)
- `keybcs2` (DOS Kamenicky Czech-Slovak) collations:
  - `keybcs2_bin`
  - `keybcs2_general_ci` (default)
- `latin2` (ISO 8859-2 Central European) collations:

  - `latin2_bin`
  - `latin2_croatian_ci`
  - `latin2_czech_cs`
  - `latin2_general_ci` (default)
  - `latin2_hungarian_ci`
- `macce` (Mac Central European) collations:
  - `macce_bin`
  - `macce_general_ci` (default)

For additional information about Central European collations in MySQL, see Collation-Charts.Org (cp1250, cp852, keybcs2, latin2, macce).

9.1.14.4. South European and Middle East Character Sets

South European and Middle Eastern character sets supported by MySQL include Armenian, Arabic, Georgian, Greek, Hebrew, and Turkish.

- `armscii8` (ARMSCII-8 Armenian) collations:
  - `armscii8_bin`
  - `armscii8_general_ci` (default)
- `cp1256` (Windows Arabic) collations:
  - `cp1256_bin`
  - `cp1256_general_ci` (default)
- `geostd8` (GEOSTD8 Georgian) collations:
  - `geostd8_bin`
  - `geostd8_general_ci` (default)
- `greek` (ISO 8859-7 Greek) collations:
  - `greek_bin`
  - `greek_general_ci` (default)
- `hebrew` (ISO 8859-8 Hebrew) collations:
  - `hebrew_bin`
  - `hebrew_general_ci` (default)
- `latin5` (ISO 8859-9 Turkish) collations:
  - `latin5_bin`
  - `latin5_turkish_ci` (default)

For additional information about South European and Middle Eastern collations in MySQL, see Collation-Charts.Org (armscii8, cp1256, geostd8, greek, hebrew, latin5).

9.1.14.5. Baltic Character Sets

The Baltic character sets cover Estonian, Latvian, and Lithuanian languages.

- `cp1257` (Windows Baltic) collations:
  - `cp1257_bin`
  - `cp1257_general_ci` (default)
  - `cp1257_lithuanian_ci`
- `latin7` (ISO 8859-13 Baltic) collations:
  - `latin7_bin`
  - `latin7_estonian_cs`
  - `latin7_general_ci` (default)
  - `latin7_general_cs`

For additional information about Baltic collations in MySQL, see Collation-Charts.Org (cp1257, latin7).

9.1.14.6. Cyrillic Character Sets

The Cyrillic character sets and collations are for use with Belarusian, Bulgarian, Russian, Ukrainian, and Serbian (Cyrillic) languages.

- `cp1251` (Windows Cyrillic) collations:
  - `cp1251_bin`
  - `cp1251_bulgarian_ci`
  - `cp1251_general_ci` (default)
  - `cp1251_general_cs`
  - `cp1251_ukrainian_ci`
- `cp866` (DOS Russian) collations:
  - `cp866_bin`
  - `cp866_general_ci` (default)
- `koi8r` (KOI8-R Relcom Russian) collations:
  - `koi8r_bin`
  - `koi8r_general_ci` (default)
- `koi8u` (KOI8-U Ukrainian) collations:
  - `koi8u_bin`
  - `koi8u_general_ci` (default)

For additional information about Cyrillic collations in MySQL, see Collation-Charts.Org (cp1251, cp866, koi8r, koi8u).).

9.1.14.7. Asian Character Sets

The Asian character sets that we support include Chinese, Japanese, Korean, and Thai. These can be complicated. For example, the Chinese sets must allow for thousands of different characters. See Section 9.1.14.7.1, “The `cp932` Character Set”, for additional information about the `cp932` and `sjis` character sets.

For answers to some common questions and problems relating support for Asian character sets in MySQL, see Section B.11, “MySQL 5.5 FAQ: MySQL Chinese, Japanese, and Korean Character Sets”.

- `big5` (Big5 Traditional Chinese) collations:

  - `big5_bin`
  - `big5_chinese_ci` (default)
- `cp932` (SJIS for Windows Japanese) collations:
  - `cp932_bin`
  - `cp932_japanese_ci` (default)
- `eucjpms` (UJIS for Windows Japanese) collations:
  - `eucjpms_bin`
  - `eucjpms_japanese_ci` (default)
- `euckr` (EUC-KR Korean) collations:
  - `euckr_bin`
  - `euckr_korean_ci` (default)
- `gb2312` (GB2312 Simplified Chinese) collations:
  - `gb2312_bin`
  - `gb2312_chinese_ci` (default)
- `gbk` (GBK Simplified Chinese) collations:
  - `gbk_bin`
  - `gbk_chinese_ci` (default)
- `sjis` (Shift-JIS Japanese) collations:
  - `sjis_bin`
  - `sjis_japanese_ci` (default)
- `tis620` (TIS620 Thai) collations:
  - `tis620_bin`
  - `tis620_thai_ci` (default)
- `ujis` (EUC-JP Japanese) collations:
  - `ujis_bin`
  - `ujis_japanese_ci` (default)

The `big5_chinese_ci` collation sorts on number of strokes.

For additional information about Asian collations in MySQL, see Collation-Charts.Org (big5, cp932, eucjpms, euckr, gb2312, gbk, sjis, tis620, ujis).

9.1.14.7.1. The `cp932` Character Set

Why is `cp932` needed?

In MySQL, the `sjis` character set corresponds to the `Shift_JIS` character set defined by IANA, which supports JIS X0201 and JIS X0208 characters. (See http://www.iana.org/assignments/character-sets.)

However, the meaning of “SHIFT JIS” as a descriptive term has become very vague and it often includes the extensions to `Shift_JIS` that are defined by various vendors.

For example, “SHIFT JIS” used in Japanese Windows environments is a Microsoft extension of `Shift_JIS` and its exact name is `Microsoft Windows Codepage : 932` or `cp932`. In addition to the characters supported by `Shift_JIS`, `cp932` supports extension characters such as NEC special characters, NEC selected—IBM extended characters, and IBM extended characters.

Many Japanese users have experienced problems using these extension characters. These problems stem from the following factors:

- MySQL automatically converts character sets.
- Character sets are converted using Unicode (`ucs2`).
- The `sjis` character set does not support the conversion of these extension characters.
- There are several conversion rules from so-called “SHIFT JIS” to Unicode, and some characters are converted to Unicode differently depending on the conversion rule. MySQL supports only one of these rules (described later).

The MySQL `cp932` character set is designed to solve these problems.

Because MySQL supports character set conversion, it is important to separate IANA `Shift_JIS` and `cp932` into two different character sets because they provide different conversion rules.

How does `cp932` differ from `sjis`?

The `cp932` character set differs from `sjis` in the following ways:

- `cp932` supports NEC special characters, NEC selected—IBM extended characters, and IBM selected characters.
- Some `cp932` characters have two different code points, both of which convert to the same Unicode code point. When converting from Unicode back to `cp932`, one of the code points must be selected. For this “round trip conversion,” the rule recommended by Microsoft is used. (See http://support.microsoft.com/kb/170559/EN-US/.)

  The conversion rule works like this:

  - If the character is in both JIS X 0208 and NEC special characters, use the code point of JIS X 0208.
  - If the character is in both NEC special characters and IBM selected characters, use the code point of NEC special characters.
  - If the character is in both IBM selected characters and NEC selected—IBM extended characters, use the code point of IBM extended characters.

  The table shown at http://www.microsoft.com/globaldev/reference/dbcs/932.htm provides information about the Unicode values of `cp932` characters. For `cp932` table entries with characters under which a four-digit number appears, the number represents the corresponding Unicode (`ucs2`) encoding. For table entries with an underlined two-digit value appears, there is a range of `cp932` character values that begin with those two digits. Clicking such a table entry takes you to a page that displays the Unicode value for each of the `cp932` characters that begin with those digits.

  The following links are of special interest. They correspond to the encodings for the following sets of characters:

  - NEC special characters:

    ```
    http://www.microsoft.com/globaldev/reference/dbcs/932/932_87.htm
    ```

  - NEC selected—IBM extended characters:

    ```
    http://www.microsoft.com/globaldev/reference/dbcs/932/932_ED.htm
    http://www.microsoft.com/globaldev/reference/dbcs/932/932_EE.htm
    ```

  - IBM selected characters:

    ```
    http://www.microsoft.com/globaldev/reference/dbcs/932/932_FA.htm
    http://www.microsoft.com/globaldev/reference/dbcs/932/932_FB.htm
    http://www.microsoft.com/globaldev/reference/dbcs/932/932_FC.htm
    ```

- `cp932` supports conversion of user-defined characters in combination with `eucjpms`, and solves the problems with `sjis`/`ujis` conversion. For details, please refer to http://www.opengroup.or.jp/jvc/cde/sjis-euc-e.html.

For some characters, conversion to and from `ucs2` is different for `sjis` and `cp932`. The following tables illustrate these differences.

Conversion to `ucs2`:

`sjis`/`cp932` Value	`sjis` -> `ucs2` Conversion	`cp932` -> `ucs2` Conversion
5C	005C	005C
7E	007E	007E
815C	2015	2015
815F	005C	FF3C
8160	301C	FF5E
8161	2016	2225
817C	2212	FF0D
8191	00A2	FFE0
8192	00A3	FFE1
81CA	00AC	FFE2

Conversion from `ucs2`:

`ucs2` value	`ucs2` -> `sjis` Conversion	`ucs2` -> `cp932` Conversion
005C	815F	5C
007E	7E	7E
00A2	8191	3F
00A3	8192	3F
00AC	81CA	3F
2015	815C	815C
2016	8161	3F
2212	817C	3F
2225	3F	8161
301C	8160	3F
FF0D	3F	817C
FF3C	3F	815F
FF5E	3F	8160
FFE0	3F	8191
FFE1	3F	8192
FFE2	3F	81CA

Users of any Japanese character sets should be aware that using `--character-set-client-handshake` (or `--skip-character-set-client-handshake`) has an important effect. See Section 5.1.2, “Server Command Options”.

9.2. Setting the Error Message Language

By default, `mysqld` produces error messages in English, but they can also be displayed in any of several other languages: Czech, Danish, Dutch, Estonian, French, German, Greek, Hungarian, Italian, Japanese, Korean, Norwegian, Norwegian-ny, Polish, Portuguese, Romanian, Russian, Slovak, Spanish, or Swedish.

You can select which language the server uses for error messages using the instructions in this section.

As of MySQL 5.5, the server searches for the error message file in two locations:

- It tries to find the file in a directory constructed from two parts, the value of `--lc-messages-dir` and the value of `--lc-messages` converted to a language name. Suppose that you start the server using this command:

  ```
  shell> mysqld --lc-messages-dir=/usr/share/mysql --lc-messages=fr_FR
  ```

  In this case, `mysqld` maps the locale `fr_FR` to the language `french` and looks for the error file in the `/usr/share/mysql/french` directory.

- If the message file cannot be found in the directory constructed as just described, the server ignores the `--lc-messages` value and uses only the `--lc-messages-dir` value as the location in which to look.

The `--lc-messages-dir` and `--lc-messages` options are accompanied by the `lc_messages_dir` and `lc_messages` system variables. `lc_messages_dir` has only a global value and is read only. `lc_messages` has global and session values and can be modified at runtime, so the error message language can be changed while the server is running, and individual clients each can have a different error message language by changing their session `lc_messages` value to a different locale name. For example, if the server is using the `fr_FR` locale for error messages, a client that wants error messages in English can execute this statement:

```
mysql> SET lc_messages = 'en_US';
```

Before MySQL 5.5, the `--lc-messages-dir` and `--lc-messages` options (and accompanying system variables) were unavailable. To start `mysqld` with a particular language for error messages, the `--language` or `-L` option were used. The option value can be a language name or the full path to the error message file. For example:

```
shell> mysqld --language=swedish
```

Or:

```
shell> mysqld --language=/usr/local/share/swedish
```

The language name should be specified in lowercase.

From MySQL 5.5 on, `--language` is treated as an alias for `--lc-messages-dir`.

By default, the language files are located in the `share/mysql/LANGUAGE` directory under the MySQL base directory.

For information about changing the character set for error messages (rather than the language), see Section 9.1.6, “Character Set for Error Messages”.

You can change the content of the error messages produced by the server using the instructions in the MySQL Internals manual, available at http://forge.mysql.com/wiki/MySQL_Internals_Error_Messages. If you do change the content of error messages, remember to repeat your changes after each upgrade to a newer version of MySQL.

9.3. Adding a Character Set

This section discusses the procedure for adding a character set to MySQL. The proper procedure depends on whether the character set is simple or complex:

- If the character set does not need special string collating routines for sorting and does not need multi-byte character support, it is simple.
- If the character set needs either of those features, it is complex.

For example, `greek` and `swe7` are simple character sets, whereas `big5` and `czech` are complex character sets.

To use the following instructions, you must have a MySQL source distribution. In the instructions, *`MYSET`* represents the name of the character set that you want to add.

1. Add a `<charset>` element for *`MYSET`* to the `sql/share/charsets/Index.xml` file. Use the existing contents in the file as a guide to adding new contents. A partial listing for the `latin1` `<charset>` element follows:

```
<charset name="latin1">
  <family>Western</family>
  <description>cp1252 West European</description>
  ...
  <collation name="latin1_swedish_ci" id="8" order="Finnish, Swedish">
    <flag>primary</flag>
    <flag>compiled</flag>
  </collation>
  <collation name="latin1_danish_ci" id="15" order="Danish"/>
  ...
  <collation name="latin1_bin"         id="47" order="Binary">
    <flag>binary</flag>
    <flag>compiled</flag>
  </collation>
  ...
</charset>
```

The `<charset>` element must list all the collations for the character set. These must include at least a binary collation and a default (primary) collation. The default collation is often named using a suffix of `general_ci` (general, case insensitive). It is possible for the binary collation to be the default collation, but usually they are different. The default collation should have a `primary` flag. The binary collation should have a `binary` flag.

You must assign a unique ID number to each collation. The range of IDs from 1024 to 2047 is reserved for user-defined collations. Before MySQL 5.5, the ID must be chosen from the range 1 to 254. To find the maximum of the currently used collation IDs, use this query:

```
SELECT MAX(ID) FROM INFORMATION_SCHEMA.COLLATIONS;
```

2. This step depends on whether you are adding a simple or complex character set. A simple character set requires only a configuration file, whereas a complex character set requires C source file that defines collation functions, multi-byte functions, or both.

   For a simple character set, create a configuration file, `MYSET.xml`, that describes the character set properties. Create this file in the `sql/share/charsets` directory. You can use a copy of `latin1.xml` as the basis for this file. The syntax for the file is very simple:

   - Comments are written as ordinary XML comments (`<!-- text -->`).
   - Words within `<map>` array elements are separated by arbitrary amounts of whitespace.
   - Each word within `<map>` array elements must be a number in hexadecimal format.
   - The `<map>` array element for the `<ctype>` element has 257 words. The other `<map>` array elements after that have 256 words. See Section 9.3.1, “Character Definition Arrays”.
   - For each collation listed in the `<charset>` element for the character set in `Index.xml`, `MYSET.xml` must contain a `<collation>` element that defines the character ordering.

   For a complex character set, create a C source file that describes the character set properties and defines the support routines necessary to properly perform operations on the character set:

   - Create the file `ctype-MYSET.c` in the `strings` directory. Look at one of the existing `ctype-*.c` files (such as `ctype-big5.c`) to see what needs to be defined. The arrays in your file must have names like `ctype_MYSET`, `to_lower_MYSET`, and so on. These correspond to the arrays for a simple character set. See Section 9.3.1, “Character Definition Arrays”.
   - For each `<collation>` element listed in the `<charset>` element for the character set in `Index.xml`, the `ctype-MYSET.c` file must provide an implementation of the collation.
   - If the character set requires string collating functions, see Section 9.3.2, “String Collating Support for Complex Character Sets”.
   - If the character set requires multi-byte character support, see Section 9.3.3, “Multi-Byte Character Support for Complex Character Sets”.

3. Modify the configuration information. Use the existing configuration information as a guide to adding information for `MYSYS`. The example here assumes that the character set has default and binary collations, but more lines are needed if `MYSET` has additional collations.

   a. Edit `mysys/charset-def.c`, and “register” the collations for the new character set.

      Add these lines to the “declaration” section:

      ```
      #ifdef HAVE_CHARSET_MYSET
      extern CHARSET_INFO my_charset_MYSET_general_ci;
      extern CHARSET_INFO my_charset_MYSET_bin;
      #endif
      ```

      Add these lines to the “registration” section:

      ```
      #ifdef HAVE_CHARSET_MYSET
        add_compiled_collation(&my_charset_MYSET_general_ci);
        add_compiled_collation(&my_charset_MYSET_bin);
      #endif
      ```

   b. If the character set uses `ctype-MYSET.c`, edit `strings/CMakeLists.txt` and add `ctype-MYSET.c` to the definition of the `STRINGS_SOURCES` variable.

   c. Edit `cmake/character_sets.cmake`:

      i. Add *`MYSET`* to the value of with `CHARSETS_AVAILABLE` in alphabetic order.

      ii. Add *`MYSET`* to the value of `CHARSETS_COMPLEX` in alphabetic order. This is needed even for simple character sets, or `CMake` will not recognize `-DDEFAULT_CHARSET=`*`MYSET`*.

4. Reconfigure, recompile, and test.

9.3.1. Character Definition Arrays

Each simple character set has a configuration file located in the `sql/share/charsets` directory. For a character set named *`MYSYS`*, the file is named *`MYSET`*`.xml`. It uses `<map>` array elements to list character set properties. `<map>` elements appear within these elements:

- `<ctype>` defines attributes for each character.
- `<lower>` and `<upper>` list the lowercase and uppercase characters.
- `<unicode>` maps 8-bit character values to Unicode values.
- `<collation>` elements indicate character ordering for comparisons and sorts, one element per collation. Binary collations need no `<map>` element because the character codes themselves provide the ordering.

For a complex character set as implemented in a `ctype-`*`MYSET`*`.c` file in the `strings` directory, there are corresponding arrays: `ctype_`*`MYSET`*`[]`, `to_lower_`*`MYSET`*`[]`, and so forth. Not every complex character set has all of the arrays. See also the existing `ctype-*.c` files for examples. See the `CHARSET_INFO.txt` file in the `strings` directory for additional information.

Most of the arrays are indexed by character value and have 256 elements. The `<ctype>` array is indexed by character value + 1 and has 257 elements. This is a legacy convention for handling `EOF`.

`<ctype>` array elements are bit values. Each element describes the attributes of a single character in the character set. Each attribute is associated with a bitmask, as defined in `include/m_ctype.h`:

```
#define _MY_U   01      /* Upper case */
#define _MY_L   02      /* Lower case */
#define _MY_NMR 04      /* Numeral (digit) */
#define _MY_SPC 010     /* Spacing character */
#define _MY_PNT 020     /* Punctuation */
#define _MY_CTR 040     /* Control character */
#define _MY_B   0100    /* Blank */
#define _MY_X   0200    /* heXadecimal digit */
```

The `<ctype>` value for a given character should be the union of the applicable bitmask values that describe the character. For example, `'A'` is an uppercase character (`_MY_U`) as well as a hexadecimal digit (`_MY_X`), so its `ctype` value should be defined like this:

```
ctype['A'+1] = _MY_U | _MY_X = 01 | 0200 = 0201
```

The bitmask values in `m_ctype.h` are octal values, but the elements of the `<ctype>` array in *`MYSET`*`.xml` should be written as hexadecimal values.

The `<lower>` and `<upper>` arrays hold the lowercase and uppercase characters corresponding to each member of the character set. For example:

```
lower['A'] should contain 'a'
upper['a'] should contain 'A'
```

Each `<collation>` array indicates how characters should be ordered for comparison and sorting purposes. MySQL sorts characters based on the values of this information. In some cases, this is the same as the `<upper>` array, which means that sorting is case-insensitive. For more complicated sorting rules (for complex character sets), see the discussion of string collating in Section 9.3.2, “String Collating Support for Complex Character Sets”.

9.3.2. String Collating Support for Complex Character Sets

For a simple character set named *`MYSET`*, sorting rules are specified in the *`MYSET`*`.xml` configuration file using `<map>` array elements within `<collation>` elements. If the sorting rules for your language are too complex to be handled with simple arrays, you must define string collating functions in the `ctype-MYSET.c` source file in the `strings` directory.

The existing character sets provide the best documentation and examples to show how these functions are implemented. Look at the `ctype-*.c` files in the `strings` directory, such as the files for the `big5`, `czech`, `gbk`, `sjis`, and `tis160` character sets. Take a look at the `MY_COLLATION_HANDLER` structures to see how they are used. See also the `CHARSET_INFO.txt` file in the `strings` directory for additional information.

9.3.3. Multi-Byte Character Support for Complex Character Sets

If you want to add support for a new character set named *`MYSET`* that includes multi-byte characters, you must use multi-byte character functions in the `ctype-MYSET.c` source file in the `strings` directory.

The existing character sets provide the best documentation and examples to show how these functions are implemented. Look at the `ctype-*.c` files in the `strings` directory, such as the files for the `euc_kr`, `gb2312`, `gbk`, `sjis`, and `ujis` character sets. Take a look at the `MY_CHARSET_HANDLER` structures to see how they are used. See also the `CHARSET_INFO.txt` file in the `strings` directory for additional information.

9.4. Adding a Collation to a Character Set

A collation is a set of rules that defines how to compare and sort character strings. Each collation in MySQL belongs to a single character set. Every character set has at least one collation, and most have two or more collations.

A collation orders characters based on weights. Each character in a character set maps to a weight. Characters with equal weights compare as equal, and characters with unequal weights compare according to the relative magnitude of their weights.

MySQL supports several collation implementations, as discussed in Section 9.4.1, “Collation Implementation Types”. Some of these can be added to MySQL without recompiling:

- Simple collations for 8-bit character sets
- UCA-based collations for Unicode character sets
- Binary (`xxx_bin`) collations

The following sections describe how to add collations of the first two types to existing character sets. All existing character sets already have a binary collation, so there is no need here to describe how to add one.

Summary of the procedure for adding a new collation:

1. Choose a collation ID
2. Add configuration information that names the collation and describes the character-ordering rules
3. Restart the server
4. Verify that the collation is present

The instructions here cover only collations that can be added without recompiling MySQL. To add a collation that does require recompiling (as implemented by means of functions in a C source file), use the instructions in Section 9.3, “Adding a Character Set”. However, instead of adding all the information required for a complete character set, just modify the appropriate files for an existing character set. That is, based on what is already present for the character set's current collations, add data structures, functions, and configuration information for the new collation.

> **Note**
>
> If you modify an existing collation, that may affect the ordering of rows for indexes on columns that use the collation. In this case, rebuild any such indexes to avoid problems such as incorrect query results. For further information, see Section 2.11.3, “Checking Whether Tables or Indexes Must Be Rebuilt”.

Additional Resources

- The Unicode Collation Algorithm (UCA) specification: http://www.unicode.org/reports/tr10/
- The Locale Data Markup Language (LDML) specification: http://www.unicode.org/reports/tr35/

- MySQL University session “How to Add a Collation”: http://forge.mysql.com/wiki/How_to_Add_a_Collation
- MySQL Blog article “Instructions for adding a new Unicode collation”: http://blogs.mysql.com/peterg/2008/05/19/instructions-for-adding-a-new-unicode-collation/

9.4.1. Collation Implementation Types

MySQL implements several types of collations:

Simple collations for 8-bit character sets

This kind of collation is implemented using an array of 256 weights that defines a one-to-one mapping from character codes to weights. `latin1_swedish_ci` is an example. It is a case-insensitive collation, so the uppercase and lowercase versions of a character have the same weights and they compare as equal.

```
mysql> SET NAMES 'latin1' COLLATE 'latin1_swedish_ci';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT 'a' = 'A';
+-----------+
| 'a' = 'A' |
+-----------+
|         1 |
+-----------+
1 row in set (0.00 sec)
```

For implementation instructions, see Section 9.4.3, “Adding a Simple Collation to an 8-Bit Character Set”.

Complex collations for 8-bit character sets

This kind of collation is implemented using functions in a C source file that define how to order characters, as described in Section 9.3, “Adding a Character Set”.

Collations for non-Unicode multi-byte character sets

For this type of collation, 8-bit (single-byte) and multi-byte characters are handled differently. For 8-bit characters, character codes map to weights in case-insensitive fashion. (For example, the single-byte characters `'a'` and `'A'` both have a weight of `0x41`.) For multi-byte characters, there are two types of relationship between character codes and weights:

- Weights equal character codes. `sjis_japanese_ci` is an example of this kind of collation. The multi-byte character `'ぢ'` has a character code of `0x82C0`, and the weight is also `0x82C0`.
- Character codes map one-to-one to weights, but a code is not necessarily equal to the weight. `gbk_chinese_ci` is an example of this kind of collation. The multi-byte character `'膰'` has a character code of `0x81B0` but a weight of `0xC286`.

For implementation instructions, see Section 9.3, “Adding a Character Set”.

Collations for Unicode multi-byte character sets

Some of these collations are based on the Unicode Collation Algorithm (UCA), others are not.

Non-UCA collations have a one-to-one mapping from character code to weight. In MySQL, such collations are case insensitive and accent insensitive. `utf8_general_ci` is an example: `'a'`, `'A'`, `'À'`, and `'á'` each have different character codes but all have a weight of `0x0041` and compare as equal.

```
mysql> SET NAMES 'utf8' COLLATE 'utf8_general_ci';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT 'a' = 'A', 'a' = 'À', 'a' = 'á';
+-----------+-----------+-----------+
| 'a' = 'A' | 'a' = 'À' | 'a' = 'á' |
+-----------+-----------+-----------+
|         1 |         1 |         1 |
+-----------+-----------+-----------+
1 row in set (0.06 sec)
```

UCA-based collations in MySQL have these properties:

- If a character has weights, each weight uses 2 bytes (16 bits)
- A character may have zero weights (or an empty weight). In this case, the character is ignorable. Example: "U+0000 NULL"

does not have a weight and is ignorable.

- A character may have one weight. Example: `'a'` has a weight of `0x0E33`.
- A character may have many weights. This is an expansion. Example: The German letter `'ß'` (SZ ligature, or SHARP S) has a weight of `0x0FEA0FEA`.
- Many characters may have one weight. This is a contraction. Example: `'ch'` is a single letter in Czech and has a weight of `0x0EE2`.

A many-characters-to-many-weights mapping is also possible (this is contraction with expansion), but is not supported by MySQL.

For implementation instructions, for a non-UCA colluation, see Section 9.3, “Adding a Character Set”. For a UCA collation, see Section 9.4.4, “Adding a UCA Collation to a Unicode Character Set”.

Miscellaneous collations

There are also a few collations that do not fall into any of the previous categories.

9.4.2. Choosing a Collation ID

Each collation must have a unique ID. To add a collation, you must choose an ID value that is not currently used. The range of IDs from 1024 to 2047 is reserved for user-defined collations. Before MySQL 5.5, the ID must be chosen from the range 1 to 254. The collation ID that you choose will appear in these contexts:

- The `ID` column of the `INFORMATION_SCHEMA.COLLATIONS` table
- The `Id` column of `SHOW COLLATION` output
- The `charsetnr` member of the `MYSQL_FIELD` C API data structure
- The `number` member of the `MY_CHARSET_INFO` data structure returned by the `mysql_get_character_set_info()` C API function

To determine the largest currently used ID, issue the following statement:

```
mysql> SELECT MAX(ID) FROM INFORMATION_SCHEMA.COLLATIONS;
+---------+
| MAX(ID) |
+---------+
|     210 |
+---------+
```

To display a list of all currently used IDs, issue this statement:

```
mysql> SELECT ID FROM INFORMATION_SCHEMA.COLLATIONS ORDER BY ID;
+-----+
| ID  |
+-----+
|   1 |
|   2 |
| ... |
|  52 |
|  53 |
|  57 |
|  58 |
| ... |
|  98 |
|  99 |
| 128 |
| 129 |
| ... |
| 210 |
+-----+
```

> **Warning**
>
> Before MySQL 5.5, which provides for a range of user-defined collation IDs, you must choose an ID in the range from 1 to 254. In this case, if you upgrade MySQL, you may find that the collation ID you choose has been assigned to a collation included in the new MySQL distribution. In this case, you will need to choose a new value for your own collation.
>
> In addition, before upgrading, you should save the configuration files that you change. If you upgrade in place, the

process will replace the your modified files.

9.4.3. Adding a Simple Collation to an 8-Bit Character Set

This section describes how to add a simple collation for an 8-bit character set by writing the `<collation>` elements associated with a `<charset>` character set description in the MySQL `Index.xml` file. The procedure described here does not require recompiling MySQL. The example adds a collation named `latin1_test_ci` to the `latin1` character set.

1. Choose a collation ID, as shown in Section 9.4.2, “Choosing a Collation ID”. The following steps use an ID of 1024.

2. Modify the `Index.xml` and `latin1.xml` configuration files. These files will be located in the directory named by the `character_sets_dir` system variable. You can check the variable value as follows, although the path name might be different on your system:

```
mysql> SHOW VARIABLES LIKE 'character_sets_dir';
+--------------------+-----------------------------------------+
| Variable_name      | Value                                   |
+--------------------+-----------------------------------------+
| character_sets_dir | /user/local/mysql/share/mysql/charsets/ |
+--------------------+-----------------------------------------+
```

3. Choose a name for the collation and list it in the `Index.xml` file. Find the `<charset>` element for the character set to which the collation is being added, and add a `<collation>` element that indicates the collation name and ID, to associate the name with the ID. For example:

```
<charset name="latin1">
  ...
  <collation name="latin1_test_ci" id="1024"/>
  ...
</charset>
```

4. In the `latin1.xml` configuration file, add a `<collation>` element that names the collation and that contains a `<map>` element that defines a character code-to-weight mapping table for character codes 0 to 255. Each value within the `<map>` element must be a number in hexadecimal format.

```
<collation name="latin1_test_ci">
<map>
 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
 60 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
 50 51 52 53 54 55 56 57 58 59 5A 7B 7C 7D 7E 7F
 80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
 90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
 B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
 41 41 41 41 5B 5D 5B 43 45 45 45 45 49 49 49 49
 44 4E 4F 4F 4F 4F 5C D7 5C 55 55 55 59 59 DE DF
 41 41 41 41 5B 5D 5B 43 45 45 45 45 49 49 49 49
 44 4E 4F 4F 4F 4F 5C F7 5C 55 55 55 59 59 DE FF
</map>
</collation>
```

5. Restart the server and use this statement to verify that the collation is present:

```
mysql> SHOW COLLATION LIKE 'latin1_test_ci';
+----------------+---------+------+---------+----------+---------+
| Collation      | Charset | Id   | Default | Compiled | Sortlen |
+----------------+---------+------+---------+----------+---------+
| latin1_test_ci | latin1  | 1024 |         |          |       1 |
+----------------+---------+------+---------+----------+---------+
```

9.4.4. Adding a UCA Collation to a Unicode Character Set

This section describes how to add a UCA collation for a Unicode character set by writing the `<collation>` element within a `<charset>` character set description in the MySQL `Index.xml` file. The procedure described here does not require recompiling MySQL. It uses a subset of the Locale Data Markup Language (LDML) specification, which is available at http://www.unicode.org/reports/tr35/. With this method, you need not define the entire collation. Instead, you begin with an existing “base” collation and describe the new collation in terms of how it differs from the base collation. The following table lists the base collations of the Unicode character sets for which UCA collations can be defined.

Table 9.1. MySQL Character Sets Available for User-Defined UCA Collations

Character Set	Base Collation
`utf8`	`utf8_unicode_ci`
`ucs2`	`ucs2_unicode_ci`
`utf16`	`utf16_unicode_ci`
`utf32`	`utf32_unicode_ci`

The following sections show how to add a collation that is defined using LDML syntax, and provide a summary of LDML rules supported in MySQL.

9.4.4.1. Defining a UCA Collation using LDML Syntax

To add a UCA collation for a Unicode character set without recompiling MySQL, use the following procedure. If you are unfamiliar with the LDML rules used to describe the collation's sort characteristics, see Section 9.4.4.2, “LDML Syntax Supported in MySQL”.

The example adds a collation named `utf8_phone_ci` to the `utf8` character set. The collation is designed for a scenario involving a Web application for which users post their names and phone numbers. Phone numbers can be given in very different formats:

```
+7-12345-67
+7-12-345-67
+7 12 345 67
+7 (12) 345 67
+71234567
```

The problem raised by dealing with these kinds of values is that the varying permissible formats make searching for a specific phone number very difficult. The solution is to define a new collation that reorders punctuation characters, making them ignorable.

1. Choose a collation ID, as shown in Section 9.4.2, “Choosing a Collation ID”. The following steps use an ID of 1029.

2. To modify the `Index.xml` configuration file. This file will be located in the directory named by the `character_sets_dir` system variable. You can check the variable value as follows, although the path name might be different on your system:

   ```
   mysql> SHOW VARIABLES LIKE 'character_sets_dir';
   +--------------------+-----------------------------------------+
   | Variable_name      | Value                                   |
   +--------------------+-----------------------------------------+
   | character_sets_dir | /user/local/mysql/share/mysql/charsets/ |
   +--------------------+-----------------------------------------+
   ```

3. Choose a name for the collation and list it in the `Index.xml` file. In addition, you'll need to provide the collation ordering rules. Find the `<charset>` element for the character set to which the collation is being added, and add a `<collation>` element that indicates the collation name and ID, to associate the name with the ID. Within the `<collation>` element, provide a `<rules>` element containing the ordering rules:

   ```
   <charset name="utf8">
     ...
     <collation name="utf8_phone_ci" id="1029">
       <rules>
         <reset>\u0000</reset>
         <i>\u0020</i> <!-- space -->
         <i>\u0028</i> <!-- left parenthesis -->
         <i>\u0029</i> <!-- right parenthesis -->
         <i>\u002B</i> <!-- plus -->
         <i>\u002D</i> <!-- hyphen -->
       </rules>
     </collation>
     ...
   </charset>
   ```

4. If you want a similar collation for other Unicode character sets, add other `<collation>` elements. For example, to define `ucs2_phone_ci`, add a `<collation>` element to the `<charset name="ucs2">` element. Remember that each collation must have its own unique ID.

5. Restart the server and use this statement to verify that the collation is present:

   ```
   mysql> SHOW COLLATION LIKE 'utf8_phone_ci';
   +---------------+---------+------+---------+----------+---------+
   ```

```
| Collation     | Charset | Id   | Default | Compiled | Sortlen |
+---------------+---------+------+---------+----------+---------+
| utf8_phone_ci | utf8    | 1029 |         |          |       8 |
+---------------+---------+------+---------+----------+---------+
```

Now test the collation to make sure that it has the desired properties.

Create a table containing some sample phone numbers using the new collation:

```
mysql> CREATE TABLE phonebook (
    ->   name VARCHAR(64),
    ->   phone VARCHAR(64) CHARACTER SET utf8 COLLATE utf8_phone_ci
    -> );
Query OK, 0 rows affected (0.09 sec)

mysql> INSERT INTO phonebook VALUES ('Svoj','+7 912 800 80 02');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO phonebook VALUES ('Hf','+7 (912) 800 80 04');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO phonebook VALUES ('Bar','+7-912-800-80-01');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO phonebook VALUES ('Ramil','(7912) 800 80 03');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO phonebook VALUES ('Sanja','+380 (912) 8008005');
Query OK, 1 row affected (0.00 sec)
```

Run some queries to see whether the ignored punctuation characters are in fact ignored for sorting and comparisons:

```
mysql> SELECT * FROM phonebook ORDER BY phone;
+-------+--------------------+
| name  | phone              |
+-------+--------------------+
| Sanja | +380 (912) 8008005 |
| Bar   | +7-912-800-80-01   |
| Svoj  | +7 912 800 80 02   |
| Ramil | (7912) 800 80 03   |
| Hf    | +7 (912) 800 80 04 |
+-------+--------------------+
5 rows in set (0.00 sec)

mysql> SELECT * FROM phonebook WHERE phone='+7(912)800-80-01';
+------+------------------+
| name | phone            |
+------+------------------+
| Bar  | +7-912-800-80-01 |
+------+------------------+
1 row in set (0.00 sec)

mysql> SELECT * FROM phonebook WHERE phone='79128008001';
+------+------------------+
| name | phone            |
+------+------------------+
| Bar  | +7-912-800-80-01 |
+------+------------------+
1 row in set (0.00 sec)

mysql> SELECT * FROM phonebook WHERE phone='7 9 1 2 8 0 0 8 0 0 1';
+------+------------------+
| name | phone            |
+------+------------------+
| Bar  | +7-912-800-80-01 |
+------+------------------+
1 row in set (0.00 sec)
```

9.4.4.2. LDML Syntax Supported in MySQL

This section describes the LDML syntax that MySQL recognizes. This is a subset of the syntax described in the LDML specification available at http://www.unicode.org/reports/tr35/, which should be consulted for further information. The rules described here are all supported except that character sorting occurs only at the primary level. Rules that specify differences at secondary or higher sort levels are recognized (and thus can be included in collation definitions) but are treated as equality at the primary level.

Character Representation

Characters named in LDML rules can be written in `\unnnn` format, where `nnnn` is the hexadecimal Unicode code point value. Within hexadecimal values, the digits `A` through `F` are not case sensitive; `\u00E1` and `\u00e1` are equivalent. Basic Latin letters `A-Z` and `a-z` can also be written literally (this is a MySQL limitation; the LDML specification permits literal non-Latin1 characters in the rules). Only characters in the Basic Multilingual Plane can be specified. This notation does not apply to characters outside the BMP range of `0000` to `FFFF`.

The `Index.xml` file itself should be written using ASCII encoding.

Syntax Rules

LDML has reset rules and shift rules to specify character ordering. Orderings are given as a set of rules that begin with a reset rule that establishes an anchor point, followed by shift rules that indicate how characters sort relative to the anchor point.

- A `<reset>` rule does not specify any ordering in and of itself. Instead, it “resets” the ordering for subsequent shift rules to cause them to be taken in relation to a given character. Either of the following rules resets subsequent shift rules to be taken in relation to the letter `'A'`:

  ```
  <reset>A</reset>

  <reset>\u0041</reset>
  ```

- The `<p>`, `<s>`, and `<t>` shift rules define primary, secondary, and tertiary differences of a character from another character:

  - Use primary differences to distinguish separate letters.
  - Use secondary differences to distinguish accent variations.
  - Use tertiary differences to distinguish lettercase variations.

  Either of these rules specifies a primary shift rule for the `'G'` character:

  ```
  <p>G</p>

  <p>\u0047</p>
  ```

- The `<i>` shift rule indicates that one character sorts identically to another. The following rules cause `'b'` to sort the same as `'a'`:

  ```
  <reset>a</reset>
  <i>b</i>
  ```

  The `<i>` shift rules is supported as of MySQL 5.5.3. Prior to 5.5.3, use `<s> ... </s>` instead.

9.5. Character Set Configuration

You can change the default server character set and collation with the `--character-set-server` and `--collation-server` options when you start the server. The collation must be a legal collation for the default character set. (Use the `SHOW COLLATION` statement to determine which collations are available for each character set.) See Section 5.1.2, “Server Command Options”.

If you try to use a character set that is not compiled into your binary, you might run into the following problems:

- Your program uses an incorrect path to determine where the character sets are stored (which is typically the `share/mysql/charsets` or `share/charsets` directory under the MySQL installation directory). This can be fixed by using the `--character-sets-dir` option when you run the program in question. For example, to specify a directory to be used by MySQL client programs, list it in the `[client]` group of your option file. The examples given here show what the setting might look like for Unix or Windows, respectively:

  ```
  [client]
  character-sets-dir=/usr/local/mysql/share/mysql/charsets

  [client]
  character-sets-dir="C:/Program Files/MySQL/MySQL Server 5.5/share/charsets"
  ```

- The character set is a complex character set that cannot be loaded dynamically. In this case, you must recompile the program with support for the character set.

  For Unicode character sets, you can define collations without recompiling by using LDML notation. See Section 9.4.4, “Adding a UCA Collation to a Unicode Character Set”.

- The character set is a dynamic character set, but you do not have a configuration file for it. In this case, you should install the configuration file for the character set from a new MySQL distribution.

- If your character set index file does not contain the name for the character set, your program displays an error message. The file is named `Index.xml` and the message is:

```
Character set 'charset_name' is not a compiled character set and is not
specified in the '/usr/share/mysql/charsets/Index.xml' file
```

To solve this problem, you should either get a new index file or manually add the name of any missing character sets to the current file.

You can force client programs to use specific character set as follows:

```
[client]
default-character-set=charset_name
```

This is normally unnecessary. However, when `character_set_system` differs from `character_set_server` or `character_set_client`, and you input characters manually (as database object identifiers, column values, or both), these may be displayed incorrectly in output from the client or the output itself may be formatted incorrectly. In such cases, starting the mysql client with `--default-character-set=system_character_set`—that is, setting the client character set to match the system character set—should fix the problem.

For `MyISAM` tables, you can check the character set name and number for a table with `myisamchk -dvv tbl_name`.

9.6. MySQL Server Time Zone Support

The MySQL server maintains several time zone settings:

- The system time zone. When the server starts, it attempts to determine the time zone of the host machine and uses it to set the `system_time_zone` system variable. The value does not change thereafter.

  You can set the system time zone for MySQL Server at startup with the `--timezone=timezone_name` option to `mysqld_safe`. You can also set it by setting the `TZ` environment variable before you start `mysqld`. The permissible values for `--timezone` or `TZ` are system dependent. Consult your operating system documentation to see what values are acceptable.

- The server's current time zone. The global `time_zone` system variable indicates the time zone the server currently is operating in. The initial value for `time_zone` is `'SYSTEM'`, which indicates that the server time zone is the same as the system time zone.

  The initial global server time zone value can be specified explicitly at startup with the `--default-time-zone=timezone` option on the command line, or you can use the following line in an option file:

  ```
  default-time-zone='timezone'
  ```

  If you have the `SUPER` privilege, you can set the global server time zone value at runtime with this statement:

  ```
  mysql> SET GLOBAL time_zone = timezone;
  ```

- Per-connection time zones. Each client that connects has its own time zone setting, given by the session `time_zone` variable. Initially, the session variable takes its value from the global `time_zone` variable, but the client can change its own time zone with this statement:

  ```
  mysql> SET time_zone = timezone;
  ```

The current session time zone setting affects display and storage of time values that are zone-sensitive. This includes the values displayed by functions such as `NOW()` or `CURTIME()`, and values stored in and retrieved from `TIMESTAMP` columns. Values for `TIMESTAMP` columns are converted from the current time zone to UTC for storage, and from UTC to the current time zone for retrieval.

The current time zone setting does not affect values displayed by functions such as `UTC_TIMESTAMP()` or values in `DATE`, `TIME`, or `DATETIME` columns. Nor are values in those data types stored in UTC; the time zone applies for them only when converting from `TIMESTAMP` values. If you want locale-specific arithmetic for `DATE`, `TIME`, or `DATETIME` values, convert them to UTC, perform the arithmetic, and then convert back.

The current values of the global and client-specific time zones can be retrieved like this:

```
mysql> SELECT @@global.time_zone, @@session.time_zone;
```

`timezone` values can be given in several formats, none of which are case sensitive:

- The value `'SYSTEM'` indicates that the time zone should be the same as the system time zone.
- The value can be given as a string indicating an offset from UTC, such as `'+10:00'` or `'-6:00'`.
- The value can be given as a named time zone, such as `'Europe/Helsinki'`, `'US/Eastern'`, or `'MET'`. Named time zones can be used only if the time zone information tables in the `mysql` database have been created and populated.

The MySQL installation procedure creates the time zone tables in the `mysql` database, but does not load them. You must do so manually using the following instructions. (If you are upgrading to MySQL 4.1.3 or later from an earlier version, you can create the tables by upgrading your `mysql` database. Use the instructions in Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”. After creating the tables, you can load them.)

> **Note**
>
> Loading the time zone information is not necessarily a one-time operation because the information changes occasionally. For example, the rules for Daylight Saving Time in the United States, Mexico, and parts of Canada changed in 2007. When such changes occur, applications that use the old rules become out of date and you may find it necessary to reload the time zone tables to keep the information used by your MySQL server current. See the notes at the end of this section.

If your system has its own *zoneinfo* database (the set of files describing time zones), you should use the `mysql_tzinfo_to_sql` program for filling the time zone tables. Examples of such systems are Linux, FreeBSD, Solaris, and Mac OS X. One likely location for these files is the `/usr/share/zoneinfo` directory. If your system does not have a zoneinfo database, you can use the downloadable package described later in this section.

The `mysql_tzinfo_to_sql` program is used to load the time zone tables. On the command line, pass the zoneinfo directory path name to `mysql_tzinfo_to_sql` and send the output into the `mysql` program. For example:

```
shell> mysql_tzinfo_to_sql /usr/share/zoneinfo | mysql -u root mysql
```

`mysql_tzinfo_to_sql` reads your system's time zone files and generates SQL statements from them. `mysql` processes those statements to load the time zone tables.

`mysql_tzinfo_to_sql` also can be used to load a single time zone file or to generate leap second information:

- To load a single time zone file *`tz_file`* that corresponds to a time zone name *`tz_name`*, invoke `mysql_tzinfo_to_sql` like this:

  ```
  shell> mysql_tzinfo_to_sql tz_file tz_name | mysql -u root mysql
  ```

  With this approach, you must execute a separate command to load the time zone file for each named zone that the server needs to know about.

- If your time zone needs to account for leap seconds, initialize the leap second information like this, where *`tz_file`* is the name of your time zone file:

  ```
  shell> mysql_tzinfo_to_sql --leap tz_file | mysql -u root mysql
  ```

- After running `mysql_tzinfo_to_sql`, it is best to restart the server so that it does not continue to use any previously cached time zone data.

If your system is one that has no zoneinfo database (for example, Windows or HP-UX), you can use the package of pre-built time zone tables that is available for download at the MySQL Developer Zone:

```
http://dev.mysql.com/downloads/timezones.html
```

This time zone package contains `.frm`, `.MYD`, and `.MYI` files for the `MyISAM` time zone tables. These tables should be part of the `mysql` database, so you should place the files in the `mysql` subdirectory of your MySQL server's data directory. The server should be stopped while you do this and restarted afterward.

> **Warning**
>
> Do not use the downloadable package if your system has a zoneinfo database. Use the `mysql_tzinfo_to_sql`

> utility instead. Otherwise, you may cause a difference in datetime handling between MySQL and other applications on your system.

For information about time zone settings in replication setup, please see Section 15.4.1, “Replication Features and Issues”.

9.6.1. Staying Current with Time Zone Changes

As mentioned earlier, when the time zone rules change, applications that use the old rules become out of date. To stay current, it is necessary to make sure that your system uses current time zone information is used. For MySQL, there are two factors to consider in staying current:

- The operating system time affects the value that the MySQL server uses for times if its time zone is set to `SYSTEM`. Make sure that your operating system is using the latest time zone information. For most operating systems, the latest update or service pack prepares your system for the time changes. Check the Web site for your operating system vendor for an update that addresses the time changes.
- If you replace the system's `/etc/localtime` timezone file with a version that uses rules differing from those in effect at `mysqld` startup, you should restart `mysqld` so that it uses the updated rules. Otherwise, `mysqld` might not notice when the system changes its time.
- If you use named time zones with MySQL, make sure that the time zone tables in the `mysql` database are up to date. If your system has its own zoneinfo database, you should reload the MySQL time zone tables whenever the zoneinfo database is updated, using the instructions given earlier in this section. For systems that do not have their own zoneinfo database, check the MySQL Developer Zone for updates. When a new update is available, download it and use it to replace your current time zone tables. `mysqld` caches time zone information that it looks up, so after replacing the time zone tables, you should restart `mysqld` to make sure that it does not continue to serve outdated time zone data.

If you are uncertain whether named time zones are available, for use either as the server's time zone setting or by clients that set their own time zone, check whether your time zone tables are empty. The following query determines whether the table that contains time zone names has any rows:

```
mysql> SELECT COUNT(*) FROM mysql.time_zone_name;
+----------+
| COUNT(*) |
+----------+
|        0 |
+----------+
```

A count of zero indicates that the table is empty. In this case, no one can be using named time zones, and you don't need to update the tables. A count greater than zero indicates that the table is not empty and that its contents are available to be used for named time zone support. In this case, you should be sure to reload your time zone tables so that anyone who uses named time zones will get correct query results.

To check whether your MySQL installation is updated properly for a change in Daylight Saving Time rules, use a test like the one following. The example uses values that are appropriate for the 2007 DST 1-hour change that occurs in the United States on March 11 at 2 a.m.

The test uses these two queries:

```
SELECT CONVERT_TZ('2007-03-11 2:00:00','US/Eastern','US/Central');
SELECT CONVERT_TZ('2007-03-11 3:00:00','US/Eastern','US/Central');
```

The two time values indicate the times at which the DST change occurs, and the use of named time zones requires that the time zone tables be used. The desired result is that both queries return the same result (the input time, converted to the equivalent value in the 'US/Central' time zone).

Before updating the time zone tables, you would see an incorrect result like this:

```
mysql> SELECT CONVERT_TZ('2007-03-11 2:00:00','US/Eastern','US/Central');
+------------------------------------------------------------+
| CONVERT_TZ('2007-03-11 2:00:00','US/Eastern','US/Central') |
+------------------------------------------------------------+
| 2007-03-11 01:00:00                                        |
+------------------------------------------------------------+

mysql> SELECT CONVERT_TZ('2007-03-11 3:00:00','US/Eastern','US/Central');
+------------------------------------------------------------+
| CONVERT_TZ('2007-03-11 3:00:00','US/Eastern','US/Central') |
+------------------------------------------------------------+
| 2007-03-11 02:00:00                                        |
+------------------------------------------------------------+
```

After updating the tables, you should see the correct result:

```
mysql> SELECT CONVERT_TZ('2007-03-11 2:00:00','US/Eastern','US/Central');
+------------------------------------------------------------+
| CONVERT_TZ('2007-03-11 2:00:00','US/Eastern','US/Central') |
+------------------------------------------------------------+
| 2007-03-11 01:00:00                                        |
+------------------------------------------------------------+

mysql> SELECT CONVERT_TZ('2007-03-11 3:00:00','US/Eastern','US/Central');
+------------------------------------------------------------+
| CONVERT_TZ('2007-03-11 3:00:00','US/Eastern','US/Central') |
+------------------------------------------------------------+
| 2007-03-11 01:00:00                                        |
+------------------------------------------------------------+
```

9.6.2. Time Zone Leap Second Support

In MySQL 5.5, leap second values are returned with a time part that ends with `:59:59`. This means that a function such as `NOW()` can return the same value for two or three consecutive seconds during the leap second. It remains true that literal temporal values having a time part that ends with `:59:60` or `:59:61` are considered invalid.

If it is necessary to search for `TIMESTAMP` values one second before the leap second, anomalous results may be obtained if you use a comparison with `'YYYY-MM-DD hh:mm:ss'` values:

```
mysql> CREATE TABLE t1 (a INT, ts TIMESTAMP DEFAULT NOW(), PRIMARY KEY (ts));
Query OK, 0 rows affected (0.11 sec)

mysql> # Simulate NOW() = '2009-01-01 02:59:59'
mysql> SET timestamp = 1230768022;
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO t1 (a) VALUES (1);
Query OK, 1 row affected (0.07 sec)

mysql> # Simulate NOW() = '2009-01-01 02:59:60'
mysql> SET timestamp = 1230768023;
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO t1 (a) VALUES (2);
Query OK, 1 row affected (0.02 sec)

mysql> SELECT * FROM t1;
+------+---------------------+
| a    | ts                  |
+------+---------------------+
|    1 | 2008-12-31 18:00:22 |
|    2 | 2008-12-31 18:00:23 |
+------+---------------------+
2 rows in set (0.02 sec)

mysql> SELECT * FROM t1 WHERE ts = '2009-01-01 02:59:59';
Empty set (0.03 sec)
```

To work around this, you can use a comparison based on the UTC value actually stored in column, which has the leap second correction applied:

```
mysql> SELECT * FROM t1 WHERE UNIX_TIMESTAMP(ts) = 1230768023;
+------+---------------------+
| a    | ts                  |
+------+---------------------+
|    2 | 2008-12-31 18:00:23 |
+------+---------------------+
1 row in set (0.02 sec)
```

9.7. MySQL Server Locale Support

The locale indicated by the `lc_time_names` system variable controls the language used to display day and month names and abbreviations. This variable affects the output from the `DATE_FORMAT()`, `DAYNAME()`, and `MONTHNAME()` functions.

The `lc_time_names` value does not affect the result from `FORMAT()`, but this function takes an optional third parameter that enables a locale to be specified to be used for the result number's decimal point, thousands separator, and grouping between separators. Permissible locale values are the same as the legal values for the `lc_time_names` system variable.

Locale names have language and region subtags listed by IANA (http://www.iana.org/assignments/language-subtag-registry) such as `'ja_JP'` or `'pt_BR'`. The default value is `'en_US'` regardless of your system's locale setting, but you can set the value at server startup or set the `GLOBAL` value if you have the `SUPER` privilege. Any client can examine the value of `lc_time_names` or set its `SESSION` value to affect the locale for its own connection.

```
mysql> SET NAMES 'utf8';
Query OK, 0 rows affected (0.09 sec)

mysql> SELECT @@lc_time_names;
```

```
+-----------------+
| @@lc_time_names |
+-----------------+
| en_US           |
+-----------------+
1 row in set (0.00 sec)

mysql> SELECT DAYNAME('2010-01-01'), MONTHNAME('2010-01-01');
+-----------------------+-------------------------+
| DAYNAME('2010-01-01') | MONTHNAME('2010-01-01') |
+-----------------------+-------------------------+
| Friday                | January                 |
+-----------------------+-------------------------+
1 row in set (0.00 sec)

mysql> SELECT DATE_FORMAT('2010-01-01','%W %a %M %b');
+-----------------------------------------+
| DATE_FORMAT('2010-01-01','%W %a %M %b') |
+-----------------------------------------+
| Friday Fri January Jan                  |
+-----------------------------------------+
1 row in set (0.00 sec)

mysql> SET lc_time_names = 'es_MX';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @@lc_time_names;
+-----------------+
| @@lc_time_names |
+-----------------+
| es_MX           |
+-----------------+
1 row in set (0.00 sec)

mysql> SELECT DAYNAME('2010-01-01'), MONTHNAME('2010-01-01');
+-----------------------+-------------------------+
| DAYNAME('2010-01-01') | MONTHNAME('2010-01-01') |
+-----------------------+-------------------------+
| viernes               | enero                   |
+-----------------------+-------------------------+
1 row in set (0.00 sec)

mysql> SELECT DATE_FORMAT('2010-01-01','%W %a %M %b');
+-----------------------------------------+
| DATE_FORMAT('2010-01-01','%W %a %M %b') |
+-----------------------------------------+
| viernes vie enero ene                   |
+-----------------------------------------+
1 row in set (0.00 sec)
```

The day or month name for each of the affected functions is converted from `utf8` to the character set indicated by the `character_set_connection` system variable.

`lc_time_names` may be set to any of the following locale values. The set of locales supported by MySQL may differ from those supported by your operating system.

`ar_AE`: Arabic - United Arab Emirates	`ar_BH`: Arabic - Bahrain
`ar_DZ`: Arabic - Algeria	`ar_EG`: Arabic - Egypt
`ar_IN`: Arabic - India	`ar_IQ`: Arabic - Iraq
`ar_JO`: Arabic - Jordan	`ar_KW`: Arabic - Kuwait
`ar_LB`: Arabic - Lebanon	`ar_LY`: Arabic - Libya
`ar_MA`: Arabic - Morocco	`ar_OM`: Arabic - Oman
`ar_QA`: Arabic - Qatar	`ar_SA`: Arabic - Saudi Arabia
`ar_SD`: Arabic - Sudan	`ar_SY`: Arabic - Syria
`ar_TN`: Arabic - Tunisia	`ar_YE`: Arabic - Yemen
`be_BY`: Belarusian - Belarus	`bg_BG`: Bulgarian - Bulgaria
`ca_ES`: Catalan - Spain	`cs_CZ`: Czech - Czech Republic
`da_DK`: Danish - Denmark	`de_AT`: German - Austria
`de_BE`: German - Belgium	`de_CH`: German - Switzerland
`de_DE`: German - Germany	`de_LU`: German - Luxembourg
`EE`: Estonian - Estonia	`el_GR`: Greek - Greece
`en_AU`: English - Australia	`en_CA`: English - Canada
`en_GB`: English - United Kingdom	`en_IN`: English - India
`en_NZ`: English - New Zealand	`en_PH`: English - Philippines
`en_US`: English - United States	`en_ZA`: English - South Africa

`en_ZW`: English - Zimbabwe	`es_AR`: Spanish - Argentina
`es_BO`: Spanish - Bolivia	`es_CL`: Spanish - Chile
`es_CO`: Spanish - Columbia	`es_CR`: Spanish - Costa Rica
`es_DO`: Spanish - Dominican Republic	`es_EC`: Spanish - Ecuador
`es_ES`: Spanish - Spain	`es_GT`: Spanish - Guatemala
`es_HN`: Spanish - Honduras	`es_MX`: Spanish - Mexico
`es_NI`: Spanish - Nicaragua	`es_PA`: Spanish - Panama
`es_PE`: Spanish - Peru	`es_PR`: Spanish - Puerto Rico
`es_PY`: Spanish - Paraguay	`es_SV`: Spanish - El Salvador
`es_US`: Spanish - United States	`es_UY`: Spanish - Uruguay
`es_VE`: Spanish - Venezuela	`eu_ES`: Basque - Basque
`fi_FI`: Finnish - Finland	`fo_FO`: Faroese - Faroe Islands
`fr_BE`: French - Belgium	`fr_CA`: French - Canada
`fr_CH`: French - Switzerland	`fr_FR`: French - France
`fr_LU`: French - Luxembourg	`gl_ES`: Galician - Spain
`gu_IN`: Gujarati - India	`he_IL`: Hebrew - Israel
`hi_IN`: Hindi - India	`hr_HR`: Croatian - Croatia
`hu_HU`: Hungarian - Hungary	`id_ID`: Indonesian - Indonesia
`is_IS`: Icelandic - Iceland	`it_CH`: Italian - Switzerland
`it_IT`: Italian - Italy	`ja_JP`: Japanese - Japan
`ko_KR`: Korean - Republic of Korea	`lt_LT`: Lithuanian - Lithuania
`lv_LV`: Latvian - Latvia	`mk_MK`: Macedonian - FYROM
`mn_MN`: Mongolia - Mongolian	`ms_MY`: Malay - Malaysia
`nb_NO`: Norwegian(Bokmål) - Norway	`nl_BE`: Dutch - Belgium
`nl_NL`: Dutch - The Netherlands	`no_NO`: Norwegian - Norway
`pl_PL`: Polish - Poland	`pt_BR`: Portugese - Brazil
`pt_PT`: Portugese - Portugal	`ro_RO`: Romanian - Romania
`ru_RU`: Russian - Russia	`ru_UA`: Russian - Ukraine
`sk_SK`: Slovak - Slovakia	`sl_SI`: Slovenian - Slovenia
`sq_AL`: Albanian - Albania	`sr_RS`: Serbian - Yugoslavia
`sv_FI`: Swedish - Finland	`sv_SE`: Swedish - Sweden
`ta_IN`: Tamil - India	`te_IN`: Telugu - India
`th_TH`: Thai - Thailand	`tr_TR`: Turkish - Turkey
`uk_UA`: Ukrainian - Ukraine	`ur_PK`: Urdu - Pakistan
`vi_VN`: Vietnamese - Viet Nam	`zh_CN`: Chinese - China
`zh_HK`: Chinese - Hong Kong	`zh_TW`: Chinese - Taiwan Province of China

`lc_time_names` currently does not affect the `STR_TO_DATE()` or `GET_FORMAT()` function.

Chapter 10. Data Types

MySQL supports a number of data types in several categories: numeric types, date and time types, and string (character) types. This chapter first gives an overview of these data types, and then provides a more detailed description of the properties of the types in each category, and a summary of the data type storage requirements. The initial overview is intentionally brief. The more detailed descriptions later in the chapter should be consulted for additional information about particular data types, such as the permissible formats in which you can specify values.

MySQL also supports extensions for handing spatial data. Section 11.17, “Spatial Extensions”, provides information about these data types.

Data type descriptions use these conventions:

- *`M`* indicates the maximum display width for integer types. For floating-point and fixed-point types, *`M`* is the total number of digits that can be stored. For string types, *`M`* is the maximum length. The maximum permissible value of *`M`* depends on the data type.
- *`D`* applies to floating-point and fixed-point types and indicates the number of digits following the decimal point. The maximum possible value is 30, but should be no greater than *`M`*–2.
- Square brackets (“`[`” and “`]`”) indicate optional parts of type definitions.

10.1. Data Type Overview

10.1.1. Overview of Numeric Types

A summary of the numeric data types follows. For additional information about properties of the numeric types, see Section 10.2, “Numeric Types”. Storage requirements are given in Section 10.5, “Data Type Storage Requirements”.

`M` indicates the maximum display width for integer types. The maximum legal display width is 255. Display width is unrelated to the range of values a type can contain, as described in Section 10.2, “Numeric Types”. For floating-point and fixed-point types, *`M`* is the total number of digits that can be stored.

If you specify `ZEROFILL` for a numeric column, MySQL automatically adds the `UNSIGNED` attribute to the column.

Numeric data types that permit the `UNSIGNED` attribute also permit `SIGNED`. However, these data types are signed by default, so the `SIGNED` attribute has no effect.

`SERIAL` is an alias for `BIGINT UNSIGNED NOT NULL AUTO_INCREMENT UNIQUE`.

`SERIAL DEFAULT VALUE` in the definition of an integer column is an alias for `NOT NULL AUTO_INCREMENT UNIQUE`.

> **Warning**
>
> When you use subtraction between integer values where one is of type `UNSIGNED`, the result is unsigned unless the `NO_UNSIGNED_SUBTRACTION` SQL mode is enabled. See Section 11.10, “Cast Functions and Operators”.

- `BIT[(`*`M`*`)]`

  A bit-field type. *`M`* indicates the number of bits per value, from 1 to 64. The default is 1 if *`M`* is omitted.

- `TINYINT[(`*`M`*`)] [UNSIGNED] [ZEROFILL]`

  A very small integer. The signed range is `-128` to `127`. The unsigned range is `0` to `255`.

- `BOOL`, `BOOLEAN`

  These types are synonyms for `TINYINT(1)`. A value of zero is considered false. Nonzero values are considered true:

```
mysql> SELECT IF(0, 'true', 'false');
+------------------------+
| IF(0, 'true', 'false') |
+------------------------+
| false                  |
+------------------------+

mysql> SELECT IF(1, 'true', 'false');
+------------------------+
| IF(1, 'true', 'false') |
+------------------------+
| true                   |
+------------------------+

mysql> SELECT IF(2, 'true', 'false');
+------------------------+
| IF(2, 'true', 'false') |
+------------------------+
| true                   |
+------------------------+
```

However, the values `TRUE` and `FALSE` are merely aliases for `1` and `0`, respectively, as shown here:

```
mysql> SELECT IF(0 = FALSE, 'true', 'false');
+--------------------------------+
| IF(0 = FALSE, 'true', 'false') |
+--------------------------------+
| true                           |
+--------------------------------+

mysql> SELECT IF(1 = TRUE, 'true', 'false');
+-------------------------------+
| IF(1 = TRUE, 'true', 'false') |
+-------------------------------+
| true                          |
+-------------------------------+

mysql> SELECT IF(2 = TRUE, 'true', 'false');
+-------------------------------+
| IF(2 = TRUE, 'true', 'false') |
+-------------------------------+
| false                         |
+-------------------------------+

mysql> SELECT IF(2 = FALSE, 'true', 'false');
+--------------------------------+
| IF(2 = FALSE, 'true', 'false') |
+--------------------------------+
| false                          |
+--------------------------------+
```

The last two statements display the results shown because `2` is equal to neither `1` nor `0`.

- `SMALLINT[(M)] [UNSIGNED] [ZEROFILL]`

  A small integer. The signed range is `-32768` to `32767`. The unsigned range is `0` to `65535`.

- `MEDIUMINT[(M)] [UNSIGNED] [ZEROFILL]`

  A medium-sized integer. The signed range is `-8388608` to `8388607`. The unsigned range is `0` to `16777215`.

- `INT[(M)] [UNSIGNED] [ZEROFILL]`

  A normal-size integer. The signed range is `-2147483648` to `2147483647`. The unsigned range is `0` to `4294967295`.

- `INTEGER[(M)] [UNSIGNED] [ZEROFILL]`

  This type is a synonym for `INT`.

- `BIGINT[(M)] [UNSIGNED] [ZEROFILL]`

  A large integer. The signed range is `-9223372036854775808` to `9223372036854775807`. The unsigned range is `0` to `18446744073709551615`.

  `SERIAL` is an alias for `BIGINT UNSIGNED NOT NULL AUTO_INCREMENT UNIQUE`.

  Some things you should be aware of with respect to `BIGINT` columns:

  - All arithmetic is done using signed `BIGINT` or `DOUBLE` values, so you should not use unsigned big integers larger than `9223372036854775807` (63 bits) except with bit functions! If you do that, some of the last digits in the result may be wrong because of rounding errors when converting a `BIGINT` value to a `DOUBLE`.

    MySQL can handle `BIGINT` in the following cases:

    - When using integers to store large unsigned values in a `BIGINT` column.
    - In `MIN(col_name)` or `MAX(col_name)`, where *`col_name`* refers to a `BIGINT` column.
    - When using operators (`+`, `-`, `*`, and so on) where both operands are integers.

  - You can always store an exact integer value in a `BIGINT` column by storing it using a string. In this case, MySQL performs a string-to-number conversion that involves no intermediate double-precision representation.
  - The `-`, `+`, and `*` operators use `BIGINT` arithmetic when both operands are integer values. This means that if you multiply two big integers (or results from functions that return integers), you may get unexpected results when the result is larger than `9223372036854775807`.

- `FLOAT[(M,D)] [UNSIGNED] [ZEROFILL]`

  A small (single-precision) floating-point number. Permissible values are `-3.402823466E+38` to `-1.175494351E-38`, `0`, and `1.175494351E-38` to `3.402823466E+38`. These are the theoretical limits, based on the IEEE standard. The actual range might be slightly smaller depending on your hardware or operating system.

  `M` is the total number of digits and *`D`* is the number of digits following the decimal point. If *`M`* and *`D`* are omitted, values are stored to the limits permitted by the hardware. A single-precision floating-point number is accurate to approximately 7 decimal places.

  `UNSIGNED`, if specified, disallows negative values.

  Using `FLOAT` might give you some unexpected problems because all calculations in MySQL are done with double precision. See Section C.5.5.7, “Solving Problems with No Matching Rows”.

- `DOUBLE[(M,D)] [UNSIGNED] [ZEROFILL]`

  A normal-size (double-precision) floating-point number. Permissible values are `-1.7976931348623157E+308` to `-2.2250738585072014E-308`, `0`, and `2.2250738585072014E-308` to `1.7976931348623157E+308`. These are the theoretical limits, based on the IEEE standard. The actual range might be slightly smaller depending on your hardware or operating system.

  `M` is the total number of digits and *`D`* is the number of digits following the decimal point. If *`M`* and *`D`* are omitted, values are stored to the limits permitted by the hardware. A double-precision floating-point number is accurate to approximately 15 decimal places.

  `UNSIGNED`, if specified, disallows negative values.

- `DOUBLE PRECISION[(M,D)] [UNSIGNED] [ZEROFILL]`, `REAL[(M,D)] [UNSIGNED] [ZEROFILL]`

  These types are synonyms for `DOUBLE`. Exception: If the `REAL_AS_FLOAT` SQL mode is enabled, `REAL` is a synonym for `FLOAT` rather than `DOUBLE`.

- `FLOAT(p) [UNSIGNED] [ZEROFILL]`

  A floating-point number. *`p`* represents the precision in bits, but MySQL uses this value only to determine whether to use `FLOAT` or `DOUBLE` for the resulting data type. If *`p`* is from 0 to 24, the data type becomes `FLOAT` with no *`M`* or *`D`* values. If *`p`* is from 25 to 53, the data type becomes `DOUBLE` with no *`M`* or *`D`* values. The range of the resulting column is the same as for the single-precision `FLOAT` or double-precision `DOUBLE` data types described earlier in this section.

  `FLOAT(p)` syntax is provided for ODBC compatibility.

- `DECIMAL[(M[,D])] [UNSIGNED] [ZEROFILL]`

  A packed “exact” fixed-point number. *`M`* is the total number of digits (the precision) and *`D`* is the number of digits after the decimal point (the scale). The decimal point and (for negative numbers) the “`-`” sign are not counted in *`M`*. If *`D`* is 0, values have no decimal point or fractional part. The maximum number of digits (*`M`*) for `DECIMAL` is 65. The maximum number of supported decimals (*`D`*) is 30. If *`D`* is omitted, the default is 0. If *`M`* is omitted, the default is 10.

  `UNSIGNED`, if specified, disallows negative values.

  All basic calculations (`+, -, *, /`) with `DECIMAL` columns are done with a precision of 65 digits.

- `DEC[(M[,D])] [UNSIGNED] [ZEROFILL]`, `NUMERIC[(M[,D])] [UNSIGNED] [ZEROFILL]`, `FIXED[(M[,D])] [UNSIGNED] [ZEROFILL]`

  These types are synonyms for `DECIMAL`. The `FIXED` synonym is available for compatibility with other database systems.

10.1.2. Overview of Date and Time Types

A summary of the temporal data types follows. For additional information about properties of the temporal types, see Section 10.3, “Date and Time Types”. Storage requirements are given in Section 10.5, “Data Type Storage Requirements”. Functions that operate on temporal values are described at Section 11.7, “Date and Time Functions”.

For the `DATETIME` and `DATE` range descriptions, “supported” means that although earlier values might work, there is no guarantee.

- `DATE`

  A date. The supported range is `'1000-01-01'` to `'9999-12-31'`. MySQL displays `DATE` values in `'YYYY-MM-DD'` format, but permits assignment of values to `DATE` columns using either strings or numbers.

- `DATETIME`

  A date and time combination. The supported range is `'1000-01-01 00:00:00'` to `'9999-12-31 23:59:59'`. MySQL displays `DATETIME` values in `'YYYY-MM-DD HH:MM:SS'` format, but permits assignment of values to `DATETIME` columns using either strings or numbers.

- `TIMESTAMP`

  A timestamp. The range is `'1970-01-01 00:00:01'` UTC to `'2038-01-19 03:14:07'` UTC. `TIMESTAMP` values are stored as the number of seconds since the epoch (`'1970-01-01 00:00:00'` UTC). A `TIMESTAMP` cannot represent the value `'1970-01-01 00:00:00'` because that is equivalent to 0 seconds from the epoch and the value 0 is reserved for representing `'0000-00-00 00:00:00'`, the “zero” `TIMESTAMP` value.

  A `TIMESTAMP` column is useful for recording the date and time of an `INSERT` or `UPDATE` operation. By default, the first `TIMESTAMP` column in a table is automatically set to the date and time of the most recent operation if you do not assign it a value yourself. You can also set any `TIMESTAMP` column to the current date and time by assigning it a `NULL` value. Variations on automatic initialization and update properties are described in Section 10.3.1.1, “`TIMESTAMP` Properties”.

  A `TIMESTAMP` value is returned as a string in the format `'YYYY-MM-DD HH:MM:SS'` with a display width fixed at 19 characters. To obtain the value as a number, you should add `+0` to the timestamp column.

  > **Note**
  >
  > The `TIMESTAMP` format that was used prior to MySQL 4.1 is not supported in MySQL 5.5; see *MySQL 3.23, 4.0, 4.1 Reference Manual* for information regarding the old format.

- `TIME`

  A time. The range is `'-838:59:59'` to `'838:59:59'`. MySQL displays `TIME` values in `'HH:MM:SS'` format, but permits assignment of values to `TIME` columns using either strings or numbers.

- `YEAR[(2|4)]`

  A year in two-digit or four-digit format. The default is four-digit format. In four-digit format, the permissible values are `1901` to `2155`, and `0000`. In two-digit format, the permissible values are `70` to `69`, representing years from 1970 to 2069. MySQL displays `YEAR` values in `YYYY` format, but permits assignment of values to `YEAR` columns using either strings or numbers.

The `SUM()` and `AVG()` aggregate functions do not work with temporal values. (They convert the values to numbers, which loses the part after the first nonnumeric character.) To work around this problem, you can convert to numeric units, perform the aggregate operation, and convert back to a temporal value. Examples:

```
SELECT SEC_TO_TIME(SUM(TIME_TO_SEC(time_col))) FROM tbl_name;
SELECT FROM_DAYS(SUM(TO_DAYS(date_col))) FROM tbl_name;
```

10.1.3. Overview of String Types

A summary of the string data types follows. For additional information about properties of the string types, see Section 10.4, “String Types”. Storage requirements are given in Section 10.5, “Data Type Storage Requirements”.

In some cases, MySQL may change a string column to a type different from that given in a `CREATE TABLE` or `ALTER TABLE` statement. See Section 12.1.14.2, “Silent Column Specification Changes”.

MySQL interprets length specifications in character column definitions in character units. This applies to `CHAR`, `VARCHAR`, and the `TEXT` types.

Column definitions for many string data types can include attributes that specify the character set or collation of the column. These attributes apply to the `CHAR`, `VARCHAR`, the `TEXT` types, `ENUM`, and `SET` data types:

- The `CHARACTER SET` attribute specifies the character set, and the `COLLATE` attribute specifies a collation for the character set. For example:

  ```
  CREATE TABLE t
  (
      c1 VARCHAR(20) CHARACTER SET utf8,
      c2 TEXT CHARACTER SET latin1 COLLATE latin1_general_cs
  );
  ```

  This table definition creates a column named `c1` that has a character set of `utf8` with the default collation for that character set, and a column named `c2` that has a character set of `latin1` and a case-sensitive collation.

  The rules for assigning the character set and collation when either or both of the `CHARACTER SET` and `COLLATE` attributes are missing are described in Section 9.1.3.4, "Column Character Set and Collation".

  `CHARSET` is a synonym for `CHARACTER SET`.

- Specifying the `CHARACTER SET binary` attribute for a character data type causes the column to be created as the corresponding binary data type: `CHAR` becomes `BINARY`, `VARCHAR` becomes `VARBINARY`, and `TEXT` becomes `BLOB`. For the `ENUM` and `SET` data types, this does not occur; they are created as declared. Suppose that you specify a table using this definition:

  ```
  CREATE TABLE t
  (
    c1 VARCHAR(10) CHARACTER SET binary,
    c2 TEXT CHARACTER SET binary,
    c3 ENUM('a','b','c') CHARACTER SET binary
  );
  ```

  The resulting table has this definition:

  ```
  CREATE TABLE t
  (
    c1 VARBINARY(10),
    c2 BLOB,
    c3 ENUM('a','b','c') CHARACTER SET binary
  );
  ```

- The `ASCII` attribute is shorthand for `CHARACTER SET latin1`.

- The `UNICODE` attribute is shorthand for `CHARACTER SET ucs2`.

- The `BINARY` attribute is shorthand for specifying the binary collation of the column character set. In this case, sorting and comparison are based on numeric character values.

Character column sorting and comparison are based on the character set assigned to the column. For the `CHAR`, `VARCHAR`, `TEXT`, `ENUM`, and `SET` data types, you can declare a column with a binary collation or the `BINARY` attribute to cause sorting and comparison to use the underlying character code values rather than a lexical ordering.

Section 9.1, "Character Set Support", provides additional information about use of character sets in MySQL.

- `[NATIONAL] CHAR[(M)] [CHARACTER SET charset_name] [COLLATE collation_name]`

  A fixed-length string that is always right-padded with spaces to the specified length when stored. *`M`* represents the column length in characters. The range of *`M`* is 0 to 255. If *`M`* is omitted, the length is 1.

  > **Note**
  >
  > Trailing spaces are removed when `CHAR` values are retrieved unless the `PAD_CHAR_TO_FULL_LENGTH` SQL mode is enabled.

  `CHAR` is shorthand for `CHARACTER`. `NATIONAL CHAR` (or its equivalent short form, `NCHAR`) is the standard SQL way to define that a `CHAR` column should use some predefined character set. MySQL 4.1 and up uses `utf8` as this predefined character set. Section 9.1.3.6, "National Character Set".

  The `CHAR BYTE` data type is an alias for the `BINARY` data type. This is a compatibility feature.

  MySQL permits you to create a column of type `CHAR(0)`. This is useful primarily when you have to be compliant with old applications that depend on the existence of a column but that do not actually use its value. `CHAR(0)` is also quite nice when you need a column that can take only two values: A column that is defined as `CHAR(0) NULL` occupies only one bit and can take only the values `NULL` and `''` (the empty string).

- `[NATIONAL] VARCHAR(M) [CHARACTER SET charset_name] [COLLATE collation_name]`

  A variable-length string. `M` represents the maximum column length in characters. The range of `M` is 0 to 65,535. The effective maximum length of a `VARCHAR` is subject to the maximum row size (65,535 bytes, which is shared among all columns) and the character set used. For example, `utf8` characters can require up to three bytes per character, so a `VARCHAR` column that uses the `utf8` character set can be declared to be a maximum of 21,844 characters. See Section E.9.4, "Table Column-Count and Row-Size Limits".

  MySQL stores `VARCHAR` values as a one-byte or two-byte length prefix plus data. The length prefix indicates the number of bytes in the value. A `VARCHAR` column uses one length byte if values require no more than 255 bytes, two length bytes if values may require more than 255 bytes.

  > **Note**
  >
  > MySQL 5.5 follows the standard SQL specification, and does *not* remove trailing spaces from `VARCHAR` values.

  `VARCHAR` is shorthand for `CHARACTER VARYING`. `NATIONAL VARCHAR` is the standard SQL way to define that a `VARCHAR` column should use some predefined character set. MySQL 4.1 and up uses `utf8` as this predefined character set. Section 9.1.3.6, "National Character Set". `NVARCHAR` is shorthand for `NATIONAL VARCHAR`.

- `BINARY(M)`

  The `BINARY` type is similar to the `CHAR` type, but stores binary byte strings rather than nonbinary character strings. `M` represents the column length in bytes.

- `VARBINARY(M)`

  The `VARBINARY` type is similar to the `VARCHAR` type, but stores binary byte strings rather than nonbinary character strings. `M` represents the maximum column length in bytes.

- `TINYBLOB`

  A `BLOB` column with a maximum length of 255 ($2^8 - 1$) bytes. Each `TINYBLOB` value is stored using a one-byte length prefix that indicates the number of bytes in the value.

- `TINYTEXT [CHARACTER SET charset_name] [COLLATE collation_name]`

  A `TEXT` column with a maximum length of 255 ($2^8 - 1$) characters. The effective maximum length is less if the value contains multi-byte characters. Each `TINYTEXT` value is stored using a one-byte length prefix that indicates the number of bytes in the value.

- `BLOB[(M)]`

  A `BLOB` column with a maximum length of 65,535 ($2^{16} - 1$) bytes. Each `BLOB` value is stored using a two-byte length prefix that indicates the number of bytes in the value.

  An optional length `M` can be given for this type. If this is done, MySQL creates the column as the smallest `BLOB` type large enough to hold values `M` bytes long.

- `TEXT[(M)] [CHARACTER SET charset_name] [COLLATE collation_name]`

  A `TEXT` column with a maximum length of 65,535 ($2^{16} - 1$) characters. The effective maximum length is less if the value contains multi-byte characters. Each `TEXT` value is stored using a two-byte length prefix that indicates the number of bytes in the value.

  An optional length `M` can be given for this type. If this is done, MySQL creates the column as the smallest `TEXT` type large enough to hold values `M` characters long.

- `MEDIUMBLOB`

  A `BLOB` column with a maximum length of 16,777,215 ($2^{24} - 1$) bytes. Each `MEDIUMBLOB` value is stored using a three-byte length prefix that indicates the number of bytes in the value.

- `MEDIUMTEXT [CHARACTER SET charset_name] [COLLATE collation_name]`

  A `TEXT` column with a maximum length of 16,777,215 ($2^{24} - 1$) characters. The effective maximum length is less if the value contains multi-byte characters. Each `MEDIUMTEXT` value is stored using a three-byte length prefix that indicates the number of bytes in the value.

- `LONGBLOB`

A `BLOB` column with a maximum length of 4,294,967,295 or 4GB (2^{32} – 1) bytes. The effective maximum length of `LONGBLOB` columns depends on the configured maximum packet size in the client/server protocol and available memory. Each `LONGBLOB` value is stored using a four-byte length prefix that indicates the number of bytes in the value.

- `LONGTEXT [CHARACTER SET charset_name] [COLLATE collation_name]`

  A `TEXT` column with a maximum length of 4,294,967,295 or 4GB (2^{32} – 1) characters. The effective maximum length is less if the value contains multi-byte characters. The effective maximum length of `LONGTEXT` columns also depends on the configured maximum packet size in the client/server protocol and available memory. Each `LONGTEXT` value is stored using a four-byte length prefix that indicates the number of bytes in the value.

- `ENUM('value1','value2',...) [CHARACTER SET charset_name] [COLLATE collation_name]`

  An enumeration. A string object that can have only one value, chosen from the list of values `'value1'`, `'value2'`, `...`, `NULL` or the special `''` error value. An `ENUM` column can have a maximum of 65,535 distinct values. `ENUM` values are represented internally as integers.

- `SET('value1','value2',...) [CHARACTER SET charset_name] [COLLATE collation_name]`

  A set. A string object that can have zero or more values, each of which must be chosen from the list of values `'value1'`, `'value2'`, `...` A `SET` column can have a maximum of 64 members. `SET` values are represented internally as integers.

10.1.4. Data Type Default Values

The `DEFAULT value` clause in a data type specification indicates a default value for a column. With one exception, the default value must be a constant; it cannot be a function or an expression. This means, for example, that you cannot set the default for a date column to be the value of a function such as `NOW()` or `CURRENT_DATE`. The exception is that you can specify `CURRENT_TIMESTAMP` as the default for a `TIMESTAMP` column. See Section 10.3.1.1, “`TIMESTAMP` Properties”.

`BLOB` and `TEXT` columns cannot be assigned a default value.

If a column definition includes no explicit `DEFAULT` value, MySQL determines the default value as follows:

If the column can take `NULL` as a value, the column is defined with an explicit `DEFAULT NULL` clause.

If the column cannot take `NULL` as the value, MySQL defines the column with no explicit `DEFAULT` clause. Exception: If the column is defined as part of a `PRIMARY KEY` but not explicitly as `NOT NULL`, MySQL creates it as a `NOT NULL` column (because `PRIMARY KEY` columns must be `NOT NULL`), but also assigns it a `DEFAULT` clause using the implicit default value. To prevent this, include an explicit `NOT NULL` in the definition of any `PRIMARY KEY` column.

For data entry for a `NOT NULL` column that has no explicit `DEFAULT` clause, if an `INSERT` or `REPLACE` statement includes no value for the column, or an `UPDATE` statement sets the column to `NULL`, MySQL handles the column according to the SQL mode in effect at the time:

- If strict SQL mode is not enabled, MySQL sets the column to the implicit default value for the column data type.
- If strict mode is enabled, an error occurs for transactional tables and the statement is rolled back. For nontransactional tables, an error occurs, but if this happens for the second or subsequent row of a multiple-row statement, the preceding rows will have been inserted.

Suppose that a table `t` is defined as follows:

```
CREATE TABLE t (i INT NOT NULL);
```

In this case, `i` has no explicit default, so in strict mode each of the following statements produce an error and no row is inserted. When not using strict mode, only the third statement produces an error; the implicit default is inserted for the first two statements, but the third fails because `DEFAULT(i)` cannot produce a value:

```
INSERT INTO t VALUES();
INSERT INTO t VALUES(DEFAULT);
INSERT INTO t VALUES(DEFAULT(i));
```

See Section 5.1.6, “Server SQL Modes”.

For a given table, you can use the `SHOW CREATE TABLE` statement to see which columns have an explicit `DEFAULT` clause.

Implicit defaults are defined as follows:

- For numeric types, the default is `0`, with the exception that for integer or floating-point types declared with the `AUTO_INCREMENT` attribute, the default is the next value in the sequence.
- For date and time types other than `TIMESTAMP`, the default is the appropriate “zero” value for the type. For the first `TIMESTAMP` column in a table, the default value is the current date and time. See Section 10.3, “Date and Time Types”.
- For string types other than `ENUM`, the default value is the empty string. For `ENUM`, the default is the first enumeration value.

`SERIAL DEFAULT VALUE` in the definition of an integer column is an alias for `NOT NULL AUTO_INCREMENT UNIQUE`.

10.2. Numeric Types

MySQL supports all the standard SQL numeric data types. These types include the exact numeric data types (`INTEGER`, `SMALLINT`, `DECIMAL`, and `NUMERIC`), as well as the approximate numeric data types (`FLOAT`, `REAL`, and `DOUBLE PRECISION`). The keyword `INT` is a synonym for `INTEGER`, and the keywords `DEC` and `FIXED` are synonyms for `DECIMAL`. MySQL treats `DOUBLE` as a synonym for `DOUBLE PRECISION` (a nonstandard extension). MySQL also treats `REAL` as a synonym for `DOUBLE PRECISION` (a nonstandard variation), unless the `REAL_AS_FLOAT` SQL mode is enabled.

The `BIT` data type stores bit-field values and is supported for `MyISAM`, `MEMORY`, `InnoDB`, and `NDBCLUSTER` tables.

For information about numeric type storage requirements, see Section 10.5, “Data Type Storage Requirements”.

The data type used for the result of a calculation on numeric operands depends on the types of the operands and the operations performed on them. For more information, see Section 11.6.1, “Arithmetic Operators”.

For information about how MySQL handles assignment of out-of-range values to columns and overflow during expression evaluation, see Section 10.6, “Out-of-Range and Overflow Handling”.

Integer Types

MySQL supports the SQL standard integer types `INTEGER` (or `INT`) and `SMALLINT`. As an extension to the standard, MySQL also supports the integer types `TINYINT`, `MEDIUMINT`, and `BIGINT`. The following table shows the required storage and range for each integer type.

Type	**Storage**	**Minimum Value**	**Maximum Value**
	(Bytes)	**(Signed/Unsigned)**	**Signed/Unsigned)**
`TINYINT`	1	`-128`	`127`
		`0`	`255`
`SMALLINT`	2	`-32768`	`32767`
		`0`	`65535`
`MEDIUMINT`	3	`-8388608`	`8388607`
		`0`	`16777215`
`INT`	4	`-2147483648`	`2147483647`
		`0`	`4294967295`
`BIGINT`	8	`-9223372036854775808`	`9223372036854775807`
		`0`	`18446744073709551615`

Floating-Point (Approximate-Value) Types

The `FLOAT` and `DOUBLE` types represent approximate numeric data values. MySQL uses four bytes for single-precision values and eight bytes for double-precision values.

For `FLOAT`, the SQL standard permits an optional specification of the precision (but not the range of the exponent) in bits following the keyword `FLOAT` in parentheses. MySQL also supports this optional precision specification, but the precision value is used only to determine storage size. A precision from 0 to 23 results in a four-byte single-precision `FLOAT` column. A precision from 24 to 53 results in an eight-byte double-precision `DOUBLE` column.

MySQL permits a nonstandard syntax: `FLOAT(M,D)` or `REAL(M,D)` or `DOUBLE PRECISION(M,D)`. Here, “`(M,D)`” means than values can be stored with up to `M` digits in total, of which `D` digits may be after the decimal point. For example, a column defined as `FLOAT(7,4)` will look like `-999.9999` when displayed. MySQL performs rounding when storing values, so if you insert `999.00009` into a `FLOAT(7,4)` column, the approximate result is `999.0001`.

Because floating-point values are approximate and not stored as exact values, attempts to treat them as exact in comparisons may lead to problems. They are also subject to platform or implementation dependencies. For more information, see Section C.5.5.8, “Problems with Floating-Point Values”

For maximum portability, code requiring storage of approximate numeric data values should use `FLOAT` or `DOUBLE PRECISION` with no specification of precision or number of digits.

Fixed-Point (Exact-Value) Types

The `DECIMAL` and `NUMERIC` types store exact numeric data values. These types are used when it is important to preserve exact precision, for example with monetary data. In MySQL, `NUMERIC` is implemented as `DECIMAL`, so the following remarks about `DECIMAL` apply equally to `NUMERIC`.

MySQL 5.5 stores `DECIMAL` values in binary format. See Section 11.18, “Precision Math”.

In a `DECIMAL` column declaration, the precision and scale can be (and usually is) specified; for example:

```
salary DECIMAL(5,2)
```

In this example, `5` is the precision and `2` is the scale. The precision represents the number of significant digits that are stored for values, and the scale represents the number of digits that can be stored following the decimal point.

Standard SQL requires that `DECIMAL(5,2)` be able to store any value with five digits and two decimals, so values that can be stored in the `salary` column range from `-999.99` to `999.99`.

In standard SQL, the syntax `DECIMAL(M)` is equivalent to `DECIMAL(M,0)`. Similarly, the syntax `DECIMAL` is equivalent to `DECIMAL(M,0)`, where the implementation is permitted to decide the value of `M`. MySQL supports both of these variant forms of `DECIMAL` syntax. The default value of `M` is 10.

If the scale is 0, `DECIMAL` values contain no decimal point or fractional part.

The maximum number of digits for `DECIMAL` is 65, but the actual range for a given `DECIMAL` column can be constrained by the precision or scale for a given column. When such a column is assigned a value with more digits following the decimal point than are permitted by the specified scale, the value is converted to that scale. (The precise behavior is operating system-specific, but generally the effect is truncation to the permissible number of digits.)

Bit-Value Type

The `BIT` data type is used to store bit-field values. A type of `BIT(M)` enables storage of `M`-bit values. `M` can range from 1 to 64.

To specify bit values, `b'value'` notation can be used. `value` is a binary value written using zeros and ones. For example, `b'111'` and `b'10000000'` represent 7 and 128, respectively. See Section 8.1.6, “Bit-Field Values”.

If you assign a value to a `BIT(M)` column that is less than `M` bits long, the value is padded on the left with zeros. For example, assigning a value of `b'101'` to a `BIT(6)` column is, in effect, the same as assigning `b'000101'`.

Numeric Type Attributes

MySQL supports an extension for optionally specifying the display width of integer data types in parentheses following the base keyword for the type. For example, `INT(4)` specifies an `INT` with a display width of four digits. This optional display width may be used by applications to display integer values having a width less than the width specified for the column by left-padding them with spaces. (That is, this width is present in the metadata returned with result sets. Whether it is used or not is up to the application.)

The display width does *not* constrain the range of values that can be stored in the column. Nor does it prevent values wider than the column display width from being displayed correctly. For example, a column specified as `SMALLINT(3)` has the usual `SMALLINT` range of `-32768` to `32767`, and values outside the range permitted by three digits are displayed in full using more than three digits.

When used in conjunction with the optional (nonstandard) attribute `ZEROFILL`, the default padding of spaces is replaced with zeros. For example, for a column declared as `INT(4) ZEROFILL`, a value of `5` is retrieved as `0005`.

> **Note**
>
> The `ZEROFILL` attribute is ignored when a column is involved in expressions or `UNION` queries.
>
> If you store values larger than the display width in an integer column that has the `ZEROFILL` attribute, you may ex-

> perience problems when MySQL generates temporary tables for some complicated joins. In these cases, MySQL assumes that the data values fit within the column display width.

All integer types can have an optional (nonstandard) attribute `UNSIGNED`. Unsigned type can be used to permit only nonnegative numbers in a column or when you need a larger upper numeric range for the column. For example, if an `INT` column is `UNSIGNED`, the size of the column's range is the same but its endpoints shift from `-2147483648` and `2147483647` up to `0` and `4294967295`.

Floating-point and fixed-point types also can be `UNSIGNED`. As with integer types, this attribute prevents negative values from being stored in the column. Unlike the integer types, the upper range of column values remains the same.

If you specify `ZEROFILL` for a numeric column, MySQL automatically adds the `UNSIGNED` attribute to the column.

Integer or floating-point data types can have the additional attribute `AUTO_INCREMENT`. When you insert a value of `NULL` (recommended) or `0` into an indexed `AUTO_INCREMENT` column, the column is set to the next sequence value. Typically this is `value+1`, where `value` is the largest value for the column currently in the table. `AUTO_INCREMENT` sequences begin with `1`.

10.3. Date and Time Types

The date and time types for representing temporal values are `DATETIME`, `DATE`, `TIMESTAMP`, `TIME`, and `YEAR`. Each temporal type has a range of legal values, as well as a “zero” value that may be used when you specify an illegal value that MySQL cannot represent. The `TIMESTAMP` type has special automatic updating behavior, described later on. For temporal type storage requirements, see Section 10.5, “Data Type Storage Requirements”.

MySQL gives warnings or errors if you try to insert an illegal date. By setting the SQL mode to the appropriate value, you can specify more exactly what kind of dates you want MySQL to support. (See Section 5.1.6, “Server SQL Modes”.) You can get MySQL to accept certain dates, such as `'2009-11-31'`, by using the `ALLOW_INVALID_DATES` SQL mode. This is useful when you want to store a “possibly wrong” value which the user has specified (for example, in a web form) in the database for future processing. Under this mode, MySQL verifies only that the month is in the range from 0 to 12 and that the day is in the range from 0 to 31. These ranges are defined to include zero because MySQL permits you to store dates where the day or month and day are zero in a `DATE` or `DATETIME` column. This is extremely useful for applications that need to store a birthdate for which you do not know the exact date. In this case, you simply store the date as `'2009-00-00'` or `'2009-01-00'`. If you store dates such as these, you should not expect to get correct results for functions such as `DATE_SUB()` or `DATE_ADD()` that require complete dates. (If you do *not* want to permit zero in dates, you can use the `NO_ZERO_IN_DATE` SQL mode).

A `DATE` value is coerced to the `DATETIME` type by adding the time portion as `'00:00:00'`. To perform the comparison by ignoring the time part of the `DATETIME` value instead, use the `CAST()` function to perform the comparison in the following way:

```
date_col = CAST(NOW() AS DATE)
```

MySQL also permits you to store `'0000-00-00'` as a “dummy date” (if you are not using the `NO_ZERO_DATE` SQL mode). This is in some cases more convenient (and uses less data and index space) than using `NULL` values.

Here are some general considerations to keep in mind when working with date and time types:

- MySQL retrieves values for a given date or time type in a standard output format, but it attempts to interpret a variety of formats for input values that you supply (for example, when you specify a value to be assigned to or compared to a date or time type). Only the formats described in the following sections are supported. It is expected that you supply legal values. Unpredictable results may occur if you use values in other formats.

- Dates containing two-digit year values are ambiguous because the century is unknown. MySQL interprets two-digit year values using the following rules:

  - Year values in the range `70-99` are converted to `1970-1999`.

  - Year values in the range `00-69` are converted to `2000-2069`.

- Although MySQL tries to interpret values in several formats, dates always must be given in year-month-day order (for example, `'98-09-04'`), rather than in the month-day-year or day-month-year orders commonly used elsewhere (for example, `'09-04-98'`, `'04-09-98'`).

- MySQL automatically converts a date or time type value to a number if the value is used in a numeric context and vice versa.

- By default, when MySQL encounters a value for a date or time type that is out of range or otherwise illegal for the type (as described at the beginning of this section), it converts the value to the “zero” value for that type. The exception is that out-of-range `TIME` values are clipped to the appropriate endpoint of the `TIME` range.

  The following table shows the format of the “zero” value for each type. Note that the use of these values produces warnings if the `NO_ZERO_DATE` SQL mode is enabled.

Data Type	“Zero” Value
`DATETIME`	`'0000-00-00 00:00:00'`
`DATE`	`'0000-00-00'`
`TIMESTAMP`	`'0000-00-00 00:00:00'`
`TIME`	`'00:00:00'`
`YEAR`	`0000`

- The “zero” values are special, but you can store or refer to them explicitly using the values shown in the table. You can also do this using the values `'0'` or `0`, which are easier to write.
- “Zero” date or time values used through MyODBC are converted automatically to `NULL` in MyODBC 2.50.12 and above, because ODBC cannot handle such values.

10.3.1. The `DATETIME`, `DATE`, and `TIMESTAMP` Types

The `DATETIME`, `DATE`, and `TIMESTAMP` types are related. This section describes their characteristics, how they are similar, and how they differ.

The `DATETIME` type is used when you need values that contain both date and time information. MySQL retrieves and displays `DATETIME` values in `'YYYY-MM-DD HH:MM:SS'` format. The supported range is `'1000-01-01 00:00:00'` to `'9999-12-31 23:59:59'`.

The `DATE` type is used when you need only a date value, without a time part. MySQL retrieves and displays `DATE` values in `'YYYY-MM-DD'` format. The supported range is `'1000-01-01'` to `'9999-12-31'`.

For the `DATETIME` and `DATE` range descriptions, “supported” means that although earlier values might work, there is no guarantee.

The `TIMESTAMP` data type has a range of `'1970-01-01 00:00:01'` UTC to `'2038-01-19 03:14:07'` UTC. It has varying properties, depending on the MySQL version and the SQL mode the server is running in. These properties are described later in this section.

You can specify `DATETIME`, `DATE`, and `TIMESTAMP` values using any of a common set of formats:

- As a string in either `'YYYY-MM-DD HH:MM:SS'` or `'YY-MM-DD HH:MM:SS'` format. A “relaxed” syntax is permitted: Any punctuation character may be used as the delimiter between date parts or time parts. For example, `'98-12-31 11:30:45'`, `'98.12.31 11+30+45'`, `'98/12/31 11*30*45'`, and `'98@12@31 11^30^45'` are equivalent.
- As a string in either `'YYYY-MM-DD'` or `'YY-MM-DD'` format. A “relaxed” syntax is permitted here, too. For example, `'98-12-31'`, `'98.12.31'`, `'98/12/31'`, and `'98@12@31'` are equivalent.
- As a string with no delimiters in either `'YYYYMMDDHHMMSS'` or `'YYMMDDHHMMSS'` format, provided that the string makes sense as a date. For example, `'20070523091528'` and `'070523091528'` are interpreted as `'2007-05-23 09:15:28'`, but `'071122129015'` is illegal (it has a nonsensical minute part) and becomes `'0000-00-00 00:00:00'`.
- As a string with no delimiters in either `'YYYYMMDD'` or `'YYMMDD'` format, provided that the string makes sense as a date. For example, `'20070523'` and `'070523'` are interpreted as `'2007-05-23'`, but `'071332'` is illegal (it has nonsensical month and day parts) and becomes `'0000-00-00'`.
- As a number in either `YYYYMMDDHHMMSS` or `YYMMDDHHMMSS` format, provided that the number makes sense as a date. For example, `19830905132800` and `830905132800` are interpreted as `'1983-09-05 13:28:00'`.
- As a number in either `YYYYMMDD` or `YYMMDD` format, provided that the number makes sense as a date. For example, `19830905` and `830905` are interpreted as `'1983-09-05'`.
- As the result of a function that returns a value that is acceptable in a `DATETIME`, `DATE`, or `TIMESTAMP` context, such as `NOW()` or `CURRENT_DATE`.

A microseconds part is permissible in temporal values in some contexts, such as in literal values, and in the arguments to or return values from some temporal functions. Microseconds are specified as a trailing `.uuuuuu` part in the value. Example:

```
mysql> SELECT MICROSECOND('2010-12-10 14:12:09.019473');
+-------------------------------------------+
| MICROSECOND('2010-12-10 14:12:09.019473') |
+-------------------------------------------+
|                                     19473 |
+-------------------------------------------+
```

However, microseconds cannot be stored into a column of any temporal data type. Any microseconds part is discarded.

Conversion of `TIME` or `DATETIME` values to numeric form (for example, by adding `+0`) results in a double value with a microseconds part of `.000000`:

```
mysql> SELECT CURTIME(), CURTIME()+0;
+-----------+---------------+
| CURTIME() | CURTIME()+0   |
+-----------+---------------+
| 10:41:36  | 104136.000000 |
+-----------+---------------+
mysql> SELECT NOW(), NOW()+0;
+---------------------+-----------------------+
| NOW()               | NOW()+0               |
+---------------------+-----------------------+
| 2007-11-30 10:41:47 | 20071130104147.000000 |
+---------------------+-----------------------+
```

Illegal `DATETIME`, `DATE`, or `TIMESTAMP` values are converted to the “zero” value of the appropriate type (`'0000-00-00 00:00:00'` or `'0000-00-00'`).

For values specified as strings that include date part delimiters, it is not necessary to specify two digits for month or day values that are less than `10`. `'1979-6-9'` is the same as `'1979-06-09'`. Similarly, for values specified as strings that include time part delimiters, it is not necessary to specify two digits for hour, minute, or second values that are less than `10`. `'1979-10-30 1:2:3'` is the same as `'1979-10-30 01:02:03'`.

Values specified as numbers should be 6, 8, 12, or 14 digits long. If a number is 8 or 14 digits long, it is assumed to be in `YYYYMMDD` or `YYYYMMDDHHMMSS` format and that the year is given by the first 4 digits. If the number is 6 or 12 digits long, it is assumed to be in `YYMMDD` or `YYMMDDHHMMSS` format and that the year is given by the first 2 digits. Numbers that are not one of these lengths are interpreted as though padded with leading zeros to the closest length.

Values specified as nondelimited strings are interpreted using their length as given. If the string is 8 or 14 characters long, the year is assumed to be given by the first 4 characters. Otherwise, the year is assumed to be given by the first 2 characters. The string is interpreted from left to right to find year, month, day, hour, minute, and second values, for as many parts as are present in the string. This means you should not use strings that have fewer than 6 characters. For example, if you specify `'9903'`, thinking that represents March, 1999, MySQL inserts a “zero” date value into your table. This occurs because the year and month values are `99` and `03`, but the day part is completely missing, so the value is not a legal date. However, you can explicitly specify a value of zero to represent missing month or day parts. For example, you can use `'990300'` to insert the value `'1999-03-00'`.

You can to some extent assign values of one date type to an object of a different date type. However, there may be some alteration of the value or loss of information:

- If you assign a `DATE` value to a `DATETIME` or `TIMESTAMP` object, the time part of the resulting value is set to `'00:00:00'` because the `DATE` value contains no time information.
- If you assign a `DATETIME` or `TIMESTAMP` value to a `DATE` object, the time part of the resulting value is deleted because the `DATE` type stores no time information.
- Remember that although `DATETIME`, `DATE`, and `TIMESTAMP` values all can be specified using the same set of formats, the types do not all have the same range of values. For example, `TIMESTAMP` values cannot be earlier than `1970` UTC or later than `'2038-01-19 03:14:07'` UTC. This means that a date such as `'1968-01-01'`, while legal as a `DATETIME` or `DATE` value, is not valid as a `TIMESTAMP` value and is converted to `0`.

Be aware of certain problems when specifying date values:

- The relaxed format permitted for values specified as strings can be deceiving. For example, a value such as `'10:11:12'` might look like a time value because of the “`:`” delimiter, but if used in a date context is interpreted as the year `'2010-11-12'`. The value `'10:45:15'` is converted to `'0000-00-00'` because `'45'` is not a legal month.
- The server requires that month and day values be legal, and not merely in the range 1 to 12 and 1 to 31, respectively. With strict mode disabled, invalid dates such as `'2004-04-31'` are converted to `'0000-00-00'` and a warning is generated. With strict mode enabled, invalid dates generate an error. To permit such dates, enable `ALLOW_INVALID_DATES`. See Section 5.1.6, “Server SQL Modes”, for more information.
- MySQL does not accept timestamp values that include a zero in the day or month column or values that are not a valid date. The sole exception to this rule is the special value `'0000-00-00 00:00:00'`.

- Dates containing two-digit year values are ambiguous because the century is unknown. MySQL interprets two-digit year values using the following rules:
  - Year values in the range `00-69` are converted to `2000-2069`.
  - Year values in the range `70-99` are converted to `1970-1999`.

10.3.1.1. `TIMESTAMP` Properties

`TIMESTAMP` columns are displayed in the same format as `DATETIME` columns. In other words, the display width is fixed at 19 characters, and the format is `'YYYY-MM-DD HH:MM:SS'`.

> **Note**
>
> In older versions of MySQL (prior to 4.1), the properties of the `TIMESTAMP` data type differed significantly in several ways from what is described in this section (see the *MySQL 3.23, 4.0, 4.1 Reference Manual* for details); these include syntax extensions which are deprecated in MySQL 5.1, and no longer supported in MySQL 5.5. This has implications for performing a dump and restore or replicating between MySQL Server versions. If you are using columns that are defined using the old `TIMESTAMP(N)` syntax, see Section 2.11.1.1, “Upgrading from MySQL 5.1 to 5.5”, prior to upgrading to MySQL 5.5.

`TIMESTAMP` values are converted from the current time zone to UTC for storage, and converted back from UTC to the current time zone for retrieval. (This occurs only for the `TIMESTAMP` data type, not for other types such as `DATETIME`.) By default, the current time zone for each connection is the server's time. The time zone can be set on a per-connection basis, as described in Section 9.6, “MySQL Server Time Zone Support”. As long as the time zone setting remains constant, you get back the same value you store. If you store a `TIMESTAMP` value, and then change the time zone and retrieve the value, the retrieved value is different from the value you stored. This occurs because the same time zone was not used for conversion in both directions. The current time zone is available as the value of the `time_zone` system variable.

The `TIMESTAMP` data type offers automatic initialization and updating. You can choose whether to use these properties and which column should have them:

- For one `TIMESTAMP` column in a table, you can assign the current timestamp as the default value and the auto-update value. It is possible to have the current timestamp be the default value for initializing the column, for the auto-update value, or both. It is not possible to have the current timestamp be the default value for one column and the auto-update value for another column.
- Any single `TIMESTAMP` column in a table can be used as the one that is initialized to the current date and time, or updated automatically. This need not be the first `TIMESTAMP` column.
- The auto-update `TIMESTAMP` column, if there is one, is automatically updated to the current timestamp when the value of any other column in the row is changed from its current value. If all other columns are set to their current values, the `TIMESTAMP` column does not change. Automatic updating does not apply if the `TIMESTAMP` column is explicitly assigned a value other than `NULL`.
- If a `DEFAULT` value is specified for the first `TIMESTAMP` column in a table, it is not ignored. The default can be `CURRENT_TIMESTAMP` or a constant date and time value.
- In a `CREATE TABLE` statement, the first `TIMESTAMP` column can be declared in any of the following ways:
  - With both `DEFAULT CURRENT_TIMESTAMP` and `ON UPDATE CURRENT_TIMESTAMP` clauses, the column has the current timestamp for its default value, and is automatically updated.
  - With neither `DEFAULT` nor `ON UPDATE` clauses, it is the same as `DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP`.
  - With a `DEFAULT CURRENT_TIMESTAMP` clause and no `ON UPDATE` clause, the column has the current timestamp for its default value but is not automatically updated.
  - With no `DEFAULT` clause and with an `ON UPDATE CURRENT_TIMESTAMP` clause, the column has a default of 0 and is automatically updated.
  - With a constant `DEFAULT` value, the column has the given default and is not automatically initialized to the current timestamp. If the column also has an `ON UPDATE CURRENT_TIMESTAMP` clause, it is automatically updated; otherwise, it has a constant default and is not automatically updated.

  In other words, you can use the current timestamp for both the initial value and the auto-update value, or either one, or neither. (For example, you can specify `ON UPDATE` to enable auto-update without also having the column auto-initialized.) The following column definitions demonstrate each possibility:

  - Auto-initialization and auto-update:

    ```
    ts TIMESTAMP DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP
    ```

  - Auto-initialization only:

    ```
    ts TIMESTAMP DEFAULT CURRENT_TIMESTAMP
    ```

  - Auto-update only:

    ```
    ts TIMESTAMP DEFAULT 0 ON UPDATE CURRENT_TIMESTAMP
    ```

  - Neither:

    ```
    ts TIMESTAMP DEFAULT 0
    ```

- To specify automatic default or updating for a `TIMESTAMP` column other than the first one, you must suppress the automatic initialization and update behaviors for the first `TIMESTAMP` column by explicitly assigning it a constant `DEFAULT` value (for example, `DEFAULT 0` or `DEFAULT '2003-01-01 00:00:00'`). Then, for the other `TIMESTAMP` column, the rules are the same as for the first `TIMESTAMP` column, except that if you omit both of the `DEFAULT` and `ON UPDATE` clauses, no automatic initialization or updating occurs.

  Example:

  ```
  CREATE TABLE t (
      ts1 TIMESTAMP DEFAULT 0,
      ts2 TIMESTAMP DEFAULT CURRENT_TIMESTAMP
                    ON UPDATE CURRENT_TIMESTAMP);
  ```

- `CURRENT_TIMESTAMP` or any of its synonyms (`CURRENT_TIMESTAMP()`, `NOW()`, `LOCALTIME`, `LOCALTIME()`, `LOCALTIMESTAMP`, or `LOCALTIMESTAMP()`) can be used in the `DEFAULT` and `ON UPDATE` clauses. They all mean "the current timestamp." (`UTC_TIMESTAMP` is not permitted. Its range of values does not align with those of the `TIMESTAMP` column anyway unless the current time zone is `UTC`.)

- The order of the `DEFAULT` and `ON UPDATE` attributes does not matter. If both `DEFAULT` and `ON UPDATE` are specified for a `TIMESTAMP` column, either can precede the other. For example, these statements are equivalent:

  ```
  CREATE TABLE t (ts TIMESTAMP);
  CREATE TABLE t (ts TIMESTAMP DEFAULT CURRENT_TIMESTAMP
                               ON UPDATE CURRENT_TIMESTAMP);
  CREATE TABLE t (ts TIMESTAMP ON UPDATE CURRENT_TIMESTAMP
                               DEFAULT CURRENT_TIMESTAMP);
  ```

Note

The examples that use `DEFAULT 0` will not work if the `NO_ZERO_DATE` SQL mode is enabled because that mode causes "zero" date values (specified as `0`, `'0000-00-00`, or `'0000-00-00 00:00:00'`) to be rejected. Be aware that the `TRADITIONAL` SQL mode includes `NO_ZERO_DATE`.

`TIMESTAMP` columns are `NOT NULL` by default, cannot contain `NULL` values, and assigning `NULL` assigns the current timestamp. However, a `TIMESTAMP` column can be permitted to contain `NULL` by declaring it with the `NULL` attribute. In this case, the default value also becomes `NULL` unless overridden with a `DEFAULT` clause that specifies a different default value. `DEFAULT NULL` can be used to explicitly specify `NULL` as the default value. (For a `TIMESTAMP` column not declared with the `NULL` attribute, `DEFAULT NULL` is illegal.) If a `TIMESTAMP` column permits `NULL` values, assigning `NULL` sets it to `NULL`, not to the current timestamp.

The following table contains several `TIMESTAMP` columns that permit `NULL` values:

```
CREATE TABLE t
(
  ts1 TIMESTAMP NULL DEFAULT NULL,
  ts2 TIMESTAMP NULL DEFAULT 0,
  ts3 TIMESTAMP NULL DEFAULT CURRENT_TIMESTAMP
);
```

Note that a `TIMESTAMP` column that permits `NULL` values will *not* take on the current timestamp except under one of the following conditions:

- Its default value is defined as `CURRENT_TIMESTAMP`
- `NOW()` or `CURRENT_TIMESTAMP` is inserted into the column

In other words, a `TIMESTAMP` column defined as `NULL` will auto-initialize only if it is created using a definition such as the following:

```
CREATE TABLE t (ts TIMESTAMP NULL DEFAULT CURRENT_TIMESTAMP);
```

Otherwise—that is, if the `TIMESTAMP` column is defined to permit `NULL` values but not using `DEFAULT CURRENT_TIMESTAMP`, as shown here…

```
CREATE TABLE t1 (ts TIMESTAMP NULL DEFAULT NULL);
CREATE TABLE t2 (ts TIMESTAMP NULL DEFAULT '0000-00-00 00:00:00');
```

…then you must explicitly insert a value corresponding to the current date and time. For example:

```
INSERT INTO t1 VALUES (NOW());
INSERT INTO t2 VALUES (CURRENT_TIMESTAMP);
```

> **Note**
>
> The MySQL server can be run with the `MAXDB` SQL mode enabled. When the server runs with this mode enabled, `TIMESTAMP` is identical with `DATETIME`. That is, if this mode is enabled at the time that a table is created, `TIMESTAMP` columns are created as `DATETIME` columns. As a result, such columns use `DATETIME` display format, have the same range of values, and there is no automatic initialization or updating to the current date and time.

To enable `MAXDB` mode, set the server SQL mode to `MAXDB` at startup using the `--sql-mode=MAXDB` server option or by setting the global `sql_mode` variable at runtime:

```
mysql> SET GLOBAL sql_mode=MAXDB;
```

A client can cause the server to run in `MAXDB` mode for its own connection as follows:

```
mysql> SET SESSION sql_mode=MAXDB;
```

10.3.2. The `TIME` Type

MySQL retrieves and displays `TIME` values in `'HH:MM:SS'` format (or `'HHH:MM:SS'` format for large hours values). `TIME` values may range from `'-838:59:59'` to `'838:59:59'`. The hours part may be so large because the `TIME` type can be used not only to represent a time of day (which must be less than 24 hours), but also elapsed time or a time interval between two events (which may be much greater than 24 hours, or even negative).

You can specify `TIME` values in a variety of formats:

- As a string in `'D HH:MM:SS.fraction'` format. You can also use one of the following “relaxed” syntaxes: `'HH:MM:SS.fraction'`, `'HH:MM:SS'`, `'HH:MM'`, `'D HH:MM:SS'`, `'D HH:MM'`, `'D HH'`, or `'SS'`. Here `D` represents days and can have a value from 0 to 34. Note that MySQL does not store the fraction part.
- As a string with no delimiters in `'HHMMSS'` format, provided that it makes sense as a time. For example, `'101112'` is understood as `'10:11:12'`, but `'109712'` is illegal (it has a nonsensical minute part) and becomes `'00:00:00'`.
- As a number in `HHMMSS` format, provided that it makes sense as a time. For example, `101112` is understood as `'10:11:12'`. The following alternative formats are also understood: `SS`, `MMSS`, `HHMMSS`, `HHMMSS.fraction`. Note that MySQL does not store the fraction part.
- As the result of a function that returns a value that is acceptable in a `TIME` context, such as `CURRENT_TIME`.

A trailing `.uuuuuu` microseconds part of `TIME` values is permitted under the same conditions as for other temporal values, as described in Section 10.3.1, “The `DATETIME`, `DATE`, and `TIMESTAMP` Types”. This includes the property that any microseconds part is discarded from values stored into `TIME` columns.

For `TIME` values specified as strings that include a time part delimiter, it is not necessary to specify two digits for hours, minutes, or seconds values that are less than `10`. `'8:3:2'` is the same as `'08:03:02'`.

Be careful about assigning abbreviated values to a `TIME` column. Without colons, MySQL interprets values using the assumption that the two rightmost digits represent seconds. (MySQL interprets `TIME` values as elapsed time rather than as time of day.) For example, you might think of `'1112'` and `1112` as meaning `'11:12:00'` (12 minutes after 11 o'clock), but MySQL interprets them as `'00:11:12'` (11 minutes, 12 seconds). Similarly, `'12'` and `12` are interpreted as `'00:00:12'`. `TIME` values with colons, by contrast, are always treated as time of the day. That is, `'11:12'` mean `'11:12:00'`, not `'00:11:12'`.

By default, values that lie outside the `TIME` range but are otherwise legal are clipped to the closest endpoint of the range. For example, `'-850:00:00'` and `'850:00:00'` are converted to `'-838:59:59'` and `'838:59:59'`. Illegal `TIME` values are converted to `'00:00:00'`. Note that because `'00:00:00'` is itself a legal `TIME` value, there is no way to tell, from a value of `'00:00:00'` stored in a table, whether the original value was specified as `'00:00:00'` or whether it was illegal.

For more restrictive treatment of invalid `TIME` values, enable strict SQL mode to cause errors to occur. See Section 5.1.6, “Server SQL Modes”.

10.3.3. The `YEAR` Type

The `YEAR` type is a one-byte type used for representing years. It can be declared as `YEAR(2)` or `YEAR(4)` to specify a display width of two or four characters. The default is four characters if no width is given.

For four-digit format, MySQL displays `YEAR` values in `YYYY` format, with a range of `1901` to `2155`, or `0000`. For two-digit format, MySQL displays only the last two (least significant) digits; for example, `70` (1970 or 2070) or `69` (2069).

You can specify input `YEAR` values in a variety of formats:

- As a four-digit string in the range `'1901'` to `'2155'`.
- As a four-digit number in the range `1901` to `2155`.
- As a two-digit string in the range `'00'` to `'99'`. Values in the ranges `'00'` to `'69'` and `'70'` to `'99'` are converted to `YEAR` values in the ranges `2000` to `2069` and `1970` to `1999`.
- As a two-digit number in the range `1` to `99`. Values in the ranges `1` to `69` and `70` to `99` are converted to `YEAR` values in the ranges `2001` to `2069` and `1970` to `1999`. Note that the range for two-digit numbers is slightly different from the range for two-digit strings, because you cannot specify zero directly as a number and have it be interpreted as `2000`. You must specify it as a string `'0'` or `'00'` or it is interpreted as `0000`.
- As the result of a function that returns a value that is acceptable in a `YEAR` context, such as `NOW()`.

Illegal `YEAR` values are converted to `0000`.

10.3.4. Year 2000 Issues and Date Types

MySQL Server itself has no problems with Year 2000 (Y2K) compliance:

- MySQL Server uses Unix time functions that handle dates into the year `2038` for `TIMESTAMP` values. For `DATE` and `DATETIME` values, dates through the year `9999` are accepted.
- All MySQL date functions are implemented in one source file, `sql/time.cc`, and are coded very carefully to be year 2000-safe.
- In MySQL, the `YEAR` data type can store the years `0` and `1901` to `2155` in one byte and display them using two or four digits. All two-digit years are considered to be in the range `1970` to `2069`, which means that if you store `01` in a `YEAR` column, MySQL Server treats it as `2001`.

Although MySQL Server itself is Y2K-safe, you may run into problems if you use it with applications that are not Y2K-safe. For example, many old applications store or manipulate years using two-digit values (which are ambiguous) rather than four-digit values. This problem may be compounded by applications that use values such as `00` or `99` as “missing” value indicators. Unfortunately, these problems may be difficult to fix because different applications may be written by different programmers, each of whom may use a different set of conventions and date-handling functions.

Thus, even though MySQL Server has no Y2K problems, *it is the application's responsibility to provide unambiguous input*. Any value containing a two-digit year is ambiguous, because the century is unknown. Such values must be interpreted into four-digit form because MySQL stores years internally using four digits.

For `DATETIME`, `DATE`, `TIMESTAMP`, and `YEAR` types, MySQL interprets dates with ambiguous year values using the following rules:

- Year values in the range `00-69` are converted to `2000-2069`.
- Year values in the range `70-99` are converted to `1970-1999`.

Remember that these rules are only heuristics that provide reasonable guesses as to what your data values mean. If the rules used by MySQL do not produce the correct values, you should provide unambiguous input containing four-digit year values.

`ORDER BY` properly sorts `YEAR` values that have two-digit years.

Some functions like `MIN()` and `MAX()` convert a `YEAR` to a number. This means that a value with a two-digit year does not work properly with these functions. The fix in this case is to convert the `TIMESTAMP` or `YEAR` to four-digit year format.

10.4. String Types

The string types are `CHAR`, `VARCHAR`, `BINARY`, `VARBINARY`, `BLOB`, `TEXT`, `ENUM`, and `SET`. This section describes how these types work and how to use them in your queries. For string type storage requirements, see Section 10.5, “Data Type Storage Requirements”.

10.4.1. The `CHAR` and `VARCHAR` Types

The `CHAR` and `VARCHAR` types are similar, but differ in the way they are stored and retrieved. They also differ in maximum length and in whether trailing spaces are retained.

The `CHAR` and `VARCHAR` types are declared with a length that indicates the maximum number of characters you want to store. For example, `CHAR(30)` can hold up to 30 characters.

The length of a `CHAR` column is fixed to the length that you declare when you create the table. The length can be any value from 0 to 255. When `CHAR` values are stored, they are right-padded with spaces to the specified length. When `CHAR` values are retrieved, trailing spaces are removed unless the `PAD_CHAR_TO_FULL_LENGTH` SQL mode is enabled.

Values in `VARCHAR` columns are variable-length strings. The length can be specified as a value from 0 to 65,535. The effective maximum length of a `VARCHAR` is subject to the maximum row size (65,535 bytes, which is shared among all columns) and the character set used. See Section E.9.4, “Table Column-Count and Row-Size Limits”.

In contrast to `CHAR`, `VARCHAR` values are stored as a one-byte or two-byte length prefix plus data. The length prefix indicates the number of bytes in the value. A column uses one length byte if values require no more than 255 bytes, two length bytes if values may require more than 255 bytes.

If strict SQL mode is not enabled and you assign a value to a `CHAR` or `VARCHAR` column that exceeds the column's maximum length, the value is truncated to fit and a warning is generated. For truncation of nonspace characters, you can cause an error to occur (rather than a warning) and suppress insertion of the value by using strict SQL mode. See Section 5.1.6, “Server SQL Modes”.

For `VARCHAR` columns, trailing spaces in excess of the column length are truncated prior to insertion and a warning is generated, regardless of the SQL mode in use. For `CHAR` columns, truncation of excess trailing spaces from inserted values is performed silently regardless of the SQL mode.

`VARCHAR` values are not padded when they are stored. Trailing spaces are retained when values are stored and retrieved, in conformance with standard SQL.

The following table illustrates the differences between `CHAR` and `VARCHAR` by showing the result of storing various string values into `CHAR(4)` and `VARCHAR(4)` columns (assuming that the column uses a single-byte character set such as `latin1`).

Value	**`CHAR(4)`**	**Storage Required**	**`VARCHAR(4)`**	**Storage Required**
`''`	`'    '`	4 bytes	`''`	1 byte
`'ab'`	`'ab  '`	4 bytes	`'ab'`	3 bytes
`'abcd'`	`'abcd'`	4 bytes	`'abcd'`	5 bytes
`'abcdefgh'`	`'abcd'`	4 bytes	`'abcd'`	5 bytes

The values shown as stored in the last row of the table apply *only when not using strict mode*; if MySQL is running in strict mode, values that exceed the column length are *not stored*, and an error results.

If a given value is stored into the `CHAR(4)` and `VARCHAR(4)` columns, the values retrieved from the columns are not always the same because trailing spaces are removed from `CHAR` columns upon retrieval. The following example illustrates this difference:

```
mysql> CREATE TABLE vc (v VARCHAR(4), c CHAR(4));
Query OK, 0 rows affected (0.01 sec)
```

```
mysql> INSERT INTO vc VALUES ('ab  ', 'ab  ');
Query OK, 1 row affected (0.00 sec)

mysql> SELECT CONCAT('(', v, ')'), CONCAT('(', c, ')') FROM vc;
+---------------------+---------------------+
| CONCAT('(', v, ')') | CONCAT('(', c, ')') |
+---------------------+---------------------+
| (ab  )              | (ab)                |
+---------------------+---------------------+
1 row in set (0.06 sec)
```

Values in `CHAR` and `VARCHAR` columns are sorted and compared according to the character set collation assigned to the column.

All MySQL collations are of type `PADSPACE`. This means that all `CHAR` and `VARCHAR` values in MySQL are compared without regard to any trailing spaces. For example:

```
mysql> CREATE TABLE names (myname CHAR(10), yourname VARCHAR(10));
Query OK, 0 rows affected (0.09 sec)

mysql> INSERT INTO names VALUES ('Monty ', 'Monty ');
Query OK, 1 row affected (0.00 sec)

mysql> SELECT myname = 'Monty  ', yourname = 'Monty  ' FROM names;
+--------------------+----------------------+
| myname = 'Monty  ' | yourname = 'Monty  ' |
+--------------------+----------------------+
|                  1 |                    1 |
+--------------------+----------------------+
1 row in set (0.00 sec)
```

This is true for all MySQL versions, and is not affected by the server SQL mode.

> **Note**
>
> For more information about MySQL character sets and collations, see Section 9.1, “Character Set Support”.

For those cases where trailing pad characters are stripped or comparisons ignore them, if a column has an index that requires unique values, inserting into the column values that differ only in number of trailing pad characters will result in a duplicate-key error. For example, if a table contains `'a'`, an attempt to store `'a  '` causes a duplicate-key error.

10.4.2. The `BINARY` and `VARBINARY` Types

The `BINARY` and `VARBINARY` types are similar to `CHAR` and `VARCHAR`, except that they contain binary strings rather than nonbinary strings. That is, they contain byte strings rather than character strings. This means that they have no character set, and sorting and comparison are based on the numeric values of the bytes in the values.

The permissible maximum length is the same for `BINARY` and `VARBINARY` as it is for `CHAR` and `VARCHAR`, except that the length for `BINARY` and `VARBINARY` is a length in bytes rather than in characters.

The `BINARY` and `VARBINARY` data types are distinct from the `CHAR BINARY` and `VARCHAR BINARY` data types. For the latter types, the `BINARY` attribute does not cause the column to be treated as a binary string column. Instead, it causes the binary collation for the column character set to be used, and the column itself contains nonbinary character strings rather than binary byte strings. For example, `CHAR(5) BINARY` is treated as `CHAR(5) CHARACTER SET latin1 COLLATE latin1_bin`, assuming that the default character set is `latin1`. This differs from `BINARY(5)`, which stores 5-bytes binary strings that have no character set or collation. For information about differences between nonbinary string binary collations and binary strings, see Section 9.1.7.6, “The `_bin` and `binary` Collations”.

If strict SQL mode is not enabled and you assign a value to a `BINARY` or `VARBINARY` column that exceeds the column's maximum length, the value is truncated to fit and a warning is generated. For cases of truncation, you can cause an error to occur (rather than a warning) and suppress insertion of the value by using strict SQL mode. See Section 5.1.6, “Server SQL Modes”.

When `BINARY` values are stored, they are right-padded with the pad value to the specified length. The pad value is `0x00` (the zero byte). Values are right-padded with `0x00` on insert, and no trailing bytes are removed on select. All bytes are significant in comparisons, including `ORDER BY` and `DISTINCT` operations. `0x00` bytes and spaces are different in comparisons, with `0x00` < space.

Example: For a `BINARY(3)` column, `'a '` becomes `'a \0'` when inserted. `'a\0'` becomes `'a\0\0'` when inserted. Both inserted values remain unchanged when selected.

For `VARBINARY`, there is no padding on insert and no bytes are stripped on select. All bytes are significant in comparisons, including `ORDER BY` and `DISTINCT` operations. `0x00` bytes and spaces are different in comparisons, with `0x00` < space.

For those cases where trailing pad bytes are stripped or comparisons ignore them, if a column has an index that requires unique values, inserting into the column values that differ only in number of trailing pad bytes will result in a duplicate-key error. For example, if a table contains `'a'`, an attempt to store `'a\0'` causes a duplicate-key error.

You should consider the preceding padding and stripping characteristics carefully if you plan to use the `BINARY` data type for storing binary data and you require that the value retrieved be exactly the same as the value stored. The following example illustrates how `0x00`-padding of `BINARY` values affects column value comparisons:

```
mysql> CREATE TABLE t (c BINARY(3));
Query OK, 0 rows affected (0.01 sec)

mysql> INSERT INTO t SET c = 'a';
Query OK, 1 row affected (0.01 sec)

mysql> SELECT HEX(c), c = 'a', c = 'a\0\0' from t;
+--------+---------+-------------+
| HEX(c) | c = 'a' | c = 'a\0\0' |
+--------+---------+-------------+
| 610000 |       0 |           1 |
+--------+---------+-------------+
1 row in set (0.09 sec)
```

If the value retrieved must be the same as the value specified for storage with no padding, it might be preferable to use `VARBINARY` or one of the `BLOB` data types instead.

10.4.3. The `BLOB` and `TEXT` Types

A `BLOB` is a binary large object that can hold a variable amount of data. The four `BLOB` types are `TINYBLOB`, `BLOB`, `MEDIUMBLOB`, and `LONGBLOB`. These differ only in the maximum length of the values they can hold. The four `TEXT` types are `TINYTEXT`, `TEXT`, `MEDIUMTEXT`, and `LONGTEXT`. These correspond to the four `BLOB` types and have the same maximum lengths and storage requirements. See Section 10.5, “Data Type Storage Requirements”.

`BLOB` values are treated as binary strings (byte strings). They have no character set, and sorting and comparison are based on the numeric values of the bytes in column values. `TEXT` values are treated as nonbinary strings (character strings). They have a character set, and values are sorted and compared based on the collation of the character set.

If strict SQL mode is not enabled and you assign a value to a `BLOB` or `TEXT` column that exceeds the column's maximum length, the value is truncated to fit and a warning is generated. For truncation of nonspace characters, you can cause an error to occur (rather than a warning) and suppress insertion of the value by using strict SQL mode. See Section 5.1.6, “Server SQL Modes”.

Truncation of excess trailing spaces from values to be inserted into `TEXT` columns always generates a warning, regardless of the SQL mode.

If a `TEXT` column is indexed, index entry comparisons are space-padded at the end. This means that, if the index requires unique values, duplicate-key errors will occur for values that differ only in the number of trailing spaces. For example, if a table contains `'a'`, an attempt to store `'a  '` causes a duplicate-key error. This is not true for `BLOB` columns.

In most respects, you can regard a `BLOB` column as a `VARBINARY` column that can be as large as you like. Similarly, you can regard a `TEXT` column as a `VARCHAR` column. `BLOB` and `TEXT` differ from `VARBINARY` and `VARCHAR` in the following ways:

- For indexes on `BLOB` and `TEXT` columns, you must specify an index prefix length. For `CHAR` and `VARCHAR`, a prefix length is optional. See Section 7.3.4, “Column Indexes”.
- `BLOB` and `TEXT` columns cannot have `DEFAULT` values.

If you use the `BINARY` attribute with a `TEXT` data type, the column is assigned the binary collation of the column character set.

`LONG` and `LONG VARCHAR` map to the `MEDIUMTEXT` data type. This is a compatibility feature.

MySQL Connector/ODBC defines `BLOB` values as `LONGVARBINARY` and `TEXT` values as `LONGVARCHAR`.

Because `BLOB` and `TEXT` values can be extremely long, you might encounter some constraints in using them:

- Only the first `max_sort_length` bytes of the column are used when sorting. The default value of `max_sort_length` is 1024. You can make more bytes significant in sorting or grouping by increasing the value of `max_sort_length` at server startup or runtime. Any client can change the value of its session `max_sort_length` variable:

  ```
  mysql> SET max_sort_length = 2000;
  mysql> SELECT id, comment FROM t
      -> ORDER BY comment;
  ```

  Another way to use `GROUP BY` or `ORDER BY` on a `BLOB` or `TEXT` column containing long values when you want more than `max_sort_length` bytes to be significant is to convert the column value into a fixed-length object. The standard way to do this is with the `SUBSTRING()` function. For example, the following statement causes 2000 bytes of the `comment` column to be taken into account for sorting:

```
mysql> SELECT id, SUBSTRING(comment,1,2000) FROM t
    -> ORDER BY SUBSTRING(comment,1,2000);
```

- Instances of `BLOB` or `TEXT` columns in the result of a query that is processed using a temporary table causes the server to use a table on disk rather than in memory because the `MEMORY` storage engine does not support those data types (see Section 7.4.3.3, "How MySQL Uses Internal Temporary Tables"). Use of disk incurs a performance penalty, so include `BLOB` or `TEXT` columns in the query result only if they are really needed. For example, avoid using `SELECT *`, which selects all columns.

- The maximum size of a `BLOB` or `TEXT` object is determined by its type, but the largest value you actually can transmit between the client and server is determined by the amount of available memory and the size of the communications buffers. You can change the message buffer size by changing the value of the `max_allowed_packet` variable, but you must do so for both the server and your client program. For example, both `mysql` and `mysqldump` enable you to change the client-side `max_allowed_packet` value. See Section 7.11.2, "Tuning Server Parameters", Section 4.5.1, "`mysql` — The MySQL Command-Line Tool", and Section 4.5.4, "`mysqldump` — A Database Backup Program". You may also want to compare the packet sizes and the size of the data objects you are storing with the storage requirements, see Section 10.5, "Data Type Storage Requirements"

Each `BLOB` or `TEXT` value is represented internally by a separately allocated object. This is in contrast to all other data types, for which storage is allocated once per column when the table is opened.

In some cases, it may be desirable to store binary data such as media files in `BLOB` or `TEXT` columns. You may find MySQL's string handling functions useful for working with such data. See Section 11.5, "String Functions". For security and other reasons, it is usually preferable to do so using application code rather than giving application users the `FILE` privilege. You can discuss specifics for various languages and platforms in the MySQL Forums (http://forums.mysql.com/).

10.4.4. The `ENUM` Type

An `ENUM` is a string object with a value chosen from a list of permitted values that are enumerated explicitly in the column specification at table creation time.

An enumeration value must be a quoted string literal; it may not be an expression, even one that evaluates to a string value. For example, you can create a table with an `ENUM` column like this:

```
CREATE TABLE sizes (
    name ENUM('small', 'medium', 'large')
);
```

However, this version of the previous `CREATE TABLE` statement does *not* work:

```
CREATE TABLE sizes (
    c1 ENUM('small', CONCAT('med','ium'), 'large')
);
```

You also may not employ a user variable as an enumeration value. This pair of statements do *not* work:

```
SET @mysize = 'medium';

CREATE TABLE sizes (
    name ENUM('small', @mysize, 'large')
);
```

If you wish to use a number as an enumeration value, you must enclose it in quotation marks. If the quotation marks are omitted, the number is regarded as an index. For this and other reasons—as explained later in this section—we strongly recommend that you do *not* use numbers as enumeration values.

Duplicate values in the definition cause a warning, or an error if strict SQL mode is enabled.

The value may also be the empty string (`''`) or `NULL` under certain circumstances:

- If you insert an invalid value into an `ENUM` (that is, a string not present in the list of permitted values), the empty string is inserted instead as a special error value. This string can be distinguished from a "normal" empty string by the fact that this string has the numeric value 0. More about this later.

  If strict SQL mode is enabled, attempts to insert invalid `ENUM` values result in an error.

- If an `ENUM` column is declared to permit `NULL`, the `NULL` value is a legal value for the column, and the default value is `NULL`. If an `ENUM` column is declared `NOT NULL`, its default value is the first element of the list of permitted values.

Each enumeration value has an index:

- Values from the list of permissible elements in the column specification are numbered beginning with 1.
- The index value of the empty string error value is 0. This means that you can use the following `SELECT` statement to find rows into which invalid `ENUM` values were assigned:

  ```
  mysql> SELECT * FROM tbl_name WHERE enum_col=0;
  ```

- The index of the `NULL` value is `NULL`.
- The term "index" here refers only to position within the list of enumeration values. It has nothing to do with table indexes.

For example, a column specified as `ENUM('one', 'two', 'three')` can have any of the values shown here. The index of each value is also shown.

Value	**Index**
`NULL`	`NULL`
`''`	0
`'one'`	1
`'two'`	2
`'three'`	3

An enumeration can have a maximum of 65,535 elements.

Trailing spaces are automatically deleted from `ENUM` member values in the table definition when a table is created.

When retrieved, values stored into an `ENUM` column are displayed using the lettercase that was used in the column definition. Note that `ENUM` columns can be assigned a character set and collation. For binary or case-sensitive collations, lettercase is taken into account when assigning values to the column.

If you retrieve an `ENUM` value in a numeric context, the column value's index is returned. For example, you can retrieve numeric values from an `ENUM` column like this:

```
mysql> SELECT enum_col+0 FROM tbl_name;
```

If you store a number into an `ENUM` column, the number is treated as the index into the possible values, and the value stored is the enumeration member with that index. (However, this does *not* work with `LOAD DATA`, which treats all input as strings.) If the numeric value is quoted, it is still interpreted as an index if there is no matching string in the list of enumeration values. For these reasons, it is not advisable to define an `ENUM` column with enumeration values that look like numbers, because this can easily become confusing. For example, the following column has enumeration members with string values of `'0'`, `'1'`, and `'2'`, but numeric index values of `1`, `2`, and `3`:

```
numbers ENUM('0','1','2')
```

If you store `2`, it is interpreted as an index value, and becomes `'1'` (the value with index 2). If you store `'2'`, it matches an enumeration value, so it is stored as `'2'`. If you store `'3'`, it does not match any enumeration value, so it is treated as an index and becomes `'2'` (the value with index 3).

```
mysql> INSERT INTO t (numbers) VALUES(2),('2'),('3');
mysql> SELECT * FROM t;
+---------+
| numbers |
+---------+
| 1       |
| 2       |
| 2       |
+---------+
```

`ENUM` values are sorted according to the order in which the enumeration members were listed in the column specification. (In other words, `ENUM` values are sorted according to their index numbers.) For example, `'a'` sorts before `'b'` for `ENUM('a', 'b')`, but `'b'` sorts before `'a'` for `ENUM('b', 'a')`. The empty string sorts before nonempty strings, and `NULL` values sort before all other enumeration values. To prevent unexpected results, specify the `ENUM` list in alphabetic order. You can also use `ORDER BY CAST(col AS CHAR)` or `ORDER BY CONCAT(col)` to make sure that the column is sorted lexically rather than by index number.

Functions such as `SUM()` or `AVG()` that expect a numeric argument cast the argument to a number if necessary. For `ENUM` values, the cast operation causes the index number to be used.

To determine all possible values for an `ENUM` column, use `SHOW COLUMNS FROM tbl_name LIKE 'enum_col'` and parse the `ENUM` definition in the `Type` column of the output.

In the C API, `ENUM` values are returned as strings. For information about using result set metadata to distinguish them from other strings, see Section 20.9.1, “C API Data Structures”.

10.4.5. The `SET` Type

A `SET` is a string object that can have zero or more values, each of which must be chosen from a list of permitted values specified when the table is created. `SET` column values that consist of multiple set members are specified with members separated by commas (“`,`”). A consequence of this is that `SET` member values should not themselves contain commas.

For example, a column specified as `SET('one', 'two') NOT NULL` can have any of these values:

```
''
'one'
'two'
'one,two'
```

A `SET` can have a maximum of 64 different members.

Duplicate values in the definition cause a warning, or an error if strict SQL mode is enabled.

Trailing spaces are automatically deleted from `SET` member values in the table definition when a table is created.

When retrieved, values stored in a `SET` column are displayed using the lettercase that was used in the column definition. Note that `SET` columns can be assigned a character set and collation. For binary or case-sensitive collations, lettercase is taken into account when assigning values to the column.

MySQL stores `SET` values numerically, with the low-order bit of the stored value corresponding to the first set member. If you retrieve a `SET` value in a numeric context, the value retrieved has bits set corresponding to the set members that make up the column value. For example, you can retrieve numeric values from a `SET` column like this:

```
mysql> SELECT set_col+0 FROM tbl_name;
```

If a number is stored into a `SET` column, the bits that are set in the binary representation of the number determine the set members in the column value. For a column specified as `SET('a','b','c','d')`, the members have the following decimal and binary values.

`SET` Member	Decimal Value	Binary Value
`'a'`	`1`	`0001`
`'b'`	`2`	`0010`
`'c'`	`4`	`0100`
`'d'`	`8`	`1000`

If you assign a value of `9` to this column, that is `1001` in binary, so the first and fourth `SET` value members `'a'` and `'d'` are selected and the resulting value is `'a,d'`.

For a value containing more than one `SET` element, it does not matter what order the elements are listed in when you insert the value. It also does not matter how many times a given element is listed in the value. When the value is retrieved later, each element in the value appears once, with elements listed according to the order in which they were specified at table creation time. For example, suppose that a column is specified as `SET('a','b','c','d')`:

```
mysql> CREATE TABLE myset (col SET('a', 'b', 'c', 'd'));
```

If you insert the values `'a,d'`, `'d,a'`, `'a,d,d'`, `'a,d,a'`, and `'d,a,d'`:

```
mysql> INSERT INTO myset (col) VALUES
-> ('a,d'), ('d,a'), ('a,d,a'), ('a,d,d'), ('d,a,d');
Query OK, 5 rows affected (0.01 sec)
Records: 5  Duplicates: 0  Warnings: 0
```

Then all these values appear as `'a,d'` when retrieved:

```
mysql> SELECT col FROM myset;
+------+
| col  |
+------+
| a,d  |
| a,d  |
| a,d  |
| a,d  |
| a,d  |
+------+
5 rows in set (0.04 sec)
```

If you set a `SET` column to an unsupported value, the value is ignored and a warning is issued:

```
mysql> INSERT INTO myset (col) VALUES ('a,d,d,s');
Query OK, 1 row affected, 1 warning (0.03 sec)

mysql> SHOW WARNINGS;
+---------+------+------------------------------------------+
| Level   | Code | Message                                  |
+---------+------+------------------------------------------+
| Warning | 1265 | Data truncated for column 'col' at row 1 |
+---------+------+------------------------------------------+
1 row in set (0.04 sec)

mysql> SELECT col FROM myset;
+------+
| col  |
+------+
| a,d  |
| a,d  |
| a,d  |
| a,d  |
| a,d  |
| a,d  |
+------+
6 rows in set (0.01 sec)
```

If strict SQL mode is enabled, attempts to insert invalid `SET` values result in an error.

`SET` values are sorted numerically. `NULL` values sort before non-`NULL` `SET` values.

Functions such as `SUM()` or `AVG()` that expect a numeric argument cast the argument to a number if necessary. For `SET` values, the cast operation causes the numeric value to be used.

Normally, you search for `SET` values using the `FIND_IN_SET()` function or the `LIKE` operator:

```
mysql> SELECT * FROM tbl_name WHERE FIND_IN_SET('value',set_col)>0;
mysql> SELECT * FROM tbl_name WHERE set_col LIKE '%value%';
```

The first statement finds rows where *`set_col`* contains the *`value`* set member. The second is similar, but not the same: It finds rows where *`set_col`* contains *`value`* anywhere, even as a substring of another set member.

The following statements also are legal:

```
mysql> SELECT * FROM tbl_name WHERE set_col & 1;
mysql> SELECT * FROM tbl_name WHERE set_col = 'val1,val2';
```

The first of these statements looks for values containing the first set member. The second looks for an exact match. Be careful with comparisons of the second type. Comparing set values to `'val1,val2'` returns different results than comparing values to `'val2,val1'`. You should specify the values in the same order they are listed in the column definition.

To determine all possible values for a `SET` column, use `SHOW COLUMNS FROM tbl_name LIKE set_col` and parse the `SET` definition in the `Type` column of the output.

In the C API, `SET` values are returned as strings. For information about using result set metadata to distinguish them from other strings, see Section 20.9.1, “C API Data Structures”.

10.5. Data Type Storage Requirements

The storage requirements for data vary, according to the storage engine being used for the table in question. Different storage engines use different methods for recording the raw data and different data types. In addition, some engines may compress the information in a given row, either on a column or entire row basis, making calculation of the storage requirements for a given table or column structure.

However, all storage engines must communicate and exchange information on a given row within a table using the same structure, and this information is consistent, irrespective of the storage engine used to write the information to disk.

This sections includes some guideliness and information for the storage requirements for each data type supported by MySQL, including details for the internal format and the sizes used by storage engines that used a fixed size representation for different types. Information is listed by category or storage engine.

The internal representation of a table has a maximum row size of 65,535 bytes, even if the storage engine is capable of supporting larger rows. This figure excludes `BLOB` or `TEXT` columns, which contribute only 9 to 12 bytes toward this size. For `BLOB` and `TEXT` data, the information is stored internally in a different area of memory than the row buffer. Different storage engines handle the allocation and storage of this data in different ways, according to the method they use for handling the corresponding types. For more information, see Chapter 13, *Storage Engines*, and Section E.9.4, "Table Column-Count and Row-Size Limits".

> **Important**
>
> For tables using the `NDBCLUSTER` storage engine, there is the factor of *4-byte alignment* to be taken into account when calculating storage requirements. This means that all `NDB` data storage is done in multiples of 4 bytes. Thus, a column value that would take 15 bytes in a table using a storage engine other than `NDB` requires 16 bytes in an `NDB` table. This requirement applies in addition to any other considerations that are discussed in this section. For example, in `NDBCLUSTER` tables, the `TINYINT`, `SMALLINT`, `MEDIUMINT`, and `INTEGER` (`INT`) column types each require 4 bytes storage per record due to the alignment factor.
>
> An exception to this rule is the `BIT` type, which is *not* 4-byte aligned. In MySQL Cluster tables, a `BIT(M)` column takes `M` bits of storage space. However, if a table definition contains 1 or more `BIT` columns (up to 32 `BIT` columns), then `NDBCLUSTER` reserves 4 bytes (32 bits) per row for these. If a table definition contains more than 32 `BIT` columns (up to 64 such columns), then `NDBCLUSTER` reserves 8 bytes (that is, 64 bits) per row.
>
> In addition, while a `NULL` itself does not require any storage space, `NDBCLUSTER` reserves 4 bytes per row if the table definition contains any columns defined as `NULL`, up to 32 `NULL` columns. (If a MySQL Cluster table is defined with more than 32 `NULL` columns up to 64 `NULL` columns, then 8 bytes per row is reserved.)

When calculating storage requirements for MySQL Cluster tables, you must also remember that every table using the `NDBCLUSTER` storage engine requires a primary key; if no primary key is defined by the user, then a "hidden" primary key will be created by `NDB`. This hidden primary key consumes 31-35 bytes per table record.

You may find the `ndb_size.pl` utility to be useful for estimating `NDB` storage requirements. This Perl script connects to a current MySQL (non-Cluster) database and creates a report on how much space that database would require if it used the `NDBCLUSTER` storage engine. See `ndb_size.pl`, for more information.

Storage Requirements for Numeric Types

Data Type	Storage Required
`TINYINT`	1 byte
`SMALLINT`	2 bytes
`MEDIUMINT`	3 bytes
`INT`, `INTEGER`	4 bytes
`BIGINT`	8 bytes
`FLOAT(p)`	4 bytes if 0 <= `p` <= 24, 8 bytes if 25 <= `p` <= 53
`FLOAT`	4 bytes
`DOUBLE [PRECISION]`, `REAL`	8 bytes
`DECIMAL(M,D)`, `NUMERIC(M,D)`	Varies; see following discussion
`BIT(M)`	approximately (`M`+7)/8 bytes

Values for `DECIMAL` (and `NUMERIC`) columns are represented using a binary format that packs nine decimal (base 10) digits into four bytes. Storage for the integer and fractional parts of each value are determined separately. Each multiple of nine digits requires four bytes, and the "leftover" digits require some fraction of four bytes. The storage required for excess digits is given by the following table.

Leftover Digits	Number of Bytes
0	0
1	1
2	1
3	2
4	2

Leftover Digits	Number of Bytes
5	3
6	3
7	4
8	4

Storage Requirements for Date and Time Types

Data Type	Storage Required
`DATE`	3 bytes
`TIME`	3 bytes
`DATETIME`	8 bytes
`TIMESTAMP`	4 bytes
`YEAR`	1 byte

The storage requirements shown in the table arise from the way that MySQL represents temporal values:

- `DATE`: A three-byte integer packed as `DD` + `MM`×32 + `YYYY`×16×32
- `TIME`: A three-byte integer packed as `DD`×24×3600 + `HH`×3600 + `MM`×60 + `SS`
- `DATETIME`: Eight bytes:
  - A four-byte integer packed as `YYYY`×10000 + `MM`×100 + `DD`
  - A four-byte integer packed as `HH`×10000 + `MM`×100 + `SS`
- `TIMESTAMP`: A four-byte integer representing seconds UTC since the epoch (`'1970-01-01 00:00:00'` UTC)
- `YEAR`: A one-byte integer

Storage Requirements for String Types

In the following table, *`M`* represents the declared column length in characters for nonbinary string types and bytes for binary string types. *`L`* represents the actual length in bytes of a given string value.

Data Type	Storage Required
`CHAR(M)`	*`M`* × *`w`* bytes, 0 `<=` *`M`* `<=` 255, where *`w`* is the number of bytes required for the maximum-length character in the character set
`BINARY(M)`	*`M`* bytes, 0 `<=` *`M`* `<=` 255
`VARCHAR(M)`, `VARBINARY(M)`	*`L`* + 1 bytes if column values require 0 – 255 bytes, *`L`* + 2 bytes if values may require more than 255 bytes
`TINYBLOB`, `TINYTEXT`	*`L`* + 1 bytes, where *`L`* < 2^{8}
`BLOB`, `TEXT`	*`L`* + 2 bytes, where *`L`* < 2^{16}
`MEDIUMBLOB`, `MEDIUMTEXT`	*`L`* + 3 bytes, where *`L`* < 2^{24}
`LONGBLOB`, `LONGTEXT`	*`L`* + 4 bytes, where *`L`* < 2^{32}
`ENUM('value1','value2',...)`	1 or 2 bytes, depending on the number of enumeration values (65,535 values maximum)
`SET('value1','value2',...)`	1, 2, 3, 4, or 8 bytes, depending on the number of set members (64 members maximum)

Variable-length string types are stored using a length prefix plus data. The length prefix requires from one to four bytes depending on the data type, and the value of the prefix is *`L`* (the byte length of the string). For example, storage for a `MEDIUMTEXT` value requires *`L`* bytes to store the value plus three bytes to store the length of the value.

To calculate the number of bytes used to store a particular `CHAR`, `VARCHAR`, or `TEXT` column value, you must take into account the character set used for that column and whether the value contains multi-byte characters. In particular, when using the `utf8` (or `utf8mb4`) Unicode character set, you must keep in mind that not all characters use the same number of bytes and can require up to three (four) bytes per character. For a breakdown of the storage used for different categories of `utf8` or `utf8mb4` characters, see Section 9.1.10, “Unicode Support”.

`VARCHAR`, `VARBINARY`, and the `BLOB` and `TEXT` types are variable-length types. For each, the storage requirements depend on these factors:

- The actual length of the column value
- The column's maximum possible length
- The character set used for the column, because some character sets contain multi-byte characters

For example, a `VARCHAR(255)` column can hold a string with a maximum length of 255 characters. Assuming that the column uses the `latin1` character set (one byte per character), the actual storage required is the length of the string (*`L`*), plus one byte to record the length of the string. For the string `'abcd'`, *`L`* is 4 and the storage requirement is five bytes. If the same column is instead declared to use the `ucs2` double-byte character set, the storage requirement is 10 bytes: The length of `'abcd'` is eight bytes and the column requires two bytes to store lengths because the maximum length is greater than 255 (up to 510 bytes).

The effective maximum number of *bytes* that can be stored in a `VARCHAR` or `VARBINARY` column is subject to the maximum row size of 65,535 bytes, which is shared among all columns. For a `VARCHAR` column that stores multi-byte characters, the effective maximum number of *characters* is less. For example, `utf8` characters can require up to three bytes per character, so a `VARCHAR` column that uses the `utf8` character set can be declared to be a maximum of 21,844 characters. See Section E.9.4, “Table Column-Count and Row-Size Limits”.

The size of an `ENUM` object is determined by the number of different enumeration values. One byte is used for enumerations with up to 255 possible values. Two bytes are used for enumerations having between 256 and 65,535 possible values. See Section 10.4.4, “The `ENUM` Type”.

The size of a `SET` object is determined by the number of different set members. If the set size is *`N`*, the object occupies `(N+7)/8` bytes, rounded up to 1, 2, 3, 4, or 8 bytes. A `SET` can have a maximum of 64 members. See Section 10.4.5, “The `SET` Type”.

10.6. Out-of-Range and Overflow Handling

When MySQL stores a value in a numeric column that is outside the permissible range of the column data type, the result depends on the SQL mode in effect at the time:

- If strict SQL mode is enabled, MySQL rejects the out-of-range value with an error, and the insert fails, in accordance with the SQL standard.
- If no restrictive modes are enabled, MySQL clips the value to the appropriate endpoint of the range and stores the resulting value instead.

  When an out-of-range value is assigned to an integer column, MySQL stores the value representing the corresponding endpoint of the column data type range. If you store 256 into a `TINYINT` or `TINYINT UNSIGNED` column, MySQL stores 127 or 255, respectively.

  When a floating-point or fixed-point column is assigned a value that exceeds the range implied by the specified (or default) precision and scale, MySQL stores the value representing the corresponding endpoint of that range.

Column-assignment conversions that occur due to clipping when MySQL is not operating in strict mode are reported as warnings for `ALTER TABLE`, `LOAD DATA INFILE`, `UPDATE`, and multiple-row `INSERT` statements. In strict mode, these statements fail, and some or all the values will not be inserted or changed, depending on whether the table is a transactional table and other factors. For details, see Section 5.1.6, “Server SQL Modes”.

As of MySQL 5.5.5, overflow during numeric expression evaluation results in an error. For example, the largest signed `BIGINT` value is 9223372036854775807, so the following expression produces an error:

```
mysql> SELECT 9223372036854775807 + 1;
ERROR 1690 (22003): BIGINT value is out of range in '(9223372036854775807 + 1)'
```

To enable the operation to succeed in this case, convert the value to unsigned;

```
mysql> SELECT CAST(9223372036854775807 AS UNSIGNED) + 1;
+-------------------------------------------+
| CAST(9223372036854775807 AS UNSIGNED) + 1 |
+-------------------------------------------+
|                       9223372036854775808 |
+-------------------------------------------+
```

Whether overflow occurs depends on the range of the operands, so another way to handle the preceding expression is to use exact-value arithmetic because `DECIMAL` values have a larger range than integers:

```
mysql> SELECT 9223372036854775807.0 + 1;
+---------------------------+
| 9223372036854775807.0 + 1 |
+---------------------------+
|     9223372036854775808.0 |
+---------------------------+
```

Before MySQL 5.5.5, overflow handling during numeric expression evaluation depends on the types of the operands:

- Integer overflow results in silent wraparound.
- `DECIMAL` overflow results in a truncated result and a warning.
- Floating-point overflow produces a `NULL` result.

Subtraction between integer values, where one is of type `UNSIGNED`, produces an unsigned result by default. Prior to MySQL 5.5.5, if the result would otherwise have been negative, it becomes the maximum integer value:

```
mysql> SET sql_mode = '';
mysql> SELECT CAST(0 AS UNSIGNED) - 1;
+-------------------------+
| CAST(0 AS UNSIGNED) - 1 |
+-------------------------+
|    18446744073709551615 |
+-------------------------+
```

As of MySQL 5.5.5, if the result would otherwise have been negative, an error results:

```
mysql> SET sql_mode = '';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT CAST(0 AS UNSIGNED) - 1;
ERROR 1690 (22003): BIGINT UNSIGNED value is out of range in '(cast(0 as unsigned) - 1)'
```

If the `NO_UNSIGNED_SUBTRACTION` SQL mode is enabled, the result is negative:

```
mysql> SET sql_mode = 'NO_UNSIGNED_SUBTRACTION';
mysql> SELECT CAST(0 AS UNSIGNED) - 1;
+-------------------------+
| CAST(0 AS UNSIGNED) - 1 |
+-------------------------+
|                      -1 |
+-------------------------+
```

If the result of such an operation is used to update an `UNSIGNED` integer column, the result is clipped to the maximum value for the column type, or clipped to 0 if `NO_UNSIGNED_SUBTRACTION` is enabled. If strict SQL mode is enabled, an error occurs and the column remains unchanged.

10.7. Choosing the Right Type for a Column

For optimum storage, you should try to use the most precise type in all cases. For example, if an integer column is used for values in the range from `1` to `99999`, `MEDIUMINT UNSIGNED` is the best type. Of the types that represent all the required values, this type uses the least amount of storage.

All basic calculations (`+`, `-`, `*`, and `/`) with `DECIMAL` columns are done with precision of 65 decimal (base 10) digits. See Section 10.1.1, “Overview of Numeric Types”.

If accuracy is not too important or if speed is the highest priority, the `DOUBLE` type may be good enough. For high precision, you can always convert to a fixed-point type stored in a `BIGINT`. This enables you to do all calculations with 64-bit integers and then convert results back to floating-point values as necessary.

`PROCEDURE ANALYSE` can be used to obtain suggestions for optimal column data types. For more information, see Section 21.4.1, “`PROCEDURE ANALYSE`”.

10.8. Using Data Types from Other Database Engines

To facilitate the use of code written for SQL implementations from other vendors, MySQL maps data types as shown in the following table. These mappings make it easier to import table definitions from other database systems into MySQL.

Other Vendor Type	**MySQL Type**
`BOOL`	`TINYINT`
`BOOLEAN`	`TINYINT`
`CHARACTER VARYING(M)`	`VARCHAR(M)`
`FIXED`	`DECIMAL`
`FLOAT4`	`FLOAT`
`FLOAT8`	`DOUBLE`
`INT1`	`TINYINT`
`INT2`	`SMALLINT`
`INT3`	`MEDIUMINT`
`INT4`	`INT`
`INT8`	`BIGINT`
`LONG VARBINARY`	`MEDIUMBLOB`
`LONG VARCHAR`	`MEDIUMTEXT`
`LONG`	`MEDIUMTEXT`
`MIDDLEINT`	`MEDIUMINT`
`NUMERIC`	`DECIMAL`

Data type mapping occurs at table creation time, after which the original type specifications are discarded. If you create a table with types used by other vendors and then issue a `DESCRIBE` *`tbl_name`* statement, MySQL reports the table structure using the equivalent MySQL types. For example:

```
mysql> CREATE TABLE t (a BOOL, b FLOAT8, c LONG VARCHAR, d NUMERIC);
Query OK, 0 rows affected (0.00 sec)

mysql> DESCRIBE t;
+-------+---------------+------+-----+---------+-------+
| Field | Type          | Null | Key | Default | Extra |
+-------+---------------+------+-----+---------+-------+
| a     | tinyint(1)    | YES  |     | NULL    |       |
| b     | double        | YES  |     | NULL    |       |
| c     | mediumtext    | YES  |     | NULL    |       |
| d     | decimal(10,0) | YES  |     | NULL    |       |
+-------+---------------+------+-----+---------+-------+
4 rows in set (0.01 sec)
```

Chapter 11. Functions and Operators

Expressions can be used at several points in SQL statements, such as in the `ORDER BY` or `HAVING` clauses of `SELECT` statements, in the `WHERE` clause of a `SELECT`, `DELETE`, or `UPDATE` statement, or in `SET` statements. Expressions can be written using literal values, column values, `NULL`, built-in functions, stored functions, user-defined functions, and operators. This chapter describes the functions and operators that are permitted for writing expressions in MySQL. Instructions for writing stored functions and user-defined functions are given in Section 17.2, “Using Stored Routines (Procedures and Functions)”, and Section 21.3, “Adding New Functions to MySQL”. See Section 8.2.4, “Function Name Parsing and Resolution”, for the rules describing how the server interprets references to different kinds of functions.

An expression that contains `NULL` always produces a `NULL` value unless otherwise indicated in the documentation for a particular function or operator.

> **Note**
>
> By default, there must be no whitespace between a function name and the parenthesis following it. This helps the MySQL parser distinguish between function calls and references to tables or columns that happen to have the same name as a function. However, spaces around function arguments are permitted.

You can tell the MySQL server to accept spaces after function names by starting it with the `--sql-mode=IGNORE_SPACE` option. (See Section 5.1.6, “Server SQL Modes”.) Individual client programs can request this behavior by using the `CLIENT_IGNORE_SPACE` option for `mysql_real_connect()`. In either case, all function names become reserved words.

For the sake of brevity, most examples in this chapter display the output from the `mysql` program in abbreviated form. Rather than showing examples in this format:

```
mysql> SELECT MOD(29,9);
+-----------+
| mod(29,9) |
+-----------+
|         2 |
+-----------+
1 rows in set (0.00 sec)
```

This format is used instead:

```
mysql> SELECT MOD(29,9);
        -> 2
```

11.1. Function and Operator Reference

> **Note**
>
> This table is part of an ongoing process to expand and simplify the information provided on these elements. Further improvements to the table, and corresponding descriptions will be applied over the coming months.

Table 11.1. Functions/Operators

Name	Description
`ABS()`	Return the absolute value
`ACOS()`	Return the arc cosine
`ADDDATE()`	Add time values (intervals) to a date value
`ADDTIME()`	Add time
`AES_DECRYPT()`	Decrypt using AES
`AES_ENCRYPT()`	Encrypt using AES
`AND`, `&&`	Logical AND
`ASCII()`	Return numeric value of left-most character
`ASIN()`	Return the arc sine
`=`	Assign a value (as part of a `SET` statement, or as part of the `SET` clause in an `UPDATE` statement)
`:=`	Assign a value
`ATAN2()`, `ATAN()`	Return the arc tangent of the two arguments
`ATAN()`	Return the arc tangent

Name	**Description**
AVG()	Return the average value of the argument
BENCHMARK()	Repeatedly execute an expression
BETWEEN ... AND ...	Check whether a value is within a range of values
BIN()	Return a string representation of the argument
BINARY	Cast a string to a binary string
BIT_AND()	Return bitwise and
BIT_COUNT()	Return the number of bits that are set
BIT_LENGTH()	Return length of argument in bits
BIT_OR()	Return bitwise or
BIT_XOR()	Return bitwise xor
&	Bitwise AND
~	Invert bits
|	Bitwise OR
^	Bitwise XOR
CASE	Case operator
CAST()	Cast a value as a certain type
CEIL()	Return the smallest integer value not less than the argument
CEILING()	Return the smallest integer value not less than the argument
CHAR_LENGTH()	Return number of characters in argument
CHAR()	Return the character for each integer passed
CHARACTER_LENGTH()	A synonym for CHAR_LENGTH()
CHARSET()	Return the character set of the argument
COALESCE()	Return the first non-NULL argument
COERCIBILITY()	Return the collation coercibility value of the string argument
COLLATION()	Return the collation of the string argument
COMPRESS()	Return result as a binary string
CONCAT_WS()	Return concatenate with separator
CONCAT()	Return concatenated string
CONNECTION_ID()	Return the connection ID (thread ID) for the connection
CONV()	Convert numbers between different number bases
CONVERT_TZ()	Convert from one timezone to another
Convert()	Cast a value as a certain type
COS()	Return the cosine
COT()	Return the cotangent
COUNT(DISTINCT)	Return the count of a number of different values
COUNT()	Return a count of the number of rows returned
CRC32()	Compute a cyclic redundancy check value
CURDATE()	Return the current date
CURRENT_DATE(), CURRENT_DATE	Synonyms for CURDATE()
CURRENT_TIME(), CURRENT_TIME	Synonyms for CURTIME()
CURRENT_TIMESTAMP(), CURRENT_TIMESTAMP	Synonyms for NOW()
CURRENT_USER(), CURRENT_USER	The authenticated user name and host name
CURTIME()	Return the current time
DATABASE()	Return the default (current) database name
DATE_ADD()	Add time values (intervals) to a date value
DATE_FORMAT()	Format date as specified
DATE_SUB()	Subtract a time value (interval) from a date

Name	Description
`DATE()`	Extract the date part of a date or datetime expression
`DATEDIFF()`	Subtract two dates
`DAY()`	Synonym for DAYOFMONTH()
`DAYNAME()`	Return the name of the weekday
`DAYOFMONTH()`	Return the day of the month (0-31)
`DAYOFWEEK()`	Return the weekday index of the argument
`DAYOFYEAR()`	Return the day of the year (1-366)
`DECODE()`	Decodes a string encrypted using ENCODE()
`DEFAULT()`	Return the default value for a table column
`DEGREES()`	Convert radians to degrees
`DES_DECRYPT()`	Decrypt a string
`DES_ENCRYPT()`	Encrypt a string
`DIV`	Integer division
`/`	Division operator
`ELT()`	Return string at index number
`ENCODE()`	Encode a string
`ENCRYPT()`	Encrypt a string
`<=>`	NULL-safe equal to operator
`=`	Equal operator
`EXP()`	Raise to the power of
`EXPORT_SET()`	Return a string such that for every bit set in the value bits, you get an on string and for every unset bit, you get an off string
`EXTRACT()`	Extract part of a date
`ExtractValue()`	Extracts a value from an XML string using XPath notation
`FIELD()`	Return the index (position) of the first argument in the subsequent arguments
`FIND_IN_SET()`	Return the index position of the first argument within the second argument
`FLOOR()`	Return the largest integer value not greater than the argument
`FORMAT()`	Return a number formatted to specified number of decimal places
`FOUND_ROWS()`	For a SELECT with a LIMIT clause, the number of rows that would be returned were there no LIMIT clause
`FROM_DAYS()`	Convert a day number to a date
`FROM_UNIXTIME()`	Format UNIX timestamp as a date
`GET_FORMAT()`	Return a date format string
`GET_LOCK()`	Get a named lock
`>=`	Greater than or equal operator
`>`	Greater than operator
`GREATEST()`	Return the largest argument
`GROUP_CONCAT()`	Return a concatenated string
`HEX()`	Return a hexadecimal representation of a decimal or string value
`HOUR()`	Extract the hour
`IF()`	If/else construct
`IFNULL()`	Null if/else construct
`IN()`	Check whether a value is within a set of values
`INET_ATON()`	Return the numeric value of an IP address
`INET_NTOA()`	Return the IP address from a numeric value
`INSERT()`	Insert a substring at the specified position up to the specified number of characters
`INSTR()`	Return the index of the first occurrence of substring
`INTERVAL()`	Return the index of the argument that is less than the first argument

Name	Description
`IS_FREE_LOCK()`	Checks whether the named lock is free
`IS NOT NULL`	NOT NULL value test
`IS NOT`	Test a value against a boolean
`IS NULL`	NULL value test
`IS_USED_LOCK()`	Checks whether the named lock is in use. Return connection identifier if true.
`IS`	Test a value against a boolean
`ISNULL()`	Test whether the argument is NULL
`LAST_DAY`	Return the last day of the month for the argument
`LAST_INSERT_ID()`	Value of the AUTOINCREMENT column for the last INSERT
`LCASE()`	Synonym for LOWER()
`LEAST()`	Return the smallest argument
`<<`	Left shift
`LEFT()`	Return the leftmost number of characters as specified
`LENGTH()`	Return the length of a string in bytes
`<=`	Less than or equal operator
`<`	Less than operator
`LIKE`	Simple pattern matching
`LN()`	Return the natural logarithm of the argument
`LOAD_FILE()`	Load the named file
`LOCALTIME()`, `LOCALTIME`	Synonym for NOW()
`LOCALTIMESTAMP`, `LOCALTIMESTAMP()`	Synonym for NOW()
`LOCATE()`	Return the position of the first occurrence of substring
`LOG10()`	Return the base-10 logarithm of the argument
`LOG2()`	Return the base-2 logarithm of the argument
`LOG()`	Return the natural logarithm of the first argument
`LOWER()`	Return the argument in lowercase
`LPAD()`	Return the string argument, left-padded with the specified string
`LTRIM()`	Remove leading spaces
`MAKE_SET()`	Return a set of comma-separated strings that have the corresponding bit in bits set
`MAKEDATE()`	Create a date from the year and day of year
`MAKETIME`	MAKETIME()
`MASTER_POS_WAIT()`	Block until the slave has read and applied all updates up to the specified position
`MATCH`	Perform full-text search
`MAX()`	Return the maximum value
`MD5()`	Calculate MD5 checksum
`MICROSECOND()`	Return the microseconds from argument
`MID()`	Return a substring starting from the specified position
`MIN()`	Return the minimum value
`-`	Minus operator
`MINUTE()`	Return the minute from the argument
`MOD()`	Return the remainder
`%`	Modulo operator
`MONTH()`	Return the month from the date passed
`MONTHNAME()`	Return the name of the month
`NAME_CONST()`	Causes the column to have the given name
`NOT BETWEEN ... AND ...`	Check whether a value is not within a range of values
`!=`, `<>`	Not equal operator

Name	Description
`NOT IN()`	Check whether a value is not within a set of values
`NOT LIKE`	Negation of simple pattern matching
`NOT REGEXP`	Negation of REGEXP
`NOT`, `!`	Negates value
`NOW()`	Return the current date and time
`NULLIF()`	Return NULL if expr1 = expr2
`OCT()`	Return an octal representation of a decimal number
`OCTET_LENGTH()`	A synonym for LENGTH()
`OLD_PASSWORD()`	Return the value of the pre-4.1 implementation of PASSWORD
`||`, `OR`	Logical OR
`ORD()`	Return character code for leftmost character of the argument
`PASSWORD()`	Calculate and return a password string
`PERIOD_ADD()`	Add a period to a year-month
`PERIOD_DIFF()`	Return the number of months between periods
`PI()`	Return the value of pi
`+`	Addition operator
`POSITION()`	A synonym for LOCATE()
`POW()`	Return the argument raised to the specified power
`POWER()`	Return the argument raised to the specified power
`PROCEDURE ANALYSE()`	Analyze the results of a query
`QUARTER()`	Return the quarter from a date argument
`QUOTE()`	Escape the argument for use in an SQL statement
`RADIANS()`	Return argument converted to radians
`RAND()`	Return a random floating-point value
`REGEXP`	Pattern matching using regular expressions
`RELEASE_LOCK()`	Releases the named lock
`REPEAT()`	Repeat a string the specified number of times
`REPLACE()`	Replace occurrences of a specified string
`REVERSE()`	Reverse the characters in a string
`>>`	Right shift
`RIGHT()`	Return the specified rightmost number of characters
`RLIKE`	Synonym for REGEXP
`ROUND()`	Round the argument
`ROW_COUNT()`	The number of rows updated
`RPAD()`	Append string the specified number of times
`RTRIM()`	Remove trailing spaces
`SCHEMA()`	A synonym for DATABASE()
`SEC_TO_TIME()`	Converts seconds to 'HH:MM:SS' format
`SECOND()`	Return the second (0-59)
`SESSION_USER()`	Synonym for USER()
`SHA1()`, `SHA()`	Calculate an SHA-1 160-bit checksum
`SHA2()`	Calculate an SHA-2 checksum
`SIGN()`	Return the sign of the argument
`SIN()`	Return the sine of the argument
`SLEEP()`	Sleep for a number of seconds
`SOUNDEX()`	Return a soundex string
`SOUNDS LIKE`	Compare sounds
`SPACE()`	Return a string of the specified number of spaces

Name	Description
`SQRT()`	Return the square root of the argument
`STD()`	Return the population standard deviation
`STDDEV_POP()`	Return the population standard deviation
`STDDEV_SAMP()`	Return the sample standard deviation
`STDDEV()`	Return the population standard deviation
`STR_TO_DATE()`	Convert a string to a date
`STRCMP()`	Compare two strings
`SUBDATE()`	A synonym for DATE_SUB() when invoked with three arguments
`SUBSTR()`	Return the substring as specified
`SUBSTRING_INDEX()`	Return a substring from a string before the specified number of occurrences of the delimiter
`SUBSTRING()`	Return the substring as specified
`SUBTIME()`	Subtract times
`SUM()`	Return the sum
`SYSDATE()`	Return the time at which the function executes
`SYSTEM_USER()`	Synonym for USER()
`TAN()`	Return the tangent of the argument
`TIME_FORMAT()`	Format as time
`TIME_TO_SEC()`	Return the argument converted to seconds
`TIME()`	Extract the time portion of the expression passed
`TIMEDIFF()`	Subtract time
`*`	Multiplication operator
`TIMESTAMP()`	With a single argument, this function returns the date or datetime expression; with two arguments, the sum of the arguments
`TIMESTAMPADD()`	Add an interval to a datetime expression
`TIMESTAMPDIFF()`	Subtract an interval from a datetime expression
`TO_DAYS()`	Return the date argument converted to days
`TO_SECONDS()`	Return the date or datetime argument converted to seconds since Year 0
`TRIM()`	Remove leading and trailing spaces
`TRUNCATE()`	Truncate to specified number of decimal places
`UCASE()`	Synonym for UPPER()
`-`	Change the sign of the argument
`UNCOMPRESS()`	Uncompress a string compressed
`UNCOMPRESSED_LENGTH()`	Return the length of a string before compression
`UNHEX()`	Convert each pair of hexadecimal digits to a character
`UNIX_TIMESTAMP()`	Return a UNIX timestamp
`UpdateXML()`	Return replaced XML fragment
`UPPER()`	Convert to uppercase
`USER()`	The user name and host name provided by the client
`UTC_DATE()`	Return the current UTC date
`UTC_TIME()`	Return the current UTC time
`UTC_TIMESTAMP()`	Return the current UTC date and time
`UUID_SHORT()`	Return an integer-valued universal identifier
`UUID()`	Return a Universal Unique Identifier (UUID)
`VALUES()`	Defines the values to be used during an INSERT
`VAR_POP()`	Return the population standard variance
`VAR_SAMP()`	Return the sample variance
`VARIANCE()`	Return the population standard variance
`VERSION()`	Returns a string that indicates the MySQL server version

Name	Description
`WEEK()`	Return the week number
`WEEKDAY()`	Return the weekday index
`WEEKOFYEAR()`	Return the calendar week of the date (0-53)
`XOR`	Logical XOR
`YEAR()`	Return the year
`YEARWEEK()`	Return the year and week

11.2. Type Conversion in Expression Evaluation

When an operator is used with operands of different types, type conversion occurs to make the operands compatible. Some conversions occur implicitly. For example, MySQL automatically converts numbers to strings as necessary, and vice versa.

```
mysql> SELECT 1+'1';
        -> 2
mysql> SELECT CONCAT(2,' test');
        -> '2 test'
```

It is also possible to convert a number to a string explicitly using the `CAST()` function. Conversion occurs implicitly with the `CONCAT()` function because it expects string arguments.

```
mysql> SELECT 38.8, CAST(38.8 AS CHAR);
        -> 38.8, '38.8'
mysql> SELECT 38.8, CONCAT(38.8);
        -> 38.8, '38.8'
```

See later in this section for information about the character set of implicit number-to-string conversions.

The following rules describe how conversion occurs for comparison operations:

- If one or both arguments are `NULL`, the result of the comparison is `NULL`, except for the `NULL`-safe `<=>` equality comparison operator. For `NULL <=> NULL`, the result is true. No conversion is needed.
- If both arguments in a comparison operation are strings, they are compared as strings.
- If both arguments are integers, they are compared as integers.
- Hexadecimal values are treated as binary strings if not compared to a number.
- If one of the arguments is a `TIMESTAMP` or `DATETIME` column and the other argument is a constant, the constant is converted to a timestamp before the comparison is performed. This is done to be more ODBC-friendly. Note that this is not done for the arguments to `IN()`! To be safe, always use complete datetime, date, or time strings when doing comparisons. For example, to achieve best results when using `BETWEEN` with date or time values, use `CAST()` to explicitly convert the values to the desired data type.
- In all other cases, the arguments are compared as floating-point (real) numbers.

The following examples illustrate conversion of strings to numbers for comparison operations:

```
mysql> SELECT 1 > '6x';
        -> 0
mysql> SELECT 7 > '6x';
        -> 1
mysql> SELECT 0 > 'x6';
        -> 0
mysql> SELECT 0 = 'x6';
        -> 1
```

For comparisons of a string column with a number, MySQL cannot use an index on the column to look up the value quickly. If *`str_col`* is an indexed string column, the index cannot be used when performing the lookup in the following statement:

```
SELECT * FROM tbl_name WHERE str_col=1;
```

The reason for this is that there are many different strings that may convert to the value `1`, such as `'1'`, `' 1'`, or `'1a'`.

Comparisons that use floating-point numbers (or values that are converted to floating-point numbers) are approximate because such numbers are inexact. This might lead to results that appear inconsistent:

```
mysql> SELECT '18015376320243458' = 18015376320243458;
        -> 1
mysql> SELECT '18015376320243459' = 18015376320243459;
        -> 0
```

Such results can occur because the values are converted to floating-point numbers, which have only 53 bits of precision and are subject to rounding:

```
mysql> SELECT '18015376320243459'+0.0;
        -> 1.8015376320243e+16
```

Furthermore, the conversion from string to floating-point and from integer to floating-point do not necessarily occur the same way. The integer may be converted to floating-point by the CPU, whereas the string is converted digit by digit in an operation that involves floating-point multiplications.

The results shown will vary on different systems, and can be affected by factors such as computer architecture or the compiler version or optimization level. One way to avoid such problems is to use `CAST()` so that a value will not be converted implicitly to a float-point number:

```
mysql> SELECT CAST('18015376320243459' AS UNSIGNED) = 18015376320243459;
        -> 1
```

For more information about floating-point comparisons, see Section C.5.5.8, “Problems with Floating-Point Values”.

As of MySQL 5.5.3, the server includes `dtoa`, a conversion library that provides the basis for improved conversion between string or `DECIMAL` values and approximate-value (`FLOAT`/`DOUBLE`) numbers:

- Consistent conversion results across platforms, which eliminates, for example, Unix versus Windows conversion differences.
- Accurate representation of values in cases where results previously did not provide sufficient precision, such as for values close to IEEE limits.
- Conversion of numbers to string format with the best possible precision. The precision of `dtoa` is always the same or better than that of the standard C library functions.

Because the conversions produced by this library differ in some cases from previous results, the potential exists for incompatibilities in applications that rely on previous results. For example, applications that depend on a specific exact result from previous conversions might need adjustment to accommodate additional precision.

The `dtoa` library provides conversions with the following properties. *`D`* represents a value with a `DECIMAL` or string representation, and *`F`* represents a floating-point number in native binary (IEEE) format.

- *`F`* -> *`D`* conversion is done with the best possible precision, returning *`D`* as the shortest string that yields *`F`* when read back in and rounded to the nearest value in native binary format as specified by IEEE.
- *`D`* -> *`F`* conversion is done such that *`F`* is the nearest native binary number to the input decimal string *`D`*.

These properties imply that *`F`* -> *`D`* -> *`F`* conversions are lossless unless *`F`* is `-inf`, `+inf`, or `NaN`. The latter values are not supported because the SQL standard defines them as invalid values for `FLOAT` or `DOUBLE`.

For *`D`* -> *`F`* -> *`D`* conversions, a sufficient condition for losslessness is that *`D`* uses 15 or fewer digits of precision, is not a denormal value, `-inf`, `+inf`, or `NaN`. In some cases, the conversion is lossless even if *`D`* has more than 15 digits of precision, but this is not always the case.

As of MySQL 5.5.3, implicit conversion of a numeric or temporal value to string produces a value that has a character set and collation determined by the `character_set_connection` and `collation_connection` system variables. (These variables commonly are set with `SET NAMES`. For information about connection character sets, see Section 9.1.4, “Connection Character Sets and Collations”.)

This change means that such a conversion results in a character (nonbinary) string (a `CHAR`, `VARCHAR`, or `LONGTEXT` value), except when the connection character set is set to `binary`. In that case, the conversion result is a binary string (a `BINARY`, `VARBINARY`, or `LONGBLOB` value).

Before MySQL 5.5.3, an implicit conversion always produced a binary string, regardless of the connection character set. Such implicit conversions to string typically occur for functions that are passed numeric or temporal values when string values are more usual, and thus could have effects beyond the type of the converted value. Consider the expression `CONCAT(1, 'abc')`. The numeric argument `1` was converted to the binary string `'1'` and the concatenation of that value with the nonbinary string `'abc'` produced the binary string `'1abc'`.

Some functions are unaffected by this change in behavior:

- `CHAR()` without a `USING` clause still returns `VARBINARY`.
- Functions that previously returned `utf8` strings still do so. Examples include `CHARSET()` and `COLLATION()`.
- Encryption and compression functions that expect string arguments and previously returned binary strings are unaffected if the return value can contain non-ASCII characters. Examples include `AES_ENCRYPT()` and `COMPRESS()`. If the return value contains only ASCII characters, the function now returns a character string with the connection character set and collation. Examples include `MD5()` and `PASSWORD()`.

11.3. Operators

Table 11.2. Operators

Name	**Description**
`AND`, `&&`	Logical AND
`=`	Assign a value (as part of a `SET` statement, or as part of the `SET` clause in an `UPDATE` statement)
`:=`	Assign a value
`BETWEEN ... AND ...`	Check whether a value is within a range of values
`BINARY`	Cast a string to a binary string
`&`	Bitwise AND
`~`	Invert bits
`|`	Bitwise OR
`^`	Bitwise XOR
`CASE`	Case operator
`DIV`	Integer division
`/`	Division operator
`<=>`	NULL-safe equal to operator
`=`	Equal operator
`>=`	Greater than or equal operator
`>`	Greater than operator
`IS NOT NULL`	NOT NULL value test
`IS NOT`	Test a value against a boolean
`IS NULL`	NULL value test
`IS`	Test a value against a boolean
`<<`	Left shift
`<=`	Less than or equal operator
`<`	Less than operator
`LIKE`	Simple pattern matching
`-`	Minus operator
`%`	Modulo operator
`NOT BETWEEN ... AND ...`	Check whether a value is not within a range of values
`!=`, `<>`	Not equal operator
`NOT LIKE`	Negation of simple pattern matching
`NOT REGEXP`	Negation of REGEXP
`NOT`, `!`	Negates value
`||`, `OR`	Logical OR
`+`	Addition operator
`REGEXP`	Pattern matching using regular expressions

Name	Description
`>>`	Right shift
`RLIKE`	Synonym for REGEXP
`SOUNDS LIKE`	Compare sounds
`*`	Multiplication operator
`-`	Change the sign of the argument
`XOR`	Logical XOR

11.3.1. Operator Precedence

Operator precedences are shown in the following list, from highest precedence to the lowest. Operators that are shown together on a line have the same precedence.

```
INTERVAL
BINARY, COLLATE
!
- (unary minus), ~ (unary bit inversion)
^
*, /, DIV, %, MOD
-, +
<<, >>
&
|
= (comparison), <=>, >=, >, <=, <, <>, !=, IS, LIKE, REGEXP, IN
BETWEEN, CASE, WHEN, THEN, ELSE
NOT
&&, AND
XOR
||, OR
= (assignment), :=
```

The precedence of `=` depends on whether it is used as a comparison operator (`=`) or as an assignment operator (`=`). When used as a comparison operator, it has the same precedence as `<=>`, `>=`, `>`, `<=`, `<`, `<>`, `!=`, `IS`, `LIKE`, `REGEXP`, and `IN`. When used as an assignment operator, it has the same precedence as `:=`. Section 12.4.4, “SET Syntax”, and Section 8.4, “User-Defined Variables”, explain how MySQL determines which interpretation of `=` should apply.

The meaning of some operators depends on the SQL mode:

- By default, `||` is a logical `OR` operator. With `PIPES_AS_CONCAT` enabled, `||` is string concatenation, with a precedence between `^` and the unary operators.
- By default, `!` has a higher precedence than `NOT`. With `HIGH_NOT_PRECEDENCE` enabled, `!` and `NOT` have the same precedence.

See Section 5.1.6, “Server SQL Modes”.

The precedence of operators determines the order of evaluation of terms in an expression. To override this order and group terms explicitly, use parentheses. For example:

```
mysql> SELECT 1+2*3;
        -> 7
mysql> SELECT (1+2)*3;
        -> 9
```

11.3.2. Comparison Functions and Operators

Table 11.3. Comparison Operators

Name	Description
`BETWEEN ... AND ...`	Check whether a value is within a range of values
`COALESCE()`	Return the first non-NULL argument
`<=>`	NULL-safe equal to operator
`=`	Equal operator
`>=`	Greater than or equal operator
`>`	Greater than operator

Name	Description
`GREATEST()`	Return the largest argument
`IN()`	Check whether a value is within a set of values
`INTERVAL()`	Return the index of the argument that is less than the first argument
`IS NOT NULL`	NOT NULL value test
`IS NOT`	Test a value against a boolean
`IS NULL`	NULL value test
`IS`	Test a value against a boolean
`ISNULL()`	Test whether the argument is NULL
`LEAST()`	Return the smallest argument
`<=`	Less than or equal operator
`<`	Less than operator
`LIKE`	Simple pattern matching
`NOT BETWEEN ... AND ...`	Check whether a value is not within a range of values
`!=`, `<>`	Not equal operator
`NOT IN()`	Check whether a value is not within a set of values
`NOT LIKE`	Negation of simple pattern matching
`STRCMP()`	Compare two strings

Comparison operations result in a value of `1` (`TRUE`), `0` (`FALSE`), or `NULL`. These operations work for both numbers and strings. Strings are automatically converted to numbers and numbers to strings as necessary.

The following relational comparison operators can be used to compare not only scalar operands, but row operands:

```
=  >  <  >=  <=  <>  !=
```

For examples of row comparisons, see Section 12.2.10.5, “Row Subqueries”.

Some of the functions in this section return values other than `1` (`TRUE`), `0` (`FALSE`), or `NULL`. For example, `LEAST()` and `GREATEST()`. However, the value they return is based on comparison operations performed according to the rules described in Section 11.2, “Type Conversion in Expression Evaluation”.

To convert a value to a specific type for comparison purposes, you can use the `CAST()` function. String values can be converted to a different character set using `CONVERT()`. See Section 11.10, “Cast Functions and Operators”.

By default, string comparisons are not case sensitive and use the current character set. The default is `latin1` (cp1252 West European), which also works well for English.

- `=`

  Equal:

  ```
  mysql> SELECT 1 = 0;
          -> 0
  mysql> SELECT '0' = 0;
          -> 1
  mysql> SELECT '0.0' = 0;
          -> 1
  mysql> SELECT '0.01' = 0;
          -> 0
  mysql> SELECT '.01' = 0.01;
          -> 1
  ```

- `<=>`

  `NULL`-safe equal. This operator performs an equality comparison like the `=` operator, but returns `1` rather than `NULL` if both operands are `NULL`, and `0` rather than `NULL` if one operand is `NULL`.

  ```
  mysql> SELECT 1 <=> 1, NULL <=> NULL, 1 <=> NULL;
          -> 1, 1, 0
  mysql> SELECT 1 = 1, NULL = NULL, 1 = NULL;
          -> 1, NULL, NULL
  ```

- `<>`, `!=`

Not equal:

```
mysql> SELECT '.01' <> '0.01';
        -> 1
mysql> SELECT .01 <> '0.01';
        -> 0
mysql> SELECT 'zapp' <> 'zappp';
        -> 1
```

- `<=`

  Less than or equal:

  ```
  mysql> SELECT 0.1 <= 2;
          -> 1
  ```

- `<`

  Less than:

  ```
  mysql> SELECT 2 < 2;
          -> 0
  ```

- `>=`

  Greater than or equal:

  ```
  mysql> SELECT 2 >= 2;
          -> 1
  ```

- `>`

  Greater than:

  ```
  mysql> SELECT 2 > 2;
          -> 0
  ```

- `IS` *`boolean_value`*

  Tests a value against a boolean value, where *`boolean_value`* can be `TRUE`, `FALSE`, or `UNKNOWN`.

  ```
  mysql> SELECT 1 IS TRUE, 0 IS FALSE, NULL IS UNKNOWN;
          -> 1, 1, 1
  ```

- `IS NOT` *`boolean_value`*

  Tests a value against a boolean value, where *`boolean_value`* can be `TRUE`, `FALSE`, or `UNKNOWN`.

  ```
  mysql> SELECT 1 IS NOT UNKNOWN, 0 IS NOT UNKNOWN, NULL IS NOT UNKNOWN;
          -> 1, 1, 0
  ```

- `IS NULL`

  Tests whether a value is `NULL`.

  ```
  mysql> SELECT 1 IS NULL, 0 IS NULL, NULL IS NULL;
          -> 0, 0, 1
  ```

  To work well with ODBC programs, MySQL supports the following extra features when using `IS NULL`:

  - If `sql_auto_is_null` variable is set to 1, then after a statement that successfully inserts an automatically generated `AUTO_INCREMENT` value, you can find that value by issuing a statement of the following form:

    ```
    SELECT * FROM tbl_name WHERE auto_col IS NULL
    ```

    If the statement returns a row, the value returned is the same as if you invoked the `LAST_INSERT_ID()` function. For details, including the return value after a multiple-row insert, see Section 11.14, “Information Functions”. If no `AUTO_INCREMENT` value was successfully inserted, the `SELECT` statement returns no row.

    The behavior of retrieving an `AUTO_INCREMENT` value by using an `IS NULL` comparison can be disabled by setting `sql_auto_is_null = 0`. See Section 5.1.3, “Server System Variables”.

The default value of `sql_auto_is_null` is 0 as of MySQL 5.5.3, and 1 for earlier versions.

- For `DATE` and `DATETIME` columns that are declared as `NOT NULL`, you can find the special date `'0000-00-00'` by using a statement like this:

  ```
  SELECT * FROM tbl_name WHERE date_column IS NULL
  ```

  This is needed to get some ODBC applications to work because ODBC does not support a `'0000-00-00'` date value.

  See Section 20.1.7.1.1, “Obtaining Auto-Increment Values”, and the description for the `FLAG_AUTO_IS_NULL` option at Section 20.1.4.2, “Connector/ODBC Connection Parameters”.

- `IS NOT NULL`

  Tests whether a value is not `NULL`.

  ```
  mysql> SELECT 1 IS NOT NULL, 0 IS NOT NULL, NULL IS NOT NULL;
          -> 1, 1, 0
  ```

- `expr BETWEEN min AND max`

  If `expr` is greater than or equal to `min` and `expr` is less than or equal to `max`, `BETWEEN` returns `1`, otherwise it returns `0`. This is equivalent to the expression `(min <= expr AND expr <= max)` if all the arguments are of the same type. Otherwise type conversion takes place according to the rules described in Section 11.2, “Type Conversion in Expression Evaluation”, but applied to all the three arguments.

  ```
  mysql> SELECT 2 BETWEEN 1 AND 3, 2 BETWEEN 3 and 1;
          -> 1, 0
  mysql> SELECT 1 BETWEEN 2 AND 3;
          -> 0
  mysql> SELECT 'b' BETWEEN 'a' AND 'c';
          -> 1
  mysql> SELECT 2 BETWEEN 2 AND '3';
          -> 1
  mysql> SELECT 2 BETWEEN 2 AND 'x-3';
          -> 0
  ```

  For best results when using `BETWEEN` with date or time values, use `CAST()` to explicitly convert the values to the desired data type. Examples: If you compare a `DATETIME` to two `DATE` values, convert the `DATE` values to `DATETIME` values. If you use a string constant such as `'2001-1-1'` in a comparison to a `DATE`, cast the string to a `DATE`.

- `expr NOT BETWEEN min AND max`

  This is the same as `NOT (expr BETWEEN min AND max)`.

- `COALESCE(value,...)`

  Returns the first non-`NULL` value in the list, or `NULL` if there are no non-`NULL` values.

  ```
  mysql> SELECT COALESCE(NULL,1);
          -> 1
  mysql> SELECT COALESCE(NULL,NULL,NULL);
          -> NULL
  ```

- `GREATEST(value1,value2,...)`

  With two or more arguments, returns the largest (maximum-valued) argument. The arguments are compared using the same rules as for `LEAST()`.

  ```
  mysql> SELECT GREATEST(2,0);
          -> 2
  mysql> SELECT GREATEST(34.0,3.0,5.0,767.0);
          -> 767.0
  mysql> SELECT GREATEST('B','A','C');
          -> 'C'
  ```

  `GREATEST()` returns `NULL` if any argument is `NULL`.

- `expr IN (value,...)`

  Returns `1` if `expr` is equal to any of the values in the `IN` list, else returns `0`. If all values are constants, they are evaluated according to the type of *`expr`* and sorted. The search for the item then is done using a binary search. This means `IN` is very quick if the `IN` value list consists entirely of constants. Otherwise, type conversion takes place according to the rules described in Section 11.2, “Type Conversion in Expression Evaluation”, but applied to all the arguments.

```
mysql> SELECT 2 IN (0,3,5,7);
        -> 0
mysql> SELECT 'wefwf' IN ('wee','wefwf','weg');
        -> 1
```

You should never mix quoted and unquoted values in an `IN` list because the comparison rules for quoted values (such as strings) and unquoted values (such as numbers) differ. Mixing types may therefore lead to inconsistent results. For example, do not write an `IN` expression like this:

```
SELECT val1 FROM tbl1 WHERE val1 IN (1,2,'a');
```

Instead, write it like this:

```
SELECT val1 FROM tbl1 WHERE val1 IN ('1','2','a');
```

The number of values in the `IN` list is only limited by the `max_allowed_packet` value.

To comply with the SQL standard, `IN` returns `NULL` not only if the expression on the left hand side is `NULL`, but also if no match is found in the list and one of the expressions in the list is `NULL`.

`IN()` syntax can also be used to write certain types of subqueries. See Section 12.2.10.3, “Subqueries with `ANY`, `IN`, or `SOME`”.

- *`expr`* `NOT IN (`*`value`*`,...)`

  This is the same as `NOT (`*`expr`* `IN (`*`value`*`,...))`.

- `ISNULL(`*`expr`*`)`

  If *`expr`* is `NULL`, `ISNULL()` returns `1`, otherwise it returns `0`.

  ```
  mysql> SELECT ISNULL(1+1);
          -> 0
  mysql> SELECT ISNULL(1/0);
          -> 1
  ```

  `ISNULL()` can be used instead of `=` to test whether a value is `NULL`. (Comparing a value to `NULL` using `=` always yields false.)

  The `ISNULL()` function shares some special behaviors with the `IS NULL` comparison operator. See the description of `IS NULL`.

- `INTERVAL(`*`N`*`,`*`N1`*`,`*`N2`*`,`*`N3`*`,...)`

  Returns `0` if *`N`* < *`N1`*, `1` if *`N`* < *`N2`* and so on or `-1` if *`N`* is `NULL`. All arguments are treated as integers. It is required that *`N1`* < *`N2`* < *`N3`* < `...` < *`Nn`* for this function to work correctly. This is because a binary search is used (very fast).

  ```
  mysql> SELECT INTERVAL(23, 1, 15, 17, 30, 44, 200);
          -> 3
  mysql> SELECT INTERVAL(10, 1, 10, 100, 1000);
          -> 2
  mysql> SELECT INTERVAL(22, 23, 30, 44, 200);
          -> 0
  ```

- `LEAST(`*`value1`*`,`*`value2`*`,...)`

  With two or more arguments, returns the smallest (minimum-valued) argument. The arguments are compared using the following rules:

  - If any argument is `NULL`, the result is `NULL`. No comparison is needed.
  - If the return value is used in an `INTEGER` context or all arguments are integer-valued, they are compared as integers.
  - If the return value is used in a `REAL` context or all arguments are real-valued, they are compared as reals.
  - If the arguments comprise a mix of numbers and strings, they are compared as numbers.
  - If any argument is a nonbinary (character) string, the arguments are compared as nonbinary strings.

- In all other cases, the arguments are compared as binary strings.

```
mysql> SELECT LEAST(2,0);
        -> 0
mysql> SELECT LEAST(34.0,3.0,5.0,767.0);
        -> 3.0
mysql> SELECT LEAST('B','A','C');
        -> 'A'
```

Note that the preceding conversion rules can produce strange results in some borderline cases:

```
mysql> SELECT CAST(LEAST(3600, 9223372036854775808.0) as SIGNED);
        -> -9223372036854775808
```

This happens because MySQL reads `9223372036854775808.0` in an integer context. The integer representation is not good enough to hold the value, so it wraps to a signed integer.

11.3.3. Logical Operators

Table 11.4. Logical Operators

Name	Description
`AND`, `&&`	Logical AND
`NOT`, `!`	Negates value
`||`, `OR`	Logical OR
`XOR`	Logical XOR

In SQL, all logical operators evaluate to `TRUE`, `FALSE`, or `NULL` (`UNKNOWN`). In MySQL, these are implemented as 1 (`TRUE`), 0 (`FALSE`), and `NULL`. Most of this is common to different SQL database servers, although some servers may return any nonzero value for `TRUE`.

MySQL evaluates any nonzero, non-`NULL` value to `TRUE`. For example, the following statements all assess to `TRUE`:

```
mysql> SELECT 10 IS TRUE;
-> 1
mysql> SELECT -10 IS TRUE;
-> 1
mysql> SELECT 'string' IS NOT NULL;
-> 1
```

- `NOT`, `!`

  Logical NOT. Evaluates to `1` if the operand is `0`, to `0` if the operand is nonzero, and `NOT NULL` returns `NULL`.

```
mysql> SELECT NOT 10;
        -> 0
mysql> SELECT NOT 0;
        -> 1
mysql> SELECT NOT NULL;
        -> NULL
mysql> SELECT ! (1+1);
        -> 0
mysql> SELECT ! 1+1;
        -> 1
```

  The last example produces `1` because the expression evaluates the same way as `(!1)+1`.

- `AND`, `&&`

  Logical AND. Evaluates to `1` if all operands are nonzero and not `NULL`, to `0` if one or more operands are `0`, otherwise `NULL` is returned.

```
mysql> SELECT 1 && 1;
        -> 1
mysql> SELECT 1 && 0;
        -> 0
mysql> SELECT 1 && NULL;
        -> NULL
mysql> SELECT 0 && NULL;
        -> 0
```

```
mysql> SELECT NULL && 0;
        -> 0
```

- `OR`, `||`

  Logical OR. When both operands are non-`NULL`, the result is `1` if any operand is nonzero, and `0` otherwise. With a `NULL` operand, the result is `1` if the other operand is nonzero, and `NULL` otherwise. If both operands are `NULL`, the result is `NULL`.

```
mysql> SELECT 1 || 1;
        -> 1
mysql> SELECT 1 || 0;
        -> 1
mysql> SELECT 0 || 0;
        -> 0
mysql> SELECT 0 || NULL;
        -> NULL
mysql> SELECT 1 || NULL;
        -> 1
```

- `XOR`

  Logical XOR. Returns `NULL` if either operand is `NULL`. For non-`NULL` operands, evaluates to `1` if an odd number of operands is nonzero, otherwise `0` is returned.

```
mysql> SELECT 1 XOR 1;
        -> 0
mysql> SELECT 1 XOR 0;
        -> 1
mysql> SELECT 1 XOR NULL;
        -> NULL
mysql> SELECT 1 XOR 1 XOR 1;
        -> 1
```

  `a XOR b` is mathematically equal to `(a AND (NOT b)) OR ((NOT a) and b)`.

11.3.4. Assignment Operators

Table 11.5. Assignment Operators

Name	Description
`=`	Assign a value (as part of a `SET` statement, or as part of the `SET` clause in an `UPDATE` statement)
`:=`	Assign a value

- `:=`

  Assignment operator. Causes the user variable on the left hand side of the operator to take on the value to its right. The value on the right hand side may be a literal value, another variable storing a value, or any legal expression that yields a scalar value, including the result of a query (provided that this value is a scalar value). You can perform multiple assignments in the same `SET` statement. You can perform multiple assignments in the same statement-

  Unlike `=`, the `:=` operator is never interpreted as a comparison operator. This means you can use `:=` in any valid SQL statement (not just in `SET` statements) to assign a value to a variable.

```
mysql> SELECT @var1, @var2;
        -> NULL, NULL
mysql> SELECT @var1 := 1, @var2;
        -> 1, NULL
mysql> SELECT @var1, @var2;
        -> 1, NULL
mysql> SELECT @var1, @var2 := @var1;
        -> 1, 1
mysql> SELECT @var1, @var2;
        -> 1, 1

mysql> SELECT @var1:=COUNT(*) FROM t1;
        -> 4
mysql> SELECT @var1;
        -> 4
```

  You can make value assignments using `:=` in other statements besides `SELECT`, such as `UPDATE`, as shown here:

```
mysql> SELECT @var1;
        -> 4
mysql> SELECT * FROM t1;
        -> 1, 3, 5, 7

mysql> UPDATE t1 SET c1 = 2 WHERE c1 = @var1:= 1;
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> SELECT @var1;
        -> 1
mysql> SELECT * FROM t1;
        -> 2, 3, 5, 7
```

While it is also possible both to set and to read the value of the same variable in a single SQL statement using the `:=` operator, this is not recommended. Section 8.4, “User-Defined Variables”, explains why you should avoid doing this.

- `=`

  This operator is used to perform value assignments in two cases, described in the next two paragraphs.

  Within a `SET` statement, `=` is treated as an assignment operator that causes the user variable on the left hand side of the operator to take on the value to its right. (In other words, when used in a `SET` statement, `=` is treated identically to `:=`.) The value on the right hand side may be a literal value, another variable storing a value, or any legal expression that yields a scalar value, including the result of a query (provided that this value is a scalar value). You can perform multiple assignments in the same `SET` statement.

  In the `SET` clause of an `UPDATE` statement, `=` also acts as an assignment operator; in this case, however, it causes the column named on the left hand side of the operator to assume the value given to the right, provided any `WHERE` conditions that are part of the `UPDATE` are met. You can make multiple assignments in the same `SET` clause of an `UPDATE` statement.

  In any other context, `=` is treated as a comparison operator.

```
mysql> SELECT @var1, @var2;
        -> NULL, NULL
mysql> SELECT @var1 := 1, @var2;
        -> 1, NULL
mysql> SELECT @var1, @var2;
        -> 1, NULL
mysql> SELECT @var1, @var2 := @var1;
        -> 1, 1
mysql> SELECT @var1, @var2;
        -> 1, 1
```

  For more information, see Section 12.4.4, “`SET` Syntax”, Section 12.2.11, “`UPDATE` Syntax”, and Section 12.2.10, “Subquery Syntax”.

11.4. Control Flow Functions

Table 11.6. Flow Control Operators

Name	**Description**
`CASE`	Case operator
`IF()`	If/else construct
`IFNULL()`	Null if/else construct
`NULLIF()`	Return NULL if expr1 = expr2

- `CASE` *`value`* `WHEN [`*`compare_value`*`] THEN` *`result`* `[WHEN [`*`compare_value`*`] THEN` *`result`* `...] [ELSE` *`result`*`] END`

  `CASE WHEN [`*`condition`*`] THEN` *`result`* `[WHEN [`*`condition`*`] THEN` *`result`* `...] [ELSE` *`result`*`] END`

  The first version returns the *`result`* where *`value=compare_value`*. The second version returns the result for the first condition that is true. If there was no matching result value, the result after `ELSE` is returned, or `NULL` if there is no `ELSE` part.

```
mysql> SELECT CASE 1 WHEN 1 THEN 'one'
    ->     WHEN 2 THEN 'two' ELSE 'more' END;
        -> 'one'
mysql> SELECT CASE WHEN 1>0 THEN 'true' ELSE 'false' END;
```

```
        -> 'true'
mysql> SELECT CASE BINARY 'B'
    ->     WHEN 'a' THEN 1 WHEN 'b' THEN 2 END;
        -> NULL
```

The return type of a `CASE` expression is the compatible aggregated type of all return values, but also depends on the context in which it is used. If used in a string context, the result is returned as a string. If used in a numeric context, the result is returned as a decimal, real, or integer value.

> **Note**
>
> The syntax of the `CASE` *expression* shown here differs slightly from that of the SQL `CASE` *statement* described in Section 12.7.6.2, “`CASE` Statement”, for use inside stored programs. The `CASE` statement cannot have an `ELSE NULL` clause, and it is terminated with `END CASE` instead of `END`.

- `IF(expr1,expr2,expr3)`

  If `expr1` is `TRUE` (`expr1 <> 0` and `expr1 <> NULL`) then `IF()` returns `expr2`; otherwise it returns `expr3`. `IF()` returns a numeric or string value, depending on the context in which it is used.

  ```
  mysql> SELECT IF(1>2,2,3);
          -> 3
  mysql> SELECT IF(1<2,'yes','no');
          -> 'yes'
  mysql> SELECT IF(STRCMP('test','test1'),'no','yes');
          -> 'no'
  ```

  If only one of `expr2` or `expr3` is explicitly `NULL`, the result type of the `IF()` function is the type of the non-`NULL` expression.

  The default return type of `IF()` (which may matter when it is stored into a temporary table) is calculated as follows.

Expression	Return Value
`expr2` or `expr3` returns a string	string
`expr2` or `expr3` returns a floating-point value	floating-point
`expr2` or `expr3` returns an integer	integer

  If `expr2` and `expr3` are both strings, the result is case sensitive if either string is case sensitive.

  > **Note**
  >
  > There is also an `IF` *statement*, which differs from the `IF()` *function* described here. See Section 12.7.6.1, “`IF` Statement”.

- `IFNULL(expr1,expr2)`

  If `expr1` is not `NULL`, `IFNULL()` returns `expr1`; otherwise it returns `expr2`. `IFNULL()` returns a numeric or string value, depending on the context in which it is used.

  ```
  mysql> SELECT IFNULL(1,0);
          -> 1
  mysql> SELECT IFNULL(NULL,10);
          -> 10
  mysql> SELECT IFNULL(1/0,10);
          -> 10
  mysql> SELECT IFNULL(1/0,'yes');
          -> 'yes'
  ```

  The default result value of `IFNULL(expr1,expr2)` is the more “general” of the two expressions, in the order `STRING`, `REAL`, or `INTEGER`. Consider the case of a table based on expressions or where MySQL must internally store a value returned by `IFNULL()` in a temporary table:

  ```
  mysql> CREATE TABLE tmp SELECT IFNULL(1,'test') AS test;
  mysql> DESCRIBE tmp;
  +-------+--------------+------+-----+---------+-------+
  | Field | Type         | Null | Key | Default | Extra |
  +-------+--------------+------+-----+---------+-------+
  | test  | varbinary(4) | NO   |     |         |       |
  +-------+--------------+------+-----+---------+-------+
  ```

  In this example, the type of the `test` column is `VARBINARY(4)`.

- `NULLIF(expr1,expr2)`

  Returns `NULL` if `expr1 = expr2` is true, otherwise returns `expr1`. This is the same as `CASE WHEN expr1 = expr2 THEN NULL ELSE expr1 END`.

  ```
  mysql> SELECT NULLIF(1,1);
          -> NULL
  mysql> SELECT NULLIF(1,2);
          -> 1
  ```

  Note that MySQL evaluates `expr1` twice if the arguments are not equal.

11.5. String Functions

Table 11.7. String Operators

Name	Description
`ASCII()`	Return numeric value of left-most character
`BIN()`	Return a string representation of the argument
`BIT_LENGTH()`	Return length of argument in bits
`CHAR_LENGTH()`	Return number of characters in argument
`CHAR()`	Return the character for each integer passed
`CHARACTER_LENGTH()`	A synonym for CHAR_LENGTH()
`CONCAT_WS()`	Return concatenate with separator
`CONCAT()`	Return concatenated string
`ELT()`	Return string at index number
`EXPORT_SET()`	Return a string such that for every bit set in the value bits, you get an on string and for every unset bit, you get an off string
`FIELD()`	Return the index (position) of the first argument in the subsequent arguments
`FIND_IN_SET()`	Return the index position of the first argument within the second argument
`FORMAT()`	Return a number formatted to specified number of decimal places
`HEX()`	Return a hexadecimal representation of a decimal or string value
`INSERT()`	Insert a substring at the specified position up to the specified number of characters
`INSTR()`	Return the index of the first occurrence of substring
`LCASE()`	Synonym for LOWER()
`LEFT()`	Return the leftmost number of characters as specified
`LENGTH()`	Return the length of a string in bytes
`LIKE`	Simple pattern matching
`LOAD_FILE()`	Load the named file
`LOCATE()`	Return the position of the first occurrence of substring
`LOWER()`	Return the argument in lowercase
`LPAD()`	Return the string argument, left-padded with the specified string
`LTRIM()`	Remove leading spaces
`MAKE_SET()`	Return a set of comma-separated strings that have the corresponding bit in bits set
`MATCH`	Perform full-text search
`MID()`	Return a substring starting from the specified position
`NOT LIKE`	Negation of simple pattern matching
`NOT REGEXP`	Negation of REGEXP
`OCTET_LENGTH()`	A synonym for LENGTH()
`ORD()`	Return character code for leftmost character of the argument
`POSITION()`	A synonym for LOCATE()

Name	Description
`QUOTE()`	Escape the argument for use in an SQL statement
`REGEXP`	Pattern matching using regular expressions
`REPEAT()`	Repeat a string the specified number of times
`REPLACE()`	Replace occurrences of a specified string
`REVERSE()`	Reverse the characters in a string
`RIGHT()`	Return the specified rightmost number of characters
`RLIKE`	Synonym for REGEXP
`RPAD()`	Append string the specified number of times
`RTRIM()`	Remove trailing spaces
`SOUNDEX()`	Return a soundex string
`SOUNDS LIKE`	Compare sounds
`SPACE()`	Return a string of the specified number of spaces
`STRCMP()`	Compare two strings
`SUBSTR()`	Return the substring as specified
`SUBSTRING_INDEX()`	Return a substring from a string before the specified number of occurrences of the delimiter
`SUBSTRING()`	Return the substring as specified
`TRIM()`	Remove leading and trailing spaces
`UCASE()`	Synonym for UPPER()
`UNHEX()`	Convert each pair of hexadecimal digits to a character
`UPPER()`	Convert to uppercase

String-valued functions return `NULL` if the length of the result would be greater than the value of the `max_allowed_packet` system variable. See Section 7.11.2, “Tuning Server Parameters”.

For functions that operate on string positions, the first position is numbered 1.

For functions that take length arguments, noninteger arguments are rounded to the nearest integer.

- `ASCII(str)`

  Returns the numeric value of the leftmost character of the string `str`. Returns `0` if `str` is the empty string. Returns `NULL` if `str` is `NULL`. `ASCII()` works for 8-bit characters.

  ```
  mysql> SELECT ASCII('2');
          -> 50
  mysql> SELECT ASCII(2);
          -> 50
  mysql> SELECT ASCII('dx');
          -> 100
  ```

  See also the `ORD()` function.

- `BIN(N)`

  Returns a string representation of the binary value of `N`, where `N` is a longlong (`BIGINT`) number. This is equivalent to `CONV(N,10,2)`. Returns `NULL` if `N` is `NULL`.

  ```
  mysql> SELECT BIN(12);
          -> '1100'
  ```

- `BIT_LENGTH(str)`

  Returns the length of the string `str` in bits.

  ```
  mysql> SELECT BIT_LENGTH('text');
          -> 32
  ```

- `CHAR(N,... [USING charset_name])`

`CHAR()` interprets each argument *`N`* as an integer and returns a string consisting of the characters given by the code values of those integers. `NULL` values are skipped.

```
mysql> SELECT CHAR(77,121,83,81,'76');
        -> 'MySQL'
mysql> SELECT CHAR(77,77.3,'77.3');
        -> 'MMM'
```

`CHAR()` arguments larger than 255 are converted into multiple result bytes. For example, `CHAR(256)` is equivalent to `CHAR(1,0)`, and `CHAR(256*256)` is equivalent to `CHAR(1,0,0)`:

```
mysql> SELECT HEX(CHAR(1,0)), HEX(CHAR(256));
+----------------+----------------+
| HEX(CHAR(1,0)) | HEX(CHAR(256)) |
+----------------+----------------+
| 0100           | 0100           |
+----------------+----------------+
mysql> SELECT HEX(CHAR(1,0,0)), HEX(CHAR(256*256));
+------------------+--------------------+
| HEX(CHAR(1,0,0)) | HEX(CHAR(256*256)) |
+------------------+--------------------+
| 010000           | 010000             |
+------------------+--------------------+
```

By default, `CHAR()` returns a binary string. To produce a string in a given character set, use the optional `USING` clause:

```
mysql> SELECT CHARSET(CHAR(0x65)), CHARSET(CHAR(0x65 USING utf8));
+---------------------+--------------------------------+
| CHARSET(CHAR(0x65)) | CHARSET(CHAR(0x65 USING utf8)) |
+---------------------+--------------------------------+
| binary              | utf8                           |
+---------------------+--------------------------------+
```

If `USING` is given and the result string is illegal for the given character set, a warning is issued. Also, if strict SQL mode is enabled, the result from `CHAR()` becomes `NULL`.

- `CHAR_LENGTH(`*`str`*`)`

  Returns the length of the string *`str`*, measured in characters. A multi-byte character counts as a single character. This means that for a string containing five two-byte characters, `LENGTH()` returns `10`, whereas `CHAR_LENGTH()` returns `5`.

- `CHARACTER_LENGTH(`*`str`*`)`

  `CHARACTER_LENGTH()` is a synonym for `CHAR_LENGTH()`.

- `CONCAT(`*`str1`*`,`*`str2`*`,...)`

  Returns the string that results from concatenating the arguments. May have one or more arguments. If all arguments are nonbinary strings, the result is a nonbinary string. If the arguments include any binary strings, the result is a binary string. A numeric argument is converted to its equivalent binary string form; if you want to avoid that, you can use an explicit type cast, as in this example:

  ```
  SELECT CONCAT(CAST(int_col AS CHAR), char_col);
  ```

  `CONCAT()` returns `NULL` if any argument is `NULL`.

  ```
  mysql> SELECT CONCAT('My', 'S', 'QL');
          -> 'MySQL'
  mysql> SELECT CONCAT('My', NULL, 'QL');
          -> NULL
  mysql> SELECT CONCAT(14.3);
          -> '14.3'
  ```

  For quoted strings, concatenation can be performed by placing the strings next to each other:

  ```
  mysql> SELECT 'My' 'S' 'QL';
          -> 'MySQL'
  ```

- `CONCAT_WS(`*`separator`*`,`*`str1`*`,`*`str2`*`,...)`

  `CONCAT_WS()` stands for Concatenate With Separator and is a special form of `CONCAT()`. The first argument is the separator for the rest of the arguments. The separator is added between the strings to be concatenated. The separator can be a string, as can the rest of the arguments. If the separator is `NULL`, the result is `NULL`.

  ```
  mysql> SELECT CONCAT_WS(',','First name','Second name','Last Name');
  ```

```
        -> 'First name,Second name,Last Name'
mysql> SELECT CONCAT_WS(',','First name',NULL,'Last Name');
        -> 'First name,Last Name'
```

`CONCAT_WS()` does not skip empty strings. However, it does skip any `NULL` values after the separator argument.

- `ELT(N,str1,str2,str3,...)`

  Returns `str1` if `N` = `1`, `str2` if `N` = `2`, and so on. Returns `NULL` if `N` is less than `1` or greater than the number of arguments. `ELT()` is the complement of `FIELD()`.

  ```
  mysql> SELECT ELT(1, 'ej', 'Heja', 'hej', 'foo');
          -> 'ej'
  mysql> SELECT ELT(4, 'ej', 'Heja', 'hej', 'foo');
          -> 'foo'
  ```

- `EXPORT_SET(bits,on,off[,separator[,number_of_bits]])`

  Returns a string such that for every bit set in the value `bits`, you get an `on` string and for every bit not set in the value, you get an `off` string. Bits in `bits` are examined from right to left (from low-order to high-order bits). Strings are added to the result from left to right, separated by the `separator` string (the default being the comma character "`,`"). The number of bits examined is given by `number_of_bits`, which has a default of 64 if not specified. `number_of_bits` is silently clipped to 64 if larger than 64. It is treated as an unsigned integer, so a value of –1 is effectively the same as 64.

  ```
  mysql> SELECT EXPORT_SET(5,'Y','N',',',4);
          -> 'Y,N,Y,N'
  mysql> SELECT EXPORT_SET(6,'1','0',',',10);
          -> '0,1,1,0,0,0,0,0,0,0'
  ```

- `FIELD(str,str1,str2,str3,...)`

  Returns the index (position) of `str` in the `str1`, `str2`, `str3`, `...` list. Returns `0` if `str` is not found.

  If all arguments to `FIELD()` are strings, all arguments are compared as strings. If all arguments are numbers, they are compared as numbers. Otherwise, the arguments are compared as double.

  If `str` is `NULL`, the return value is `0` because `NULL` fails equality comparison with any value. `FIELD()` is the complement of `ELT()`.

  ```
  mysql> SELECT FIELD('ej', 'Hej', 'ej', 'Heja', 'hej', 'foo');
          -> 2
  mysql> SELECT FIELD('fo', 'Hej', 'ej', 'Heja', 'hej', 'foo');
          -> 0
  ```

- `FIND_IN_SET(str,strlist)`

  Returns a value in the range of 1 to `N` if the string `str` is in the string list `strlist` consisting of `N` substrings. A string list is a string composed of substrings separated by "`,`" characters. If the first argument is a constant string and the second is a column of type `SET`, the `FIND_IN_SET()` function is optimized to use bit arithmetic. Returns `0` if `str` is not in `strlist` or if `strlist` is the empty string. Returns `NULL` if either argument is `NULL`. This function does not work properly if the first argument contains a comma ("`,`") character.

  ```
  mysql> SELECT FIND_IN_SET('b','a,b,c,d');
          -> 2
  ```

- `FORMAT(X,D[,locale])`

  Formats the number `X` to a format like `'#,###,###.##'`, rounded to `D` decimal places, and returns the result as a string. If `D` is `0`, the result has no decimal point or fractional part.

  The optional third parameter enables a locale to be specified to be used for the result number's decimal point, thousands separator, and grouping between separators. Permissible locale values are the same as the legal values for the `lc_time_names` system variable (see Section 9.7, "MySQL Server Locale Support"). If no locale is specified, the default is `'en_US'`.

  ```
  mysql> SELECT FORMAT(12332.123456, 4);
          -> '12,332.1235'
  mysql> SELECT FORMAT(12332.1,4);
          -> '12,332.1000'
  mysql> SELECT FORMAT(12332.2,0);
          -> '12,332'
  mysql> SELECT FORMAT(12332.2,2,'de_DE');
          -> '12.332,20'
  ```

- `HEX(str)`, `HEX(N)`

  For a string argument `str`, `HEX()` returns a hexadecimal string representation of `str` where each character in `str` is converted to two hexadecimal digits. The inverse of this operation is performed by the `UNHEX()` function.

  For a numeric argument `N`, `HEX()` returns a hexadecimal string representation of the value of `N` treated as a longlong (`BIGINT`) number. This is equivalent to `CONV(N,10,16)`. The inverse of this operation is performed by `CONV(HEX(N),16,10)`.

  ```
  mysql> SELECT 0x616263, HEX('abc'), UNHEX(HEX('abc'));
          -> 'abc', 616263, 'abc'
  mysql> SELECT HEX(255), CONV(HEX(255),16,10);
          -> 'FF', 255
  ```

- `INSERT(str,pos,len,newstr)`

  Returns the string `str`, with the substring beginning at position `pos` and `len` characters long replaced by the string `newstr`. Returns the original string if `pos` is not within the length of the string. Replaces the rest of the string from position `pos` if `len` is not within the length of the rest of the string. Returns `NULL` if any argument is `NULL`.

  ```
  mysql> SELECT INSERT('Quadratic', 3, 4, 'What');
          -> 'QuWhattic'
  mysql> SELECT INSERT('Quadratic', -1, 4, 'What');
          -> 'Quadratic'
  mysql> SELECT INSERT('Quadratic', 3, 100, 'What');
          -> 'QuWhat'
  ```

  This function is multi-byte safe.

- `INSTR(str,substr)`

  Returns the position of the first occurrence of substring `substr` in string `str`. This is the same as the two-argument form of `LOCATE()`, except that the order of the arguments is reversed.

  ```
  mysql> SELECT INSTR('foobarbar', 'bar');
          -> 4
  mysql> SELECT INSTR('xbar', 'foobar');
          -> 0
  ```

  This function is multi-byte safe, and is case sensitive only if at least one argument is a binary string.

- `LCASE(str)`

  `LCASE()` is a synonym for `LOWER()`.

- `LEFT(str,len)`

  Returns the leftmost `len` characters from the string `str`, or `NULL` if any argument is `NULL`.

  ```
  mysql> SELECT LEFT('foobarbar', 5);
          -> 'fooba'
  ```

- `LENGTH(str)`

  Returns the length of the string `str`, measured in bytes. A multi-byte character counts as multiple bytes. This means that for a string containing five two-byte characters, `LENGTH()` returns `10`, whereas `CHAR_LENGTH()` returns `5`.

  ```
  mysql> SELECT LENGTH('text');
          -> 4
  ```

- `LOAD_FILE(file_name)`

  Reads the file and returns the file contents as a string. To use this function, the file must be located on the server host, you must specify the full path name to the file, and you must have the `FILE` privilege. The file must be readable by all and its size less than `max_allowed_packet` bytes. If the `secure_file_priv` system variable is set to a nonempty directory name, the file to be loaded must be located in that directory.

  If the file does not exist or cannot be read because one of the preceding conditions is not satisfied, the function returns `NULL`.

  The `character_set_filesystem` system variable controls interpretation of file names that are given as literal strings.

  ```
  mysql> UPDATE t
              SET blob_col=LOAD_FILE('/tmp/picture')
  ```

```
            WHERE id=1;
```

- `LOCATE(substr,str)`, `LOCATE(substr,str,pos)`

  The first syntax returns the position of the first occurrence of substring *`substr`* in string *`str`*. The second syntax returns the position of the first occurrence of substring *`substr`* in string *`str`*, starting at position *`pos`*. Returns `0` if *`substr`* is not in *`str`*.

  ```
  mysql> SELECT LOCATE('bar', 'foobarbar');
          -> 4
  mysql> SELECT LOCATE('xbar', 'foobar');
          -> 0
  mysql> SELECT LOCATE('bar', 'foobarbar', 5);
          -> 7
  ```

  This function is multi-byte safe, and is case-sensitive only if at least one argument is a binary string.

- `LOWER(str)`

  Returns the string *`str`* with all characters changed to lowercase according to the current character set mapping. The default is `latin1` (cp1252 West European).

  ```
  mysql> SELECT LOWER('QUADRATICALLY');
          -> 'quadratically'
  ```

  `LOWER()` (and `UPPER()`) are ineffective when applied to binary strings (`BINARY`, `VARBINARY`, `BLOB`). To perform lettercase conversion, convert the string to a nonbinary string:

  ```
  mysql> SET @str = BINARY 'New York';
  mysql> SELECT LOWER(@str), LOWER(CONVERT(@str USING latin1));
  +-------------+-----------------------------------+
  | LOWER(@str) | LOWER(CONVERT(@str USING latin1)) |
  +-------------+-----------------------------------+
  | New York    | new york                          |
  +-------------+-----------------------------------+
  ```

  This function is multi-byte safe.

- `LPAD(str,len,padstr)`

  Returns the string *`str`*, left-padded with the string *`padstr`* to a length of *`len`* characters. If *`str`* is longer than *`len`*, the return value is shortened to *`len`* characters.

  ```
  mysql> SELECT LPAD('hi',4,'??');
          -> '??hi'
  mysql> SELECT LPAD('hi',1,'??');
          -> 'h'
  ```

- `LTRIM(str)`

  Returns the string *`str`* with leading space characters removed.

  ```
  mysql> SELECT LTRIM('  barbar');
          -> 'barbar'
  ```

  This function is multi-byte safe.

- `MAKE_SET(bits,str1,str2,...)`

  Returns a set value (a string containing substrings separated by “`,`” characters) consisting of the strings that have the corresponding bit in *`bits`* set. *`str1`* corresponds to bit 0, *`str2`* to bit 1, and so on. `NULL` values in *`str1`*, *`str2`*, *`...`* are not appended to the result.

  ```
  mysql> SELECT MAKE_SET(1,'a','b','c');
          -> 'a'
  mysql> SELECT MAKE_SET(1 | 4,'hello','nice','world');
          -> 'hello,world'
  mysql> SELECT MAKE_SET(1 | 4,'hello','nice',NULL,'world');
          -> 'hello'
  mysql> SELECT MAKE_SET(0,'a','b','c');
          -> ''
  ```

- `MID(str,pos,len)`

  `MID(str,pos,len)` is a synonym for `SUBSTRING(str,pos,len)`.

- `OCTET_LENGTH(str)`

  `OCTET_LENGTH()` is a synonym for `LENGTH()`.

- `ORD(str)`

  If the leftmost character of the string `str` is a multi-byte character, returns the code for that character, calculated from the numeric values of its constituent bytes using this formula:

  ```
    (1st byte code)
  + (2nd byte code * 256)
  + (3rd byte code * 256^2) ...
  ```

  If the leftmost character is not a multi-byte character, `ORD()` returns the same value as the `ASCII()` function.

  ```
  mysql> SELECT ORD('2');
          -> 50
  ```

- `POSITION(substr IN str)`

  `POSITION(substr IN str)` is a synonym for `LOCATE(substr,str)`.

- `QUOTE(str)`

  Quotes a string to produce a result that can be used as a properly escaped data value in an SQL statement. The string is returned enclosed by single quotation marks and with each instance of backslash (“`\`”), single quote (“`'`”), ASCII `NUL`, and Control+Z preceded by a backslash. If the argument is `NULL`, the return value is the word “NULL” without enclosing single quotation marks.

  ```
  mysql> SELECT QUOTE('Don\'t!');
          -> 'Don\'t!'
  mysql> SELECT QUOTE(NULL);
          -> NULL
  ```

  For comparison, see the quoting rules for literal strings and within the C API in Section 8.1.1, “Strings”, and Section 20.9.3.53, “`mysql_real_escape_string()`”.

- `REPEAT(str,count)`

  Returns a string consisting of the string `str` repeated `count` times. If `count` is less than 1, returns an empty string. Returns `NULL` if `str` or `count` are `NULL`.

  ```
  mysql> SELECT REPEAT('MySQL', 3);
          -> 'MySQLMySQLMySQL'
  ```

- `REPLACE(str,from_str,to_str)`

  Returns the string `str` with all occurrences of the string `from_str` replaced by the string `to_str`. `REPLACE()` performs a case-sensitive match when searching for `from_str`.

  ```
  mysql> SELECT REPLACE('www.mysql.com', 'w', 'Ww');
          -> 'WwWwWw.mysql.com'
  ```

  This function is multi-byte safe.

- `REVERSE(str)`

  Returns the string `str` with the order of the characters reversed.

  ```
  mysql> SELECT REVERSE('abc');
          -> 'cba'
  ```

  This function is multi-byte safe.

- `RIGHT(str,len)`

  Returns the rightmost `len` characters from the string `str`, or `NULL` if any argument is `NULL`.

  ```
  mysql> SELECT RIGHT('foobarbar', 4);
  ```

```
        -> 'rbar'
```

This function is multi-byte safe.

- `RPAD(str,len,padstr)`

  Returns the string `str`, right-padded with the string `padstr` to a length of `len` characters. If `str` is longer than `len`, the return value is shortened to `len` characters.

  ```
  mysql> SELECT RPAD('hi',5,'?');
          -> 'hi???'
  mysql> SELECT RPAD('hi',1,'?');
          -> 'h'
  ```

  This function is multi-byte safe.

- `RTRIM(str)`

  Returns the string `str` with trailing space characters removed.

  ```
  mysql> SELECT RTRIM('barbar   ');
          -> 'barbar'
  ```

  This function is multi-byte safe.

- `SOUNDEX(str)`

  Returns a soundex string from `str`. Two strings that sound almost the same should have identical soundex strings. A standard soundex string is four characters long, but the `SOUNDEX()` function returns an arbitrarily long string. You can use `SUBSTRING()` on the result to get a standard soundex string. All nonalphabetic characters in `str` are ignored. All international alphabetic characters outside the A-Z range are treated as vowels.

  ### Important

  When using `SOUNDEX()`, you should be aware of the following limitations:

  - This function, as currently implemented, is intended to work well with strings that are in the English language only. Strings in other languages may not produce reliable results.

  - This function is not guaranteed to provide consistent results with strings that use multi-byte character sets, including `utf-8`.

    We hope to remove these limitations in a future release. See Bug #22638 for more information.

  ```
  mysql> SELECT SOUNDEX('Hello');
          -> 'H400'
  mysql> SELECT SOUNDEX('Quadratically');
          -> 'Q36324'
  ```

  ### Note

  This function implements the original Soundex algorithm, not the more popular enhanced version (also described by D. Knuth). The difference is that original version discards vowels first and duplicates second, whereas the enhanced version discards duplicates first and vowels second.

- `expr1 SOUNDS LIKE expr2`

  This is the same as `SOUNDEX(expr1) = SOUNDEX(expr2)`.

- `SPACE(N)`

  Returns a string consisting of `N` space characters.

  ```
  mysql> SELECT SPACE(6);
          -> '      '
  ```

- `SUBSTR(str,pos)`, `SUBSTR(str FROM pos)`, `SUBSTR(str,pos,len)`, `SUBSTR(str FROM pos FOR len)`

  `SUBSTR()` is a synonym for `SUBSTRING()`.

- `SUBSTRING(str,pos)`, `SUBSTRING(str FROM pos)`, `SUBSTRING(str,pos,len)`, `SUBSTRING(str FROM` `pos FOR len)`

The forms without a *`len`* argument return a substring from string *`str`* starting at position *`pos`*. The forms with a *`len`* argument return a substring *`len`* characters long from string *`str`*, starting at position *`pos`*. The forms that use `FROM` are standard SQL syntax. It is also possible to use a negative value for *`pos`*. In this case, the beginning of the substring is *`pos`* characters from the end of the string, rather than the beginning. A negative value may be used for *`pos`* in any of the forms of this function.

For all forms of `SUBSTRING()`, the position of the first character in the string from which the substring is to be extracted is reckoned as `1`.

```
mysql> SELECT SUBSTRING('Quadratically',5);
        -> 'ratically'
mysql> SELECT SUBSTRING('foobarbar' FROM 4);
        -> 'barbar'
mysql> SELECT SUBSTRING('Quadratically',5,6);
        -> 'ratica'
mysql> SELECT SUBSTRING('Sakila', -3);
        -> 'ila'
mysql> SELECT SUBSTRING('Sakila', -5, 3);
        -> 'aki'
mysql> SELECT SUBSTRING('Sakila' FROM -4 FOR 2);
        -> 'ki'
```

This function is multi-byte safe.

If *`len`* is less than 1, the result is the empty string.

- `SUBSTRING_INDEX(`*`str`*`,`*`delim`*`,`*`count`*`)`

  Returns the substring from string *`str`* before *`count`* occurrences of the delimiter *`delim`*. If *`count`* is positive, everything to the left of the final delimiter (counting from the left) is returned. If *`count`* is negative, everything to the right of the final delimiter (counting from the right) is returned. `SUBSTRING_INDEX()` performs a case-sensitive match when searching for *`delim`*.

```
mysql> SELECT SUBSTRING_INDEX('www.mysql.com', '.', 2);
        -> 'www.mysql'
mysql> SELECT SUBSTRING_INDEX('www.mysql.com', '.', -2);
        -> 'mysql.com'
```

  This function is multi-byte safe.

- `TRIM([{BOTH | LEADING | TRAILING} [`*`remstr`*`] FROM] `*`str`*`)`, `TRIM([`*`remstr`*` FROM] `*`str`*`)`

  Returns the string *`str`* with all *`remstr`* prefixes or suffixes removed. If none of the specifiers `BOTH`, `LEADING`, or `TRAILING` is given, `BOTH` is assumed. *`remstr`* is optional and, if not specified, spaces are removed.

```
mysql> SELECT TRIM('  bar   ');
        -> 'bar'
mysql> SELECT TRIM(LEADING 'x' FROM 'xxxbarxxx');
        -> 'barxxx'
mysql> SELECT TRIM(BOTH 'x' FROM 'xxxbarxxx');
        -> 'bar'
mysql> SELECT TRIM(TRAILING 'xyz' FROM 'barxxyz');
        -> 'barx'
```

  This function is multi-byte safe.

- `UCASE(`*`str`*`)`

  `UCASE()` is a synonym for `UPPER()`.

- `UNHEX(`*`str`*`)`

  For a string argument *`str`*, `UNHEX(`*`str`*`)` performs the inverse operation of `HEX(`*`str`*`)`. That is, it interprets each pair of characters in the argument as a hexadecimal number and converts it to the character represented by the number. The return value is a binary string.

```
mysql> SELECT UNHEX('4D7953514C');
        -> 'MySQL'
mysql> SELECT 0x4D7953514C;
        -> 'MySQL'
mysql> SELECT UNHEX(HEX('string'));
        -> 'string'
mysql> SELECT HEX(UNHEX('1267'));
        -> '1267'
```

  The characters in the argument string must be legal hexadecimal digits: `'0'` .. `'9'`, `'A'` .. `'F'`, `'a'` .. `'f'`. If the argument contains any nonhexadecimal digits, the result is `NULL`:

```
mysql> SELECT UNHEX('GG');
+-------------+
| UNHEX('GG') |
+-------------+
| NULL        |
+-------------+
```

A `NULL` result can occur if the argument to `UNHEX()` is a `BINARY` column, because values are padded with 0x00 bytes when stored but those bytes are not stripped on retrieval. For example, `'41'` is stored into a `CHAR(3)` column as `'41 '` and retrieved as `'41'` (with the trailing pad space stripped), so `UNHEX()` for the column value returns `'A'`. By contrast `'41'` is stored into a `BINARY(3)` column as `'41\0'` and retrieved as `'41\0'` (with the trailing pad `0x00` byte not stripped). `'\0'` is not a legal hexadecimal digit, so `UNHEX()` for the column value returns `NULL`.

For a numeric argument *`N`*, the inverse of `HEX(N)` is not performed by `UNHEX()`. Use `CONV(HEX(N),16,10)` instead. See the description of `HEX()`.

- `UPPER(str)`

  Returns the string *`str`* with all characters changed to uppercase according to the current character set mapping. The default is `latin1` (cp1252 West European).

  ```
  mysql> SELECT UPPER('Hej');
          -> 'HEJ'
  ```

  See the description of `LOWER()` for information that also applies to `UPPER()`, such as information about how to perform lettercase conversion of binary strings (`BINARY`, `VARBINARY`, `BLOB`) for which these functions are ineffective.

  This function is multi-byte safe.

11.5.1. String Comparison Functions

Table 11.8. String Comparison Operators

Name	Description
`LIKE`	Simple pattern matching
`NOT LIKE`	Negation of simple pattern matching
`STRCMP()`	Compare two strings

If a string function is given a binary string as an argument, the resulting string is also a binary string. A number converted to a string is treated as a binary string. This affects only comparisons.

Normally, if any expression in a string comparison is case sensitive, the comparison is performed in case-sensitive fashion.

- `expr LIKE pat [ESCAPE 'escape_char']`

  Pattern matching using SQL simple regular expression comparison. Returns `1` (`TRUE`) or `0` (`FALSE`). If either *`expr`* or *`pat`* is `NULL`, the result is `NULL`.

  The pattern need not be a literal string. For example, it can be specified as a string expression or table column.

  Per the SQL standard, `LIKE` performs matching on a per-character basis, thus it can produce results different from the `=` comparison operator:

  ```
  mysql> SELECT 'ä' LIKE 'ae' COLLATE latin1_german2_ci;
  +-----------------------------------------+
  | 'ä' LIKE 'ae' COLLATE latin1_german2_ci |
  +-----------------------------------------+
  |                                       0 |
  +-----------------------------------------+
  mysql> SELECT 'ä' = 'ae' COLLATE latin1_german2_ci;
  +--------------------------------------+
  | 'ä' = 'ae' COLLATE latin1_german2_ci |
  +--------------------------------------+
  |                                    1 |
  +--------------------------------------+
  ```

  In particular, trailing spaces are significant, which is not true for `CHAR` or `VARCHAR` comparisons performed with the `=` operat-

or:

```
mysql> SELECT 'a' = 'a ', 'a' LIKE 'a ';
+------------+---------------+
| 'a' = 'a ' | 'a' LIKE 'a ' |
+------------+---------------+
|          1 |             0 |
+------------+---------------+
1 row in set (0.00 sec)
```

With `LIKE` you can use the following two wildcard characters in the pattern.

Character	Description
`%`	Matches any number of characters, even zero characters
`_`	Matches exactly one character

```
mysql> SELECT 'David!' LIKE 'David_';
        -> 1
mysql> SELECT 'David!' LIKE '%D%v%';
        -> 1
```

To test for literal instances of a wildcard character, precede it by the escape character. If you do not specify the `ESCAPE` character, “`\`” is assumed.

String	Description
`\%`	Matches one “`%`” character
`\_`	Matches one “`_`” character

```
mysql> SELECT 'David!' LIKE 'David\_';
        -> 0
mysql> SELECT 'David_' LIKE 'David\_';
        -> 1
```

To specify a different escape character, use the `ESCAPE` clause:

```
mysql> SELECT 'David_' LIKE 'David|_' ESCAPE '|';
        -> 1
```

The escape sequence should be empty or one character long. The expression must evaluate as a constant at execution time. If the `NO_BACKSLASH_ESCAPES` SQL mode is enabled, the sequence cannot be empty.

The following two statements illustrate that string comparisons are not case sensitive unless one of the operands is a binary string:

```
mysql> SELECT 'abc' LIKE 'ABC';
        -> 1
mysql> SELECT 'abc' LIKE BINARY 'ABC';
        -> 0
```

In MySQL, `LIKE` is permitted on numeric expressions. (This is an extension to the standard SQL `LIKE`.)

```
mysql> SELECT 10 LIKE '1%';
        -> 1
```

Note

Because MySQL uses C escape syntax in strings (for example, “`\n`” to represent a newline character), you must double any “`\`” that you use in `LIKE` strings. For example, to search for “`\n`”, specify it as “`\\n`”. To search for “`\`”, specify it as “`\\\\`”; this is because the backslashes are stripped once by the parser and again when the pattern match is made, leaving a single backslash to be matched against.

Exception: At the end of the pattern string, backslash can be specified as “`\\`”. At the end of the string, backslash stands for itself because there is nothing following to escape. Suppose that a table contains the following values:

```
mysql> SELECT filename FROM t1;
+--------------+
| filename     |
+--------------+
| C:           |
| C:\          |
| C:\Programs  |
| C:\Programs\ |
+--------------+
```

To test for values that end with backslash, you can match the values using either of the following patterns:

```
mysql> SELECT filename, filename LIKE '%\\' FROM t1;
+--------------+---------------------+
| filename     | filename LIKE '%\\' |
+--------------+---------------------+
| C:           |                   0 |
| C:\          |                   1 |
| C:\Programs  |                   0 |
| C:\Programs\ |                   1 |
+--------------+---------------------+

mysql> SELECT filename, filename LIKE '%\\\\' FROM t1;
+--------------+-----------------------+
| filename     | filename LIKE '%\\\\' |
+--------------+-----------------------+
| C:           |                     0 |
| C:\          |                     1 |
| C:\Programs  |                     0 |
| C:\Programs\ |                     1 |
+--------------+-----------------------+
```

- `expr NOT LIKE pat [ESCAPE 'escape_char']`

  This is the same as `NOT (expr LIKE pat [ESCAPE 'escape_char'])`.

  Note

  Aggregate queries involving `NOT LIKE` comparisons with columns containing `NULL` may yield unexpected results. For example, consider the following table and data:

  ```
  CREATE TABLE foo (bar VARCHAR(10));

  INSERT INTO foo VALUES (NULL), (NULL);
  ```

  The query `SELECT COUNT(*) FROM foo WHERE bar LIKE '%baz%';` returns `0`. You might assume that `SELECT COUNT(*) FROM foo WHERE bar NOT LIKE '%baz%';` would return `2`. However, this is not the case: The second query returns `0`. This is because `NULL NOT LIKE expr` always returns `NULL`, regardless of the value of `expr`. The same is true for aggregate queries involving `NULL` and comparisons using `NOT RLIKE` or `NOT REGEXP`. In such cases, you must test explicitly for `NOT NULL` using `OR` (and not `AND`), as shown here:

  ```
  SELECT COUNT(*) FROM foo WHERE bar NOT LIKE '%baz%' OR bar IS NULL;
  ```

- `STRCMP(expr1,expr2)`

  `STRCMP()` returns `0` if the strings are the same, `-1` if the first argument is smaller than the second according to the current sort order, and `1` otherwise.

  ```
  mysql> SELECT STRCMP('text', 'text2');
          -> -1
  mysql> SELECT STRCMP('text2', 'text');
          -> 1
  mysql> SELECT STRCMP('text', 'text');
          -> 0
  ```

  `STRCMP()` performs the comparison using the collation of the arguments.

  ```
  mysql> SET @s1 = _latin1 'x' COLLATE latin1_general_ci;
  mysql> SET @s2 = _latin1 'X' COLLATE latin1_general_ci;
  mysql> SET @s3 = _latin1 'x' COLLATE latin1_general_cs;
  mysql> SET @s4 = _latin1 'X' COLLATE latin1_general_cs;
  mysql> SELECT STRCMP(@s1, @s2), STRCMP(@s3, @s4);
  +------------------+------------------+
  | STRCMP(@s1, @s2) | STRCMP(@s3, @s4) |
  +------------------+------------------+
  |                0 |                1 |
  +------------------+------------------+
  ```

  If the collations are incompatible, one of the arguments must be converted to be compatible with the other. See Section 9.1.7.5, “Collation of Expressions”.

  ```
  mysql> SELECT STRCMP(@s1, @s3);
  ERROR 1267 (HY000) at line 10: Illegal mix of collations (latin1_general_ci,IMPLICIT) and (latin1_general_cs,IMPLIC
  mysql> SELECT STRCMP(@s1, @s3 COLLATE latin1_general_ci);
  ```

```
+---------------------------------------------+
| STRCMP(@s1, @s3 COLLATE latin1_general_ci) |
+---------------------------------------------+
|                                           0 |
+---------------------------------------------+
```

11.5.2. Regular Expressions

Table 11.9. String Regular Expression Operators

Name	Description
`NOT REGEXP`	Negation of REGEXP
`REGEXP`	Pattern matching using regular expressions
`RLIKE`	Synonym for REGEXP

A regular expression is a powerful way of specifying a pattern for a complex search.

MySQL uses Henry Spencer's implementation of regular expressions, which is aimed at conformance with POSIX 1003.2. MySQL uses the extended version to support pattern-matching operations performed with the `REGEXP` operator in SQL statements.

This section summarizes, with examples, the special characters and constructs that can be used in MySQL for `REGEXP` operations. It does not contain all the details that can be found in Henry Spencer's `regex(7)` manual page. That manual page is included in MySQL source distributions, in the `regex.7` file under the `regex` directory. See also Section 3.3.4.7, “Pattern Matching”.

- `expr NOT REGEXP pat`, `expr NOT RLIKE pat`

  This is the same as `NOT (expr REGEXP pat)`.

- `expr REGEXP pat`, `expr RLIKE pat`

  Performs a pattern match of a string expression `expr` against a pattern `pat`. The pattern can be an extended regular expression. The syntax for regular expressions is discussed in Section 11.5.2, “Regular Expressions”. Returns `1` if `expr` matches `pat`; otherwise it returns `0`. If either `expr` or `pat` is `NULL`, the result is `NULL`. `RLIKE` is a synonym for `REGEXP`, provided for `mSQL` compatibility.

  The pattern need not be a literal string. For example, it can be specified as a string expression or table column.

  > **Note**
  >
  > Because MySQL uses the C escape syntax in strings (for example, “`\n`” to represent the newline character), you must double any “`\`” that you use in your `REGEXP` strings.

  `REGEXP` is not case sensitive, except when used with binary strings.

```
mysql> SELECT 'Monty!' REGEXP '.*';
        -> 1
mysql> SELECT 'new*\n*line' REGEXP 'new\\*.\\*line';
        -> 1
mysql> SELECT 'a' REGEXP 'A', 'a' REGEXP BINARY 'A';
        -> 1  0
mysql> SELECT 'a' REGEXP '^[a-d]';
        -> 1
```

  `REGEXP` and `RLIKE` use the current character set when deciding the type of a character. The default is `latin1` (cp1252 West European).

  > **Warning**
  >
  > The `REGEXP` and `RLIKE` operators work in byte-wise fashion, so they are not multi-byte safe and may produce unexpected results with multi-byte character sets. In addition, these operators compare characters by their byte values and accented characters may not compare as equal even if a given collation treats them as equal.

A regular expression describes a set of strings. The simplest regular expression is one that has no special characters in it. For example, the regular expression `hello` matches `hello` and nothing else.

Nontrivial regular expressions use certain special constructs so that they can match more than one string. For example, the regular expression `hello|word` matches either the string `hello` or the string `word`.

As a more complex example, the regular expression `B[an]*s` matches any of the strings `Bananas`, `Baaaaas`, `Bs`, and any other string starting with a `B`, ending with an `s`, and containing any number of `a` or `n` characters in between.

A regular expression for the `REGEXP` operator may use any of the following special characters and constructs:

- `^`

  Match the beginning of a string.

  ```
  mysql> SELECT 'fo\nfo' REGEXP '^fo$';                   -> 0
  mysql> SELECT 'fofo' REGEXP '^fo';                      -> 1
  ```

- `$`

  Match the end of a string.

  ```
  mysql> SELECT 'fo\no' REGEXP '^fo\no$';                 -> 1
  mysql> SELECT 'fo\no' REGEXP '^fo$';                    -> 0
  ```

- `.`

  Match any character (including carriage return and newline).

  ```
  mysql> SELECT 'fofo' REGEXP '^f.*$';                    -> 1
  mysql> SELECT 'fo\r\nfo' REGEXP '^f.*$';                -> 1
  ```

- `a*`

  Match any sequence of zero or more `a` characters.

  ```
  mysql> SELECT 'Ban' REGEXP '^Ba*n';                     -> 1
  mysql> SELECT 'Baaan' REGEXP '^Ba*n';                   -> 1
  mysql> SELECT 'Bn' REGEXP '^Ba*n';                      -> 1
  ```

- `a+`

  Match any sequence of one or more `a` characters.

  ```
  mysql> SELECT 'Ban' REGEXP '^Ba+n';                     -> 1
  mysql> SELECT 'Bn' REGEXP '^Ba+n';                      -> 0
  ```

- `a?`

  Match either zero or one `a` character.

  ```
  mysql> SELECT 'Bn' REGEXP '^Ba?n';                      -> 1
  mysql> SELECT 'Ban' REGEXP '^Ba?n';                     -> 1
  mysql> SELECT 'Baan' REGEXP '^Ba?n';                    -> 0
  ```

- `de|abc`

  Match either of the sequences `de` or `abc`.

  ```
  mysql> SELECT 'pi' REGEXP 'pi|apa';                     -> 1
  mysql> SELECT 'axe' REGEXP 'pi|apa';                    -> 0
  mysql> SELECT 'apa' REGEXP 'pi|apa';                    -> 1
  mysql> SELECT 'apa' REGEXP '^(pi|apa)$';                -> 1
  mysql> SELECT 'pi' REGEXP '^(pi|apa)$';                 -> 1
  mysql> SELECT 'pix' REGEXP '^(pi|apa)$';                -> 0
  ```

- `(abc)*`

  Match zero or more instances of the sequence `abc`.

  ```
  mysql> SELECT 'pi' REGEXP '^(pi)*$';                    -> 1
  mysql> SELECT 'pip' REGEXP '^(pi)*$';                   -> 0
  mysql> SELECT 'pipi' REGEXP '^(pi)*$';                  -> 1
  ```

- `{1}`, `{2,3}`

`{n}` or `{m,n}` notation provides a more general way of writing regular expressions that match many occurrences of the previous atom (or “piece”) of the pattern. `m` and `n` are integers.

- `a*`

  Can be written as `a{0,}`.

- `a+`

  Can be written as `a{1,}`.

- `a?`

  Can be written as `a{0,1}`.

To be more precise, `a{n}` matches exactly `n` instances of `a`. `a{n,}` matches `n` or more instances of `a`. `a{m,n}` matches `m` through `n` instances of `a`, inclusive.

`m` and `n` must be in the range from `0` to `RE_DUP_MAX` (default 255), inclusive. If both `m` and `n` are given, `m` must be less than or equal to `n`.

```
mysql> SELECT 'abcde' REGEXP 'a[bcd]{2}e';              -> 0
mysql> SELECT 'abcde' REGEXP 'a[bcd]{3}e';              -> 1
mysql> SELECT 'abcde' REGEXP 'a[bcd]{1,10}e';           -> 1
```

- `[a-dX]`, `[^a-dX]`

  Matches any character that is (or is not, if ^ is used) either `a`, `b`, `c`, `d` or `X`. A `-` character between two other characters forms a range that matches all characters from the first character to the second. For example, `[0-9]` matches any decimal digit. To include a literal `]` character, it must immediately follow the opening bracket `[`. To include a literal `-` character, it must be written first or last. Any character that does not have a defined special meaning inside a `[]` pair matches only itself.

```
mysql> SELECT 'aXbc' REGEXP '[a-dXYZ]';                 -> 1
mysql> SELECT 'aXbc' REGEXP '^[a-dXYZ]$';               -> 0
mysql> SELECT 'aXbc' REGEXP '^[a-dXYZ]+$';              -> 1
mysql> SELECT 'aXbc' REGEXP '^[^a-dXYZ]+$';             -> 0
mysql> SELECT 'gheis' REGEXP '^[^a-dXYZ]+$';            -> 1
mysql> SELECT 'gheisa' REGEXP '^[^a-dXYZ]+$';           -> 0
```

- `[.characters.]`

  Within a bracket expression (written using `[` and `]`), matches the sequence of characters of that collating element. `characters` is either a single character or a character name like `newline`. The following table lists the permissible character names.

  The following table shows the permissible character names and the characters that they match. For characters given as numeric values, the values are represented in octal.

Name	Character	Name	Character
`NUL`	`0`	`SOH`	`001`
`STX`	`002`	`ETX`	`003`
`EOT`	`004`	`ENQ`	`005`
`ACK`	`006`	`BEL`	`007`
`alert`	`007`	`BS`	`010`
`backspace`	`'\b'`	`HT`	`011`
`tab`	`'\t'`	`LF`	`012`
`newline`	`'\n'`	`VT`	`013`
`vertical-tab`	`'\v'`	`FF`	`014`
`form-feed`	`'\f'`	`CR`	`015`
`carriage-return`	`'\r'`	`SO`	`016`
`SI`	`017`	`DLE`	`020`
`DC1`	`021`	`DC2`	`022`
`DC3`	`023`	`DC4`	`024`
`NAK`	`025`	`SYN`	`026`
`ETB`	`027`	`CAN`	`030`

Name	Character	Name	Character
EM	031	SUB	032
ESC	033	IS4	034
FS	034	IS3	035
GS	035	IS2	036
RS	036	IS1	037
US	037	space	' '
exclamation-mark	'!'	quotation-mark	'"'
number-sign	'#'	dollar-sign	'$'
percent-sign	'%'	ampersand	'&'
apostrophe	'\''	left-parenthesis	'('
right-parenthesis	')'	asterisk	'*'
plus-sign	'+'	comma	','
hyphen	'-'	hyphen-minus	'-'
period	'.'	full-stop	'.'
slash	'/'	solidus	'/'
zero	'0'	one	'1'
two	'2'	three	'3'
four	'4'	five	'5'
six	'6'	seven	'7'
eight	'8'	nine	'9'
colon	':'	semicolon	';'
less-than-sign	'<'	equals-sign	'='
greater-than-sign	'>'	question-mark	'?'
commercial-at	'@'	left-square-bracket	'['
backslash	'\\'	reverse-solidus	'\\'
right-square-bracket	']'	circumflex	'^'
circumflex-accent	'^'	underscore	'_'
low-line	'_'	grave-accent	'`'
left-brace	'{'	left-curly-bracket	'{'
vertical-line	'|'	right-brace	'}'
right-curly-bracket	'}'	tilde	'~'
DEL	177		

```
mysql> SELECT '~' REGEXP '[[.~.]]';                        -> 1
mysql> SELECT '~' REGEXP '[[.tilde.]]';                    -> 1
```

- `[=character_class=]`

  Within a bracket expression (written using `[` and `]`), `[=character_class=]` represents an equivalence class. It matches all characters with the same collation value, including itself. For example, if `o` and `(+)` are the members of an equivalence class, `[[=o=]]`, `[[=(+)=]]`, and `[o(+)]` are all synonymous. An equivalence class may not be used as an endpoint of a range.

- `[:character_class:]`

  Within a bracket expression (written using `[` and `]`), `[:character_class:]` represents a character class that matches all characters belonging to that class. The following table lists the standard class names. These names stand for the character classes defined in the `ctype(3)` manual page. A particular locale may provide other class names. A character class may not be used as an endpoint of a range.

Character Class Name	Meaning
alnum	Alphanumeric characters

Character Class Name	Meaning
`alpha`	Alphabetic characters
`blank`	Whitespace characters
`cntrl`	Control characters
`digit`	Digit characters
`graph`	Graphic characters
`lower`	Lowercase alphabetic characters
`print`	Graphic or space characters
`punct`	Punctuation characters
`space`	Space, tab, newline, and carriage return
`upper`	Uppercase alphabetic characters
`xdigit`	Hexadecimal digit characters

```
mysql> SELECT 'justalnums' REGEXP '[[:alnum:]]+';       -> 1
mysql> SELECT '!!' REGEXP '[[:alnum:]]+';               -> 0
```

- `[[:<:]]`, `[[:>:]]`

  These markers stand for word boundaries. They match the beginning and end of words, respectively. A word is a sequence of word characters that is not preceded by or followed by word characters. A word character is an alphanumeric character in the `alnum` class or an underscore (_).

  ```
  mysql> SELECT 'a word a' REGEXP '[[:<:]]word[[:>:]]';   -> 1
  mysql> SELECT 'a xword a' REGEXP '[[:<:]]word[[:>:]]';  -> 0
  ```

To use a literal instance of a special character in a regular expression, precede it by two backslash (\) characters. The MySQL parser interprets one of the backslashes, and the regular expression library interprets the other. For example, to match the string `1+2` that contains the special `+` character, only the last of the following regular expressions is the correct one:

```
mysql> SELECT '1+2' REGEXP '1+2';                       -> 0
mysql> SELECT '1+2' REGEXP '1\+2';                      -> 0
mysql> SELECT '1+2' REGEXP '1\\+2';                     -> 1
```

11.6. Numeric Functions and Operators

Table 11.10. Numeric Functions and Operators

Name	Description
`ABS()`	Return the absolute value
`ACOS()`	Return the arc cosine
`ASIN()`	Return the arc sine
`ATAN2()`, `ATAN()`	Return the arc tangent of the two arguments
`ATAN()`	Return the arc tangent
`CEIL()`	Return the smallest integer value not less than the argument
`CEILING()`	Return the smallest integer value not less than the argument
`CONV()`	Convert numbers between different number bases
`COS()`	Return the cosine
`COT()`	Return the cotangent
`CRC32()`	Compute a cyclic redundancy check value
`DEGREES()`	Convert radians to degrees
`DIV`	Integer division
`/`	Division operator
`EXP()`	Raise to the power of
`FLOOR()`	Return the largest integer value not greater than the argument

Name	Description
`LN()`	Return the natural logarithm of the argument
`LOG10()`	Return the base-10 logarithm of the argument
`LOG2()`	Return the base-2 logarithm of the argument
`LOG()`	Return the natural logarithm of the first argument
`-`	Minus operator
`MOD()`	Return the remainder
`%`	Modulo operator
`OCT()`	Return an octal representation of a decimal number
`PI()`	Return the value of pi
`+`	Addition operator
`POW()`	Return the argument raised to the specified power
`POWER()`	Return the argument raised to the specified power
`RADIANS()`	Return argument converted to radians
`RAND()`	Return a random floating-point value
`ROUND()`	Round the argument
`SIGN()`	Return the sign of the argument
`SIN()`	Return the sine of the argument
`SQRT()`	Return the square root of the argument
`TAN()`	Return the tangent of the argument
`*`	Multiplication operator
`TRUNCATE()`	Truncate to specified number of decimal places
`-`	Change the sign of the argument

11.6.1. Arithmetic Operators

Table 11.11. Arithmetic Operators

Name	Description
`DIV`	Integer division
`/`	Division operator
`-`	Minus operator
`%`	Modulo operator
`+`	Addition operator
`*`	Multiplication operator
`-`	Change the sign of the argument

The usual arithmetic operators are available. The result is determined according to the following rules:

- In the case of `-`, `+`, and `*`, the result is calculated with `BIGINT` (64-bit) precision if both operands are integers.
- If both operands are integers and any of them are unsigned, the result is an unsigned integer. For subtraction, if the `NO_UNSIGNED_SUBTRACTION` SQL mode is enabled, the result is signed even if any operand is unsigned.
- If any of the operands of a `+`, `-`, `/`, `*`, `%` is a real or string value, the precision of the result is the precision of the operand with the maximum precision.
- In division performed with `/`, the scale of the result when using two exact-value operands is the scale of the first operand plus the value of the `div_precision_increment` system variable (which is 4 by default). For example, the result of the expression `5.05 / 0.014` has a scale of six decimal places (`360.714286`).

These rules are applied for each operation, such that nested calculations imply the precision of each component. Hence, `(14620 / 9432456) / (24250 / 9432456)`, resolves first to `(0.0014) / (0.0026)`, with the final result having 8 decimal places (`0.60288653`).

Because of these rules and the way they are applied, care should be taken to ensure that components and subcomponents of a calculation use the appropriate level of precision. See Section 11.10, “Cast Functions and Operators”.

For information about handling of overflow in numeric expression evaluation, see Section 10.6, “Out-of-Range and Overflow Handling”.

Arithmetic operators apply to numbers. For other types of values, alternative operations may be available. For example, to add date values, use `DATE_ADD()`; see Section 11.7, “Date and Time Functions”.

- `+`

  Addition:

  ```
  mysql> SELECT 3+5;
          -> 8
  ```

- `-`

  Subtraction:

  ```
  mysql> SELECT 3-5;
          -> -2
  ```

- `-`

  Unary minus. This operator changes the sign of the operand.

  ```
  mysql> SELECT - 2;
          -> -2
  ```

  > **Note**
  >
  > If this operator is used with a `BIGINT`, the return value is also a `BIGINT`. This means that you should avoid using `-` on integers that may have the value of -2^{63}.

- `*`

  Multiplication:

  ```
  mysql> SELECT 3*5;
          -> 15
  mysql> SELECT 18014398509481984*18014398509481984.0;
          -> 324518553658426726783156020576256.0
  mysql> SELECT 18014398509481984*18014398509481984;
          -> 0
  ```

  The result of the last expression is incorrect because the result of the integer multiplication exceeds the 64-bit range of `BIGINT` calculations. (See Section 10.2, “Numeric Types”.)

- `/`

  Division:

  ```
  mysql> SELECT 3/5;
          -> 0.60
  ```

  Division by zero produces a `NULL` result:

  ```
  mysql> SELECT 102/(1-1);
          -> NULL
  ```

  A division is calculated with `BIGINT` arithmetic only if performed in a context where its result is converted to an integer.

- `DIV`

  Integer division. Similar to `FLOOR()`, but is safe with `BIGINT` values.

  As of MySQL 5.5.3, if either operand has a noninteger type, the operands are converted to `DECIMAL` and divided using `DECIMAL` arithmetic before converting the result to `BIGINT`. If the result exceeds `BIGINT` range, an error occurs. Before

MySQL 5.5.3, incorrect results may occur for noninteger operands that exceed `BIGINT` range.

```
mysql> SELECT 5 DIV 2;
        -> 2
```

- `N % M`

  Modulo operation. Returns the remainder of *`N`* divided by *`M`*. For more information, see the description for the `MOD()` function in Section 11.6.2, “Mathematical Functions”.

11.6.2. Mathematical Functions

Table 11.12. Mathematical Functions

Name	Description
`ABS()`	Return the absolute value
`ACOS()`	Return the arc cosine
`ASIN()`	Return the arc sine
`ATAN2()`, `ATAN()`	Return the arc tangent of the two arguments
`ATAN()`	Return the arc tangent
`CEIL()`	Return the smallest integer value not less than the argument
`CEILING()`	Return the smallest integer value not less than the argument
`CONV()`	Convert numbers between different number bases
`COS()`	Return the cosine
`COT()`	Return the cotangent
`CRC32()`	Compute a cyclic redundancy check value
`DEGREES()`	Convert radians to degrees
`EXP()`	Raise to the power of
`FLOOR()`	Return the largest integer value not greater than the argument
`LN()`	Return the natural logarithm of the argument
`LOG10()`	Return the base-10 logarithm of the argument
`LOG2()`	Return the base-2 logarithm of the argument
`LOG()`	Return the natural logarithm of the first argument
`MOD()`	Return the remainder
`OCT()`	Return an octal representation of a decimal number
`PI()`	Return the value of pi
`POW()`	Return the argument raised to the specified power
`POWER()`	Return the argument raised to the specified power
`RADIANS()`	Return argument converted to radians
`RAND()`	Return a random floating-point value
`ROUND()`	Round the argument
`SIGN()`	Return the sign of the argument
`SIN()`	Return the sine of the argument
`SQRT()`	Return the square root of the argument
`TAN()`	Return the tangent of the argument
`TRUNCATE()`	Truncate to specified number of decimal places

All mathematical functions return `NULL` in the event of an error.

- `ABS(X)`

  Returns the absolute value of *`X`*.

```
mysql> SELECT ABS(2);
        -> 2
mysql> SELECT ABS(-32);
        -> 32
```

This function is safe to use with `BIGINT` values.

- `ACOS(X)`

  Returns the arc cosine of *X*, that is, the value whose cosine is *X*. Returns `NULL` if *X* is not in the range `-1` to `1`.

  ```
  mysql> SELECT ACOS(1);
          -> 0
  mysql> SELECT ACOS(1.0001);
          -> NULL
  mysql> SELECT ACOS(0);
          -> 1.5707963267949
  ```

- `ASIN(X)`

  Returns the arc sine of *X*, that is, the value whose sine is *X*. Returns `NULL` if *X* is not in the range `-1` to `1`.

  ```
  mysql> SELECT ASIN(0.2);
          -> 0.20135792079033
  mysql> SELECT ASIN('foo');

  +-------------+
  | ASIN('foo') |
  +-------------+
  |           0 |
  +-------------+
  1 row in set, 1 warning (0.00 sec)

  mysql> SHOW WARNINGS;
  +---------+------+-----------------------------------------+
  | Level   | Code | Message                                 |
  +---------+------+-----------------------------------------+
  | Warning | 1292 | Truncated incorrect DOUBLE value: 'foo' |
  +---------+------+-----------------------------------------+
  ```

- `ATAN(X)`

  Returns the arc tangent of *X*, that is, the value whose tangent is *X*.

  ```
  mysql> SELECT ATAN(2);
          -> 1.1071487177941
  mysql> SELECT ATAN(-2);
          -> -1.1071487177941
  ```

- `ATAN(Y,X)`, `ATAN2(Y,X)`

  Returns the arc tangent of the two variables *X* and *Y*. It is similar to calculating the arc tangent of `Y / X`, except that the signs of both arguments are used to determine the quadrant of the result.

  ```
  mysql> SELECT ATAN(-2,2);
          -> -0.78539816339745
  mysql> SELECT ATAN2(PI(),0);
          -> 1.5707963267949
  ```

- `CEIL(X)`

  `CEIL()` is a synonym for `CEILING()`.

- `CEILING(X)`

  Returns the smallest integer value not less than *X*.

  ```
  mysql> SELECT CEILING(1.23);
          -> 2
  mysql> SELECT CEILING(-1.23);
          -> -1
  ```

  For exact-value numeric arguments, the return value has an exact-value numeric type. For string or floating-point arguments, the return value has a floating-point type.

- `CONV(N,from_base,to_base)`

Converts numbers between different number bases. Returns a string representation of the number `N`, converted from base `from_base` to base `to_base`. Returns `NULL` if any argument is `NULL`. The argument `N` is interpreted as an integer, but may be specified as an integer or a string. The minimum base is `2` and the maximum base is `36`. If `to_base` is a negative number, `N` is regarded as a signed number. Otherwise, `N` is treated as unsigned. `CONV()` works with 64-bit precision.

```
mysql> SELECT CONV('a',16,2);
        -> '1010'
mysql> SELECT CONV('6E',18,8);
        -> '172'
mysql> SELECT CONV(-17,10,-18);
        -> '-H'
mysql> SELECT CONV(10+'10'+'10'+0xa,10,10);
        -> '40'
```

- `COS(X)`

  Returns the cosine of `X`, where `X` is given in radians.

```
mysql> SELECT COS(PI());
        -> -1
```

- `COT(X)`

  Returns the cotangent of `X`.

```
mysql> SELECT COT(12);
        -> -1.5726734063977
mysql> SELECT COT(0);
        -> NULL
```

- `CRC32(expr)`

  Computes a cyclic redundancy check value and returns a 32-bit unsigned value. The result is `NULL` if the argument is `NULL`. The argument is expected to be a string and (if possible) is treated as one if it is not.

```
mysql> SELECT CRC32('MySQL');
        -> 3259397556
mysql> SELECT CRC32('mysql');
        -> 2501908538
```

- `DEGREES(X)`

  Returns the argument `X`, converted from radians to degrees.

```
mysql> SELECT DEGREES(PI());
        -> 180
mysql> SELECT DEGREES(PI() / 2);
        -> 90
```

- `EXP(X)`

  Returns the value of *e* (the base of natural logarithms) raised to the power of `X`. The inverse of this function is `LOG()` (using a single argument only) or `LN()`.

```
mysql> SELECT EXP(2);
        -> 7.3890560989307
mysql> SELECT EXP(-2);
        -> 0.13533528323661
mysql> SELECT EXP(0);
        -> 1
```

- `FLOOR(X)`

  Returns the largest integer value not greater than `X`.

```
mysql> SELECT FLOOR(1.23);
        -> 1
mysql> SELECT FLOOR(-1.23);
        -> -2
```

  For exact-value numeric arguments, the return value has an exact-value numeric type. For string or floating-point arguments, the return value has a floating-point type.

- `FORMAT(X,D)`

Formats the number `X` to a format like `'#,###,###.##'`, rounded to `D` decimal places, and returns the result as a string. For details, see Section 11.5, “String Functions”.

- `HEX(N_or_S)`

  This function can be used to obtain a hexadecimal representation of a decimal number or a string; the manner in which it does so varies according to the argument's type. See this function's description in Section 11.5, “String Functions”, for details.

- `LN(X)`

  Returns the natural logarithm of `X`; that is, the base-*e* logarithm of `X`. If `X` is less than or equal to 0, then `NULL` is returned.

  ```
  mysql> SELECT LN(2);
          -> 0.69314718055995
  mysql> SELECT LN(-2);
          -> NULL
  ```

  This function is synonymous with `LOG(X)`. The inverse of this function is the `EXP()` function.

- `LOG(X)`, `LOG(B,X)`

  If called with one parameter, this function returns the natural logarithm of `X`. If `X` is less than or equal to 0, then `NULL` is returned.

  The inverse of this function (when called with a single argument) is the `EXP()` function.

  ```
  mysql> SELECT LOG(2);
          -> 0.69314718055995
  mysql> SELECT LOG(-2);
          -> NULL
  ```

  If called with two parameters, this function returns the logarithm of `X` to the base `B`. If `X` is less than or equal to 0, or if `B` is less than or equal to 1, then `NULL` is returned.

  ```
  mysql> SELECT LOG(2,65536);
          -> 16
  mysql> SELECT LOG(10,100);
          -> 2
  mysql> SELECT LOG(1,100);
          -> NULL
  ```

  `LOG(B,X)` is equivalent to `LOG(X) / LOG(B)`.

- `LOG2(X)`

  Returns the base-2 logarithm of `X`.

  ```
  mysql> SELECT LOG2(65536);
          -> 16
  mysql> SELECT LOG2(-100);
          -> NULL
  ```

  `LOG2()` is useful for finding out how many bits a number requires for storage. This function is equivalent to the expression `LOG(X) / LOG(2)`.

- `LOG10(X)`

  Returns the base-10 logarithm of `X`.

  ```
  mysql> SELECT LOG10(2);
          -> 0.30102999566398
  mysql> SELECT LOG10(100);
          -> 2
  mysql> SELECT LOG10(-100);
          -> NULL
  ```

  `LOG10(X)` is equivalent to `LOG(10,X)`.

- `MOD(N,M)`, `N % M`, `N MOD M`

  Modulo operation. Returns the remainder of `N` divided by `M`.

  ```
  mysql> SELECT MOD(234, 10);
          -> 4
  ```

```
mysql> SELECT 253 % 7;
        -> 1
mysql> SELECT MOD(29,9);
        -> 2
mysql> SELECT 29 MOD 9;
        -> 2
```

This function is safe to use with `BIGINT` values.

`MOD()` also works on values that have a fractional part and returns the exact remainder after division:

```
mysql> SELECT MOD(34.5,3);
        -> 1.5
```

`MOD(N,0)` returns `NULL`.

- `OCT(N)`

  Returns a string representation of the octal value of *`N`*, where *`N`* is a longlong (`BIGINT`) number. This is equivalent to `CONV(N,10,8)`. Returns `NULL` if *`N`* is `NULL`.

  ```
  mysql> SELECT OCT(12);
          -> '14'
  ```

- `PI()`

  Returns the value of π (pi). The default number of decimal places displayed is seven, but MySQL uses the full double-precision value internally.

  ```
  mysql> SELECT PI();
          -> 3.141593
  mysql> SELECT PI()+0.000000000000000000;
          -> 3.141592653589793116
  ```

- `POW(X,Y)`

  Returns the value of *`X`* raised to the power of *`Y`*.

  ```
  mysql> SELECT POW(2,2);
          -> 4
  mysql> SELECT POW(2,-2);
          -> 0.25
  ```

- `POWER(X,Y)`

  This is a synonym for `POW()`.

- `RADIANS(X)`

  Returns the argument *`X`*, converted from degrees to radians. (Note that π radians equals 180 degrees.)

  ```
  mysql> SELECT RADIANS(90);
          -> 1.5707963267949
  ```

- `RAND()`, `RAND(N)`

  Returns a random floating-point value *`v`* in the range `0` <= *`v`* < `1.0`. If a constant integer argument *`N`* is specified, it is used as the seed value, which produces a repeatable sequence of column values. In the following example, note that the sequences of values produced by `RAND(3)` is the same both places where it occurs.

  ```
  mysql> CREATE TABLE t (i INT);
  Query OK, 0 rows affected (0.42 sec)

  mysql> INSERT INTO t VALUES(1),(2),(3);
  Query OK, 3 rows affected (0.00 sec)
  Records: 3  Duplicates: 0  Warnings: 0

  mysql> SELECT i, RAND() FROM t;
  +------+------------------+
  | i    | RAND()           |
  +------+------------------+
  |    1 | 0.61914388706828 |
  |    2 | 0.93845168309142 |
  |    3 | 0.83482678498591 |
  +------+------------------+
  3 rows in set (0.00 sec)
  ```

```
mysql> SELECT i, RAND(3) FROM t;
+------+------------------+
| i    | RAND(3)          |
+------+------------------+
|    1 | 0.90576975597606 |
|    2 | 0.37307905813035 |
|    3 | 0.14808605345719 |
+------+------------------+
3 rows in set (0.00 sec)

mysql> SELECT i, RAND() FROM t;
+------+------------------+
| i    | RAND()           |
+------+------------------+
|    1 | 0.35877890638893 |
|    2 | 0.28941420772058 |
|    3 | 0.37073435016976 |
+------+------------------+
3 rows in set (0.00 sec)

mysql> SELECT i, RAND(3) FROM t;
+------+------------------+
| i    | RAND(3)          |
+------+------------------+
|    1 | 0.90576975597606 |
|    2 | 0.37307905813035 |
|    3 | 0.14808605345719 |
+------+------------------+
3 rows in set (0.01 sec)
```

With a constant initializer, the seed is initialized once when the statement is compiled, prior to execution. If a nonconstant initializer (such as a column name) is used as the argument, the seed is initialized with the value for each invocation of `RAND()`. (One implication of this is that for equal argument values, `RAND()` will return the same value each time.)

To obtain a random integer *R* in the range *i* <= *R* < *j*, use the expression `FLOOR(i + RAND() * (j – i))`. For example, to obtain a random integer in the range the range `7` <= *R* < `12`, you could use the following statement:

```
SELECT FLOOR(7 + (RAND() * 5));
```

`RAND()` in a `WHERE` clause is re-evaluated every time the `WHERE` is executed.

You cannot use a column with `RAND()` values in an `ORDER BY` clause, because `ORDER BY` would evaluate the column multiple times. However, you can retrieve rows in random order like this:

```
mysql> SELECT * FROM tbl_name ORDER BY RAND();
```

`ORDER BY RAND()` combined with `LIMIT` is useful for selecting a random sample from a set of rows:

```
mysql> SELECT * FROM table1, table2 WHERE a=b AND c<d -> ORDER BY RAND() LIMIT 1000;
```

`RAND()` is not meant to be a perfect random generator. It is a fast way to generate random numbers on demand that is portable between platforms for the same MySQL version.

- `ROUND(X)`, `ROUND(X,D)`

  Rounds the argument *X* to *D* decimal places. The rounding algorithm depends on the data type of *X*. *D* defaults to 0 if not specified. *D* can be negative to cause *D* digits left of the decimal point of the value *X* to become zero.

  ```
  mysql> SELECT ROUND(-1.23);
          -> -1
  mysql> SELECT ROUND(-1.58);
          -> -2
  mysql> SELECT ROUND(1.58);
          -> 2
  mysql> SELECT ROUND(1.298, 1);
          -> 1.3
  mysql> SELECT ROUND(1.298, 0);
          -> 1
  mysql> SELECT ROUND(23.298, -1);
          -> 20
  ```

  The return type is the same type as that of the first argument (assuming that it is integer, double, or decimal). This means that for an integer argument, the result is an integer (no decimal places):

  ```
  mysql> SELECT ROUND(150.000,2), ROUND(150,2);
  +------------------+--------------+
  | ROUND(150.000,2) | ROUND(150,2) |
  +------------------+--------------+
  |           150.00 |          150 |
  +------------------+--------------+
  ```

`ROUND()` uses the following rules depending on the type of the first argument:

- For exact-value numbers, `ROUND()` uses the “round half up” or “round toward nearest” rule: A value with a fractional part of .5 or greater is rounded up to the next integer if positive or down to the next integer if negative. (In other words, it is rounded away from zero.) A value with a fractional part less than .5 is rounded down to the next integer if positive or up to the next integer if negative.
- For approximate-value numbers, the result depends on the C library. On many systems, this means that `ROUND()` uses the "round to nearest even" rule: A value with any fractional part is rounded to the nearest even integer.

The following example shows how rounding differs for exact and approximate values:

```
mysql> SELECT ROUND(2.5), ROUND(25E-1);
+------------+--------------+
| ROUND(2.5) | ROUND(25E-1) |
+------------+--------------+
| 3          |            2 |
+------------+--------------+
```

For more information, see Section 11.18, “Precision Math”.

- `SIGN(X)`

  Returns the sign of the argument as `-1`, `0`, or `1`, depending on whether *`X`* is negative, zero, or positive.

```
mysql> SELECT SIGN(-32);
        -> -1
mysql> SELECT SIGN(0);
        -> 0
mysql> SELECT SIGN(234);
        -> 1
```

- `SIN(X)`

  Returns the sine of *`X`*, where *`X`* is given in radians.

```
mysql> SELECT SIN(PI());
        -> 1.2246063538224e-16
mysql> SELECT ROUND(SIN(PI()));
        -> 0
```

- `SQRT(X)`

  Returns the square root of a nonnegative number *`X`*.

```
mysql> SELECT SQRT(4);
        -> 2
mysql> SELECT SQRT(20);
        -> 4.4721359549996
mysql> SELECT SQRT(-16);
        -> NULL
```

- `TAN(X)`

  Returns the tangent of *`X`*, where *`X`* is given in radians.

```
mysql> SELECT TAN(PI());
        -> -1.2246063538224e-16
mysql> SELECT TAN(PI()+1);
        -> 1.5574077246549
```

- `TRUNCATE(X,D)`

  Returns the number *`X`*, truncated to *`D`* decimal places. If *`D`* is `0`, the result has no decimal point or fractional part. *`D`* can be negative to cause *`D`* digits left of the decimal point of the value *`X`* to become zero.

```
mysql> SELECT TRUNCATE(1.223,1);
        -> 1.2
mysql> SELECT TRUNCATE(1.999,1);
        -> 1.9
mysql> SELECT TRUNCATE(1.999,0);
        -> 1
mysql> SELECT TRUNCATE(-1.999,1);
        -> -1.9
mysql> SELECT TRUNCATE(122,-2);
       -> 100
```

```
mysql> SELECT TRUNCATE(10.28*100,0);
       -> 1028
```

All numbers are rounded toward zero.

11.7. Date and Time Functions

This section describes the functions that can be used to manipulate temporal values. See Section 10.3, “Date and Time Types”, for a description of the range of values each date and time type has and the valid formats in which values may be specified.

Table 11.13. Date/Time Functions

Name	Description
`ADDDATE()`	Add time values (intervals) to a date value
`ADDTIME()`	Add time
`CONVERT_TZ()`	Convert from one timezone to another
`CURDATE()`	Return the current date
`CURRENT_DATE()`, `CURRENT_DATE`	Synonyms for CURDATE()
`CURRENT_TIME()`, `CURRENT_TIME`	Synonyms for CURTIME()
`CURRENT_TIMESTAMP()`, `CURRENT_TIMESTAMP`	Synonyms for NOW()
`CURTIME()`	Return the current time
`DATE_ADD()`	Add time values (intervals) to a date value
`DATE_FORMAT()`	Format date as specified
`DATE_SUB()`	Subtract a time value (interval) from a date
`DATE()`	Extract the date part of a date or datetime expression
`DATEDIFF()`	Subtract two dates
`DAY()`	Synonym for DAYOFMONTH()
`DAYNAME()`	Return the name of the weekday
`DAYOFMONTH()`	Return the day of the month (0-31)
`DAYOFWEEK()`	Return the weekday index of the argument
`DAYOFYEAR()`	Return the day of the year (1-366)
`EXTRACT()`	Extract part of a date
`FROM_DAYS()`	Convert a day number to a date
`FROM_UNIXTIME()`	Format UNIX timestamp as a date
`GET_FORMAT()`	Return a date format string
`HOUR()`	Extract the hour
`LAST_DAY`	Return the last day of the month for the argument
`LOCALTIME()`, `LOCALTIME`	Synonym for NOW()
`LOCALTIMESTAMP`, `LOCALTIMESTAMP()`	Synonym for NOW()
`MAKEDATE()`	Create a date from the year and day of year
`MAKETIME`	MAKETIME()
`MICROSECOND()`	Return the microseconds from argument
`MINUTE()`	Return the minute from the argument
`MONTH()`	Return the month from the date passed
`MONTHNAME()`	Return the name of the month
`NOW()`	Return the current date and time
`PERIOD_ADD()`	Add a period to a year-month
`PERIOD_DIFF()`	Return the number of months between periods
`QUARTER()`	Return the quarter from a date argument
`SEC_TO_TIME()`	Converts seconds to 'HH:MM:SS' format

Name	**Description**
`SECOND()`	Return the second (0-59)
`STR_TO_DATE()`	Convert a string to a date
`SUBDATE()`	A synonym for DATE_SUB() when invoked with three arguments
`SUBTIME()`	Subtract times
`SYSDATE()`	Return the time at which the function executes
`TIME_FORMAT()`	Format as time
`TIME_TO_SEC()`	Return the argument converted to seconds
`TIME()`	Extract the time portion of the expression passed
`TIMEDIFF()`	Subtract time
`TIMESTAMP()`	With a single argument, this function returns the date or datetime expression; with two arguments, the sum of the arguments
`TIMESTAMPADD()`	Add an interval to a datetime expression
`TIMESTAMPDIFF()`	Subtract an interval from a datetime expression
`TO_DAYS()`	Return the date argument converted to days
`TO_SECONDS()`	Return the date or datetime argument converted to seconds since Year 0
`UNIX_TIMESTAMP()`	Return a UNIX timestamp
`UTC_DATE()`	Return the current UTC date
`UTC_TIME()`	Return the current UTC time
`UTC_TIMESTAMP()`	Return the current UTC date and time
`WEEK()`	Return the week number
`WEEKDAY()`	Return the weekday index
`WEEKOFYEAR()`	Return the calendar week of the date (0-53)
`YEAR()`	Return the year
`YEARWEEK()`	Return the year and week

Here is an example that uses date functions. The following query selects all rows with a *`date_col`* value from within the last 30 days:

```
mysql> SELECT something FROM tbl_name
    -> WHERE DATE_SUB(CURDATE(),INTERVAL 30 DAY) <= date_col;
```

The query also selects rows with dates that lie in the future.

Functions that expect date values usually accept datetime values and ignore the time part. Functions that expect time values usually accept datetime values and ignore the date part.

Functions that return the current date or time each are evaluated only once per query at the start of query execution. This means that multiple references to a function such as `NOW()` within a single query always produce the same result. (For our purposes, a single query also includes a call to a stored program (stored routine, trigger, or event) and all subprograms called by that program.) This principle also applies to `CURDATE()`, `CURTIME()`, `UTC_DATE()`, `UTC_TIME()`, `UTC_TIMESTAMP()`, and to any of their synonyms.

The `CURRENT_TIMESTAMP()`, `CURRENT_TIME()`, `CURRENT_DATE()`, and `FROM_UNIXTIME()` functions return values in the connection's current time zone, which is available as the value of the `time_zone` system variable. In addition, `UNIX_TIMESTAMP()` assumes that its argument is a datetime value in the current time zone. See Section 9.6, “MySQL Server Time Zone Support”.

Some date functions can be used with “zero” dates or incomplete dates such as `'2001-11-00'`, whereas others cannot. Functions that extract parts of dates typically work with incomplete dates and thus can return 0 when you might otherwise expect a nonzero value. For example:

```
mysql> SELECT DAYOFMONTH('2001-11-00'), MONTH('2005-00-00');
        -> 0, 0
```

Other functions expect complete dates and return `NULL` for incomplete dates. These include functions that perform date arithmetic or that map parts of dates to names. For example:

```
mysql> SELECT DATE_ADD('2006-05-00',INTERVAL 1 DAY);
        -> NULL
```

```
mysql> SELECT DAYNAME('2006-05-00');
        -> NULL
```

- `ADDDATE(date,INTERVAL expr unit)`, `ADDDATE(expr,days)`

  When invoked with the `INTERVAL` form of the second argument, `ADDDATE()` is a synonym for `DATE_ADD()`. The related function `SUBDATE()` is a synonym for `DATE_SUB()`. For information on the `INTERVAL` *`unit`* argument, see the discussion for `DATE_ADD()`.

  ```
  mysql> SELECT DATE_ADD('2008-01-02', INTERVAL 31 DAY);
          -> '2008-02-02'
  mysql> SELECT ADDDATE('2008-01-02', INTERVAL 31 DAY);
          -> '2008-02-02'
  ```

  When invoked with the *`days`* form of the second argument, MySQL treats it as an integer number of days to be added to *`expr`*.

  ```
  mysql> SELECT ADDDATE('2008-01-02', 31);
          -> '2008-02-02'
  ```

- `ADDTIME(expr1,expr2)`

  `ADDTIME()` adds *`expr2`* to *`expr1`* and returns the result. *`expr1`* is a time or datetime expression, and *`expr2`* is a time expression.

  ```
  mysql> SELECT ADDTIME('2007-12-31 23:59:59.999999', '1 1:1:1.000002');
          -> '2008-01-02 01:01:01.000001'
  mysql> SELECT ADDTIME('01:00:00.999999', '02:00:00.999998');
          -> '03:00:01.999997'
  ```

- `CONVERT_TZ(dt,from_tz,to_tz)`

  `CONVERT_TZ()` converts a datetime value *`dt`* from the time zone given by *`from_tz`* to the time zone given by *`to_tz`* and returns the resulting value. Time zones are specified as described in Section 9.6, “MySQL Server Time Zone Support”. This function returns `NULL` if the arguments are invalid.

  If the value falls out of the supported range of the `TIMESTAMP` type when converted from *`from_tz`* to UTC, no conversion occurs. The `TIMESTAMP` range is described in Section 10.1.2, “Overview of Date and Time Types”.

  ```
  mysql> SELECT CONVERT_TZ('2004-01-01 12:00:00','GMT','MET');
          -> '2004-01-01 13:00:00'
  mysql> SELECT CONVERT_TZ('2004-01-01 12:00:00','+00:00','+10:00');
          -> '2004-01-01 22:00:00'
  ```

  > **Note**
  >
  > To use named time zones such as `'MET'` or `'Europe/Moscow'`, the time zone tables must be properly set up. See Section 9.6, “MySQL Server Time Zone Support”, for instructions.

- `CURDATE()`

  Returns the current date as a value in `'YYYY-MM-DD'` or `YYYYMMDD` format, depending on whether the function is used in a string or numeric context.

  ```
  mysql> SELECT CURDATE();
          -> '2008-06-13'
  mysql> SELECT CURDATE() + 0;
          -> 20080613
  ```

- `CURRENT_DATE`, `CURRENT_DATE()`

  `CURRENT_DATE` and `CURRENT_DATE()` are synonyms for `CURDATE()`.

- `CURTIME()`

  Returns the current time as a value in `'HH:MM:SS'` or `HHMMSS.uuuuuu` format, depending on whether the function is used in a string or numeric context. The value is expressed in the current time zone.

  ```
  mysql> SELECT CURTIME();
          -> '23:50:26'
  mysql> SELECT CURTIME() + 0;
          -> 235026.000000
  ```

- `CURRENT_TIME`, `CURRENT_TIME()`

  `CURRENT_TIME` and `CURRENT_TIME()` are synonyms for `CURTIME()`.

- `CURRENT_TIMESTAMP`, `CURRENT_TIMESTAMP()`

  `CURRENT_TIMESTAMP` and `CURRENT_TIMESTAMP()` are synonyms for `NOW()`.

- `DATE(expr)`

  Extracts the date part of the date or datetime expression *`expr`*.

  ```
  mysql> SELECT DATE('2003-12-31 01:02:03');
          -> '2003-12-31'
  ```

- `DATEDIFF(expr1,expr2)`

  `DATEDIFF()` returns *`expr1`* – *`expr2`* expressed as a value in days from one date to the other. *`expr1`* and *`expr2`* are date or date-and-time expressions. Only the date parts of the values are used in the calculation.

  ```
  mysql> SELECT DATEDIFF('2007-12-31 23:59:59','2007-12-30');
          -> 1
  mysql> SELECT DATEDIFF('2010-11-30 23:59:59','2010-12-31');
          -> -31
  ```

- `DATE_ADD(date,INTERVAL expr unit)`, `DATE_SUB(date,INTERVAL expr unit)`

  These functions perform date arithmetic. The *`date`* argument specifies the starting date or datetime value. *`expr`* is an expression specifying the interval value to be added or subtracted from the starting date. *`expr`* is a string; it may start with a "`-`" for negative intervals. *`unit`* is a keyword indicating the units in which the expression should be interpreted.

  The `INTERVAL` keyword and the *`unit`* specifier are not case sensitive.

  The following table shows the expected form of the *`expr`* argument for each *`unit`* value.

`unit` **Value**	**Expected** ***`expr`*** **Format**
`MICROSECOND`	`MICROSECONDS`
`SECOND`	`SECONDS`
`MINUTE`	`MINUTES`
`HOUR`	`HOURS`
`DAY`	`DAYS`
`WEEK`	`WEEKS`
`MONTH`	`MONTHS`
`QUARTER`	`QUARTERS`
`YEAR`	`YEARS`
`SECOND_MICROSECOND`	`'SECONDS.MICROSECONDS'`
`MINUTE_MICROSECOND`	`'MINUTES:SECONDS.MICROSECONDS'`
`MINUTE_SECOND`	`'MINUTES:SECONDS'`
`HOUR_MICROSECOND`	`'HOURS:MINUTES:SECONDS.MICROSECONDS'`
`HOUR_SECOND`	`'HOURS:MINUTES:SECONDS'`
`HOUR_MINUTE`	`'HOURS:MINUTES'`
`DAY_MICROSECOND`	`'DAYS HOURS:MINUTES:SECONDS.MICROSECONDS'`
`DAY_SECOND`	`'DAYS HOURS:MINUTES:SECONDS'`
`DAY_MINUTE`	`'DAYS HOURS:MINUTES'`
`DAY_HOUR`	`'DAYS HOURS'`
`YEAR_MONTH`	`'YEARS-MONTHS'`

  The return value depends on the arguments:

  - `DATETIME` if the first argument is a `DATETIME` (or `TIMESTAMP`) value, or if the first argument is a `DATE` and the *`unit`* value uses `HOURS`, `MINUTES`, or `SECONDS`.

- String otherwise.

To ensure that the result is `DATETIME`, you can use `CAST()` to convert the first argument to `DATETIME`.

MySQL permits any punctuation delimiter in the *`expr`* format. Those shown in the table are the suggested delimiters. If the *`date`* argument is a `DATE` value and your calculations involve only `YEAR`, `MONTH`, and `DAY` parts (that is, no time parts), the result is a `DATE` value. Otherwise, the result is a `DATETIME` value.

Date arithmetic also can be performed using `INTERVAL` together with the `+` or `-` operator:

```
date + INTERVAL expr unit
date - INTERVAL expr unit
```

`INTERVAL expr unit` is permitted on either side of the `+` operator if the expression on the other side is a date or datetime value. For the `-` operator, `INTERVAL expr unit` is permitted only on the right side, because it makes no sense to subtract a date or datetime value from an interval.

```
mysql> SELECT '2008-12-31 23:59:59' + INTERVAL 1 SECOND;
        -> '2009-01-01 00:00:00'
mysql> SELECT INTERVAL 1 DAY + '2008-12-31';
        -> '2009-01-01'
mysql> SELECT '2005-01-01' - INTERVAL 1 SECOND;
        -> '2004-12-31 23:59:59'
mysql> SELECT DATE_ADD('2000-12-31 23:59:59',
    ->                 INTERVAL 1 SECOND);
        -> '2001-01-01 00:00:00'
mysql> SELECT DATE_ADD('2010-12-31 23:59:59',
    ->                 INTERVAL 1 DAY);
        -> '2011-01-01 23:59:59'
mysql> SELECT DATE_ADD('2100-12-31 23:59:59',
    ->                 INTERVAL '1:1' MINUTE_SECOND);
        -> '2101-01-01 00:01:00'
mysql> SELECT DATE_SUB('2005-01-01 00:00:00',
    ->                 INTERVAL '1 1:1:1' DAY_SECOND);
        -> '2004-12-30 22:58:59'
mysql> SELECT DATE_ADD('1900-01-01 00:00:00',
    ->                 INTERVAL '-1 10' DAY_HOUR);
        -> '1899-12-30 14:00:00'
mysql> SELECT DATE_SUB('1998-01-02', INTERVAL 31 DAY);
        -> '1997-12-02'
mysql> SELECT DATE_ADD('1992-12-31 23:59:59.000002',
    ->            INTERVAL '1.999999' SECOND_MICROSECOND);
        -> '1993-01-01 00:00:01.000001'
```

If you specify an interval value that is too short (does not include all the interval parts that would be expected from the *`unit`* keyword), MySQL assumes that you have left out the leftmost parts of the interval value. For example, if you specify a *`unit`* of `DAY_SECOND`, the value of *`expr`* is expected to have days, hours, minutes, and seconds parts. If you specify a value like `'1:10'`, MySQL assumes that the days and hours parts are missing and the value represents minutes and seconds. In other words, `'1:10' DAY_SECOND` is interpreted in such a way that it is equivalent to `'1:10' MINUTE_SECOND`. This is analogous to the way that MySQL interprets `TIME` values as representing elapsed time rather than as a time of day.

Because *`expr`* is treated as a string, be careful if you specify a nonstring value with `INTERVAL`. For example, with an interval specifier of `HOUR_MINUTE`, `6/4` evaluates to `1.5000` and is treated as 1 hour, 5000 minutes:

```
mysql> SELECT 6/4;
        -> 1.5000
mysql> SELECT DATE_ADD('2009-01-01', INTERVAL 6/4 HOUR_MINUTE);
        -> '2009-01-04 12:20:00'
```

To ensure interpretation of the interval value as you expect, a `CAST()` operation may be used. To treat `6/4` as 1 hour, 5 minutes, cast it to a `DECIMAL` value with a single fractional digit:

```
mysql> SELECT CAST(6/4 AS DECIMAL(3,1));
        -> 1.5
mysql> SELECT DATE_ADD('1970-01-01 12:00:00',
    ->                 INTERVAL CAST(6/4 AS DECIMAL(3,1)) HOUR_MINUTE);
        -> '1970-01-01 13:05:00'
```

If you add to or subtract from a date value something that contains a time part, the result is automatically converted to a datetime value:

```
mysql> SELECT DATE_ADD('2013-01-01', INTERVAL 1 DAY);
        -> '2013-01-02'
mysql> SELECT DATE_ADD('2013-01-01', INTERVAL 1 HOUR);
        -> '2013-01-01 01:00:00'
```

If you add `MONTH`, `YEAR_MONTH`, or `YEAR` and the resulting date has a day that is larger than the maximum day for the new month, the day is adjusted to the maximum days in the new month:

```
mysql> SELECT DATE_ADD('2009-01-30', INTERVAL 1 MONTH);
        -> '2009-02-28'
```

Date arithmetic operations require complete dates and do not work with incomplete dates such as `'2006-07-00'` or badly malformed dates:

```
mysql> SELECT DATE_ADD('2006-07-00', INTERVAL 1 DAY);
        -> NULL
mysql> SELECT '2005-03-32' + INTERVAL 1 MONTH;
        -> NULL
```

- `DATE_FORMAT(date,format)`

  Formats the `date` value according to the `format` string.

  The following specifiers may be used in the `format` string. The "`%`" character is required before format specifier characters.

Specifier	**Description**
`%a`	Abbreviated weekday name (`Sun`..`Sat`)
`%b`	Abbreviated month name (`Jan`..`Dec`)
`%c`	Month, numeric (`0`..`12`)
`%D`	Day of the month with English suffix (`0th`, `1st`, `2nd`, `3rd`, …)
`%d`	Day of the month, numeric (`00`..`31`)
`%e`	Day of the month, numeric (`0`..`31`)
`%f`	Microseconds (`000000`..`999999`)
`%H`	Hour (`00`..`23`)
`%h`	Hour (`01`..`12`)
`%I`	Hour (`01`..`12`)
`%i`	Minutes, numeric (`00`..`59`)
`%j`	Day of year (`001`..`366`)
`%k`	Hour (`0`..`23`)
`%l`	Hour (`1`..`12`)
`%M`	Month name (`January`..`December`)
`%m`	Month, numeric (`00`..`12`)
`%p`	`AM` or `PM`
`%r`	Time, 12-hour (`hh:mm:ss` followed by `AM` or `PM`)
`%S`	Seconds (`00`..`59`)
`%s`	Seconds (`00`..`59`)
`%T`	Time, 24-hour (`hh:mm:ss`)
`%U`	Week (`00`..`53`), where Sunday is the first day of the week
`%u`	Week (`00`..`53`), where Monday is the first day of the week
`%V`	Week (`01`..`53`), where Sunday is the first day of the week; used with `%X`
`%v`	Week (`01`..`53`), where Monday is the first day of the week; used with `%x`
`%W`	Weekday name (`Sunday`..`Saturday`)
`%w`	Day of the week (`0`=Sunday..`6`=Saturday)
`%X`	Year for the week where Sunday is the first day of the week, numeric, four digits; used with `%V`
`%x`	Year for the week, where Monday is the first day of the week, numeric, four digits; used with `%v`
`%Y`	Year, numeric, four digits
`%y`	Year, numeric (two digits)
`%%`	A literal "`%`" character
`%x`	`x`, for any "`x`" not listed above

Ranges for the month and day specifiers begin with zero due to the fact that MySQL permits the storing of incomplete dates such as `'2014-00-00'`.

The language used for day and month names and abbreviations is controlled by the value of the `lc_time_names` system variable (Section 9.7, “MySQL Server Locale Support”).

`DATE_FORMAT()` returns a string with a character set and collation given by `character_set_connection` and `collation_connection` so that it can return month and weekday names containing non-ASCII characters.

```
mysql> SELECT DATE_FORMAT('2009-10-04 22:23:00', '%W %M %Y');
        -> 'Sunday October 2009'
mysql> SELECT DATE_FORMAT('2007-10-04 22:23:00', '%H:%i:%s');
        -> '22:23:00'
mysql> SELECT DATE_FORMAT('1900-10-04 22:23:00',
    ->                 '%D %y %a %d %m %b %j');
        -> '4th 00 Thu 04 10 Oct 277'
mysql> SELECT DATE_FORMAT('1997-10-04 22:23:00',
    ->                 '%H %k %I %r %T %S %w');
        -> '22 22 10 10:23:00 PM 22:23:00 00 6'
mysql> SELECT DATE_FORMAT('1999-01-01', '%X %V');
        -> '1998 52'
mysql> SELECT DATE_FORMAT('2006-06-00', '%d');
        -> '00'
```

- `DATE_SUB(`*`date`*`,INTERVAL `*`expr unit`*`)`

  See the description for `DATE_ADD()`.

- `DAY(`*`date`*`)`

  `DAY()` is a synonym for `DAYOFMONTH()`.

- `DAYNAME(`*`date`*`)`

  Returns the name of the weekday for *`date`*. The language used for the name is controlled by the value of the `lc_time_names` system variable (Section 9.7, “MySQL Server Locale Support”).

```
mysql> SELECT DAYNAME('2007-02-03');
        -> 'Saturday'
```

- `DAYOFMONTH(`*`date`*`)`

  Returns the day of the month for *`date`*, in the range `1` to `31`, or `0` for dates such as `'0000-00-00'` or `'2008-00-00'` that have a zero day part.

```
mysql> SELECT DAYOFMONTH('2007-02-03');
        -> 3
```

- `DAYOFWEEK(`*`date`*`)`

  Returns the weekday index for *`date`* (`1` = Sunday, `2` = Monday, …, `7` = Saturday). These index values correspond to the ODBC standard.

```
mysql> SELECT DAYOFWEEK('2007-02-03');
        -> 7
```

- `DAYOFYEAR(`*`date`*`)`

  Returns the day of the year for *`date`*, in the range `1` to `366`.

```
mysql> SELECT DAYOFYEAR('2007-02-03');
        -> 34
```

- `EXTRACT(`*`unit`*` FROM `*`date`*`)`

  The `EXTRACT()` function uses the same kinds of unit specifiers as `DATE_ADD()` or `DATE_SUB()`, but extracts parts from the date rather than performing date arithmetic.

```
mysql> SELECT EXTRACT(YEAR FROM '2009-07-02');
       -> 2009
mysql> SELECT EXTRACT(YEAR_MONTH FROM '2009-07-02 01:02:03');
       -> 200907
mysql> SELECT EXTRACT(DAY_MINUTE FROM '2009-07-02 01:02:03');
       -> 20102
mysql> SELECT EXTRACT(MICROSECOND
    ->              FROM '2003-01-02 10:30:00.000123');
        -> 123
```

- `FROM_DAYS(N)`

  Given a day number *N*, returns a `DATE` value.

  ```
  mysql> SELECT FROM_DAYS(730669);
          -> '2007-07-03'
  ```

  Use `FROM_DAYS()` with caution on old dates. It is not intended for use with values that precede the advent of the Gregorian calendar (1582). See Section 11.8, "What Calendar Is Used By MySQL?".

- `FROM_UNIXTIME(unix_timestamp)`, `FROM_UNIXTIME(unix_timestamp,format)`

  Returns a representation of the *unix_timestamp* argument as a value in `'YYYY-MM-DD HH:MM:SS'` or `YYYYMMDDHHMMSS.uuuuuu` format, depending on whether the function is used in a string or numeric context. The value is expressed in the current time zone. *unix_timestamp* is an internal timestamp value such as is produced by the `UNIX_TIMESTAMP()` function.

  If *format* is given, the result is formatted according to the *format* string, which is used the same way as listed in the entry for the `DATE_FORMAT()` function.

  ```
  mysql> SELECT FROM_UNIXTIME(1196440219);
          -> '2007-11-30 10:30:19'
  mysql> SELECT FROM_UNIXTIME(1196440219) + 0;
          -> 20071130103019.000000
  mysql> SELECT FROM_UNIXTIME(UNIX_TIMESTAMP(),
      ->                      '%Y %D %M %h:%i:%s %x');
          -> '2007 30th November 10:30:59 2007'
  ```

  Note: If you use `UNIX_TIMESTAMP()` and `FROM_UNIXTIME()` to convert between `TIMESTAMP` values and Unix timestamp values, the conversion is lossy because the mapping is not one-to-one in both directions. For details, see the description of the `UNIX_TIMESTAMP()` function.

- `GET_FORMAT({DATE|TIME|DATETIME}, {'EUR'|'USA'|'JIS'|'ISO'|'INTERNAL'})`

  Returns a format string. This function is useful in combination with the `DATE_FORMAT()` and the `STR_TO_DATE()` functions.

  The possible values for the first and second arguments result in several possible format strings (for the specifiers used, see the table in the `DATE_FORMAT()` function description). ISO format refers to ISO 9075, not ISO 8601.

Function Call	**Result**
`GET_FORMAT(DATE,'USA')`	`'%m.%d.%Y'`
`GET_FORMAT(DATE,'JIS')`	`'%Y-%m-%d'`
`GET_FORMAT(DATE,'ISO')`	`'%Y-%m-%d'`
`GET_FORMAT(DATE,'EUR')`	`'%d.%m.%Y'`
`GET_FORMAT(DATE,'INTERNAL')`	`'%Y%m%d'`
`GET_FORMAT(DATETIME,'USA')`	`'%Y-%m-%d %H.%i.%s'`
`GET_FORMAT(DATETIME,'JIS')`	`'%Y-%m-%d %H:%i:%s'`
`GET_FORMAT(DATETIME,'ISO')`	`'%Y-%m-%d %H:%i:%s'`
`GET_FORMAT(DATETIME,'EUR')`	`'%Y-%m-%d %H.%i.%s'`
`GET_FORMAT(DATETIME,'INTERNAL')`	`'%Y%m%d%H%i%s'`
`GET_FORMAT(TIME,'USA')`	`'%h:%i:%s %p'`
`GET_FORMAT(TIME,'JIS')`	`'%H:%i:%s'`
`GET_FORMAT(TIME,'ISO')`	`'%H:%i:%s'`
`GET_FORMAT(TIME,'EUR')`	`'%H.%i.%s'`
`GET_FORMAT(TIME,'INTERNAL')`	`'%H%i%s'`

  `TIMESTAMP` can also be used as the first argument to `GET_FORMAT()`, in which case the function returns the same values as for `DATETIME`.

  ```
  mysql> SELECT DATE_FORMAT('2003-10-03',GET_FORMAT(DATE,'EUR'));
  ```

```
        -> '03.10.2003'
mysql> SELECT STR_TO_DATE('10.31.2003',GET_FORMAT(DATE,'USA'));
        -> '2003-10-31'
```

- `HOUR(time)`

  Returns the hour for *`time`*. The range of the return value is `0` to `23` for time-of-day values. However, the range of `TIME` values actually is much larger, so `HOUR` can return values greater than `23`.

  ```
  mysql> SELECT HOUR('10:05:03');
          -> 10
  mysql> SELECT HOUR('272:59:59');
          -> 272
  ```

- `LAST_DAY(date)`

  Takes a date or datetime value and returns the corresponding value for the last day of the month. Returns `NULL` if the argument is invalid.

  ```
  mysql> SELECT LAST_DAY('2003-02-05');
          -> '2003-02-28'
  mysql> SELECT LAST_DAY('2004-02-05');
          -> '2004-02-29'
  mysql> SELECT LAST_DAY('2004-01-01 01:01:01');
          -> '2004-01-31'
  mysql> SELECT LAST_DAY('2003-03-32');
          -> NULL
  ```

- `LOCALTIME`, `LOCALTIME()`

  `LOCALTIME` and `LOCALTIME()` are synonyms for `NOW()`.

- `LOCALTIMESTAMP`, `LOCALTIMESTAMP()`

  `LOCALTIMESTAMP` and `LOCALTIMESTAMP()` are synonyms for `NOW()`.

- `MAKEDATE(year,dayofyear)`

  Returns a date, given year and day-of-year values. *`dayofyear`* must be greater than 0 or the result is `NULL`.

  ```
  mysql> SELECT MAKEDATE(2011,31), MAKEDATE(2011,32);
          -> '2011-01-31', '2011-02-01'
  mysql> SELECT MAKEDATE(2011,365), MAKEDATE(2014,365);
          -> '2011-12-31', '2014-12-31'
  mysql> SELECT MAKEDATE(2011,0);
          -> NULL
  ```

- `MAKETIME(hour,minute,second)`

  Returns a time value calculated from the *`hour`*, *`minute`*, and *`second`* arguments.

  ```
  mysql> SELECT MAKETIME(12,15,30);
          -> '12:15:30'
  ```

- `MICROSECOND(expr)`

  Returns the microseconds from the time or datetime expression *`expr`* as a number in the range from `0` to `999999`.

  ```
  mysql> SELECT MICROSECOND('12:00:00.123456');
          -> 123456
  mysql> SELECT MICROSECOND('2009-12-31 23:59:59.000010');
          -> 10
  ```

- `MINUTE(time)`

  Returns the minute for *`time`*, in the range `0` to `59`.

  ```
  mysql> SELECT MINUTE('2008-02-03 10:05:03');
          -> 5
  ```

- `MONTH(date)`

  Returns the month for *`date`*, in the range `1` to `12` for January to December, or `0` for dates such as `'0000-00-00'` or `'2008-00-00'` that have a zero month part.

```
mysql> SELECT MONTH('2008-02-03');
        -> 2
```

- `MONTHNAME(date)`

  Returns the full name of the month for `date`. The language used for the name is controlled by the value of the `lc_time_names` system variable (Section 9.7, “MySQL Server Locale Support”).

  ```
  mysql> SELECT MONTHNAME('2008-02-03');
          -> 'February'
  ```

- `NOW()`

  Returns the current date and time as a value in `'YYYY-MM-DD HH:MM:SS'` or `YYYYMMDDHHMMSS.uuuuuu` format, depending on whether the function is used in a string or numeric context. The value is expressed in the current time zone.

  ```
  mysql> SELECT NOW();
          -> '2007-12-15 23:50:26'
  mysql> SELECT NOW() + 0;
          -> 20071215235026.000000
  ```

  `NOW()` returns a constant time that indicates the time at which the statement began to execute. (Within a stored function or trigger, `NOW()` returns the time at which the function or triggering statement began to execute.) This differs from the behavior for `SYSDATE()`, which returns the exact time at which it executes.

  ```
  mysql> SELECT NOW(), SLEEP(2), NOW();
  +---------------------+----------+---------------------+
  | NOW()               | SLEEP(2) | NOW()               |
  +---------------------+----------+---------------------+
  | 2006-04-12 13:47:36 |        0 | 2006-04-12 13:47:36 |
  +---------------------+----------+---------------------+

  mysql> SELECT SYSDATE(), SLEEP(2), SYSDATE();
  +---------------------+----------+---------------------+
  | SYSDATE()           | SLEEP(2) | SYSDATE()           |
  +---------------------+----------+---------------------+
  | 2006-04-12 13:47:44 |        0 | 2006-04-12 13:47:46 |
  +---------------------+----------+---------------------+
  ```

  In addition, the `SET TIMESTAMP` statement affects the value returned by `NOW()` but not by `SYSDATE()`. This means that timestamp settings in the binary log have no effect on invocations of `SYSDATE()`. Setting the timestamp to a nonzero value causes each subsequent invocation of `NOW()` to return that value. Setting the timestamp to zero cancels this effect so that `NOW()` once again returns the current date and time.

  See the description for `SYSDATE()` for additional information about the differences between the two functions.

- `PERIOD_ADD(P,N)`

  Adds `N` months to period `P` (in the format `YYMM` or `YYYYMM`). Returns a value in the format `YYYYMM`. Note that the period argument `P` is *not* a date value.

  ```
  mysql> SELECT PERIOD_ADD(200801,2);
          -> 200803
  ```

- `PERIOD_DIFF(P1,P2)`

  Returns the number of months between periods `P1` and `P2`. `P1` and `P2` should be in the format `YYMM` or `YYYYMM`. Note that the period arguments `P1` and `P2` are *not* date values.

  ```
  mysql> SELECT PERIOD_DIFF(200802,200703);
          -> 11
  ```

- `QUARTER(date)`

  Returns the quarter of the year for `date`, in the range `1` to `4`.

  ```
  mysql> SELECT QUARTER('2008-04-01');
          -> 2
  ```

- `SECOND(time)`

  Returns the second for `time`, in the range `0` to `59`.

```
mysql> SELECT SECOND('10:05:03');
        -> 3
```

- `SEC_TO_TIME(seconds)`

  Returns the *`seconds`* argument, converted to hours, minutes, and seconds, as a `TIME` value. The range of the result is constrained to that of the `TIME` data type. A warning occurs if the argument corresponds to a value outside that range.

```
mysql> SELECT SEC_TO_TIME(2378);
        -> '00:39:38'
mysql> SELECT SEC_TO_TIME(2378) + 0;
        -> 3938
```

- `STR_TO_DATE(str,format)`

  This is the inverse of the `DATE_FORMAT()` function. It takes a string *`str`* and a format string *`format`*. `STR_TO_DATE()` returns a `DATETIME` value if the format string contains both date and time parts, or a `DATE` or `TIME` value if the string contains only date or time parts. If the date, time, or datetime value extracted from *`str`* is illegal, `STR_TO_DATE()` returns `NULL` and produces a warning.

  The server scans *`str`* attempting to match *`format`* to it. The format string can contain literal characters and format specifiers beginning with `%`. Literal characters in *`format`* must match literally in *`str`*. Format specifiers in *`format`* must match a date or time part in *`str`*. For the specifiers that can be used in *`format`*, see the `DATE_FORMAT()` function description.

```
mysql> SELECT STR_TO_DATE('01,5,2013','%d,%m,%Y');
        -> '2013-05-01'
mysql> SELECT STR_TO_DATE('May 1, 2013','%M %d,%Y');
        -> '2013-05-01'
```

  Scanning starts at the beginning of *`str`* and fails if *`format`* is found not to match. Extra characters at the end of *`str`* are ignored.

```
mysql> SELECT STR_TO_DATE('a09:30:17','a%h:%i:%s');
        -> '09:30:17'
mysql> SELECT STR_TO_DATE('a09:30:17','%h:%i:%s');
        -> NULL
mysql> SELECT STR_TO_DATE('09:30:17a','%h:%i:%s');
        -> '09:30:17'
```

  Unspecified date or time parts have a value of 0, so incompletely specified values in *`str`* produce a result with some or all parts set to 0:

```
mysql> SELECT STR_TO_DATE('abc','abc');
        -> '0000-00-00'
mysql> SELECT STR_TO_DATE('9','%m');
        -> '0000-09-00'
mysql> SELECT STR_TO_DATE('9','%s');
        -> '00:00:09'
```

  Range checking on the parts of date values is as described in Section 10.3.1, “The `DATETIME`, `DATE`, and `TIMESTAMP` Types”. This means, for example, that “zero” dates or dates with part values of 0 are permitted unless the SQL mode is set to disallow such values.

```
mysql> SELECT STR_TO_DATE('00/00/0000', '%m/%d/%Y');
        -> '0000-00-00'
mysql> SELECT STR_TO_DATE('04/31/2004', '%m/%d/%Y');
        -> '2004-04-31'
```

  > **Note**
  >
  > You cannot use format `"%X%V"` to convert a year-week string to a date because the combination of a year and week does not uniquely identify a year and month if the week crosses a month boundary. To convert a year-week to a date, you should also specify the weekday:
  >
  > ```
  > mysql> SELECT STR_TO_DATE('200442 Monday', '%X%V %W');
  >         -> '2004-10-18'
  > ```

- `SUBDATE(date,INTERVAL expr unit)`, `SUBDATE(expr,days)`

  When invoked with the `INTERVAL` form of the second argument, `SUBDATE()` is a synonym for `DATE_SUB()`. For information on the `INTERVAL` *`unit`* argument, see the discussion for `DATE_ADD()`.

```
mysql> SELECT DATE_SUB('2008-01-02', INTERVAL 31 DAY);
```

```
        -> '2007-12-02'
mysql> SELECT SUBDATE('2008-01-02', INTERVAL 31 DAY);
        -> '2007-12-02'
```

The second form enables the use of an integer value for *`days`*. In such cases, it is interpreted as the number of days to be subtracted from the date or datetime expression *`expr`*.

```
mysql> SELECT SUBDATE('2008-01-02 12:00:00', 31);
        -> '2007-12-02 12:00:00'
```

- `SUBTIME(expr1,expr2)`

  `SUBTIME()` returns *`expr1`* – *`expr2`* expressed as a value in the same format as *`expr1`*. *`expr1`* is a time or datetime expression, and *`expr2`* is a time expression.

  ```
  mysql> SELECT SUBTIME('2007-12-31 23:59:59.999999','1 1:1:1.000002');
          -> '2007-12-30 22:58:58.999997'
  mysql> SELECT SUBTIME('01:00:00.999999', '02:00:00.999998');
          -> '-00:59:59.999999'
  ```

- `SYSDATE()`

  Returns the current date and time as a value in `'YYYY-MM-DD HH:MM:SS'` or `YYYYMMDDHHMMSS.uuuuuu` format, depending on whether the function is used in a string or numeric context.

  `SYSDATE()` returns the time at which it executes. This differs from the behavior for `NOW()`, which returns a constant time that indicates the time at which the statement began to execute. (Within a stored function or trigger, `NOW()` returns the time at which the function or triggering statement began to execute.)

  ```
  mysql> SELECT NOW(), SLEEP(2), NOW();
  +---------------------+----------+---------------------+
  | NOW()               | SLEEP(2) | NOW()               |
  +---------------------+----------+---------------------+
  | 2006-04-12 13:47:36 |        0 | 2006-04-12 13:47:36 |
  +---------------------+----------+---------------------+

  mysql> SELECT SYSDATE(), SLEEP(2), SYSDATE();
  +---------------------+----------+---------------------+
  | SYSDATE()           | SLEEP(2) | SYSDATE()           |
  +---------------------+----------+---------------------+
  | 2006-04-12 13:47:44 |        0 | 2006-04-12 13:47:46 |
  +---------------------+----------+---------------------+
  ```

  In addition, the `SET TIMESTAMP` statement affects the value returned by `NOW()` but not by `SYSDATE()`. This means that timestamp settings in the binary log have no effect on invocations of `SYSDATE()`.

  Because `SYSDATE()` can return different values even within the same statement, and is not affected by `SET TIMESTAMP`, it is nondeterministic and therefore unsafe for replication if statement-based binary logging is used. If that is a problem, you can use row-based logging.

  Alternatively, you can use the `--sysdate-is-now` option to cause `SYSDATE()` to be an alias for `NOW()`. This works if the option is used on both the master and the slave.

  The nondeterministic nature of `SYSDATE()` also means that indexes cannot be used for evaluating expressions that refer to it.

- `TIME(expr)`

  Extracts the time part of the time or datetime expression *`expr`* and returns it as a string.

  This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

  ```
  mysql> SELECT TIME('2003-12-31 01:02:03');
          -> '01:02:03'
  mysql> SELECT TIME('2003-12-31 01:02:03.000123');
          -> '01:02:03.000123'
  ```

- `TIMEDIFF(expr1,expr2)`

  `TIMEDIFF()` returns *`expr1`* – *`expr2`* expressed as a time value. *`expr1`* and *`expr2`* are time or date-and-time expressions, but both must be of the same type.

  ```
  mysql> SELECT TIMEDIFF('2000:01:01 00:00:00',
      ->                 '2000:01:01 00:00:00.000001');
          -> '-00:00:00.000001'
  mysql> SELECT TIMEDIFF('2008-12-31 23:59:59.000001',
  ```

```
    ->                 '2008-12-30 01:01:01.000002');
        -> '46:58:57.999999'
```

- `TIMESTAMP(expr)`, `TIMESTAMP(expr1,expr2)`

  With a single argument, this function returns the date or datetime expression *`expr`* as a datetime value. With two arguments, it adds the time expression *`expr2`* to the date or datetime expression *`expr1`* and returns the result as a datetime value.

```
mysql> SELECT TIMESTAMP('2003-12-31');
        -> '2003-12-31 00:00:00'
mysql> SELECT TIMESTAMP('2003-12-31 12:00:00','12:00:00');
        -> '2004-01-01 00:00:00'
```

- `TIMESTAMPADD(unit,interval,datetime_expr)`

  Adds the integer expression *`interval`* to the date or datetime expression *`datetime_expr`*. The unit for *`interval`* is given by the *`unit`* argument, which should be one of the following values: `MICROSECOND` (microseconds), `SECOND`, `MINUTE`, `HOUR`, `DAY`, `WEEK`, `MONTH`, `QUARTER`, or `YEAR`.

  It is possible to use `FRAC_SECOND` in place of `MICROSECOND`, but `FRAC_SECOND` is deprecated. `FRAC_SECOND` was removed in MySQL 5.5.3.

  The *`unit`* value may be specified using one of keywords as shown, or with a prefix of `SQL_TSI_`. For example, `DAY` and `SQL_TSI_DAY` both are legal.

```
mysql> SELECT TIMESTAMPADD(MINUTE,1,'2003-01-02');
        -> '2003-01-02 00:01:00'
mysql> SELECT TIMESTAMPADD(WEEK,1,'2003-01-02');
        -> '2003-01-09'
```

- `TIMESTAMPDIFF(unit,datetime_expr1,datetime_expr2)`

  Returns *`datetime_expr2`* – *`datetime_expr1`*, where *`datetime_expr1`* and *`datetime_expr2`* are date or datetime expressions. One expression may be a date and the other a datetime; a date value is treated as a datetime having the time part `'00:00:00'` where necessary. The unit for the result (an integer) is given by the *`unit`* argument. The legal values for *`unit`* are the same as those listed in the description of the `TIMESTAMPADD()` function.

```
mysql> SELECT TIMESTAMPDIFF(MONTH,'2003-02-01','2003-05-01');
        -> 3
mysql> SELECT TIMESTAMPDIFF(YEAR,'2002-05-01','2001-01-01');
        -> -1
mysql> SELECT TIMESTAMPDIFF(MINUTE,'2003-02-01','2003-05-01 12:05:55');
        -> 128885
```

> **Note**
>
> The order of the date or datetime arguments for this function is the opposite of that used with the `TIMESTAMP()` function when invoked with 2 arguments.

- `TIME_FORMAT(time,format)`

  This is used like the `DATE_FORMAT()` function, but the *`format`* string may contain format specifiers only for hours, minutes, seconds, and microseconds. Other specifiers produce a `NULL` value or `0`.

  If the *`time`* value contains an hour part that is greater than `23`, the `%H` and `%k` hour format specifiers produce a value larger than the usual range of `0..23`. The other hour format specifiers produce the hour value modulo 12.

```
mysql> SELECT TIME_FORMAT('100:00:00', '%H %k %h %I %l');
        -> '100 100 04 04 4'
```

- `TIME_TO_SEC(time)`

  Returns the *`time`* argument, converted to seconds.

```
mysql> SELECT TIME_TO_SEC('22:23:00');
        -> 80580
mysql> SELECT TIME_TO_SEC('00:39:38');
        -> 2378
```

- `TO_DAYS(date)`

  Given a date *`date`*, returns a day number (the number of days since year 0).

```
mysql> SELECT TO_DAYS(950501);
        -> 728779
mysql> SELECT TO_DAYS('2007-10-07');
        -> 733321
```

`TO_DAYS()` is not intended for use with values that precede the advent of the Gregorian calendar (1582), because it does not take into account the days that were lost when the calendar was changed. For dates before 1582 (and possibly a later year in other locales), results from this function are not reliable. See Section 11.8, “What Calendar Is Used By MySQL?”, for details.

Remember that MySQL converts two-digit year values in dates to four-digit form using the rules in Section 10.3, “Date and Time Types”. For example, `'2008-10-07'` and `'08-10-07'` are seen as identical dates:

```
mysql> SELECT TO_DAYS('2008-10-07'), TO_DAYS('08-10-07');
        -> 733687, 733687
```

In MySQL, the zero date is defined as `'0000-00-00'`, even though this date is itself considered invalid. This means that, for `'0000-00-00'` and `'0000-01-01'`, `TO_DAYS()` returns the values shown here:

```
mysql> SELECT TO_DAYS('0000-00-00');
+-----------------------+
| to_days('0000-00-00') |
+-----------------------+
|                  NULL |
+-----------------------+
1 row in set, 1 warning (0.00 sec)

mysql> SHOW WARNINGS;
+---------+------+----------------------------------------+
| Level   | Code | Message                                |
+---------+------+----------------------------------------+
| Warning | 1292 | Incorrect datetime value: '0000-00-00' |
+---------+------+----------------------------------------+
1 row in set (0.00 sec)


mysql> SELECT TO_DAYS('0000-01-01');
+-----------------------+
| to_days('0000-01-01') |
+-----------------------+
|                     1 |
+-----------------------+
1 row in set (0.00 sec)
```

This is true whether or not the `ALLOW_INVALID_DATES` SQL server mode is enabled.

- `TO_SECONDS(expr)`

  Given a date or datetime *`expr`*, returns a the number of seconds since the year 0. If *`expr`* is not a valid date or datetime value, returns `NULL`.

```
mysql> SELECT TO_SECONDS(950501);
        -> 62966505600
mysql> SELECT TO_SECONDS('2009-11-29');
        -> 63426672000
mysql> SELECT TO_SECONDS('2009-11-29 13:43:32');
        -> 63426721412
mysql> SELECT TO_SECONDS( NOW() );
        -> 63426721458
```

  Like `TO_DAYS()`, `TO_SECONDS()` is not intended for use with values that precede the advent of the Gregorian calendar (1582), because it does not take into account the days that were lost when the calendar was changed. For dates before 1582 (and possibly a later year in other locales), results from this function are not reliable. See Section 11.8, “What Calendar Is Used By MySQL?”, for details.

  Like `TO_DAYS()`, `TO_SECONDS()`, converts two-digit year values in dates to four-digit form using the rules in Section 10.3, “Date and Time Types”.

  `TO_SECONDS()` is available beginning with MySQL 5.5.0.

  In MySQL, the zero date is defined as `'0000-00-00'`, even though this date is itself considered invalid. This means that, for `'0000-00-00'` and `'0000-01-01'`, `TO_SECONDS()` returns the values shown here:

```
mysql> SELECT TO_SECONDS('0000-00-00');
+--------------------------+
| TO_SECONDS('0000-00-00') |
+--------------------------+
|                     NULL |
+--------------------------+
1 row in set, 1 warning (0.00 sec)
```

```
mysql> SHOW WARNINGS;
+---------+------+----------------------------------------+
| Level   | Code | Message                                |
+---------+------+----------------------------------------+
| Warning | 1292 | Incorrect datetime value: '0000-00-00' |
+---------+------+----------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT TO_SECONDS('0000-01-01');
+--------------------------+
| TO_SECONDS('0000-01-01') |
+--------------------------+
|                    86400 |
+--------------------------+
1 row in set (0.00 sec)
```

This is true whether or not the `ALLOW_INVALID_DATES` SQL server mode is enabled.

- `UNIX_TIMESTAMP()`, `UNIX_TIMESTAMP(date)`

  If called with no argument, returns a Unix timestamp (seconds since `'1970-01-01 00:00:00'` UTC) as an unsigned integer. If `UNIX_TIMESTAMP()` is called with a *`date`* argument, it returns the value of the argument as seconds since `'1970-01-01 00:00:00'` UTC. *`date`* may be a `DATE` string, a `DATETIME` string, a `TIMESTAMP`, or a number in the format `YYMMDD` or `YYYYMMDD`. The server interprets *`date`* as a value in the current time zone and converts it to an internal value in UTC. Clients can set their time zone as described in Section 9.6, “MySQL Server Time Zone Support”.

```
mysql> SELECT UNIX_TIMESTAMP();
        -> 1196440210
mysql> SELECT UNIX_TIMESTAMP('2007-11-30 10:30:19');
        -> 1196440219
```

  When `UNIX_TIMESTAMP()` is used on a `TIMESTAMP` column, the function returns the internal timestamp value directly, with no implicit “string-to-Unix-timestamp” conversion. If you pass an out-of-range date to `UNIX_TIMESTAMP()`, it returns `0`.

  Note: If you use `UNIX_TIMESTAMP()` and `FROM_UNIXTIME()` to convert between `TIMESTAMP` values and Unix timestamp values, the conversion is lossy because the mapping is not one-to-one in both directions. For example, due to conventions for local time zone changes, it is possible for two `UNIX_TIMESTAMP()` to map two `TIMESTAMP` values to the same Unix timestamp value. `FROM_UNIXTIME()` will map that value back to only one of the original `TIMESTAMP` values. Here is an example, using `TIMESTAMP` values in the `CET` time zone:

```
mysql> SELECT UNIX_TIMESTAMP('2005-03-27 03:00:00');
+---------------------------------------+
| UNIX_TIMESTAMP('2005-03-27 03:00:00') |
+---------------------------------------+
|                            1111885200 |
+---------------------------------------+
mysql> SELECT UNIX_TIMESTAMP('2005-03-27 02:00:00');
+---------------------------------------+
| UNIX_TIMESTAMP('2005-03-27 02:00:00') |
+---------------------------------------+
|                            1111885200 |
+---------------------------------------+
mysql> SELECT FROM_UNIXTIME(1111885200);
+---------------------------+
| FROM_UNIXTIME(1111885200) |
+---------------------------+
| 2005-03-27 03:00:00       |
+---------------------------+
```

  If you want to subtract `UNIX_TIMESTAMP()` columns, you might want to cast the result to signed integers. See Section 11.10, “Cast Functions and Operators”.

- `UTC_DATE`, `UTC_DATE()`

  Returns the current UTC date as a value in `'YYYY-MM-DD'` or `YYYYMMDD` format, depending on whether the function is used in a string or numeric context.

```
mysql> SELECT UTC_DATE(), UTC_DATE() + 0;
        -> '2003-08-14', 20030814
```

- `UTC_TIME`, `UTC_TIME()`

  Returns the current UTC time as a value in `'HH:MM:SS'` or `HHMMSS.uuuuuu` format, depending on whether the function is used in a string or numeric context.

```
mysql> SELECT UTC_TIME(), UTC_TIME() + 0;
```

```
        -> '18:07:53', 180753.000000
```

- `UTC_TIMESTAMP`, `UTC_TIMESTAMP()`

  Returns the current UTC date and time as a value in `'YYYY-MM-DD HH:MM:SS'` or `YYYYMMDDHHMMSS.uuuuuu` format, depending on whether the function is used in a string or numeric context.

  ```
  mysql> SELECT UTC_TIMESTAMP(), UTC_TIMESTAMP() + 0;
          -> '2003-08-14 18:08:04', 20030814180804.000000
  ```

- `WEEK(date[,mode])`

  This function returns the week number for *`date`*. The two-argument form of `WEEK()` enables you to specify whether the week starts on Sunday or Monday and whether the return value should be in the range from `0` to `53` or from `1` to `53`. If the *`mode`* argument is omitted, the value of the `default_week_format` system variable is used. See Section 5.1.3, “Server System Variables”.

  The following table describes how the *`mode`* argument works.

Mode	First day of week	Range	Week 1 is the first week …
0	Sunday	0-53	with a Sunday in this year
1	Monday	0-53	with more than 3 days this year
2	Sunday	1-53	with a Sunday in this year
3	Monday	1-53	with more than 3 days this year
4	Sunday	0-53	with more than 3 days this year
5	Monday	0-53	with a Monday in this year
6	Sunday	1-53	with more than 3 days this year
7	Monday	1-53	with a Monday in this year

```
mysql> SELECT WEEK('2008-02-20');
        -> 7
mysql> SELECT WEEK('2008-02-20',0);
        -> 7
mysql> SELECT WEEK('2008-02-20',1);
        -> 8
mysql> SELECT WEEK('2008-12-31',1);
        -> 53
```

Note that if a date falls in the last week of the previous year, MySQL returns `0` if you do not use `2`, `3`, `6`, or `7` as the optional *`mode`* argument:

```
mysql> SELECT YEAR('2000-01-01'), WEEK('2000-01-01',0);
        -> 2000, 0
```

One might argue that MySQL should return `52` for the `WEEK()` function, because the given date actually occurs in the 52nd week of 1999. We decided to return `0` instead because we want the function to return “the week number in the given year.” This makes use of the `WEEK()` function reliable when combined with other functions that extract a date part from a date.

If you would prefer the result to be evaluated with respect to the year that contains the first day of the week for the given date, use `0`, `2`, `5`, or `7` as the optional *`mode`* argument.

```
mysql> SELECT WEEK('2000-01-01',2);
        -> 52
```

Alternatively, use the `YEARWEEK()` function:

```
mysql> SELECT YEARWEEK('2000-01-01');
        -> 199952
mysql> SELECT MID(YEARWEEK('2000-01-01'),5,2);
        -> '52'
```

- `WEEKDAY(date)`

  Returns the weekday index for *`date`* (`0` = Monday, `1` = Tuesday, … `6` = Sunday).

  ```
  mysql> SELECT WEEKDAY('2008-02-03 22:23:00');
          -> 6
  ```

```
mysql> SELECT WEEKDAY('2007-11-06');
        -> 1
```

- `WEEKOFYEAR(date)`

  Returns the calendar week of the date as a number in the range from `1` to `53`. `WEEKOFYEAR()` is a compatibility function that is equivalent to `WEEK(date,3)`.

  ```
  mysql> SELECT WEEKOFYEAR('2008-02-20');
          -> 8
  ```

- `YEAR(date)`

  Returns the year for `date`, in the range `1000` to `9999`, or `0` for the "zero" date.

  ```
  mysql> SELECT YEAR('1987-01-01');
          -> 1987
  ```

- `YEARWEEK(date)`, `YEARWEEK(date,mode)`

  Returns year and week for a date. The `mode` argument works exactly like the `mode` argument to `WEEK()`. The year in the result may be different from the year in the date argument for the first and the last week of the year.

  ```
  mysql> SELECT YEARWEEK('1987-01-01');
          -> 198653
  ```

  Note that the week number is different from what the `WEEK()` function would return (`0`) for optional arguments `0` or `1`, as `WEEK()` then returns the week in the context of the given year.

11.8. What Calendar Is Used By MySQL?

MySQL uses what is known as a *proleptic Gregorian calendar*.

Every country that has switched from the Julian to the Gregorian calendar has had to discard at least ten days during the switch. To see how this works, consider the month of October 1582, when the first Julian-to-Gregorian switch occurred.

Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
1	2	3	4	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

There are no dates between October 4 and October 15. This discontinuity is called the *cutover*. Any dates before the cutover are Julian, and any dates following the cutover are Gregorian. Dates during a cutover are nonexistent.

A calendar applied to dates when it was not actually in use is called *proleptic*. Thus, if we assume there was never a cutover and Gregorian rules always rule, we have a proleptic Gregorian calendar. This is what is used by MySQL, as is required by standard SQL. For this reason, dates prior to the cutover stored as MySQL `DATE` or `DATETIME` values must be adjusted to compensate for the difference. It is important to realize that the cutover did not occur at the same time in all countries, and that the later it happened, the more days were lost. For example, in Great Britain, it took place in 1752, when Wednesday September 2 was followed by Thursday September 14. Russia remained on the Julian calendar until 1918, losing 13 days in the process, and what is popularly referred to as its "October Revolution" occurred in November according to the Gregorian calendar.

11.9. Full-Text Search Functions

`MATCH (col1,col2,...) AGAINST (expr [search_modifier])`

```
search_modifier:
  {
       IN NATURAL LANGUAGE MODE
     | IN NATURAL LANGUAGE MODE WITH QUERY EXPANSION
     | IN BOOLEAN MODE
     | WITH QUERY EXPANSION
  }
```

MySQL has support for full-text indexing and searching:

- A full-text index in MySQL is an index of type `FULLTEXT`.
- Full-text indexes can be used only with `MyISAM` tables, and can be created only for `CHAR`, `VARCHAR`, or `TEXT` columns.
- A `FULLTEXT` index definition can be given in the `CREATE TABLE` statement when a table is created, or added later using `ALTER TABLE` or `CREATE INDEX`.
- For large data sets, it is much faster to load your data into a table that has no `FULLTEXT` index and then create the index after that, than to load data into a table that has an existing `FULLTEXT` index.

Full-text searching is performed using `MATCH() ... AGAINST` syntax. `MATCH()` takes a comma-separated list that names the columns to be searched. `AGAINST` takes a string to search for, and an optional modifier that indicates what type of search to perform. The search string must be a literal string, not a variable or a column name. There are three types of full-text searches:

- A natural language search interprets the search string as a phrase in natural human language (a phrase in free text). There are no special operators. The stopword list applies. In addition, words that are present in 50% or more of the rows are considered common and do not match.

  Full-text searches are natural language searches if the `IN NATURAL LANGUAGE MODE` modifier is given or if no modifier is given. For more information, see Section 11.9.1, “Natural Language Full-Text Searches”.

- A boolean search interprets the search string using the rules of a special query language. The string contains the words to search for. It can also contain operators that specify requirements such that a word must be present or absent in matching rows, or that it should be weighted higher or lower than usual. Common words such as “some” or “then” are stopwords and do not match if present in the search string. The `IN BOOLEAN MODE` modifier specifies a boolean search. For more information, see Section 11.9.2, “Boolean Full-Text Searches”.
- A query expansion search is a modification of a natural language search. The search string is used to perform a natural language search. Then words from the most relevant rows returned by the search are added to the search string and the search is done again. The query returns the rows from the second search. The `IN NATURAL LANGUAGE MODE WITH QUERY EXPANSION` or `WITH QUERY EXPANSION` modifier specifies a query expansion search. For more information, see Section 11.9.3, “Full-Text Searches with Query Expansion”.

Constraints on full-text searching are listed in Section 11.9.5, “Full-Text Restrictions”.

The `myisam_ftdump` utility can be used to dump the contents of a full-text index. This may be helpful for debugging full-text queries. See Section 4.6.2, “`myisam_ftdump` — Display Full-Text Index information”.

11.9.1. Natural Language Full-Text Searches

By default or with the `IN NATURAL LANGUAGE MODE` modifier, the `MATCH()` function performs a natural language search for a string against a *text collection*. A collection is a set of one or more columns included in a `FULLTEXT` index. The search string is given as the argument to `AGAINST()`. For each row in the table, `MATCH()` returns a relevance value; that is, a similarity measure between the search string and the text in that row in the columns named in the `MATCH()` list.

```
mysql> CREATE TABLE articles (
    ->   id INT UNSIGNED AUTO_INCREMENT NOT NULL PRIMARY KEY,
    ->   title VARCHAR(200),
    ->   body TEXT,
    ->   FULLTEXT (title,body)
    -> ) ENGINE=MyISAM;
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO articles (title,body) VALUES
    -> ('MySQL Tutorial','DBMS stands for DataBase ...'),
    -> ('How To Use MySQL Well','After you went through a ...'),
    -> ('Optimizing MySQL','In this tutorial we will show ...'),
    -> ('1001 MySQL Tricks','1. Never run mysqld as root. 2. ...'),
    -> ('MySQL vs. YourSQL','In the following database comparison ...'),
    -> ('MySQL Security','When configured properly, MySQL ...');
Query OK, 6 rows affected (0.00 sec)
Records: 6  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM articles
    -> WHERE MATCH (title,body)
    -> AGAINST ('database' IN NATURAL LANGUAGE MODE);
+----+-------------------+------------------------------------------+
| id | title             | body                                     |
+----+-------------------+------------------------------------------+
|  5 | MySQL vs. YourSQL | In the following database comparison ... |
|  1 | MySQL Tutorial    | DBMS stands for DataBase ...             |
+----+-------------------+------------------------------------------+
2 rows in set (0.00 sec)
```

By default, the search is performed in case-insensitive fashion. However, you can perform a case-sensitive full-text search by using a binary collation for the indexed columns. For example, a column that uses the `latin1` character set of can be assigned a collation of `latin1_bin` to make it case sensitive for full-text searches.

When `MATCH()` is used in a `WHERE` clause, as in the example shown earlier, the rows returned are automatically sorted with the highest relevance first. Relevance values are nonnegative floating-point numbers. Zero relevance means no similarity. Relevance is computed based on the number of words in the row, the number of unique words in that row, the total number of words in the collection, and the number of documents (rows) that contain a particular word.

To simply count matches, you could use a query like this:

```
mysql> SELECT COUNT(*) FROM articles
    -> WHERE MATCH (title,body)
    -> AGAINST ('database' IN NATURAL LANGUAGE MODE);
+----------+
| COUNT(*) |
+----------+
|        2 |
+----------+
1 row in set (0.00 sec)
```

However, you might find it quicker to rewrite the query as follows:

```
mysql> SELECT
    -> COUNT(IF(MATCH (title,body) AGAINST ('database' IN NATURAL LANGUAGE MODE), 1, NULL))
    -> AS count
    -> FROM articles;
+-------+
| count |
+-------+
|     2 |
+-------+
1 row in set (0.03 sec)
```

The first query sorts the results by relevance whereas the second does not. However, the second query performs a full table scan and the first does not. The first may be faster if the search matches few rows; otherwise, the second may be faster because it would read many rows anyway.

For natural-language full-text searches, it is a requirement that the columns named in the `MATCH()` function be the same columns included in some `FULLTEXT` index in your table. For the preceding query, note that the columns named in the `MATCH()` function (`title` and `body`) are the same as those named in the definition of the `article` table's `FULLTEXT` index. If you wanted to search the `title` or `body` separately, you would need to create separate `FULLTEXT` indexes for each column.

It is also possible to perform a boolean search or a search with query expansion. These search types are described in Section 11.9.2, “Boolean Full-Text Searches”, and Section 11.9.3, “Full-Text Searches with Query Expansion”.

A full-text search that uses an index can name columns only from a single table in the `MATCH()` clause because an index cannot span multiple tables. A boolean search can be done in the absence of an index (albeit more slowly), in which case it is possible to name columns from multiple tables.

The preceding example is a basic illustration that shows how to use the `MATCH()` function where rows are returned in order of decreasing relevance. The next example shows how to retrieve the relevance values explicitly. Returned rows are not ordered because the `SELECT` statement includes neither `WHERE` nor `ORDER BY` clauses:

```
mysql> SELECT id, MATCH (title,body)
    -> AGAINST ('Tutorial' IN NATURAL LANGUAGE MODE) AS score
    -> FROM articles;
+----+------------------+
| id | score            |
+----+------------------+
|  1 | 0.65545833110809 |
|  2 |                0 |
|  3 | 0.66266459226608 |
|  4 |                0 |
|  5 |                0 |
|  6 |                0 |
+----+------------------+
6 rows in set (0.00 sec)
```

The following example is more complex. The query returns the relevance values and it also sorts the rows in order of decreasing relevance. To achieve this result, you should specify `MATCH()` twice: once in the `SELECT` list and once in the `WHERE` clause. This causes no additional overhead, because the MySQL optimizer notices that the two `MATCH()` calls are identical and invokes the full-text search code only once.

```
mysql> SELECT id, body, MATCH (title,body) AGAINST
    -> ('Security implications of running MySQL as root'
    -> IN NATURAL LANGUAGE MODE) AS score
    -> FROM articles WHERE MATCH (title,body) AGAINST
    -> ('Security implications of running MySQL as root'
    -> IN NATURAL LANGUAGE MODE);
+----+-------------------------------------+-----------------+
| id | body                                | score           |
+----+-------------------------------------+-----------------+
|  4 | 1. Never run mysqld as root. 2. ... | 1.5219271183014 |
|  6 | When configured properly, MySQL ... | 1.3114095926285 |
+----+-------------------------------------+-----------------+
2 rows in set (0.00 sec)
```

The MySQL `FULLTEXT` implementation regards any sequence of true word characters (letters, digits, and underscores) as a word. That sequence may also contain apostrophes ("`'`"), but not more than one in a row. This means that `aaa'bbb` is regarded as one word, but `aaa''bbb` is regarded as two words. Apostrophes at the beginning or the end of a word are stripped by the `FULLTEXT` parser; `'aaa'bbb'` would be parsed as `aaa'bbb`.

The `FULLTEXT` parser determines where words start and end by looking for certain delimiter characters; for example, "` `" (space), "`,`" (comma), and "`.`" (period). If words are not separated by delimiters (as in, for example, Chinese), the `FULLTEXT` parser cannot determine where a word begins or ends. To be able to add words or other indexed terms in such languages to a `FULLTEXT` index, you must preprocess them so that they are separated by some arbitrary delimiter such as "`"`".

In MySQL 5.5, it is possible to write a plugin that replaces the built-in full-text parser. For details, see Section 21.2, "The MySQL Plugin API". For example parser plugin source code, see the `plugin/fulltext` directory of a MySQL source distribution.

Some words are ignored in full-text searches:

- Any word that is too short is ignored. The default minimum length of words that are found by full-text searches is four characters.
- Words in the stopword list are ignored. A stopword is a word such as "the" or "some" that is so common that it is considered to have zero semantic value. There is a built-in stopword list, but it can be overwritten by a user-defined list.

The default stopword list is given in Section 11.9.4, "Full-Text Stopwords". The default minimum word length and stopword list can be changed as described in Section 11.9.6, "Fine-Tuning MySQL Full-Text Search".

Every correct word in the collection and in the query is weighted according to its significance in the collection or query. Consequently, a word that is present in many documents has a lower weight (and may even have a zero weight), because it has lower semantic value in this particular collection. Conversely, if the word is rare, it receives a higher weight. The weights of the words are combined to compute the relevance of the row.

Such a technique works best with large collections (in fact, it was carefully tuned this way). For very small tables, word distribution does not adequately reflect their semantic value, and this model may sometimes produce bizarre results. For example, although the word "MySQL" is present in every row of the `articles` table shown earlier, a search for the word produces no results:

```
mysql> SELECT * FROM articles
    -> WHERE MATCH (title,body)
    -> AGAINST ('MySQL' IN NATURAL LANGUAGE MODE);
Empty set (0.00 sec)
```

The search result is empty because the word "MySQL" is present in at least 50% of the rows. As such, it is effectively treated as a stopword. For large data sets, this is the most desirable behavior: A natural language query should not return every second row from a 1GB table. For small data sets, it may be less desirable.

A word that matches half of the rows in a table is less likely to locate relevant documents. In fact, it most likely finds plenty of irrelevant documents. We all know this happens far too often when we are trying to find something on the Internet with a search engine. It is with this reasoning that rows containing the word are assigned a low semantic value for *the particular data set in which they occur*. A given word may reach the 50% threshold in one data set but not another.

The 50% threshold has a significant implication when you first try full-text searching to see how it works: If you create a table and insert only one or two rows of text into it, every word in the text occurs in at least 50% of the rows. As a result, no search returns any results. Be sure to insert at least three rows, and preferably many more. Users who need to bypass the 50% limitation can use the boolean search mode; see Section 11.9.2, "Boolean Full-Text Searches".

11.9.2. Boolean Full-Text Searches

MySQL can perform boolean full-text searches using the `IN BOOLEAN MODE` modifier. With this modifier, certain characters have special meaning at the beginning or end of words in the search string. In the following query, the `+` and `-` operators indicate that a word is required to be present or absent, respectively, for a match to occur. Thus, the query retrieves all the rows that contain the word "MySQL" but that do *not* contain the word "YourSQL":

```
mysql> SELECT * FROM articles WHERE MATCH (title,body)
    -> AGAINST ('+MySQL -YourSQL' IN BOOLEAN MODE);
+----+-----------------------+-------------------------------------+
| id | title                 | body                                |
+----+-----------------------+------------------------------------+
|  1 | MySQL Tutorial        | DBMS stands for DataBase ...       |
|  2 | How To Use MySQL Well | After you went through a ...       |
|  3 | Optimizing MySQL      | In this tutorial we will show ...  |
|  4 | 1001 MySQL Tricks     | 1. Never run mysqld as root. 2. ... |
|  6 | MySQL Security        | When configured properly, MySQL ... |
+----+-----------------------+------------------------------------+
```

> **Note**
>
> In implementing this feature, MySQL uses what is sometimes referred to as *implied Boolean logic*, in which
>
> - `+` stands for `AND`
> - `-` stands for `NOT`
> - [*no operator*] implies `OR`

Boolean full-text searches have these characteristics:

- They do not use the 50% threshold.
- They do not automatically sort rows in order of decreasing relevance. You can see this from the preceding query result: The row with the highest relevance is the one that contains “MySQL” twice, but it is listed last, not first.
- They can work even without a `FULLTEXT` index, although a search executed in this fashion would be quite slow.
- The minimum and maximum word length full-text parameters apply.
- The stopword list applies.

The boolean full-text search capability supports the following operators:

- `+`

  A leading plus sign indicates that this word *must* be present in each row that is returned.

- `-`

  A leading minus sign indicates that this word must *not* be present in any of the rows that are returned.

  Note: The `-` operator acts only to exclude rows that are otherwise matched by other search terms. Thus, a boolean-mode search that contains only terms preceded by `-` returns an empty result. It does not return “all rows except those containing any of the excluded terms.”

- (no operator)

  By default (when neither `+` nor `-` is specified) the word is optional, but the rows that contain it are rated higher. This mimics the behavior of `MATCH() ... AGAINST()` without the `IN BOOLEAN MODE` modifier.

- `> <`

  These two operators are used to change a word's contribution to the relevance value that is assigned to a row. The `>` operator increases the contribution and the `<` operator decreases it. See the example following this list.

- `( )`

  Parentheses group words into subexpressions. Parenthesized groups can be nested.

- `~`

  A leading tilde acts as a negation operator, causing the word's contribution to the row's relevance to be negative. This is useful for marking “noise” words. A row containing such a word is rated lower than others, but is not excluded altogether, as it would be with the `-` operator.

- `*`

  The asterisk serves as the truncation (or wildcard) operator. Unlike the other operators, it should be *appended* to the word to be affected. Words match if they begin with the word preceding the `*` operator.

If a word is specified with the truncation operator, it is not stripped from a boolean query, even if it is too short (as determined from the `ft_min_word_len` setting) or a stopword. This occurs because the word is not seen as too short or a stopword, but as a prefix that must be present in the document in the form of a word that begins with the prefix. Suppose that `ft_min_word_len=4`. Then a search for `'+word +the*'` will likely return fewer rows than a search for `'+word +the'`:

- The former query remains as is and requires both `word` and `the*` (a word starting with `the`) to be present in the document.
- The latter query is transformed to `+word` (requiring only `word` to be present). `the` is both too short and a stopword, and either condition is enough to cause it to be ignored.

- `"`

  A phrase that is enclosed within double quote (“`"`”) characters matches only rows that contain the phrase *literally, as it was typed*. The full-text engine splits the phrase into words and performs a search in the `FULLTEXT` index for the words. Nonword characters need not be matched exactly: Phrase searching requires only that matches contain exactly the same words as the phrase and in the same order. For example, `"test phrase"` matches `"test, phrase"`.

  If the phrase contains no words that are in the index, the result is empty. For example, if all words are either stopwords or shorter than the minimum length of indexed words, the result is empty.

The following examples demonstrate some search strings that use boolean full-text operators:

- `'apple banana'`

  Find rows that contain at least one of the two words.

- `'+apple +juice'`

  Find rows that contain both words.

- `'+apple macintosh'`

  Find rows that contain the word “apple”, but rank rows higher if they also contain “macintosh”.

- `'+apple -macintosh'`

  Find rows that contain the word “apple” but not “macintosh”.

- `'+apple ~macintosh'`

  Find rows that contain the word “apple”, but if the row also contains the word “macintosh”, rate it lower than if row does not. This is “softer” than a search for `'+apple -macintosh'`, for which the presence of “macintosh” causes the row not to be returned at all.

- `'+apple +(>turnover <strudel)'`

  Find rows that contain the words “apple” and “turnover”, or “apple” and “strudel” (in any order), but rank “apple turnover” higher than “apple strudel”.

- `'apple*'`

  Find rows that contain words such as “apple”, “apples”, “applesauce”, or “applet”.

- `'"some words"'`

  Find rows that contain the exact phrase “some words” (for example, rows that contain “some words of wisdom” but not “some noise words”). Note that the “`"`” characters that enclose the phrase are operator characters that delimit the phrase. They are not the quotation marks that enclose the search string itself.

11.9.3. Full-Text Searches with Query Expansion

Full-text search supports query expansion (and in particular, its variant “blind query expansion”). This is generally useful when a search phrase is too short, which often means that the user is relying on implied knowledge that the full-text search engine lacks. For example, a user searching for “database” may really mean that “MySQL”, “Oracle”, “DB2”, and “RDBMS” all are phrases that should match “databases” and should be returned, too. This is implied knowledge.

Blind query expansion (also known as automatic relevance feedback) is enabled by adding `WITH QUERY EXPANSION` or `IN NATURAL LANGUAGE MODE WITH QUERY EXPANSION` following the search phrase. It works by performing the search twice, where the search phrase for the second search is the original search phrase concatenated with the few most highly relevant documents from the first search. Thus, if one of these documents contains the word “databases” and the word “MySQL”, the second search finds the documents that contain the word “MySQL” even if they do not contain the word “database”. The following example shows this difference:

```
mysql> SELECT * FROM articles
    -> WHERE MATCH (title,body)
    -> AGAINST ('database' IN NATURAL LANGUAGE MODE);
+----+-------------------+------------------------------------------+
| id | title             | body                                     |
+----+-------------------+------------------------------------------+
|  5 | MySQL vs. YourSQL | In the following database comparison ... |
|  1 | MySQL Tutorial    | DBMS stands for DataBase ...             |
+----+-------------------+------------------------------------------+
2 rows in set (0.00 sec)

mysql> SELECT * FROM articles
    -> WHERE MATCH (title,body)
    -> AGAINST ('database' WITH QUERY EXPANSION);
+----+-------------------+------------------------------------------+
| id | title             | body                                     |
+----+-------------------+------------------------------------------+
|  1 | MySQL Tutorial    | DBMS stands for DataBase ...             |
|  5 | MySQL vs. YourSQL | In the following database comparison ... |
|  3 | Optimizing MySQL  | In this tutorial we will show ...        |
+----+-------------------+------------------------------------------+
3 rows in set (0.00 sec)
```

Another example could be searching for books by Georges Simenon about Maigret, when a user is not sure how to spell “Maigret”. A search for “Megre and the reluctant witnesses” finds only “Maigret and the Reluctant Witnesses” without query expansion. A search with query expansion finds all books with the word “Maigret” on the second pass.

> **Note**
>
> Because blind query expansion tends to increase noise significantly by returning nonrelevant documents, it is meaningful to use only when a search phrase is rather short.

11.9.4. Full-Text Stopwords

The stopword list is loaded and searched for full-text queries using the server character set and collation (the values of the `character_set_server` and `collation_server` system variables). False hits or misses may occur for stopword lookups if the stopword file or columns used for full-text indexing or searches have a character set or collation different from `character_set_server` or `collation_server`.

Case sensitivity of stopword lookups depends on the server collation. For example, lookups are case insensitive if the collation is `latin1_swedish_ci`, whereas lookups are case sensitive if the collation is `latin1_general_cs` or `latin1_bin`.

As of MySQL 5.5.6, the stopword file is loaded and searched using `latin1` if `character_set_server` is `ucs2`, `utf16`, or `utf32`. If any table was created with `FULLTEXT` indexes while the server character set was `ucs2`, `utf16`, or `utf32`, it should be repaired using this statement:

```
REPAIR TABLE tbl_name QUICK;
```

The following table shows the default list of full-text stopwords. In a MySQL source distribution, you can find this list in the `storage/myisam/ft_static.c` file.

a's	able	about	above	according
accordingly	across	actually	after	afterwards
again	against	ain't	all	allow
allows	almost	alone	along	already
also	although	always	am	among
amongst	an	and	another	any
anybody	anyhow	anyone	anything	anyway
anyways	anywhere	apart	appear	appreciate
appropriate	are	aren't	around	as
aside	ask	asking	associated	at
available	away	awfully	be	became
because	become	becomes	becoming	been

before	beforehand	behind	being	believe
below	beside	besides	best	better
between	beyond	both	brief	but
by	c'mon	c's	came	can
can't	cannot	cant	cause	causes
certain	certainly	changes	clearly	co
com	come	comes	concerning	consequently
consider	considering	contain	containing	contains
corresponding	could	couldn't	course	currently
definitely	described	despite	did	didn't
different	do	does	doesn't	doing
don't	done	down	downwards	during
each	edu	eg	eight	either
else	elsewhere	enough	entirely	especially
et	etc	even	ever	every
everybody	everyone	everything	everywhere	ex
exactly	example	except	far	few
fifth	first	five	followed	following
follows	for	former	formerly	forth
four	from	further	furthermore	get
gets	getting	given	gives	go
goes	going	gone	got	gotten
greetings	had	hadn't	happens	hardly
has	hasn't	have	haven't	having
he	he's	hello	help	hence
her	here	here's	hereafter	hereby
herein	hereupon	hers	herself	hi
him	himself	his	hither	hopefully
how	howbeit	however	i'd	i'll
i'm	i've	ie	if	ignored
immediate	in	inasmuch	inc	indeed
indicate	indicated	indicates	inner	insofar
instead	into	inward	is	isn't
it	it'd	it'll	it's	its
itself	just	keep	keeps	kept
know	known	knows	last	lately
later	latter	latterly	least	less
lest	let	let's	like	liked
likely	little	look	looking	looks
ltd	mainly	many	may	maybe
me	mean	meanwhile	merely	might
more	moreover	most	mostly	much
must	my	myself	name	namely
nd	near	nearly	necessary	need
needs	neither	never	nevertheless	new
next	nine	no	nobody	non
none	noone	nor	normally	not
nothing	novel	now	nowhere	obviously

of	off	often	oh	ok
okay	old	on	once	one
ones	only	onto	or	other
others	otherwise	ought	our	ours
ourselves	out	outside	over	overall
own	particular	particularly	per	perhaps
placed	please	plus	possible	presumably
probably	provides	que	quite	qv
rather	rd	re	really	reasonably
regarding	regardless	regards	relatively	respectively
right	said	same	saw	say
saying	says	second	secondly	see
seeing	seem	seemed	seeming	seems
seen	self	selves	sensible	sent
serious	seriously	seven	several	shall
she	should	shouldn't	since	six
so	some	somebody	somehow	someone
something	sometime	sometimes	somewhat	somewhere
soon	sorry	specified	specify	specifying
still	sub	such	sup	sure
t's	take	taken	tell	tends
th	than	thank	thanks	thanx
that	that's	thats	the	their
theirs	them	themselves	then	thence
there	there's	thereafter	thereby	therefore
therein	theres	thereupon	these	they
they'd	they'll	they're	they've	think
third	this	thorough	thoroughly	those
though	three	through	throughout	thru
thus	to	together	too	took
toward	towards	tried	tries	truly
try	trying	twice	two	un
under	unfortunately	unless	unlikely	until
unto	up	upon	us	use
used	useful	uses	using	usually
value	various	very	via	viz
vs	want	wants	was	wasn't
way	we	we'd	we'll	we're
we've	welcome	well	went	were
weren't	what	what's	whatever	when
whence	whenever	where	where's	whereafter
whereas	whereby	wherein	whereupon	wherever
whether	which	while	whither	who
who's	whoever	whole	whom	whose
why	will	willing	wish	with
within	without	won't	wonder	would
wouldn't	yes	yet	you	you'd
you'll	you're	you've	your	yours

yourself	yourselves	zero		

11.9.5. Full-Text Restrictions

- Full-text searches are supported for `MyISAM` tables only.
- Full-text searches can be used with most multi-byte character sets. The exception is that for Unicode, the `utf8` character set can be used, but not the `ucs2` character set. However, although `FULLTEXT` indexes on `ucs2` columns cannot be used, you can perform `IN BOOLEAN MODE` searches on a `ucs2` column that has no such index.

  The remarks for `utf8` also apply to `utf8mb4`, and the remarks for `ucs2` also apply to `utf16` and `utf32`.
- Ideographic languages such as Chinese and Japanese do not have word delimiters. Therefore, the `FULLTEXT` parser *cannot determine where words begin and end in these and other such languages*. The implications of this and some workarounds for the problem are described in Section 11.9, "Full-Text Search Functions".
- Although the use of multiple character sets within a single table is supported, all columns in a `FULLTEXT` index must use the same character set and collation.
- The `MATCH()` column list must match exactly the column list in some `FULLTEXT` index definition for the table, unless this `MATCH()` is `IN BOOLEAN MODE`. Boolean-mode searches can be done on nonindexed columns, although they are likely to be slow.
- The argument to `AGAINST()` must be a constant string.
- Index hints are more limited for `FULLTEXT` searches than for non-`FULLTEXT` searches. See Section 12.2.9.2, "Index Hint Syntax".

11.9.6. Fine-Tuning MySQL Full-Text Search

MySQL's full-text search capability has few user-tunable parameters. You can exert more control over full-text searching behavior if you have a MySQL source distribution because some changes require source code modifications. See Section 2.9, "Installing MySQL from Source".

Note that full-text search is carefully tuned for the most effectiveness. Modifying the default behavior in most cases can actually decrease effectiveness. *Do not alter the MySQL sources unless you know what you are doing*.

Most full-text variables described in this section must be set at server startup time. A server restart is required to change them; they cannot be modified while the server is running.

Some variable changes require that you rebuild the `FULLTEXT` indexes in your tables. Instructions for doing so are given later in this section.

- The minimum and maximum lengths of words to be indexed are defined by the `ft_min_word_len` and `ft_max_word_len` system variables. (See Section 5.1.3, "Server System Variables".) The default minimum value is four characters; the default maximum is version dependent. If you change either value, you must rebuild your `FULLTEXT` indexes. For example, if you want three-character words to be searchable, you can set the `ft_min_word_len` variable by putting the following lines in an option file:

  ```
  [mysqld]
  ft_min_word_len=3
  ```

  Then restart the server and rebuild your `FULLTEXT` indexes. Note particularly the remarks regarding `myisamchk` in the instructions following this list.
- To override the default stopword list, set the `ft_stopword_file` system variable. (See Section 5.1.3, "Server System Variables".) The variable value should be the path name of the file containing the stopword list, or the empty string to disable stopword filtering. The server looks for the file in the data directory unless an absolute path name is given to specify a different directory. After changing the value of this variable or the contents of the stopword file, restart the server and rebuild your `FULLTEXT` indexes.

  The stopword list is free-form. That is, you may use any nonalphanumeric character such as newline, space, or comma to separate stopwords. Exceptions are the underscore character ("`_`") and a single apostrophe ("`'`") which are treated as part of a word. The character set of the stopword list is the server's default character set; see Section 9.1.3.1, "Server Character Set and Collation".

- The 50% threshold for natural language searches is determined by the particular weighting scheme chosen. To disable it, look for the following line in `storage/myisam/ftdefs.h`:

  ```
  #define GWS_IN_USE GWS_PROB
  ```

  Change that line to this:

  ```
  #define GWS_IN_USE GWS_FREQ
  ```

  Then recompile MySQL. There is no need to rebuild the indexes in this case.

  > **Note**
  >
  > By making this change, you *severely* decrease MySQL's ability to provide adequate relevance values for the `MATCH()` function. If you really need to search for such common words, it would be better to search using `IN BOOLEAN MODE` instead, which does not observe the 50% threshold.

- To change the operators used for boolean full-text searches, set the `ft_boolean_syntax` system variable. This variable can be changed while the server is running, but you must have the `SUPER` privilege to do so. No rebuilding of indexes is necessary in this case. See Section 5.1.3, "Server System Variables", which describes the rules governing how to set this variable.

- If you want to change the set of characters that are considered word characters, you can do so in several ways, as described in the following list. After making the modification, you must rebuild the indexes for each table that contains any `FULLTEXT` indexes. Suppose that you want to treat the hyphen character ('-') as a word character. Use one of these methods:

  - Modify the MySQL source: In `storage/myisam/ftdefs.h`, see the `true_word_char()` and `misc_word_char()` macros. Add `'-'` to one of those macros and recompile MySQL.

  - Modify a character set file: This requires no recompilation. The `true_word_char()` macro uses a "character type" table to distinguish letters and numbers from other characters. . You can edit the contents of the `<ctype><map>` array in one of the character set XML files to specify that `'-'` is a "letter." Then use the given character set for your `FULLTEXT` indexes. For information about the `<ctype><map>` array format, see Section 9.3.1, "Character Definition Arrays".

  - Add a new collation for the character set used by the indexed columns, and alter the columns to use that collation. For general information about adding collations, see Section 9.4, "Adding a Collation to a Character Set". For an example specific to full-text indexing, see Section 11.9.7, "Adding a Collation for Full-Text Indexing".

If you modify full-text variables that affect indexing (`ft_min_word_len`, `ft_max_word_len`, or `ft_stopword_file`), or if you change the stopword file itself, you must rebuild your `FULLTEXT` indexes after making the changes and restarting the server. To rebuild the indexes in this case, it is sufficient to do a `QUICK` repair operation:

```
mysql> REPAIR TABLE tbl_name QUICK;
```

Alternatively, use `ALTER TABLE` with the `DROP INDEX` and `ADD INDEX` options to drop and re-create each `FULLTEXT` index. In some cases, this may be faster than a repair operation.

Each table that contains any `FULLTEXT` index must be repaired as just shown. Otherwise, queries for the table may yield incorrect results, and modifications to the table will cause the server to see the table as corrupt and in need of repair.

Note that if you use `myisamchk` to perform an operation that modifies table indexes (such as repair or analyze), the `FULLTEXT` indexes are rebuilt using the *default* full-text parameter values for minimum word length, maximum word length, and stopword file unless you specify otherwise. This can result in queries failing.

The problem occurs because these parameters are known only by the server. They are not stored in `MyISAM` index files. To avoid the problem if you have modified the minimum or maximum word length or stopword file values used by the server, specify the same `ft_min_word_len`, `ft_max_word_len`, and `ft_stopword_file` values for `myisamchk` that you use for `mysqld`. For example, if you have set the minimum word length to 3, you can repair a table with `myisamchk` like this:

```
shell> myisamchk --recover --ft_min_word_len=3 tbl_name.MYI
```

To ensure that `myisamchk` and the server use the same values for full-text parameters, place each one in both the `[mysqld]` and `[myisamchk]` sections of an option file:

```
[mysqld]
ft_min_word_len=3

[myisamchk]
ft_min_word_len=3
```

An alternative to using `myisamchk` for index modification is to use the `REPAIR TABLE`, `ANALYZE TABLE`, `OPTIMIZE TABLE`, or `ALTER TABLE` statements. These statements are performed by the server, which knows the proper full-text parameter values to use.

11.9.7. Adding a Collation for Full-Text Indexing

This section describes how to add a new collation for full-text searches. The sample collation is like `latin1_swedish_ci` but treats the `'-'` character as a letter rather than as a punctuation character so that it can be indexed as a word character. General information about adding collations is given in Section 9.4, "Adding a Collation to a Character Set"; it is assumed that you have read it and are familiar with the files involved.

To add a collation for full-text indexing, use this procedure:

1. Add a collation to the `Index.xml` file. The collation ID must be unused, so choose a value different from 62 if that ID is already taken on your system.

```
<charset name="latin1">
...
<collation name="latin1_fulltext_ci" id="62"/>
</charset>
```

2. Declare the sort order for the collation in the `latin1.xml` file. In this case, the order can be copied from `latin1_swedish_ci`:

```
<collation name="latin1_fulltext_ci">
<map>
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
41 41 41 41 5C 5B 5C 43 45 45 45 45 49 49 49 49
44 4E 4F 4F 4F 4F 5D D7 D8 55 55 55 59 59 DE DF
41 41 41 41 5C 5B 5C 43 45 45 45 45 49 49 49 49
44 4E 4F 4F 4F 4F 5D F7 D8 55 55 55 59 59 DE FF
</map>
</collation>
```

3. Modify the `ctype` array in `latin1.xml`. Change the value corresponding to 0x2D (which is the code for the `'-'` character) from 10 (punctuation) to 01 (small letter). In the following array, this is the element in the fourth row down, third value from the end.

```
<ctype>
<map>
00
20 20 20 20 20 20 20 20 20 28 28 28 28 28 20 20
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
48 10 10 10 10 10 10 10 10 10 10 10 10 01 10 10
84 84 84 84 84 84 84 84 84 84 10 10 10 10 10 10
10 81 81 81 81 81 81 01 01 01 01 01 01 01 01 01
01 01 01 01 01 01 01 01 01 01 01 10 10 10 10 10
10 82 82 82 82 82 82 02 02 02 02 02 02 02 02 02
02 02 02 02 02 02 02 02 02 02 02 10 10 10 10 20
10 00 10 02 10 10 10 10 10 10 01 10 01 00 01 00
00 10 10 10 10 10 10 10 10 10 02 10 02 00 02 01
48 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01
01 01 01 01 01 01 01 10 01 01 01 01 01 01 01 02
02 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02
02 02 02 02 02 02 02 10 02 02 02 02 02 02 02 02
</map>
</ctype>
```

4. Restart the server.

5. To employ the new collation, include it in the definition of columns that are to use it:

```
mysql> DROP TABLE IF EXISTS t1;
Query OK, 0 rows affected (0.13 sec)

mysql> CREATE TABLE t1 (
    -> a TEXT CHARACTER SET latin1 COLLATE latin1_fulltext_ci,
    -> FULLTEXT INDEX(a)
    -> ) ENGINE=MyISAM;
Query OK, 0 rows affected (0.47 sec)
```

6. Test the collation to verify that hyphen is considered as a word character:

```
mysql> INSERT INTO t1 VALUEs ('----'),('....'),('abcd');
Query OK, 3 rows affected (0.22 sec)
Records: 3  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM t1 WHERE MATCH a AGAINST ('----' IN BOOLEAN MODE);
+------+
| a    |
+------+
| ---- |
+------+
1 row in set (0.00 sec)
```

11.10. Cast Functions and Operators

Table 11.14. Cast Functions

Name	Description
`BINARY`	Cast a string to a binary string
`CAST()`	Cast a value as a certain type
`Convert()`	Cast a value as a certain type

- `BINARY`

  The `BINARY` operator casts the string following it to a binary string. This is an easy way to force a column comparison to be done byte by byte rather than character by character. This causes the comparison to be case sensitive even if the column is not defined as `BINARY` or `BLOB`. `BINARY` also causes trailing spaces to be significant.

  ```
  mysql> SELECT 'a' = 'A';
          -> 1
  mysql> SELECT BINARY 'a' = 'A';
          -> 0
  mysql> SELECT 'a' = 'a ';
          -> 1
  mysql> SELECT BINARY 'a' = 'a ';
          -> 0
  ```

  In a comparison, `BINARY` affects the entire operation; it can be given before either operand with the same result.

  `BINARY` *`str`* is shorthand for `CAST(`*`str`*` AS BINARY)`.

  Note that in some contexts, if you cast an indexed column to `BINARY`, MySQL is not able to use the index efficiently.

- `CAST(`*`expr`*` AS `*`type`*`)`

  The `CAST()` function takes a value of one type and produce a value of another type, similar to `CONVERT()`. See the description of `CONVERT()` for more information.

- `CONVERT(`*`expr`*`,`*`type`*`)`, `CONVERT(`*`expr`*` USING `*`transcoding_name`*`)`

  The `CONVERT()` and `CAST()` functions take a value of one type and produce a value of another type.

  The *`type`* can be one of the following values:

  - `BINARY[(`*`N`*`)]`
  - `CHAR[(`*`N`*`)]`
  - `DATE`
  - `DATETIME`
  - `DECIMAL[(`*`M`*`[,`*`D`*`])]`
  - `SIGNED [INTEGER]`

- `TIME`
- `UNSIGNED [INTEGER]`

`BINARY` produces a string with the `BINARY` data type. See Section 10.4.2, “The `BINARY` and `VARBINARY` Types” for a description of how this affects comparisons. If the optional length *`N`* is given, `BINARY(N)` causes the cast to use no more than *`N`* bytes of the argument. Values shorter than *`N`* bytes are padded with `0x00` bytes to a length of *`N`*.

`CHAR(N)` causes the cast to use no more than *`N`* characters of the argument.

`CAST()` and `CONVERT(... USING ...)` are standard SQL syntax. The non-`USING` form of `CONVERT()` is ODBC syntax.

`CONVERT()` with `USING` is used to convert data between different character sets. In MySQL, transcoding names are the same as the corresponding character set names. For example, this statement converts the string `'abc'` in the default character set to the corresponding string in the `utf8` character set:

```
SELECT CONVERT('abc' USING utf8);
```

Normally, you cannot compare a `BLOB` value or other binary string in case-insensitive fashion because binary strings have no character set, and thus no concept of lettercase. To perform a case-insensitive comparison, use the `CONVERT()` function to convert the value to a nonbinary string. Comparisons of the result use the string collation. For example, if the character set of the result has a case-insensitive collation, a `LIKE` operation is not case sensitive:

```
SELECT 'A' LIKE CONVERT(blob_col USING latin1) FROM tbl_name;
```

To use a different character set, substitute its name for `latin1` in the preceding statement. To specify a particular collation for the converted string, use a `COLLATE` clause following the `CONVERT()` call, as described in Section 9.1.9.2, “`CONVERT()` and `CAST()`”. For example, to use `latin1_german1_ci`:

```
SELECT 'A' LIKE CONVERT(blob_col USING latin1) COLLATE latin1_german1_ci
  FROM tbl_name;
```

`CONVERT()` can be used more generally for comparing strings that are represented in different character sets.

`LOWER()` (and `UPPER()`) are ineffective when applied to binary strings (`BINARY`, `VARBINARY`, `BLOB`). To perform lettercase conversion, convert the string to a nonbinary string:

```
mysql> SET @str = BINARY 'New York';
mysql> SELECT LOWER(@str), LOWER(CONVERT(@str USING latin1));
+-------------+-----------------------------------+
| LOWER(@str) | LOWER(CONVERT(@str USING latin1)) |
+-------------+-----------------------------------+
| New York    | new york                          |
+-------------+-----------------------------------+
```

The cast functions are useful when you want to create a column with a specific type in a `CREATE TABLE ... SELECT` statement:

```
CREATE TABLE new_table SELECT CAST('2000-01-01' AS DATE);
```

The functions also can be useful for sorting `ENUM` columns in lexical order. Normally, sorting of `ENUM` columns occurs using the internal numeric values. Casting the values to `CHAR` results in a lexical sort:

```
SELECT enum_col FROM tbl_name ORDER BY CAST(enum_col AS CHAR);
```

`CAST(str AS BINARY)` is the same thing as `BINARY str`. `CAST(expr AS CHAR)` treats the expression as a string with the default character set.

`CAST()` also changes the result if you use it as part of a more complex expression such as `CONCAT('Date: ',CAST(NOW() AS DATE))`.

You should not use `CAST()` to extract data in different formats but instead use string functions like `LEFT()` or `EXTRACT()`. See Section 11.7, “Date and Time Functions”.

To cast a string to a numeric value in numeric context, you normally do not have to do anything other than to use the string value as though it were a number:

```
mysql> SELECT 1+'1';
```

```
        -> 2
```

If you use a string in an arithmetic operation, it is converted to a floating-point number during expression evaluation.

If you use a number in string context, the number automatically is converted to a string:

```
mysql> SELECT CONCAT('hello you ',2);
        -> 'hello you 2'
```

For information about implicit conversion of numbers to strings, see Section 11.2, “Type Conversion in Expression Evaluation”.

MySQL supports arithmetic with both signed and unsigned 64-bit values. If you are using numeric operators (such as `+` or `-`) and one of the operands is an unsigned integer, the result is unsigned by default (see Section 11.6.1, “Arithmetic Operators”). You can override this by using the `SIGNED` or `UNSIGNED` cast operator to cast a value to a signed or unsigned 64-bit integer, respectively.

```
mysql> SELECT CAST(1-2 AS UNSIGNED)
        -> 18446744073709551615
mysql> SELECT CAST(CAST(1-2 AS UNSIGNED) AS SIGNED);
        -> -1
```

If either operand is a floating-point value, the result is a floating-point value and is not affected by the preceding rule. (In this context, `DECIMAL` column values are regarded as floating-point values.)

```
mysql> SELECT CAST(1 AS UNSIGNED) - 2.0;
        -> -1.0
```

The SQL mode affects the result of conversion operations. Examples:

- If you convert a “zero” date string to a date, `CONVERT()` and `CAST()` return `NULL` and produce a warning when the `NO_ZERO_DATE` SQL mode is enabled.
- For integer subtraction, if the `NO_UNSIGNED_SUBTRACTION` SQL mode is enabled, the subtraction result is signed even if any operand is unsigned.

For more information, see Section 5.1.6, “Server SQL Modes”.

11.11. XML Functions

Table 11.15. XML Functions

Name	Description
`ExtractValue()`	Extracts a value from an XML string using XPath notation
`UpdateXML()`	Return replaced XML fragment

This section discusses XML and related functionality in MySQL.

> **Note**
>
> It is possible to obtain XML-formatted output from MySQL in the `mysql` and `mysqldump` clients by invoking them with the `--xml` option. See Section 4.5.1, “`mysql` — The MySQL Command-Line Tool”, and Section 4.5.4, “`mysqldump` — A Database Backup Program”.

Two functions providing basic XPath 1.0 (XML Path Language, version 1.0) capabilities are available. Some basic information about XPath syntax and usage is provided later in this section; however, an in-depth discussion of these topics is beyond the scope of this Manual, and you should refer to the XML Path Language (XPath) 1.0 standard for definitive information. A useful resource for those new to XPath or who desire a refresher in the basics is the Zvon.org XPath Tutorial, which is available in several languages.

> **Note**
>
> These functions remain under development. We continue to improve these and other aspects of XML and XPath functionality in MySQL 5.5 and onwards. You may discuss these, ask questions about them, and obtain help from other users with them in the MySQL XML User Forum.

XPath expressions used with these functions support user variables and local stored program variables. User variables are weakly checked; variables local to stored programs are strongly checked (see also Bug #26518):

- **User variables (weak checking).** Variables using the syntax `$@variable_name` (that is, user variables) are not checked. No warnings or errors are issued by the server if a variable has the wrong type or has previously not been assigned a value. This also means the user is fully responsible for any typographical errors, since no warnings will be given if (for example) `$@myvairable` is used where `$@myvariable` was intended.

  Example:

```
mysql> SET @xml = '<a><b>X</b><b>Y</b></a>';
Query OK, 0 rows affected (0.00 sec)

mysql> SET @i =1, @j = 2;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @i, ExtractValue(@xml, '//b[$@i]');
+------+--------------------------------+
| @i   | ExtractValue(@xml, '//b[$@i]') |
+------+--------------------------------+
|    1 | X                              |
+------+--------------------------------+
1 row in set (0.00 sec)

mysql> SELECT @j, ExtractValue(@xml, '//b[$@j]');
+------+--------------------------------+
| @j   | ExtractValue(@xml, '//b[$@j]') |
+------+--------------------------------+
|    2 | Y                              |
+------+--------------------------------+
1 row in set (0.00 sec)

mysql> SELECT @k, ExtractValue(@xml, '//b[$@k]');
+------+--------------------------------+
| @k   | ExtractValue(@xml, '//b[$@k]') |
+------+--------------------------------+
| NULL |                                |
+------+--------------------------------+
1 row in set (0.00 sec)
```

- **Variables in stored programs (strong checking).** Variables using the syntax `$variable_name` can be declared and used with these functions when they are called inside stored programs. Such variables are local to the stored program in which they are defined, and are strongly checked for type and value.

  Example:

```
mysql> DELIMITER |

mysql> CREATE PROCEDURE myproc ()
    -> BEGIN
    ->   DECLARE i INT DEFAULT 1;
    ->   DECLARE xml VARCHAR(25) DEFAULT '<a>X</a><a>Y</a><a>Z</a>';
    ->
    ->   WHILE i < 4 DO
    ->     SELECT xml, i, ExtractValue(xml, '//a[$i]');
    ->     SET i = i+1;
    ->   END WHILE;
    -> END |
Query OK, 0 rows affected (0.01 sec)

mysql> DELIMITER ;

mysql> CALL myproc;
+--------------------------+---+------------------------------+
| xml                      | i | ExtractValue(xml, '//a[$i]') |
+--------------------------+---+------------------------------+
| <a>X</a><a>Y</a><a>Z</a> | 1 | X                            |
+--------------------------+---+------------------------------+
1 row in set (0.00 sec)

+--------------------------+---+------------------------------+
| xml                      | i | ExtractValue(xml, '//a[$i]') |
+--------------------------+---+------------------------------+
| <a>X</a><a>Y</a><a>Z</a> | 2 | Y                            |
+--------------------------+---+------------------------------+
1 row in set (0.01 sec)

+--------------------------+---+------------------------------+
| xml                      | i | ExtractValue(xml, '//a[$i]') |
+--------------------------+---+------------------------------+
| <a>X</a><a>Y</a><a>Z</a> | 3 | Z                            |
+--------------------------+---+------------------------------+
1 row in set (0.01 sec)
```

  Parameters. Variables used in XPath expressions inside stored routines that are passed in as parameters are also subject to strong checking.

Expressions containing user variables or variables local to stored programs must otherwise (except for notation) conform to the rules for XPath expressions containing variables as given in the XPath 1.0 specification.

Note

Currently, a user variable used to store an XPath expression is treated as an empty string. Because of this, it is not possible to store an XPath expression as a user variable. (Bug #32911)

- `ExtractValue(xml_frag, xpath_expr)`

  `ExtractValue()` takes two string arguments, a fragment of XML markup *`xml_frag`* and an XPath expression *`xpath_expr`* (also known as a *locator*); it returns the text (`CDATA`) of the first text node which is a child of the element(s) matched by the XPath expression. It is the equivalent of performing a match using the *`xpath_expr`* after appending `/text()`. In other words, `ExtractValue('<a><b>Sakila</b></a>', '/a/b')` and `ExtractValue('<a><b>Sakila</b></a>', '/a/b/text()')` produce the same result.

  If multiple matches are found, the content of the first child text node of each matching element is returned (in the order matched) as a single, space-delimited string.

  If no matching text node is found for the expression (including the implicit `/text()`)—for whatever reason, as long as *`xpath_expr`* is valid, and *`xml_frag`* consists of elements which are properly nested and closed—an empty string is returned. No distinction is made between a match on an empty element and no match at all. This is by design.

  If you need to determine whether no matching element was found in *`xml_frag`* or such an element was found but contained no child text nodes, you should test the result of an expression that uses the XPath `count()` function. For example, both of these statements return an empty string, as shown here:

```
mysql> SELECT ExtractValue('<a><b/></a>', '/a/b');
+-------------------------------------+
| ExtractValue('<a><b/></a>', '/a/b') |
+-------------------------------------+
|                                     |
+-------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT ExtractValue('<a><c/></a>', '/a/b');
+-------------------------------------+
| ExtractValue('<a><c/></a>', '/a/b') |
+-------------------------------------+
|                                     |
+-------------------------------------+
1 row in set (0.00 sec)
```

  However, you can determine whether there was actually a matching element using the following:

```
mysql> SELECT ExtractValue('<a><b/></a>', 'count(/a/b)');
+-------------------------------------+
| ExtractValue('<a><b/></a>', 'count(/a/b)') |
+-------------------------------------+
| 1                                   |
+-------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT ExtractValue('<a><c/></a>', 'count(/a/b)');
+-------------------------------------+
| ExtractValue('<a><c/></a>', 'count(/a/b)') |
+-------------------------------------+
| 0                                   |
+-------------------------------------+
1 row in set (0.01 sec)
```

Important

`ExtractValue()` returns only `CDATA`, and does not return any tags that might be contained within a matching tag, nor any of their content (see the result returned as `val1` in the following example).

```
mysql> SELECT
    ->   ExtractValue('<a>ccc<b>ddd</b></a>', '/a') AS val1,
    ->   ExtractValue('<a>ccc<b>ddd</b></a>', '/a/b') AS val2,
    ->   ExtractValue('<a>ccc<b>ddd</b></a>', '//b') AS val3,
    ->   ExtractValue('<a>ccc<b>ddd</b></a>', '/b') AS val4,
    ->   ExtractValue('<a>ccc<b>ddd</b><b>eee</b></a>', '//b') AS val5;

+------+------+------+------+---------+
| val1 | val2 | val3 | val4 | val5    |
+------+------+------+------+---------+
| ccc  | ddd  | ddd  |      | ddd eee |
+------+------+------+------+---------+
```

  This function uses the current SQL collation for making comparisons with `contains()`, performing the same collation aggregation as other string functions (such as `CONCAT()`), in taking into account the collation coercibility of their arguments; see Section 9.1.7.5, “Collation of Expressions”, for an explanation of the rules governing this behavior.

(Previously, binary—that is, case-sensitive—comparison was always used.)

`NULL` is returned if *`xml_frag`* contains elements which are not properly nested or closed, and a warning is generated, as shown in this example:

```
mysql> SELECT ExtractValue('<a>c</a><b', '//a');
+-----------------------------------+
| ExtractValue('<a>c</a><b', '//a') |
+-----------------------------------+
| NULL                              |
+-----------------------------------+
1 row in set, 1 warning (0.00 sec)

mysql> SHOW WARNINGS;
+---------+------+-------------------------------------------------------------------------------------------+
| Level   | Code | Message                                                                                   |
+---------+------+-------------------------------------------------------------------------------------------+
| Warning | 1523 | Incorrect XML value: 'parse error at line 1 pos 11: END-OF-INPUT unexpected ('>' wanted)' |
+---------+------+-------------------------------------------------------------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT ExtractValue('<a>c</a><b/>', '//a');
+-------------------------------------+
| ExtractValue('<a>c</a><b/>', '//a') |
+-------------------------------------+
| c                                   |
+-------------------------------------+
1 row in set (0.00 sec)
```

- `UpdateXML(`*`xml_target`*`, `*`xpath_expr`*`, `*`new_xml`*`)`

  This function replaces a single portion of a given fragment of XML markup *`xml_target`* with a new XML fragment *`new_xml`*, and then returns the changed XML. The portion of *`xml_target`* that is replaced matches an XPath expression *`xpath_expr`* supplied by the user. If no expression matching *`xpath_expr`* is found, or if multiple matches are found, the function returns the original *`xml_target`* XML fragment. All three arguments should be strings.

  ```
  mysql> SELECT
      ->   UpdateXML('<a><b>ccc</b><d></d></a>', '/a', '<e>fff</e>') AS val1,
      ->   UpdateXML('<a><b>ccc</b><d></d></a>', '/b', '<e>fff</e>') AS val2,
      ->   UpdateXML('<a><b>ccc</b><d></d></a>', '//b', '<e>fff</e>') AS val3,
      ->   UpdateXML('<a><b>ccc</b><d></d></a>', '/a/d', '<e>fff</e>') AS val4,
      ->   UpdateXML('<a><d></d><b>ccc</b><d></d></a>', '/a/d', '<e>fff</e>') AS val5
      -> \G

  *************************** 1. row ***************************
  val1: <e>fff</e>
  val2: <a><b>ccc</b><d></d></a>
  val3: <a><e>fff</e><d></d></a>
  val4: <a><b>ccc</b><e>fff</e></a>
  val5: <a><d></d><b>ccc</b><d></d></a>
  ```

Note

A discussion in depth of XPath syntax and usage are beyond the scope of this Manual. Please see the XML Path Language (XPath) 1.0 specification for definitive information. A useful resource for those new to XPath or who are wishing a refresher in the basics is the Zvon.org XPath Tutorial, which is available in several languages.

Descriptions and examples of some basic XPath expressions follow:

- *`/tag`*

  Matches *`<tag/>`* if and only if *`<tag/>`* is the root element.

  Example: `/a` has a match in `<a><b/></a>` because it matches the outermost (root) tag. It does not match the inner *`a`* element in `<b><a/></b>` because in this instance it is the child of another element.

- *`/tag1/tag2`*

  Matches *`<tag2/>`* if and only if it is a child of *`<tag1/>`*, and *`<tag1/>`* is the root element.

  Example: `/a/b` matches the *`b`* element in the XML fragment `<a><b/></a>` because it is a child of the root element *`a`*. It does not have a match in `<b><a/></b>` because in this case, *`b`* is the root element (and hence the child of no other element). Nor does the XPath expression have a match in `<a><c><b/></c></a>`; here, *`b`* is a descendant of *`a`*, but not actually a child of *`a`*.

  This construct is extendable to three or more elements. For example, the XPath expression `/a/b/c` matches the *`c`* element in the fragment `<a><b><c/></b></a>`.

- *`//tag`*

  Matches any instance of `<tag>`.

  Example: `//a` matches the *`a`* element in any of the following: `<a><b><c/></b></a>`; `<c><a><b/></a></b>`; `<c><b><a/></b></c>`.

  `//` can be combined with `/`. For example, `//a/b` matches the *`b`* element in either of the fragments `<a><b/></a>` or `<a><b><c/></b></a>`

  > **Note**
  >
  > *`//tag`* is the equivalent of `/descendant-or-self::*/tag`. A common error is to confuse this with `/descendant-or-self::tag`, although the latter expression can actually lead to very different results, as can be seen here:

```
mysql> SET @xml = '<a><b><c>w</c><b>x</b><d>y</d>z</b></a>';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @xml;
+-----------------------------------------+
| @xml                                    |
+-----------------------------------------+
| <a><b><c>w</c><b>x</b><d>y</d>z</b></a> |
+-----------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT ExtractValue(@xml, '//b[1]');
+------------------------------+
| ExtractValue(@xml, '//b[1]') |
+------------------------------+
| x z                          |
+------------------------------+
1 row in set (0.00 sec)

mysql> SELECT ExtractValue(@xml, '//b[2]');
+------------------------------+
| ExtractValue(@xml, '//b[2]') |
+------------------------------+
|                              |
+------------------------------+
1 row in set (0.01 sec)

mysql> SELECT ExtractValue(@xml, '/descendant-or-self::*/b[1]');
+---------------------------------------------------+
| ExtractValue(@xml, '/descendant-or-self::*/b[1]') |
+---------------------------------------------------+
| x z                                               |
+---------------------------------------------------+
1 row in set (0.06 sec)

mysql> SELECT ExtractValue(@xml, '/descendant-or-self::*/b[2]');
+---------------------------------------------------+
| ExtractValue(@xml, '/descendant-or-self::*/b[2]') |
+---------------------------------------------------+
|                                                   |
+---------------------------------------------------+
1 row in set (0.00 sec)


mysql> SELECT ExtractValue(@xml, '/descendant-or-self::b[1]');
+-------------------------------------------------+
| ExtractValue(@xml, '/descendant-or-self::b[1]') |
+-------------------------------------------------+
| z                                               |
+-------------------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT ExtractValue(@xml, '/descendant-or-self::b[2]');
+-------------------------------------------------+
| ExtractValue(@xml, '/descendant-or-self::b[2]') |
+-------------------------------------------------+
| x                                               |
+-------------------------------------------------+
1 row in set (0.00 sec)
```

- The `*` operator acts as a "wildcard" that matches any element. For example, the expression `/*/b` matches the *`b`* element in either of the XML fragments `<a><b/></a>` or `<c><b/></c>`. However, the expression does not produce a match in the fragment `<b><a/></b>` because *`b`* must be a child of some other element. The wildcard may be used in any position: The expression `/*/b/*` will match any child of a *`b`* element that is itself not the root element.

- You can match any of several locators using the `|` (`UNION`) operator. For example, the expression `//b|//c` matches all *`b`* and *`c`* elements in the XML target.

- It is also possible to match an element based on the value of one or more of its attributes. This done using the syntax `tag[@attribute="value"]`. For example, the expression `//b[@id="idB"]` matches the second `b` element in the fragment `<a><b id="idA"/><c/><b id="idB"/></a>`. To match against *any* element having `attribute="value"`, use the XPath expression `//*[attribute="value"]`.

  To filter multiple attribute values, simply use multiple attribute-comparison clauses in succession. For example, the expression `//b[@c="x"][@d="y"]` matches the element `<b c="x" d="y"/>` occurring anywhere in a given XML fragment.

  To find elements for which the same attribute matches any of several values, you can use multiple locators joined by the `|` operator. For example, to match all `b` elements whose `c` attributes have either of the values 23 or 17, use the expression `/b[@c="23"]|//b[@c="17"]`. You can also use the logical `or` operator for this purpose: `//b[@c="23" or @c="17"]`.

  > **Note**
  >
  > The difference between `or` and `|` is that `or` joins conditions, while `|` joins result sets.

XPath Limitations. The XPath syntax supported by these functions is currently subject to the following limitations:

- Nodeset-to-nodeset comparison (such as `'/a/b[@c=@d]'`) is not supported.
- All of the standard XPath comparison operators are supported. (Bug #22823)
- Relative locator expressions are resolved in the context of the root node. For example, consider the following query and result:

```
mysql> SELECT ExtractValue(
    ->   '<a><b c="1">X</b><b c="2">Y</b></a>',
    ->    'a/b'
    -> ) AS result;
+--------+
| result |
+--------+
| X Y    |
+--------+
1 row in set (0.03 sec)
```

  In this case, the locator `a/b` resolves to `/a/b`.

  Relative locators are also supported within predicates. In the following example, `d[../@c="1"]` is resolved as `/a/b[@c="1"]/d`:

```
mysql> SELECT ExtractValue(
    ->      '<a>
    ->        <b c="1"><d>X</d></b>
    ->        <b c="2"><d>X</d></b>
    ->      </a>',
    ->      'a/b/d[../@c="1"]')
    -> AS result;
+--------+
| result |
+--------+
| X      |
+--------+
1 row in set (0.00 sec)
```

- Locators prefixed with expressions that evaluate as scalar values—including variable references, literals, numbers, and scalar function calls—are not permitted, and their use results in an error.
- The `::` operator is not supported in combination with node types such as the following:
  - `axis::comment()`
  - `axis::text()`
  - `axis::processing-instructions()`
  - `axis::node()`

  However, name tests (such as `axis::name` and `axis::*`) are supported, as shown in these examples:

```
mysql> SELECT ExtractValue('<a><b>x</b><c>y</c></a>','/a/child::b');
+-------------------------------------------------------+
| ExtractValue('<a><b>x</b><c>y</c></a>','/a/child::b') |
+-------------------------------------------------------+
| x                                                     |
+-------------------------------------------------------+
1 row in set (0.02 sec)

mysql> SELECT ExtractValue('<a><b>x</b><c>y</c></a>','/a/child::*');
+---------------------------------------------------------+
| ExtractValue('<a><b>x</b><c>y</c></a>','/a/child::*') |
+---------------------------------------------------------+
| x y                                                     |
+---------------------------------------------------------+
1 row in set (0.01 sec)
```

- “Up-and-down” navigation is not supported in cases where the path would lead “above” the root element. That is, you cannot use expressions which match on descendants of ancestors of a given element, where one or more of the ancestors of the current element is also an ancestor of the root element (see Bug #16321).
- The following XPath functions are not supported, or have known issues as indicated:
  - `id()`
  - `lang()`
  - `local-name()`
  - `name()`
  - `namespace-uri()`
  - `normalize-space()`
  - `starts-with()`
  - `string()`
  - `substring-after()`
  - `substring-before()`
  - `translate()`
- The following axes are not supported:
  - `following-sibling`
  - `following`
  - `preceding-sibling`
  - `preceding`

XPath expressions passed as arguments to `ExtractValue()` and `UpdateXML()` may contain the colon character (“`:`”) in element selectors, which enables their use with markup employing XML namespaces notation. For example:

```
mysql> SET @xml = '<a>111<b:c>222<d>333</d><e:f>444</e:f></b:c></a>';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT ExtractValue(@xml, '//e:f');
+-----------------------------+
| ExtractValue(@xml, '//e:f') |
+-----------------------------+
| 444                         |
+-----------------------------+
1 row in set (0.00 sec)

mysql> SELECT UpdateXML(@xml, '//b:c', '<g:h>555</g:h>');
+---------------------------------------------+
| UpdateXML(@xml, '//b:c', '<g:h>555</g:h>') |
+---------------------------------------------+
| <a>111<g:h>555</g:h></a>                    |
+---------------------------------------------+
1 row in set (0.00 sec)
```

This is similar in some respects to what is permitted by Apache Xalan and some other parsers, and is much simpler than requiring namespace declarations or the use of the `namespace-uri()` and `local-name()` functions.

Error handling. For both `ExtractValue()` and `UpdateXML()`, the XPath locator used must be valid and the XML to be searched must consist of elements which are properly nested and closed. If the locator is invalid, an error is generated:

```
mysql> SELECT ExtractValue('<a>c</a><b/>', '/&a');
```

```
ERROR 1105 (HY000): XPATH syntax error: '&a'
```

If `xml_frag` does not consist of elements which are properly nested and closed, `NULL` is returned and a warning is generated, as shown in this example:

```
mysql> SELECT ExtractValue('<a>c</a><b', '//a');
+-----------------------------------+
| ExtractValue('<a>c</a><b', '//a') |
+-----------------------------------+
| NULL                              |
+-----------------------------------+
1 row in set, 1 warning (0.00 sec)

mysql> SHOW WARNINGS;
+---------+------+-------------------------------------------------------------------------------------------+
| Level   | Code | Message                                                                                   |
+---------+------+-------------------------------------------------------------------------------------------+
| Warning | 1523 | Incorrect XML value: 'parse error at line 1 pos 11: END-OF-INPUT unexpected ('>' wanted)' |
+---------+------+-------------------------------------------------------------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT ExtractValue('<a>c</a><b/>', '//a');
+-------------------------------------+
| ExtractValue('<a>c</a><b/>', '//a') |
+-------------------------------------+
| c                                   |
+-------------------------------------+
1 row in set (0.00 sec)
```

Important

The replacement XML used as the third argument to `UpdateXML()` is *not* checked to determine whether it consists solely of elements which are properly nested and closed.

XPath Injection. *code injection* occurs when malicious code is introduced into the system to gain unauthorized access to privileges and data. It is based on exploiting assumptions made by developers about the type and content of data input from users. XPath is no exception in this regard.

A common scenario in which this can happen is the case of application which handles authorization by matching the combination of a login name and password with those found in an XML file, using an XPath expression like this one:

```
//user[login/text()='neapolitan' and password/text()='1c3cr34m']/attribute::id
```

This is the XPath equivalent of an SQL statement like this one:

```
SELECT id FROM users WHERE login='neapolitan' AND password='1c3cr34m';
```

A PHP application employing XPath might handle the login process like this:

```
<?php

  $file     =   "users.xml";

  $login    =   $POST["login"];
  $password =   $POST["password"];

  $xpath = "//user[login/text()=$login and password/text()=$password]/attribute::id";

  if( file_exists($file) )
  {
    $xml = simplexml_load_file($file);

    if($result = $xml->xpath($xpath))
      echo "You are now logged in as user $result[0].";
    else
      echo "Invalid login name or password.";
  }
  else
    exit("Failed to open $file.");

?>
```

No checks are performed on the input. This means that a malevolent user can “short-circuit” the test by entering `' or 1=1` for both the login name and password, resulting in `$xpath` being evaluated as shown here:

```
//user[login/text()='' or 1=1 and password/text()='' or 1=1]/attribute::id
```

Since the expression inside the square brackets always evaluates as `true`, it is effectively the same as this one, which matches the `id` attribute of every `user` element in the XML document:

```
//user/attribute::id
```

One way in which this particular attack can be circumvented is simply by quoting the variable names to be interpolated in the definition of `$xpath`, forcing the values passed from a Web form to be converted to strings:

```
$xpath = "//user[login/text()='$login' and password/text()='$password']/attribute::id";
```

This is the same strategy that is often recommended for preventing SQL injection attacks. In general, the practices you should follow for preventing XPath injection attacks are the same as for preventing SQL injection:

- Never accepted untested data from users in your application.
- Check all user-submitted data for type; reject or convert data that is of the wrong type
- Test numeric data for out of range values; truncate, round, or reject values that are out of range. Test strings for illegal characters and either strip them out or reject input containing them.
- Do not output explicit error messages that might provide an unauthorized user with clues that could be used to compromise the system; log these to a file or database table instead.

Just as SQL injection attacks can be used to obtain information about database schemas, so can XPath injection be used to traverse XML files to uncover their structure, as discussed in Amit Klein's paper Blind XPath Injection (PDF file, 46KB).

It is also important to check the output being sent back to the client. Consider what can happen when we use the MySQL `ExtractValue()` function:

```
mysql> SELECT ExtractValue(
    ->     LOAD_FILE('users.xml'),
    ->     '//user[login/text()="" or 1=1 and password/text()="" or 1=1]/attribute::id'
    -> ) AS id;
+-------------------------------+
| id                            |
+-------------------------------+
| 00327 13579 02403 42354 28570 |
+-------------------------------+
1 row in set (0.01 sec)
```

Because `ExtractValue()` returns multiple matches as a single space-delimited string, this injection attack provides every valid ID contained within `users.xml` to the user as a single row of output. As an extra safeguard, you should also test output before returning it to the user. Here is a simple example:

```
mysql> SELECT @id = ExtractValue(
    ->     LOAD_FILE('users.xml'),
    ->     '//user[login/text()="" or 1=1 and password/text()="" or 1=1]/attribute::id'
    -> );
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT IF(
    ->     INSTR(@id, ' ') = 0,
    ->     @id,
    ->     'Unable to retrieve user ID')
    -> AS singleID;
+----------------------------+
| singleID                   |
+----------------------------+
| Unable to retrieve user ID |
+----------------------------+
1 row in set (0.00 sec)
```

In general, the guidelines for returning data to users securely are the same as for accepting user input. These can be summed up as:

- Always test outgoing data for type and permissible values.
- Never permit unauthorized users to view error messages that might provide information about the application that could be used to exploit it.

11.12. Bit Functions

Table 11.16. Bitwise Functions

Name	**Description**
`BIT_COUNT()`	Return the number of bits that are set
`&`	Bitwise AND
`~`	Invert bits
`|`	Bitwise OR
`^`	Bitwise XOR
`<<`	Left shift
`>>`	Right shift

MySQL uses `BIGINT` (64-bit) arithmetic for bit operations, so these operators have a maximum range of 64 bits.

- `|`

  Bitwise OR:

  ```
  mysql> SELECT 29 | 15;
          -> 31
  ```

  The result is an unsigned 64-bit integer.

- `&`

  Bitwise AND:

  ```
  mysql> SELECT 29 & 15;
          -> 13
  ```

  The result is an unsigned 64-bit integer.

- `^`

  Bitwise XOR:

  ```
  mysql> SELECT 1 ^ 1;
          -> 0
  mysql> SELECT 1 ^ 0;
          -> 1
  mysql> SELECT 11 ^ 3;
          -> 8
  ```

  The result is an unsigned 64-bit integer.

- `<<`

  Shifts a longlong (`BIGINT`) number to the left.

  ```
  mysql> SELECT 1 << 2;
          -> 4
  ```

  The result is an unsigned 64-bit integer. The value is truncated to 64 bits. In particular, if the shift count is greater or equal to the width of an unsigned 64-bit number, the result is zero.

- `>>`

  Shifts a longlong (`BIGINT`) number to the right.

  ```
  mysql> SELECT 4 >> 2;
          -> 1
  ```

  The result is an unsigned 64-bit integer. The value is truncated to 64 bits. In particular, if the shift count is greater or equal to the width of an unsigned 64-bit number, the result is zero.

- `~`

  Invert all bits.

  ```
  mysql> SELECT 5 & ~1;
          -> 4
  ```

The result is an unsigned 64-bit integer.

- `BIT_COUNT(N)`

  Returns the number of bits that are set in the argument `N`.

```
mysql> SELECT BIT_COUNT(29), BIT_COUNT(b'101010');
        -> 4, 3
```

11.13. Encryption and Compression Functions

Table 11.17. Encryption Functions

Name	Description
`AES_DECRYPT()`	Decrypt using AES
`AES_ENCRYPT()`	Encrypt using AES
`COMPRESS()`	Return result as a binary string
`DECODE()`	Decodes a string encrypted using ENCODE()
`DES_DECRYPT()`	Decrypt a string
`DES_ENCRYPT()`	Encrypt a string
`ENCODE()`	Encode a string
`ENCRYPT()`	Encrypt a string
`MD5()`	Calculate MD5 checksum
`OLD_PASSWORD()`	Return the value of the pre-4.1 implementation of PASSWORD
`PASSWORD()`	Calculate and return a password string
`SHA1(), SHA()`	Calculate an SHA-1 160-bit checksum
`SHA2()`	Calculate an SHA-2 checksum
`UNCOMPRESS()`	Uncompress a string compressed
`UNCOMPRESSED_LENGTH()`	Return the length of a string before compression

Many encryption and compression functions return strings for which the result might contain arbitrary byte values. If you want to store these results, use a column with a `VARBINARY` or `BLOB` binary string data type. This will avoid potential problems with trailing space removal or character set conversion that would change data values, such as may occur if you use a nonbinary string data type (`CHAR`, `VARCHAR`, `TEXT`).

Some encryption functions return strings of ASCII characters: `MD5()`, `OLD_PASSWORD()`, `PASSWORD()`, `SHA()`, `SHA1()`. As of MySQL 5.5.3, their return value is a nonbinary string that has a character set and collation determined by the `character_set_connection` and `collation_connection` system variables. Before 5.5.3, these functions return binary strings. The same change was made for `SHA2()` in MySQL 5.5.6.

For versions in which functions such as `MD5()` or `SHA1()` return a string of hex digits as a binary string, the return value cannot be converted to uppercase or compared in case-insensitive fashion as is. You must convert the value to a nonbinary string. See the discussion of binary string conversion in Section 11.10, “Cast Functions and Operators”.

If an application stores values from a function such as `MD5()` or `SHA1()` that returns a string of hex digits, more efficient storage and comparisons can be obtained by converting the hex representation to binary using `UNHEX()` and storing the result in a `BINARY(N)` column. Each pair of hex digits requires one byte in binary form, so the value of `N` depends on the length of the hex string. `N` is 16 for an `MD5()` value and 20 for a `SHA1()` value. For `SHA2()`, `N` ranges from 28 to 32 depending on the argument specifying the desired bit length of the result.

The size penalty for storing the hex string in a `CHAR` column is at least two times, up to eight times if the value is stored in a column that uses the `utf8` character set (where each character uses 4 bytes). Storing the string also results in slower comparisons because of the larger values and the need to take character set collation rules into account.

Suppose that an application stores `MD5()` string values in a `CHAR(32)` column:

```
CREATE TABLE md5_tbl (md5_val CHAR(32), ...);
INSERT INTO md5_tbl (md5_val, ...) VALUES(MD5('abcdef'), ...);
```

To convert hex strings to more compact form, modify the application to use `UNHEX()` and `BINARY(16)` instead as follows:

```
CREATE TABLE md5_tbl (md5_val BINARY(16), ...);
INSERT INTO md5_tbl (md5_val, ...) VALUES(UNHEX(MD5('abcdef')), ...);
```

Applications should be prepared to handle the very rare case that a hashing function produces the same value for two different input values. One way to make collisions detectable is to make the hash column a primary key.

> **Note**
>
> Exploits for the MD5 and SHA-1 algorithms have become known. You may wish to consider using one of the other encryption functions described in this section instead, such as `SHA2()`.

> **Caution**
>
> Passwords or other sensitive values supplied as arguments to encryption functions are sent in plaintext to the MySQL server unless an SSL connection is used. Also, such values will appear in any MySQL logs to which they are written. To avoid these types of exposure, applications can encrypt sensitive values on the client side before sending them to the server. The same considerations apply to encryption keys. To avoid exposing these, applications can use stored procedures to encrypt and decrypt values on the server side.

- `AES_DECRYPT(`*`crypt_str`*`,`*`key_str`*`)`

  This function decrypts data using the official AES (Advanced Encryption Standard) algorithm. For more information, see the description of `AES_ENCRYPT()`.

- `AES_ENCRYPT(`*`str`*`,`*`key_str`*`)`

  `AES_ENCRYPT()` and `AES_DECRYPT()` enable encryption and decryption of data using the official AES (Advanced Encryption Standard) algorithm, previously known as “Rijndael.” Encoding with a 128-bit key length is used, but you can extend it up to 256 bits by modifying the source. We chose 128 bits because it is much faster and it is secure enough for most purposes.

  `AES_ENCRYPT()` encrypts a string and returns a binary string. `AES_DECRYPT()` decrypts the encrypted string and returns the original string. The input arguments may be any length. If either argument is `NULL`, the result of this function is also `NULL`.

  Because AES is a block-level algorithm, padding is used to encode uneven length strings and so the result string length may be calculated using this formula:

  ```
  16 * (trunc(string_length / 16) + 1)
  ```

  If `AES_DECRYPT()` detects invalid data or incorrect padding, it returns `NULL`. However, it is possible for `AES_DECRYPT()` to return a non-`NULL` value (possibly garbage) if the input data or the key is invalid.

  You can use the AES functions to store data in an encrypted form by modifying your queries:

  ```
  INSERT INTO t VALUES (1,AES_ENCRYPT('text','password'));
  ```

  `AES_ENCRYPT()` and `AES_DECRYPT()` can be considered the most cryptographically secure encryption functions currently available in MySQL.

- `COMPRESS(`*`string_to_compress`*`)`

  Compresses a string and returns the result as a binary string. This function requires MySQL to have been compiled with a compression library such as `zlib`. Otherwise, the return value is always `NULL`. The compressed string can be uncompressed with `UNCOMPRESS()`.

  ```
  mysql> SELECT LENGTH(COMPRESS(REPEAT('a',1000)));
          -> 21
  mysql> SELECT LENGTH(COMPRESS(''));
          -> 0
  mysql> SELECT LENGTH(COMPRESS('a'));
          -> 13
  mysql> SELECT LENGTH(COMPRESS(REPEAT('a',16)));
          -> 15
  ```

  The compressed string contents are stored the following way:

  - Empty strings are stored as empty strings.

  - Nonempty strings are stored as a four-byte length of the uncompressed string (low byte first), followed by the compressed string. If the string ends with space, an extra "`.`" character is added to avoid problems with endspace trimming should the result be stored in a `CHAR` or `VARCHAR` column. (However, use of nonbinary string data types such as `CHAR` or `VARCHAR` to store compressed strings is not recommended anyway because character set conversion may occur. Use a `VARBINARY` or `BLOB` binary string column instead.)

- `DECODE(crypt_str,pass_str)`

  Decrypts the encrypted string `crypt_str` using `pass_str` as the password. `crypt_str` should be a string returned from `ENCODE()`.

- `DES_DECRYPT(crypt_str[,key_str])`

  Decrypts a string encrypted with `DES_ENCRYPT()`. If an error occurs, this function returns `NULL`.

  This function works only if MySQL has been configured with SSL support. See Section 5.5.8, "Using SSL for Secure Connections".

  If no `key_str` argument is given, `DES_DECRYPT()` examines the first byte of the encrypted string to determine the DES key number that was used to encrypt the original string, and then reads the key from the DES key file to decrypt the message. For this to work, the user must have the `SUPER` privilege. The key file can be specified with the `--des-key-file` server option.

  If you pass this function a `key_str` argument, that string is used as the key for decrypting the message.

  If the `crypt_str` argument does not appear to be an encrypted string, MySQL returns the given `crypt_str`.

- `DES_ENCRYPT(str[,{key_num|key_str}])`

  Encrypts the string with the given key using the Triple-DES algorithm.

  This function works only if MySQL has been configured with SSL support. See Section 5.5.8, "Using SSL for Secure Connections".

  The encryption key to use is chosen based on the second argument to `DES_ENCRYPT()`, if one was given. With no argument, the first key from the DES key file is used. With a `key_num` argument, the given key number (0 to 9) from the DES key file is used. With a `key_str` argument, the given key string is used to encrypt `str`.

  The key file can be specified with the `--des-key-file` server option.

  The return string is a binary string where the first character is `CHAR(128 | key_num)`. If an error occurs, `DES_ENCRYPT()` returns `NULL`.

  The 128 is added to make it easier to recognize an encrypted key. If you use a string key, `key_num` is 127.

  The string length for the result is given by this formula:

  ```
  new_len = orig_len + (8 - (orig_len % 8)) + 1
  ```

  Each line in the DES key file has the following format:

  ```
  key_num des_key_str
  ```

  Each `key_num` value must be a number in the range from `0` to `9`. Lines in the file may be in any order. `des_key_str` is the string that is used to encrypt the message. There should be at least one space between the number and the key. The first key is the default key that is used if you do not specify any key argument to `DES_ENCRYPT()`.

  You can tell MySQL to read new key values from the key file with the `FLUSH DES_KEY_FILE` statement. This requires the `RELOAD` privilege.

  One benefit of having a set of default keys is that it gives applications a way to check for the existence of encrypted column values, without giving the end user the right to decrypt those values.

  ```
  mysql> SELECT customer_address FROM customer_table
       > WHERE crypted_credit_card = DES_ENCRYPT('credit_card_number');
  ```

- `ENCODE(str,pass_str)`

  Encrypt `str` using `pass_str` as the password. To decrypt the result, use `DECODE()`.

  The result is a binary string of the same length as `str`.

The strength of the encryption is based on how good the random generator is. It should suffice for short strings.

- `ENCRYPT(str[,salt])`

  Encrypts *`str`* using the Unix `crypt()` system call and returns a binary string. The *`salt`* argument must be a string with at least two characters or the result will be `NULL`. If no *`salt`* argument is given, a random value is used.

  ```
  mysql> SELECT ENCRYPT('hello');
          -> 'VxuFAJXVARROc'
  ```

  `ENCRYPT()` ignores all but the first eight characters of *`str`*, at least on some systems. This behavior is determined by the implementation of the underlying `crypt()` system call.

  The use of `ENCRYPT()` with the `ucs2`, `utf16`, or `utf32` multi-byte character sets is not recommended because the system call expects a string terminated by a zero byte.

  If `crypt()` is not available on your system (as is the case with Windows), `ENCRYPT()` always returns `NULL`.

- `MD5(str)`

  Calculates an MD5 128-bit checksum for the string. The value is returned as a string of 32 hex digits, or `NULL` if the argument was `NULL`. The return value can, for example, be used as a hash key. See the notes at the beginning of this section about storing hash values efficiently.

  As of MySQL 5.5.3, the return value is a nonbinary string in the connection character set. Before 5.5.3, the return value is a binary string; see the notes at the beginning of this section about using the value as a nonbinary string.

  ```
  mysql> SELECT MD5('testing');
          -> 'ae2b1fca515949e5d54fb22b8ed95575'
  ```

  This is the “RSA Data Security, Inc. MD5 Message-Digest Algorithm.”

  See the note regarding the MD5 algorithm at the beginning this section.

- `OLD_PASSWORD(str)`

  `OLD_PASSWORD()` was added when the implementation of `PASSWORD()` was changed in MySQL 4.1 to improve security. `OLD_PASSWORD()` returns the value of the pre-4.1 implementation of `PASSWORD()` as a string, and is intended to permit you to reset passwords for any pre-4.1 clients that need to connect to your version 5.5 MySQL server without locking them out. See Section 5.3.2.3, “Password Hashing in MySQL”.

  As of MySQL 5.5.3, the return value is a nonbinary string in the connection character set. Before 5.5.3, the return value is a binary string.

- `PASSWORD(str)`

  Calculates and returns a password string from the plaintext password *`str`* and returns a string, or `NULL` if the argument was `NULL`. This is the function that is used for encrypting MySQL passwords for storage in the `Password` column of the `user` grant table.

  As of MySQL 5.5.3, the return value is a nonbinary string in the connection character set. Before 5.5.3, the return value is a binary string.

  ```
  mysql> SELECT PASSWORD('badpwd');
          -> '*AAB3E285149C0135D51A520E1940DD3263DC008C'
  ```

  `PASSWORD()` encryption is one-way (not reversible).

  `PASSWORD()` does not perform password encryption in the same way that Unix passwords are encrypted. See `ENCRYPT()`.

  ### Note

  The `PASSWORD()` function is used by the authentication system in MySQL Server; you should *not* use it in your own applications. For that purpose, consider `MD5()` or `SHA2()` instead. Also see RFC 2195, section 2 (Challenge-Response Authentication Mechanism (CRAM)), for more information about handling passwords and authentication securely in your applications.

  ### Important

  Statements that invoke `PASSWORD()` may be recorded in server logs or in a history file such as

> `~/.mysql_history`, which means that plaintext passwords may be read by anyone having read access to that information. See Section 5.3.2, “Password Security in MySQL”.

- `SHA1(str)`, `SHA(str)`

  Calculates an SHA-1 160-bit checksum for the string, as described in RFC 3174 (Secure Hash Algorithm). The value is returned as a string of 40 hex digits, or `NULL` if the argument was `NULL`. One of the possible uses for this function is as a hash key. See the notes at the beginning of this section about storing hash values efficiently. You can also use `SHA1()` as a cryptographic function for storing passwords. `SHA()` is synonymous with `SHA1()`.

  As of MySQL 5.5.3, the return value is a nonbinary string in the connection character set. Before 5.5.3, the return value is a binary string; see the notes at the beginning of this section about using the value as a nonbinary string.

  ```
  mysql> SELECT SHA1('abc');
          -> 'a9993e364706816aba3e25717850c26c9cd0d89d'
  ```

  `SHA1()` can be considered a cryptographically more secure equivalent of `MD5()`. However, see the note regarding the MD5 and SHA-1 algorithms at the beginning this section.

- `SHA2(str, hash_length)`

  Calculates the SHA-2 family of hash functions (SHA-224, SHA-256, SHA-384, and SHA-512). The first argument is the cleartext string to be hashed. The second argument indicates the desired bit length of the result, which must have a value of 224, 256, 384, 512, or 0 (which is equivalent to 256). If either argument is `NULL` or the hash length is not one of the permitted values, the return value is `NULL`. Otherwise, the function result is a hash value containing the desired number of bits. See the notes at the beginning of this section about storing hash values efficiently.

  As of MySQL 5.5.6, the return value is a nonbinary string in the connection character set. Before 5.5.6, the return value is a binary string; see the notes at the beginning of this section about using the value as a nonbinary string.

  ```
  mysql> SELECT SHA2('abc', 224);
          -> '23097d223405d8228642a477bda255b32aadbce4bda0b3f7e36c9da7'
  ```

  This function works only if MySQL has been configured with SSL support. See Section 5.5.8, “Using SSL for Secure Connections”.

  `SHA2()` can be considered cryptographically more secure than `MD5()` or `SHA1()`.

  `SHA2()` was added in MySQL 5.5.5.

- `UNCOMPRESS(string_to_uncompress)`

  Uncompresses a string compressed by the `COMPRESS()` function. If the argument is not a compressed value, the result is `NULL`. This function requires MySQL to have been compiled with a compression library such as `zlib`. Otherwise, the return value is always `NULL`.

  ```
  mysql> SELECT UNCOMPRESS(COMPRESS('any string'));
          -> 'any string'
  mysql> SELECT UNCOMPRESS('any string');
          -> NULL
  ```

- `UNCOMPRESSED_LENGTH(compressed_string)`

  Returns the length that the compressed string had before being compressed.

  ```
  mysql> SELECT UNCOMPRESSED_LENGTH(COMPRESS(REPEAT('a',30)));
          -> 30
  ```

11.14. Information Functions

Table 11.18. Information Functions

Name	**Description**
`BENCHMARK()`	Repeatedly execute an expression
`CHARSET()`	Return the character set of the argument
`COERCIBILITY()`	Return the collation coercibility value of the string argument
`COLLATION()`	Return the collation of the string argument

Name	Description
`CONNECTION_ID()`	Return the connection ID (thread ID) for the connection
`CURRENT_USER()`, `CURRENT_USER`	The authenticated user name and host name
`DATABASE()`	Return the default (current) database name
`FOUND_ROWS()`	For a SELECT with a LIMIT clause, the number of rows that would be returned were there no LIMIT clause
`LAST_INSERT_ID()`	Value of the AUTOINCREMENT column for the last INSERT
`ROW_COUNT()`	The number of rows updated
`SCHEMA()`	A synonym for DATABASE()
`SESSION_USER()`	Synonym for USER()
`SYSTEM_USER()`	Synonym for USER()
`USER()`	The user name and host name provided by the client
`VERSION()`	Returns a string that indicates the MySQL server version

- `BENCHMARK(`*`count`*`,`*`expr`*`)`

  The `BENCHMARK()` function executes the expression *`expr`* repeatedly *`count`* times. It may be used to time how quickly MySQL processes the expression. The result value is always `0`. The intended use is from within the `mysql` client, which reports query execution times:

  ```
  mysql> SELECT BENCHMARK(1000000,ENCODE('hello','goodbye'));
  +----------------------------------------------+
  | BENCHMARK(1000000,ENCODE('hello','goodbye')) |
  +----------------------------------------------+
  |                                            0 |
  +----------------------------------------------+
  1 row in set (4.74 sec)
  ```

  The time reported is elapsed time on the client end, not CPU time on the server end. It is advisable to execute `BENCHMARK()` several times, and to interpret the result with regard to how heavily loaded the server machine is.

  `BENCHMARK()` is intended for measuring the runtime performance of scalar expressions, which has some significant implications for the way that you use it and interpret the results:

  - Only scalar expressions can be used. Although the expression can be a subquery, it must return a single column and at most a single row. For example, `BENCHMARK(10, (SELECT * FROM t))` will fail if the table `t` has more than one column or more than one row.

  - Executing a `SELECT` *`expr`* statement *`N`* times differs from executing `SELECT BENCHMARK(`*`N`*`, `*`expr`*`)` in terms of the amount of overhead involved. The two have very different execution profiles and you should not expect them to take the same amount of time. The former involves the parser, optimizer, table locking, and runtime evaluation *`N`* times each. The latter involves only runtime evaluation *`N`* times, and all the other components just once. Memory structures already allocated are reused, and runtime optimizations such as local caching of results already evaluated for aggregate functions can alter the results. Use of `BENCHMARK()` thus measures performance of the runtime component by giving more weight to that component and removing the "noise" introduced by the network, parser, optimizer, and so forth.

- `CHARSET(`*`str`*`)`

  Returns the character set of the string argument.

  ```
  mysql> SELECT CHARSET('abc');
          -> 'latin1'
  mysql> SELECT CHARSET(CONVERT('abc' USING utf8));
          -> 'utf8'
  mysql> SELECT CHARSET(USER());
          -> 'utf8'
  ```

- `COERCIBILITY(`*`str`*`)`

  Returns the collation coercibility value of the string argument.

  ```
  mysql> SELECT COERCIBILITY('abc' COLLATE latin1_swedish_ci);
          -> 0
  mysql> SELECT COERCIBILITY(USER());
          -> 3
  mysql> SELECT COERCIBILITY('abc');
          -> 4
  ```

The return values have the meanings shown in the following table. Lower values have higher precedence.

Coercibility	Meaning	Example
`0`	Explicit collation	Value with `COLLATE` clause
`1`	No collation	Concatenation of strings with different collations
`2`	Implicit collation	Column value, stored routine parameter or local variable
`3`	System constant	`USER()` return value
`4`	Coercible	Literal string
`5`	Ignorable	`NULL` or an expression derived from `NULL`

- `COLLATION(str)`

  Returns the collation of the string argument.

  ```
  mysql> SELECT COLLATION('abc');
          -> 'latin1_swedish_ci'
  mysql> SELECT COLLATION(_utf8'abc');
          -> 'utf8_general_ci'
  ```

- `CONNECTION_ID()`

  Returns the connection ID (thread ID) for the connection. Every connection has an ID that is unique among the set of currently connected clients.

  ```
  mysql> SELECT CONNECTION_ID();
          -> 23786
  ```

- `CURRENT_USER`, `CURRENT_USER()`

  Returns the user name and host name combination for the MySQL account that the server used to authenticate the current client. This account determines your access privileges. The return value is a string in the `utf8` character set.

  The value of `CURRENT_USER()` can differ from the value of `USER()`.

  ```
  mysql> SELECT USER();
          -> 'davida@localhost'
  mysql> SELECT * FROM mysql.user;
  ERROR 1044: Access denied for user ''@'localhost' to
  database 'mysql'
  mysql> SELECT CURRENT_USER();
          -> '@localhost'
  ```

  The example illustrates that although the client specified a user name of `davida` (as indicated by the value of the `USER()` function), the server authenticated the client using an anonymous user account (as seen by the empty user name part of the `CURRENT_USER()` value). One way this might occur is that there is no account listed in the grant tables for `davida`.

  Within a stored program or view, `CURRENT_USER()` returns the account for the user who defined the object (as given by its `DEFINER` value). For stored procedures and functions and views defined with the `SQL SECURITY INVOKER` characteristic, `CURRENT_USER()` returns the object's invoker.

- `DATABASE()`

  Returns the default (current) database name as a string in the `utf8` character set. If there is no default database, `DATABASE()` returns `NULL`. Within a stored routine, the default database is the database that the routine is associated with, which is not necessarily the same as the database that is the default in the calling context.

  ```
  mysql> SELECT DATABASE();
          -> 'test'
  ```

  If there is no default database, `DATABASE()` returns `NULL`.

- `FOUND_ROWS()`

  A `SELECT` statement may include a `LIMIT` clause to restrict the number of rows the server returns to the client. In some cases, it is desirable to know how many rows the statement would have returned without the `LIMIT`, but without running the statement again. To obtain this row count, include a `SQL_CALC_FOUND_ROWS` option in the `SELECT` statement, and then invoke `FOUND_ROWS()` afterward:

```
mysql> SELECT SQL_CALC_FOUND_ROWS * FROM tbl_name
    -> WHERE id > 100 LIMIT 10;
mysql> SELECT FOUND_ROWS();
```

The second `SELECT` returns a number indicating how many rows the first `SELECT` would have returned had it been written without the `LIMIT` clause.

In the absence of the `SQL_CALC_FOUND_ROWS` option in the most recent successful `SELECT` statement, `FOUND_ROWS()` returns the number of rows in the result set returned by that statement. If the statement includes a `LIMIT` clause, `FOUND_ROWS()` returns the number of rows up to the limit. For example, `FOUND_ROWS()` returns 10 or 60, respectively, if the statement includes `LIMIT 10` or `LIMIT 50, 10`.

The row count available through `FOUND_ROWS()` is transient and not intended to be available past the statement following the `SELECT SQL_CALC_FOUND_ROWS` statement. If you need to refer to the value later, save it:

```
mysql> SELECT SQL_CALC_FOUND_ROWS * FROM ... ;
mysql> SET @rows = FOUND_ROWS();
```

If you are using `SELECT SQL_CALC_FOUND_ROWS`, MySQL must calculate how many rows are in the full result set. However, this is faster than running the query again without `LIMIT`, because the result set need not be sent to the client.

`SQL_CALC_FOUND_ROWS` and `FOUND_ROWS()` can be useful in situations when you want to restrict the number of rows that a query returns, but also determine the number of rows in the full result set without running the query again. An example is a Web script that presents a paged display containing links to the pages that show other sections of a search result. Using `FOUND_ROWS()` enables you to determine how many other pages are needed for the rest of the result.

The use of `SQL_CALC_FOUND_ROWS` and `FOUND_ROWS()` is more complex for `UNION` statements than for simple `SELECT` statements, because `LIMIT` may occur at multiple places in a `UNION`. It may be applied to individual `SELECT` statements in the `UNION`, or global to the `UNION` result as a whole.

The intent of `SQL_CALC_FOUND_ROWS` for `UNION` is that it should return the row count that would be returned without a global `LIMIT`. The conditions for use of `SQL_CALC_FOUND_ROWS` with `UNION` are:

- The `SQL_CALC_FOUND_ROWS` keyword must appear in the first `SELECT` of the `UNION`.
- The value of `FOUND_ROWS()` is exact only if `UNION ALL` is used. If `UNION` without `ALL` is used, duplicate removal occurs and the value of `FOUND_ROWS()` is only approximate.
- If no `LIMIT` is present in the `UNION`, `SQL_CALC_FOUND_ROWS` is ignored and returns the number of rows in the temporary table that is created to process the `UNION`.

Beyond the cases described here, the behavior of `FOUND_ROWS()` is undefined (for example, its value following a `SELECT` statement that fails with an error).

> **Important**
>
> `FOUND_ROWS()` is not replicated reliably using statement-based replication. This function is automatically replicated using row-based replication.

- `LAST_INSERT_ID()`, `LAST_INSERT_ID(`*`expr`*`)`

  `LAST_INSERT_ID()` (with no argument) returns the *first* automatically generated value *successfully* inserted for an `AUTO_INCREMENT` column as a result of the most recently executed `INSERT` statement. The value of `LAST_INSERT_ID()` remains unchanged if no rows are successfully inserted.

  For example, after inserting a row that generates an `AUTO_INCREMENT` value, you can get the value like this:

  ```
  mysql> SELECT LAST_INSERT_ID();
          -> 195
  ```

  The currently executing statement does not affect the value of `LAST_INSERT_ID()`. Suppose that you generate an `AUTO_INCREMENT` value with one statement, and then refer to `LAST_INSERT_ID()` in a multiple-row `INSERT` statement that inserts rows into a table with its own `AUTO_INCREMENT` column. The value of `LAST_INSERT_ID()` will remain stable in the second statement; its value for the second and later rows is not affected by the earlier row insertions. (However, if you mix references to `LAST_INSERT_ID()` and `LAST_INSERT_ID(`*`expr`*`)`, the effect is undefined.)

  If the previous statement returned an error, the value of `LAST_INSERT_ID()` is undefined. For transactional tables, if the statement is rolled back due to an error, the value of `LAST_INSERT_ID()` is left undefined. For manual `ROLLBACK`, the value of `LAST_INSERT_ID()` is not restored to that before the transaction; it remains as it was at the point of the `ROLLBACK`.

Within the body of a stored routine (procedure or function) or a trigger, the value of `LAST_INSERT_ID()` changes the same way as for statements executed outside the body of these kinds of objects. The effect of a stored routine or trigger upon the value of `LAST_INSERT_ID()` that is seen by following statements depends on the kind of routine:

- If a stored procedure executes statements that change the value of `LAST_INSERT_ID()`, the changed value is seen by statements that follow the procedure call.
- For stored functions and triggers that change the value, the value is restored when the function or trigger ends, so following statements will not see a changed value.

The ID that was generated is maintained in the server on a *per-connection basis*. This means that the value returned by the function to a given client is the first `AUTO_INCREMENT` value generated for most recent statement affecting an `AUTO_INCREMENT` column *by that client*. This value cannot be affected by other clients, even if they generate `AUTO_INCREMENT` values of their own. This behavior ensures that each client can retrieve its own ID without concern for the activity of other clients, and without the need for locks or transactions.

The value of `LAST_INSERT_ID()` is not changed if you set the `AUTO_INCREMENT` column of a row to a non-“magic” value (that is, a value that is not `NULL` and not `0`).

Important

If you insert multiple rows using a single `INSERT` statement, `LAST_INSERT_ID()` returns the value generated for the *first* inserted row *only*. The reason for this is to make it possible to reproduce easily the same `INSERT` statement against some other server.

For example:

```
mysql> USE test;
Database changed
mysql> CREATE TABLE t (
    ->   id INT AUTO_INCREMENT NOT NULL PRIMARY KEY,
    ->   name VARCHAR(10) NOT NULL
    -> );
Query OK, 0 rows affected (0.09 sec)

mysql> INSERT INTO t VALUES (NULL, 'Bob');
Query OK, 1 row affected (0.01 sec)

mysql> SELECT * FROM t;
+----+------+
| id | name |
+----+------+
|  1 | Bob  |
+----+------+
1 row in set (0.01 sec)

mysql> SELECT LAST_INSERT_ID();
+------------------+
| LAST_INSERT_ID() |
+------------------+
|                1 |
+------------------+
1 row in set (0.00 sec)

mysql> INSERT INTO t VALUES
    -> (NULL, 'Mary'), (NULL, 'Jane'), (NULL, 'Lisa');
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM t;
+----+------+
| id | name |
+----+------+
|  1 | Bob  |
|  2 | Mary |
|  3 | Jane |
|  4 | Lisa |
+----+------+
4 rows in set (0.01 sec)

mysql> SELECT LAST_INSERT_ID();
+------------------+
| LAST_INSERT_ID() |
+------------------+
|                2 |
+------------------+
1 row in set (0.00 sec)
```

Although the second `INSERT` statement inserted three new rows into `t`, the ID generated for the first of these rows was `2`, and it is this value that is returned by `LAST_INSERT_ID()` for the following `SELECT` statement.

If you use `INSERT IGNORE` and the row is ignored, the `AUTO_INCREMENT` counter is not incremented and

`LAST_INSERT_ID()` returns `0`, which reflects that no row was inserted.

If *`expr`* is given as an argument to `LAST_INSERT_ID()`, the value of the argument is returned by the function and is remembered as the next value to be returned by `LAST_INSERT_ID()`. This can be used to simulate sequences:

1. Create a table to hold the sequence counter and initialize it:

   ```
   mysql> CREATE TABLE sequence (id INT NOT NULL);
   mysql> INSERT INTO sequence VALUES (0);
   ```

2. Use the table to generate sequence numbers like this:

   ```
   mysql> UPDATE sequence SET id=LAST_INSERT_ID(id+1);
   mysql> SELECT LAST_INSERT_ID();
   ```

   The `UPDATE` statement increments the sequence counter and causes the next call to `LAST_INSERT_ID()` to return the updated value. The `SELECT` statement retrieves that value. The `mysql_insert_id()` C API function can also be used to get the value. See Section 20.9.3.37, “`mysql_insert_id()`”.

You can generate sequences without calling `LAST_INSERT_ID()`, but the utility of using the function this way is that the ID value is maintained in the server as the last automatically generated value. It is multi-user safe because multiple clients can issue the `UPDATE` statement and get their own sequence value with the `SELECT` statement (or `mysql_insert_id()`), without affecting or being affected by other clients that generate their own sequence values.

Note that `mysql_insert_id()` is only updated after `INSERT` and `UPDATE` statements, so you cannot use the C API function to retrieve the value for `LAST_INSERT_ID(expr)` after executing other SQL statements like `SELECT` or `SET`.

- `ROW_COUNT()`

  Before MySQL 5.5.5, `ROW_COUNT()` returns the number of rows changed, deleted, or inserted by the last statement if it was an `UPDATE`, `DELETE`, or `INSERT`. For other statements, the value may not be meaningful.

  As of MySQL 5.5.5, `ROW_COUNT()` returns a value as follows:

  - DDL statements: 0. This applies to statements such as `CREATE TABLE` or `DROP TABLE`.
  - DML statements other than `SELECT`: The number of affected rows. This applies to statements such as `UPDATE`, `INSERT`, or `DELETE` (as before), but now also to statements such as `ALTER TABLE` and `LOAD DATA INFILE`.
  - `SELECT`: -1 if the statement returns a result set, or the number of rows “affected” if it does not. For example, for `SELECT * FROM t1`, `ROW_COUNT()` returns -1. For `SELECT * FROM t1 INTO OUTFILE 'file_name'`, `ROW_COUNT()` returns the number of rows written to the file.
  - `SIGNAL` statements: 0.

  For `UPDATE` statements, the affected-rows value by default is the number of rows actually changed. If you specify the `CLIENT_FOUND_ROWS` flag to `mysql_real_connect()` when connecting to `mysqld`, the affected-rows value is the number of rows “found”; that is, matched by the `WHERE` clause.

  For `REPLACE` statements, the affected-rows value is 2 if the new row replaced an old row, because in this case, one row was inserted after the duplicate was deleted.

  For `INSERT ... ON DUPLICATE KEY UPDATE` statements, the affected-rows value is 1 if the row is inserted as a new row and 2 if an existing row is updated.

  The `ROW_COUNT()` value is similar to the value from the `mysql_affected_rows()` C API function and the row count that the `mysql` client displays following statement execution.

  ```
  mysql> INSERT INTO t VALUES(1),(2),(3);
  Query OK, 3 rows affected (0.00 sec)
  Records: 3  Duplicates: 0  Warnings: 0

  mysql> SELECT ROW_COUNT();
  +-------------+
  | ROW_COUNT() |
  +-------------+
  |           3 |
  +-------------+
  1 row in set (0.00 sec)

  mysql> DELETE FROM t WHERE i IN(1,2);
  Query OK, 2 rows affected (0.00 sec)

  mysql> SELECT ROW_COUNT();
  +-------------+
  | ROW_COUNT() |
  ```

```
+-------------+
|           2 |
+-------------+
1 row in set (0.00 sec)
```

> **Important**
>
> `ROW_COUNT()` is not replicated reliably using statement-based replication. This function is automatically replicated using row-based replication.

- `SCHEMA()`

  This function is a synonym for `DATABASE()`.

- `SESSION_USER()`

  `SESSION_USER()` is a synonym for `USER()`.

- `SYSTEM_USER()`

  `SYSTEM_USER()` is a synonym for `USER()`.

- `USER()`

  Returns the current MySQL user name and host name as a string in the `utf8` character set.

  ```
  mysql> SELECT USER();
          -> 'davida@localhost'
  ```

  The value indicates the user name you specified when connecting to the server, and the client host from which you connected. The value can be different from that of `CURRENT_USER()`.

  You can extract only the user name part like this:

  ```
  mysql> SELECT SUBSTRING_INDEX(USER(),'@',1);
          -> 'davida'
  ```

- `VERSION()`

  Returns a string that indicates the MySQL server version. The string uses the `utf8` character set. The value might have a suffix in addition to the version number. See the description of the `version` system variable in Section 5.1.3, “Server System Variables”.

  This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

  ```
  mysql> SELECT VERSION();
          -> '5.5.16-standard'
  ```

11.15. Miscellaneous Functions

Table 11.19. Miscellaneous Functions

Name	Description
`DEFAULT()`	Return the default value for a table column
`GET_LOCK()`	Get a named lock
`INET_ATON()`	Return the numeric value of an IP address
`INET_NTOA()`	Return the IP address from a numeric value
`IS_FREE_LOCK()`	Checks whether the named lock is free
`IS_USED_LOCK()`	Checks whether the named lock is in use. Return connection identifier if true.
`MASTER_POS_WAIT()`	Block until the slave has read and applied all updates up to the specified position
`NAME_CONST()`	Causes the column to have the given name
`RAND()`	Return a random floating-point value

Name	Description
`RELEASE_LOCK()`	Releases the named lock
`SLEEP()`	Sleep for a number of seconds
`UUID_SHORT()`	Return an integer-valued universal identifier
`UUID()`	Return a Universal Unique Identifier (UUID)
`VALUES()`	Defines the values to be used during an INSERT

- `DEFAULT(col_name)`

  Returns the default value for a table column. An error results if the column has no default value.

  ```
  mysql> UPDATE t SET i = DEFAULT(i)+1 WHERE id < 100;
  ```

- `FORMAT(X,D)`

  Formats the number *`X`* to a format like `'#,###,###.##'`, rounded to *`D`* decimal places, and returns the result as a string. For details, see Section 11.5, “String Functions”.

- `GET_LOCK(str,timeout)`

  Tries to obtain a lock with a name given by the string *`str`*, using a timeout of *`timeout`* seconds. Returns `1` if the lock was obtained successfully, `0` if the attempt timed out (for example, because another client has previously locked the name), or `NULL` if an error occurred (such as running out of memory or the thread was killed with `mysqladmin kill`). If you have a lock obtained with `GET_LOCK()`, it is released when you execute `RELEASE_LOCK()`, execute a new `GET_LOCK()`, or your connection terminates (either normally or abnormally). Locks obtained with `GET_LOCK()` do not interact with transactions. That is, committing a transaction does not release any such locks obtained during the transaction.

  This function can be used to implement application locks or to simulate record locks. Names are locked on a server-wide basis. If a name has been locked by one client, `GET_LOCK()` blocks any request by another client for a lock with the same name. This enables clients that agree on a given lock name to use the name to perform cooperative advisory locking. But be aware that it also enables a client that is not among the set of cooperating clients to lock a name, either inadvertently or deliberately, and thus prevent any of the cooperating clients from locking that name. One way to reduce the likelihood of this is to use lock names that are database-specific or application-specific. For example, use lock names of the form *`db_name.str`* or *`app_name.str`*.

  ```
  mysql> SELECT GET_LOCK('lock1',10);
          -> 1
  mysql> SELECT IS_FREE_LOCK('lock2');
          -> 1
  mysql> SELECT GET_LOCK('lock2',10);
          -> 1
  mysql> SELECT RELEASE_LOCK('lock2');
          -> 1
  mysql> SELECT RELEASE_LOCK('lock1');
          -> NULL
  ```

  The second `RELEASE_LOCK()` call returns `NULL` because the lock `'lock1'` was automatically released by the second `GET_LOCK()` call.

  If multiple clients are waiting for a lock, the order in which they will acquire it is undefined and depends on factors such as the thread library in use. In particular, applications should not assume that clients will acquire the lock in the same order that they issued the lock requests.

  > **Note**
  >
  > Before MySQL 5.5.3, if a client attempts to acquire a lock that is already held by another client, it blocks according to the *`timeout`* argument. If the blocked client terminates, its thread does not die until the lock request times out.

  This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

- `INET_ATON(expr)`

  Given the dotted-quad representation of an IPv4 network address as a string, returns an integer that represents the numeric value of the address in network byte order (big endian). `INET_ATON()` returns `NULL` if it does not understand its argument.

  ```
  mysql> SELECT INET_ATON('10.0.5.9');
          -> 167773449
  ```

For this example, the return value is calculated as 10×256^3 + 0×256^2 + 5×256 + 9.

`INET_ATON()` may or may not return a non-`NULL` result for short-form IP addresses (such as `'127.1'` as a representation of `'127.0.0.1'`). Because of this, `INET_ATON()`a should not be used for such addresses.

> **Note**
>
> To store values generated by `INET_ATON()`, use an `INT UNSIGNED` column rather than `INT`, which is signed. If you use a signed column, values corresponding to IP addresses for which the first octet is greater than 127 cannot be stored correctly. See Section 10.6, “Out-of-Range and Overflow Handling”.

- `INET_NTOA(expr)`

  Given a numeric IPv4 network address in network byte order, returns the dotted-quad representation of the address as a string. `INET_NTOA()` returns `NULL` if it does not understand its argument.

  As of MySQL 5.5.3, the return value is a nonbinary string in the connection character set. Before 5.5.3, the return value is a binary string.

```
mysql> SELECT INET_NTOA(167773449);
        -> '10.0.5.9'
```

- `IS_FREE_LOCK(str)`

  Checks whether the lock named *`str`* is free to use (that is, not locked). Returns `1` if the lock is free (no one is using the lock), `0` if the lock is in use, and `NULL` if an error occurs (such as an incorrect argument).

  This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

- `IS_USED_LOCK(str)`

  Checks whether the lock named *`str`* is in use (that is, locked). If so, it returns the connection identifier of the client that holds the lock. Otherwise, it returns `NULL`.

  This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

- `MASTER_POS_WAIT(log_name,log_pos[,timeout])`

  This function is useful for control of master/slave synchronization. It blocks until the slave has read and applied all updates up to the specified position in the master log. The return value is the number of log events the slave had to wait for to advance to the specified position. The function returns `NULL` if the slave SQL thread is not started, the slave's master information is not initialized, the arguments are incorrect, or an error occurs. It returns `-1` if the timeout has been exceeded. If the slave SQL thread stops while `MASTER_POS_WAIT()` is waiting, the function returns `NULL`. If the slave is past the specified position, the function returns immediately.

  If a *`timeout`* value is specified, `MASTER_POS_WAIT()` stops waiting when *`timeout`* seconds have elapsed. *`timeout`* must be greater than 0; a zero or negative *`timeout`* means no timeout.

  This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

- `NAME_CONST(name,value)`

  Returns the given value. When used to produce a result set column, `NAME_CONST()` causes the column to have the given name. The arguments should be constants.

```
mysql> SELECT NAME_CONST('myname', 14);
+--------+
| myname |
+--------+
|     14 |
+--------+
```

  This function is for internal use only. The server uses it when writing statements from stored programs that contain references to local program variables, as described in Section 17.7, “Binary Logging of Stored Programs”, You might see this function in the output from `mysqlbinlog`.

- `RELEASE_LOCK(str)`

Releases the lock named by the string *`str`* that was obtained with `GET_LOCK()`. Returns `1` if the lock was released, `0` if the lock was not established by this thread (in which case the lock is not released), and `NULL` if the named lock did not exist. The lock does not exist if it was never obtained by a call to `GET_LOCK()` or if it has previously been released.

The `DO` statement is convenient to use with `RELEASE_LOCK()`. See Section 12.2.3, "`DO` Syntax".

This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

- `SLEEP(`*`duration`*`)`

  Sleeps (pauses) for the number of seconds given by the *`duration`* argument, then returns 0. If `SLEEP()` is interrupted, it returns 1. The duration may have a fractional part given in microseconds.

  This function is unsafe for statement-based replication. Beginning with MySQL 5.5.1, a warning is logged if you use this function when `binlog_format` is set to `STATEMENT`. (Bug #47995)

- `UUID()`

  Returns a Universal Unique Identifier (UUID) generated according to "DCE 1.1: Remote Procedure Call" (Appendix A) CAE (Common Applications Environment) Specifications published by The Open Group in October 1997 (Document Number C706, http://www.opengroup.org/public/pubs/catalog/c706.htm).

  A UUID is designed as a number that is globally unique in space and time. Two calls to `UUID()` are expected to generate two different values, even if these calls are performed on two separate computers that are not connected to each other.

  A UUID is a 128-bit number represented by a `utf8` string of five hexadecimal numbers in `aaaaaaaa-bbbb-cccc-dddd-eeeeeeeeeeee` format:

  - The first three numbers are generated from a timestamp.
  - The fourth number preserves temporal uniqueness in case the timestamp value loses monotonicity (for example, due to daylight saving time).
  - The fifth number is an IEEE 802 node number that provides spatial uniqueness. A random number is substituted if the latter is not available (for example, because the host computer has no Ethernet card, or we do not know how to find the hardware address of an interface on your operating system). In this case, spatial uniqueness cannot be guaranteed. Nevertheless, a collision should have *very* low probability.

    Currently, the MAC address of an interface is taken into account only on FreeBSD and Linux. On other operating systems, MySQL uses a randomly generated 48-bit number.

```
mysql> SELECT UUID();
        -> '6ccd780c-baba-1026-9564-0040f4311e29'
```

  Warning

  Although `UUID()` values are intended to be unique, they are not necessarily unguessable or unpredictable. If unpredictability is required, UUID values should be generated some other way.

  Note

  `UUID()` does not work with statement-based replication.

- `UUID_SHORT()`

  Returns a "short" universal identifier as a 64-bit unsigned integer (rather than a string-form 128-bit identifier as returned by the `UUID()` function).

  The value of `UUID_SHORT()` is guaranteed to be unique if the following conditions hold:

  - The `server_id` of the current host is unique among your set of master and slave servers
  - `server_id` is between 0 and 255
  - You do not set back your system time for your server between `mysqld` restarts
  - You do not invoke `UUID_SHORT()` on average more than 16 million times per second between `mysqld` restarts

  The `UUID_SHORT()` return value is constructed this way:

```
  (server_id & 255) << 56
+ (server_startup_time_in_seconds << 24)
+ incremented_variable++;
```

```
mysql> SELECT UUID_SHORT();
        -> 92395783831158784
```

Note that `UUID_SHORT()` does not work with statement-based replication.

- `VALUES(col_name)`

  In an `INSERT ... ON DUPLICATE KEY UPDATE` statement, you can use the `VALUES(col_name)` function in the `UPDATE` clause to refer to column values from the `INSERT` portion of the statement. In other words, `VALUES(col_name)` in the `UPDATE` clause refers to the value of *`col_name`* that would be inserted, had no duplicate-key conflict occurred. This function is especially useful in multiple-row inserts. The `VALUES()` function is meaningful only in the `ON DUPLICATE KEY UPDATE` clause of `INSERT` statements and returns `NULL` otherwise. See Section 12.2.5.3, “`INSERT ... ON DUPLICATE KEY UPDATE` Syntax”.

```
mysql> INSERT INTO table (a,b,c) VALUES (1,2,3),(4,5,6)
    -> ON DUPLICATE KEY UPDATE c=VALUES(a)+VALUES(b);
```

11.16. Functions and Modifiers for Use with `GROUP BY` Clauses

11.16.1. `GROUP BY` (Aggregate) Functions

Table 11.20. Aggregate (`GROUP BY`) Functions

Name	Description
`AVG()`	Return the average value of the argument
`BIT_AND()`	Return bitwise and
`BIT_OR()`	Return bitwise or
`BIT_XOR()`	Return bitwise xor
`COUNT(DISTINCT)`	Return the count of a number of different values
`COUNT()`	Return a count of the number of rows returned
`GROUP_CONCAT()`	Return a concatenated string
`MAX()`	Return the maximum value
`MIN()`	Return the minimum value
`STD()`	Return the population standard deviation
`STDDEV_POP()`	Return the population standard deviation
`STDDEV_SAMP()`	Return the sample standard deviation
`STDDEV()`	Return the population standard deviation
`SUM()`	Return the sum
`VAR_POP()`	Return the population standard variance
`VAR_SAMP()`	Return the sample variance
`VARIANCE()`	Return the population standard variance

This section describes group (aggregate) functions that operate on sets of values. Unless otherwise stated, group functions ignore `NULL` values.

If you use a group function in a statement containing no `GROUP BY` clause, it is equivalent to grouping on all rows. For more information, see Section 11.16.3, “`GROUP BY` and `HAVING` with Hidden Columns”.

For numeric arguments, the variance and standard deviation functions return a `DOUBLE` value. The `SUM()` and `AVG()` functions return a `DECIMAL` value for exact-value arguments (integer or `DECIMAL`), and a `DOUBLE` value for approximate-value arguments (`FLOAT` or `DOUBLE`).

The `SUM()` and `AVG()` aggregate functions do not work with temporal values. (They convert the values to numbers, losing everything after the first nonnumeric character.) To work around this problem, you can convert to numeric units, perform the aggregate operation, and convert back to a temporal value. Examples:

```
SELECT SEC_TO_TIME(SUM(TIME_TO_SEC(time_col))) FROM tbl_name;
SELECT FROM_DAYS(SUM(TO_DAYS(date_col))) FROM tbl_name;
```

Functions such as `SUM()` or `AVG()` that expect a numeric argument cast the argument to a number if necessary. For `SET` or `ENUM` values, the cast operation causes the underlying numeric value to be used.

- `AVG([DISTINCT] expr)`

  Returns the average value of *`expr`*. The `DISTINCT` option can be used to return the average of the distinct values of *`expr`*.

  `AVG()` returns `NULL` if there were no matching rows.

  ```
  mysql> SELECT student_name, AVG(test_score)
      ->        FROM student
      ->        GROUP BY student_name;
  ```

- `BIT_AND(expr)`

  Returns the bitwise `AND` of all bits in *`expr`*. The calculation is performed with 64-bit (`BIGINT`) precision.

  This function returns `18446744073709551615` if there were no matching rows. (This is the value of an unsigned `BIGINT` value with all bits set to 1.)

- `BIT_OR(expr)`

  Returns the bitwise `OR` of all bits in *`expr`*. The calculation is performed with 64-bit (`BIGINT`) precision.

  This function returns `0` if there were no matching rows.

- `BIT_XOR(expr)`

  Returns the bitwise `XOR` of all bits in *`expr`*. The calculation is performed with 64-bit (`BIGINT`) precision.

  This function returns `0` if there were no matching rows.

- `COUNT(expr)`

  Returns a count of the number of non-`NULL` values of *`expr`* in the rows retrieved by a `SELECT` statement. The result is a `BIGINT` value.

  `COUNT()` returns `0` if there were no matching rows.

  ```
  mysql> SELECT student.student_name,COUNT(*)
      ->        FROM student,course
      ->        WHERE student.student_id=course.student_id
      ->        GROUP BY student_name;
  ```

  `COUNT(*)` is somewhat different in that it returns a count of the number of rows retrieved, whether or not they contain `NULL` values.

  `COUNT(*)` is optimized to return very quickly if the `SELECT` retrieves from one table, no other columns are retrieved, and there is no `WHERE` clause. For example:

  ```
  mysql> SELECT COUNT(*) FROM student;
  ```

  This optimization applies only to `MyISAM` tables only, because an exact row count is stored for this storage engine and can be accessed very quickly. For transactional storage engines such as `InnoDB`, storing an exact row count is more problematic because multiple transactions may be occurring, each of which may affect the count.

- `COUNT(DISTINCT expr,[expr...])`

  Returns a count of the number of rows with different non-`NULL` *`expr`* values.

  `COUNT(DISTINCT)` returns `0` if there were no matching rows.

  ```
  mysql> SELECT COUNT(DISTINCT results) FROM student;
  ```

  In MySQL, you can obtain the number of distinct expression combinations that do not contain `NULL` by giving a list of expressions. In standard SQL, you would have to do a concatenation of all expressions inside `COUNT(DISTINCT ...)`.

- `GROUP_CONCAT(expr)`

  This function returns a string result with the concatenated non-`NULL` values from a group. It returns `NULL` if there are no non-`NULL` values. The full syntax is as follows:

  ```
  GROUP_CONCAT([DISTINCT] expr [,expr ...]
               [ORDER BY {unsigned_integer | col_name | expr}
                   [ASC | DESC] [,col_name ...]]
               [SEPARATOR str_val])
  ```

  ```
  mysql> SELECT student_name,
      ->     GROUP_CONCAT(test_score)
      ->     FROM student
      ->     GROUP BY student_name;
  ```

  Or:

  ```
  mysql> SELECT student_name,
      ->     GROUP_CONCAT(DISTINCT test_score
      ->               ORDER BY test_score DESC SEPARATOR ' ')
      ->     FROM student
      ->     GROUP BY student_name;
  ```

  In MySQL, you can get the concatenated values of expression combinations. To eliminate duplicate values, use the `DISTINCT` clause. To sort values in the result, use the `ORDER BY` clause. To sort in reverse order, add the `DESC` (descending) keyword to the name of the column you are sorting by in the `ORDER BY` clause. The default is ascending order; this may be specified explicitly using the `ASC` keyword. The default separator between values in a group is comma (“`,`”). To specify a separator explicitly, use `SEPARATOR` followed by the string value that should be inserted between group values. To eliminate the separator altogether, specify `SEPARATOR ''`.

  The result is truncated to the maximum length that is given by the `group_concat_max_len` system variable, which has a default value of 1024. The value can be set higher, although the effective maximum length of the return value is constrained by the value of `max_allowed_packet`. The syntax to change the value of `group_concat_max_len` at runtime is as follows, where `val` is an unsigned integer:

  ```
  SET [GLOBAL | SESSION] group_concat_max_len = val;
  ```

  The return value is a nonbinary or binary string, depending on whether the arguments are nonbinary or binary strings. The result type is `TEXT` or `BLOB` unless `group_concat_max_len` is less than or equal to 512, in which case the result type is `VARCHAR` or `VARBINARY`.

  See also `CONCAT()` and `CONCAT_WS()`: Section 11.5, “String Functions”.

- `MAX([DISTINCT] expr)`

  Returns the maximum value of `expr`. `MAX()` may take a string argument; in such cases, it returns the maximum string value. See Section 7.3.1, “How MySQL Uses Indexes”. The `DISTINCT` keyword can be used to find the maximum of the distinct values of `expr`, however, this produces the same result as omitting `DISTINCT`.

  `MAX()` returns `NULL` if there were no matching rows.

  ```
  mysql> SELECT student_name, MIN(test_score), MAX(test_score)
      ->        FROM student
      ->        GROUP BY student_name;
  ```

  For `MAX()`, MySQL currently compares `ENUM` and `SET` columns by their string value rather than by the string's relative position in the set. This differs from how `ORDER BY` compares them. This is expected to be rectified in a future MySQL release.

- `MIN([DISTINCT] expr)`

  Returns the minimum value of `expr`. `MIN()` may take a string argument; in such cases, it returns the minimum string value. See Section 7.3.1, “How MySQL Uses Indexes”. The `DISTINCT` keyword can be used to find the minimum of the distinct values of `expr`, however, this produces the same result as omitting `DISTINCT`.

  `MIN()` returns `NULL` if there were no matching rows.

  ```
  mysql> SELECT student_name, MIN(test_score), MAX(test_score)
      ->        FROM student
      ->        GROUP BY student_name;
  ```

  For `MIN()`, MySQL currently compares `ENUM` and `SET` columns by their string value rather than by the string's relative position in the set. This differs from how `ORDER BY` compares them. This is expected to be rectified in a future MySQL release.

- `STD(expr)`

  Returns the population standard deviation of *`expr`*. This is an extension to standard SQL. The standard SQL function `STDDEV_POP()` can be used instead.

  This function returns `NULL` if there were no matching rows.

- `STDDEV(expr)`

  Returns the population standard deviation of *`expr`*. This function is provided for compatibility with Oracle. The standard SQL function `STDDEV_POP()` can be used instead.

  This function returns `NULL` if there were no matching rows.

- `STDDEV_POP(expr)`

  Returns the population standard deviation of *`expr`* (the square root of `VAR_POP()`). You can also use `STD()` or `STDDEV()`, which are equivalent but not standard SQL.

  `STDDEV_POP()` returns `NULL` if there were no matching rows.

- `STDDEV_SAMP(expr)`

  Returns the sample standard deviation of *`expr`* (the square root of `VAR_SAMP()`.

  `STDDEV_SAMP()` returns `NULL` if there were no matching rows.

- `SUM([DISTINCT] expr)`

  Returns the sum of *`expr`*. If the return set has no rows, `SUM()` returns `NULL`. The `DISTINCT` keyword can be used in MySQL 5.5 to sum only the distinct values of *`expr`*.

  `SUM()` returns `NULL` if there were no matching rows.

- `VAR_POP(expr)`

  Returns the population standard variance of *`expr`*. It considers rows as the whole population, not as a sample, so it has the number of rows as the denominator. You can also use `VARIANCE()`, which is equivalent but is not standard SQL.

  `VAR_POP()` returns `NULL` if there were no matching rows.

- `VAR_SAMP(expr)`

  Returns the sample variance of *`expr`*. That is, the denominator is the number of rows minus one.

  `VAR_SAMP()` returns `NULL` if there were no matching rows.

- `VARIANCE(expr)`

  Returns the population standard variance of *`expr`*. This is an extension to standard SQL. The standard SQL function `VAR_POP()` can be used instead.

  `VARIANCE()` returns `NULL` if there were no matching rows.

11.16.2. `GROUP BY` Modifiers

The `GROUP BY` clause permits a `WITH ROLLUP` modifier that causes extra rows to be added to the summary output. These rows represent higher-level (or super-aggregate) summary operations. `ROLLUP` thus enables you to answer questions at multiple levels of analysis with a single query. It can be used, for example, to provide support for OLAP (Online Analytical Processing) operations.

Suppose that a table named `sales` has `year`, `country`, `product`, and `profit` columns for recording sales profitability:

```
CREATE TABLE sales
(
    year    INT NOT NULL,
    country VARCHAR(20) NOT NULL,
    product VARCHAR(32) NOT NULL,
    profit  INT
);
```

The table's contents can be summarized per year with a simple `GROUP BY` like this:

```
mysql> SELECT year, SUM(profit) FROM sales GROUP BY year;
+------+-------------+
| year | SUM(profit) |
+------+-------------+
| 2000 |        4525 |
| 2001 |        3010 |
+------+-------------+
```

This output shows the total profit for each year, but if you also want to determine the total profit summed over all years, you must add up the individual values yourself or run an additional query.

Or you can use `ROLLUP`, which provides both levels of analysis with a single query. Adding a `WITH ROLLUP` modifier to the `GROUP BY` clause causes the query to produce another row that shows the grand total over all year values:

```
mysql> SELECT year, SUM(profit) FROM sales GROUP BY year WITH ROLLUP;
+------+-------------+
| year | SUM(profit) |
+------+-------------+
| 2000 |        4525 |
| 2001 |        3010 |
| NULL |        7535 |
+------+-------------+
```

The grand total super-aggregate line is identified by the value `NULL` in the `year` column.

`ROLLUP` has a more complex effect when there are multiple `GROUP BY` columns. In this case, each time there is a “break” (change in value) in any but the last grouping column, the query produces an extra super-aggregate summary row.

For example, without `ROLLUP`, a summary on the `sales` table based on `year`, `country`, and `product` might look like this:

```
mysql> SELECT year, country, product, SUM(profit)
    -> FROM sales
    -> GROUP BY year, country, product;
+------+---------+------------+-------------+
| year | country | product    | SUM(profit) |
+------+---------+------------+-------------+
| 2000 | Finland | Computer   |        1500 |
| 2000 | Finland | Phone      |         100 |
| 2000 | India   | Calculator |         150 |
| 2000 | India   | Computer   |        1200 |
| 2000 | USA     | Calculator |          75 |
| 2000 | USA     | Computer   |        1500 |
| 2001 | Finland | Phone      |          10 |
| 2001 | USA     | Calculator |          50 |
| 2001 | USA     | Computer   |        2700 |
| 2001 | USA     | TV         |         250 |
+------+---------+------------+-------------+
```

The output indicates summary values only at the year/country/product level of analysis. When `ROLLUP` is added, the query produces several extra rows:

```
mysql> SELECT year, country, product, SUM(profit)
    -> FROM sales
    -> GROUP BY year, country, product WITH ROLLUP;
+------+---------+------------+-------------+
| year | country | product    | SUM(profit) |
+------+---------+------------+-------------+
| 2000 | Finland | Computer   |        1500 |
| 2000 | Finland | Phone      |         100 |
| 2000 | Finland | NULL       |        1600 |
| 2000 | India   | Calculator |         150 |
| 2000 | India   | Computer   |        1200 |
| 2000 | India   | NULL       |        1350 |
| 2000 | USA     | Calculator |          75 |
| 2000 | USA     | Computer   |        1500 |
| 2000 | USA     | NULL       |        1575 |
| 2000 | NULL    | NULL       |        4525 |
| 2001 | Finland | Phone      |          10 |
| 2001 | Finland | NULL       |          10 |
| 2001 | USA     | Calculator |          50 |
| 2001 | USA     | Computer   |        2700 |
| 2001 | USA     | TV         |         250 |
| 2001 | USA     | NULL       |        3000 |
| 2001 | NULL    | NULL       |        3010 |
| NULL | NULL    | NULL       |        7535 |
+------+---------+------------+-------------+
```

For this query, adding `ROLLUP` causes the output to include summary information at four levels of analysis, not just one. Here is how to interpret the `ROLLUP` output:

- Following each set of product rows for a given year and country, an extra summary row is produced showing the total for all products. These rows have the `product` column set to `NULL`.
- Following each set of rows for a given year, an extra summary row is produced showing the total for all countries and products. These rows have the `country` and `products` columns set to `NULL`.
- Finally, following all other rows, an extra summary row is produced showing the grand total for all years, countries, and products. This row has the `year`, `country`, and `products` columns set to `NULL`.

Other Considerations When using `ROLLUP`

The following items list some behaviors specific to the MySQL implementation of `ROLLUP`:

When you use `ROLLUP`, you cannot also use an `ORDER BY` clause to sort the results. In other words, `ROLLUP` and `ORDER BY` are mutually exclusive. However, you still have some control over sort order. `GROUP BY` in MySQL sorts results, and you can use explicit `ASC` and `DESC` keywords with columns named in the `GROUP BY` list to specify sort order for individual columns. (The higher-level summary rows added by `ROLLUP` still appear after the rows from which they are calculated, regardless of the sort order.)

`LIMIT` can be used to restrict the number of rows returned to the client. `LIMIT` is applied after `ROLLUP`, so the limit applies against the extra rows added by `ROLLUP`. For example:

```
mysql> SELECT year, country, product, SUM(profit)
    -> FROM sales
    -> GROUP BY year, country, product WITH ROLLUP
    -> LIMIT 5;
+------+---------+------------+-------------+
| year | country | product    | SUM(profit) |
+------+---------+------------+-------------+
| 2000 | Finland | Computer   |        1500 |
| 2000 | Finland | Phone      |         100 |
| 2000 | Finland | NULL       |        1600 |
| 2000 | India   | Calculator |         150 |
| 2000 | India   | Computer   |        1200 |
+------+---------+------------+-------------+
```

Using `LIMIT` with `ROLLUP` may produce results that are more difficult to interpret, because you have less context for understanding the super-aggregate rows.

The `NULL` indicators in each super-aggregate row are produced when the row is sent to the client. The server looks at the columns named in the `GROUP BY` clause following the leftmost one that has changed value. For any column in the result set with a name that is a lexical match to any of those names, its value is set to `NULL`. (If you specify grouping columns by column number, the server identifies which columns to set to `NULL` by number.)

Because the `NULL` values in the super-aggregate rows are placed into the result set at such a late stage in query processing, you cannot test them as `NULL` values within the query itself. For example, you cannot add `HAVING product IS NULL` to the query to eliminate from the output all but the super-aggregate rows.

On the other hand, the `NULL` values do appear as `NULL` on the client side and can be tested as such using any MySQL client programming interface.

11.16.3. `GROUP BY` and `HAVING` with Hidden Columns

In standard SQL, a query that includes a `GROUP BY` clause cannot refer to nonaggregated columns in the select list that are not named in the `GROUP BY` clause. For example, this query is illegal in standard SQL because the `name` column in the select list does not appear in the `GROUP BY`:

```
SELECT o.custid, c.name, MAX(o.payment)
  FROM orders AS o, customers AS c
  WHERE o.custid = c.custid
  GROUP BY o.custid;
```

For the query to be legal, the `name` column must be omitted from the select list or named in the `GROUP BY` clause.

MySQL extends the use of `GROUP BY` so that the select list can refer to nonaggregated columns not named in the `GROUP BY` clause. This means that the preceding query is legal in MySQL. You can use this feature to get better performance by avoiding unnecessary column sorting and grouping. However, this is useful primarily when all values in each nonaggregated column not named in the `GROUP BY` are the same for each group. The server is free to choose any value from each group, so unless they are the same, the values chosen are indeterminate. Furthermore, the selection of values from each group cannot be influenced by adding an `ORDER BY` clause. Sorting of the result set occurs after values have been chosen, and `ORDER BY` does not affect which values the server chooses.

A similar MySQL extension applies to the `HAVING` clause. Standard SQL does not permit the `HAVING` clause to name any column not found in the `GROUP BY` clause unless it is enclosed in an aggregate function. MySQL permits the use of such columns to simplify calculations. This extension assumes that the nongrouped columns will have the same group-wise values. Otherwise, the result is indeterminate.

To disable the MySQL `GROUP BY` extension, enable the `ONLY_FULL_GROUP_BY` SQL mode. This enables standard SQL behavior: Columns not named in the `GROUP BY` clause cannot be used in the select list or `HAVING` clause unless enclosed in an aggregate function.

For example, the following query returns `name` values that occur only once in table `orders`:

```
SELECT name, COUNT(name) FROM orders
  GROUP BY name
  HAVING COUNT(name) = 1;
```

However, the result of the following similar query that uses an alias for the aggregated column depends on the SQL mode:

```
SELECT name, COUNT(name) AS c FROM orders
  GROUP BY name
  HAVING c = 1;
```

In this case, a `non-grouping field 'c' is used in HAVING clause` error occurs if `ONLY_FULL_GROUP_BY` is enabled because the extension does not apply. The column `c` in the `HAVING` clause is not enclosed in an aggregate function (instead, it *is* an aggregate function).

The select list extension also applies to `ORDER BY`. That is, you can use nonaggregated columns in the `ORDER BY` clause that do not appear in the `GROUP BY` clause. (However, as mentioned previously, `ORDER BY` does not affect which values are chosen from nonaggregated columns; it only sorts them after they have been chosen.) This extension does not apply if the `ONLY_FULL_GROUP_BY` SQL mode is enabled.

In some cases, you can use `MIN()` and `MAX()` to obtain a specific column value even if it is not unique. If the `sort` column contains integers no larger than 6 digits, the following query gives the value of `column` from the row containing the smallest `sort` value:

```
SUBSTR(MIN(CONCAT(LPAD(sort,6,'0'),column)),7)
```

See Section 3.6.4, “The Rows Holding the Group-wise Maximum of a Certain Column”.

If you are trying to follow standard SQL, you cannot use expressions in `GROUP BY` clauses. As a workaround, use an alias for the expression:

```
SELECT id, FLOOR(value/100) AS val
  FROM tbl_name
  GROUP BY id, val;
```

MySQL permits expressions in `GROUP BY` clauses, so the alias is unnecessary:

```
SELECT id, FLOOR(value/100)
  FROM tbl_name
  GROUP BY id, FLOOR(value/100);
```

11.17. Spatial Extensions

MySQL supports spatial extensions to enable the generation, storage, and analysis of geographic features. These features are available for `MyISAM`, `InnoDB`, `NDB`, and `ARCHIVE` tables.

For spatial columns, `MyISAM` supports both `SPATIAL` and non-`SPATIAL` indexes. Other storage engines support non-`SPATIAL` indexes, as described in Section 12.1.11, “`CREATE INDEX` Syntax”.

This chapter covers the following topics:

- The basis of these spatial extensions in the OpenGIS geometry model
- Data formats for representing spatial data
- How to use spatial data in MySQL
- Use of indexing for spatial data
- MySQL differences from the OpenGIS specification

Additional Resources

- The Open Geospatial Consortium publishes the *OpenGIS® Simple Features Specifications For SQL*, a document that proposes several conceptual ways for extending an SQL RDBMS to support spatial data. This specification is available from the OGC Web site at http://www.opengis.org/docs/99-049.pdf.
- If you have questions or concerns about the use of the spatial extensions to MySQL, you can discuss them in the GIS forum: http://forums.mysql.com/list.php?23.

11.17.1. Introduction to MySQL Spatial Support

MySQL implements spatial extensions following the specification of the Open Geospatial Consortium (OGC). This is an international consortium of more than 250 companies, agencies, and universities participating in the development of publicly available conceptual solutions that can be useful with all kinds of applications that manage spatial data. The OGC maintains a Web site at http://www.opengis.org/.

In 1997, the Open Geospatial Consortium published the *OpenGIS® Simple Features Specifications For SQL*, a document that proposes several conceptual ways for extending an SQL RDBMS to support spatial data. This specification is available from the OGC Web site at http://www.opengis.org/docs/99-049.pdf. It contains additional information relevant to this chapter.

MySQL implements a subset of the **SQL with Geometry Types** environment proposed by OGC. This term refers to an SQL environment that has been extended with a set of geometry types. A geometry-valued SQL column is implemented as a column that has a geometry type. The specification describe a set of SQL geometry types, as well as functions on those types to create and analyze geometry values.

A **geographic feature** is anything in the world that has a location. A feature can be:

- An entity. For example, a mountain, a pond, a city.
- A space. For example, town district, the tropics.
- A definable location. For example, a crossroad, as a particular place where two streets intersect.

Some documents use the term **geospatial feature** to refer to geographic features.

Geometry is another word that denotes a geographic feature. Originally the word **geometry** meant measurement of the earth. Another meaning comes from cartography, referring to the geometric features that cartographers use to map the world.

This chapter uses all of these terms synonymously: **geographic feature**, **geospatial feature**, **feature**, or **geometry**. Here, the term most commonly used is **geometry**, defined as *a point or an aggregate of points representing anything in the world that has a location*.

11.17.2. The OpenGIS Geometry Model

The set of geometry types proposed by OGC's **SQL with Geometry Types** environment is based on the **OpenGIS Geometry Model**. In this model, each geometric object has the following general properties:

- It is associated with a Spatial Reference System, which describes the coordinate space in which the object is defined.
- It belongs to some geometry class.

11.17.2.1. The Geometry Class Hierarchy

The geometry classes define a hierarchy as follows:

- `Geometry` (noninstantiable)
  - `Point` (instantiable)
  - `Curve` (noninstantiable)
    - `LineString` (instantiable)
      - `Line`

        - `LinearRing`
  - `Surface` (noninstantiable)
    - `Polygon` (instantiable)
  - `GeometryCollection` (instantiable)
    - `MultiPoint` (instantiable)
    - `MultiCurve` (noninstantiable)
      - `MultiLineString` (instantiable)
    - `MultiSurface` (noninstantiable)
      - `MultiPolygon` (instantiable)

It is not possible to create objects in noninstantiable classes. It is possible to create objects in instantiable classes. All classes have properties, and instantiable classes may also have assertions (rules that define valid class instances).

`Geometry` is the base class. It is an abstract class. The instantiable subclasses of `Geometry` are restricted to zero-, one-, and two-dimensional geometric objects that exist in two-dimensional coordinate space. All instantiable geometry classes are defined so that valid instances of a geometry class are topologically closed (that is, all defined geometries include their boundary).

The base `Geometry` class has subclasses for `Point`, `Curve`, `Surface`, and `GeometryCollection`:

- `Point` represents zero-dimensional objects.
- `Curve` represents one-dimensional objects, and has subclass `LineString`, with sub-subclasses `Line` and `LinearRing`.
- `Surface` is designed for two-dimensional objects and has subclass `Polygon`.
- `GeometryCollection` has specialized zero-, one-, and two-dimensional collection classes named `MultiPoint`, `MultiLineString`, and `MultiPolygon` for modeling geometries corresponding to collections of `Points`, `LineStrings`, and `Polygons`, respectively. `MultiCurve` and `MultiSurface` are introduced as abstract superclasses that generalize the collection interfaces to handle `Curves` and `Surfaces`.

`Geometry`, `Curve`, `Surface`, `MultiCurve`, and `MultiSurface` are defined as noninstantiable classes. They define a common set of methods for their subclasses and are included for extensibility.

`Point`, `LineString`, `Polygon`, `GeometryCollection`, `MultiPoint`, `MultiLineString`, and `MultiPolygon` are instantiable classes.

11.17.2.2. Class `Geometry`

`Geometry` is the root class of the hierarchy. It is a noninstantiable class but has a number of properties that are common to all geometry values created from any of the `Geometry` subclasses. These properties are described in the following list. Particular subclasses have their own specific properties, described later.

Geometry Properties

A geometry value has the following properties:

- Its **type**. Each geometry belongs to one of the instantiable classes in the hierarchy.
- Its **SRID**, or Spatial Reference Identifier. This value identifies the geometry's associated Spatial Reference System that describes the coordinate space in which the geometry object is defined.

  In MySQL, the SRID value is just an integer associated with the geometry value. All calculations are done assuming Euclidean (planar) geometry.
- Its **coordinates** in its Spatial Reference System, represented as double-precision (eight-byte) numbers. All nonempty geometries include at least one pair of (X,Y) coordinates. Empty geometries contain no coordinates.

Coordinates are related to the SRID. For example, in different coordinate systems, the distance between two objects may differ even when objects have the same coordinates, because the distance on the **planar** coordinate system and the distance on the **geocentric** system (coordinates on the Earth's surface) are different things.

- Its **interior**, **boundary**, and **exterior**.

  Every geometry occupies some position in space. The exterior of a geometry is all space not occupied by the geometry. The interior is the space occupied by the geometry. The boundary is the interface between the geometry's interior and exterior.

- Its **MBR** (Minimum Bounding Rectangle), or Envelope. This is the bounding geometry, formed by the minimum and maximum (X,Y) coordinates:

  ```
  ((MINX MINY, MAXX MINY, MAXX MAXY, MINX MAXY, MINX MINY))
  ```

- Whether the value is **simple** or **nonsimple**. Geometry values of types (`LineString`, `MultiPoint`, `MultiLineString`) are either simple or nonsimple. Each type determines its own assertions for being simple or nonsimple.

- Whether the value is **closed** or **not closed**. Geometry values of types (`LineString`, `MultiString`) are either closed or not closed. Each type determines its own assertions for being closed or not closed.

- Whether the value is **empty** or **nonempty** A geometry is empty if it does not have any points. Exterior, interior, and boundary of an empty geometry are not defined (that is, they are represented by a `NULL` value). An empty geometry is defined to be always simple and has an area of 0.

- Its **dimension**. A geometry can have a dimension of –1, 0, 1, or 2:

  - –1 for an empty geometry.
  - 0 for a geometry with no length and no area.
  - 1 for a geometry with nonzero length and zero area.
  - 2 for a geometry with nonzero area.

  `Point` objects have a dimension of zero. `LineString` objects have a dimension of 1. `Polygon` objects have a dimension of 2. The dimensions of `MultiPoint`, `MultiLineString`, and `MultiPolygon` objects are the same as the dimensions of the elements they consist of.

11.17.2.3. Class `Point`

A `Point` is a geometry that represents a single location in coordinate space.

`Point` Examples

- Imagine a large-scale map of the world with many cities. A `Point` object could represent each city.
- On a city map, a `Point` object could represent a bus stop.

`Point` Properties

- X-coordinate value.
- Y-coordinate value.
- `Point` is defined as a zero-dimensional geometry.
- The boundary of a `Point` is the empty set.

11.17.2.4. Class `Curve`

A `Curve` is a one-dimensional geometry, usually represented by a sequence of points. Particular subclasses of `Curve` define the type of interpolation between points. `Curve` is a noninstantiable class.

`Curve` Properties

- A `Curve` has the coordinates of its points.
- A `Curve` is defined as a one-dimensional geometry.
- A `Curve` is simple if it does not pass through the same point twice.
- A `Curve` is closed if its start point is equal to its endpoint.
- The boundary of a closed `Curve` is empty.
- The boundary of a nonclosed `Curve` consists of its two endpoints.
- A `Curve` that is simple and closed is a `LinearRing`.

11.17.2.5. Class `LineString`

A `LineString` is a `Curve` with linear interpolation between points.

`LineString` Examples

- On a world map, `LineString` objects could represent rivers.
- In a city map, `LineString` objects could represent streets.

`LineString` Properties

- A `LineString` has coordinates of segments, defined by each consecutive pair of points.
- A `LineString` is a `Line` if it consists of exactly two points.
- A `LineString` is a `LinearRing` if it is both closed and simple.

11.17.2.6. Class `Surface`

A `Surface` is a two-dimensional geometry. It is a noninstantiable class. Its only instantiable subclass is `Polygon`.

`Surface` Properties

- A `Surface` is defined as a two-dimensional geometry.
- The OpenGIS specification defines a simple `Surface` as a geometry that consists of a single “patch” that is associated with a single exterior boundary and zero or more interior boundaries.
- The boundary of a simple `Surface` is the set of closed curves corresponding to its exterior and interior boundaries.

11.17.2.7. Class `Polygon`

A `Polygon` is a planar `Surface` representing a multisided geometry. It is defined by a single exterior boundary and zero or more interior boundaries, where each interior boundary defines a hole in the `Polygon`.

`Polygon` Examples

- On a region map, `Polygon` objects could represent forests, districts, and so on.

`Polygon` Assertions

- The boundary of a `Polygon` consists of a set of `LinearRing` objects (that is, `LineString` objects that are both simple and closed) that make up its exterior and interior boundaries.
- A `Polygon` has no rings that cross. The rings in the boundary of a `Polygon` may intersect at a `Point`, but only as a tangent.

- A `Polygon` has no lines, spikes, or punctures.
- A `Polygon` has an interior that is a connected point set.
- A `Polygon` may have holes. The exterior of a `Polygon` with holes is not connected. Each hole defines a connected component of the exterior.

The preceding assertions make a `Polygon` a simple geometry.

11.17.2.8. Class `GeometryCollection`

A `GeometryCollection` is a geometry that is a collection of one or more geometries of any class.

All the elements in a `GeometryCollection` must be in the same Spatial Reference System (that is, in the same coordinate system). There are no other constraints on the elements of a `GeometryCollection`, although the subclasses of `GeometryCollection` described in the following sections may restrict membership. Restrictions may be based on:

- Element type (for example, a `MultiPoint` may contain only `Point` elements)
- Dimension
- Constraints on the degree of spatial overlap between elements

11.17.2.9. Class `MultiPoint`

A `MultiPoint` is a geometry collection composed of `Point` elements. The points are not connected or ordered in any way.

`MultiPoint` Examples

- On a world map, a `MultiPoint` could represent a chain of small islands.
- On a city map, a `MultiPoint` could represent the outlets for a ticket office.

`MultiPoint` Properties

- A `MultiPoint` is a zero-dimensional geometry.
- A `MultiPoint` is simple if no two of its `Point` values are equal (have identical coordinate values).
- The boundary of a `MultiPoint` is the empty set.

11.17.2.10. Class `MultiCurve`

A `MultiCurve` is a geometry collection composed of `Curve` elements. `MultiCurve` is a noninstantiable class.

`MultiCurve` Properties

- A `MultiCurve` is a one-dimensional geometry.
- A `MultiCurve` is simple if and only if all of its elements are simple; the only intersections between any two elements occur at points that are on the boundaries of both elements.
- A `MultiCurve` boundary is obtained by applying the “mod 2 union rule” (also known as the “odd-even rule”): A point is in the boundary of a `MultiCurve` if it is in the boundaries of an odd number of `MultiCurve` elements.
- A `MultiCurve` is closed if all of its elements are closed.
- The boundary of a closed `MultiCurve` is always empty.

11.17.2.11. Class `MultiLineString`

A `MultiLineString` is a `MultiCurve` geometry collection composed of `LineString` elements.

`MultiLineString` Examples

- On a region map, a `MultiLineString` could represent a river system or a highway system.

11.17.2.12. Class `MultiSurface`

A `MultiSurface` is a geometry collection composed of surface elements. `MultiSurface` is a noninstantiable class. Its only instantiable subclass is `MultiPolygon`.

`MultiSurface` Assertions

- Two `MultiSurface` surfaces have no interiors that intersect.
- Two `MultiSurface` elements have boundaries that intersect at most at a finite number of points.

11.17.2.13. Class `MultiPolygon`

A `MultiPolygon` is a `MultiSurface` object composed of `Polygon` elements.

`MultiPolygon` Examples

- On a region map, a `MultiPolygon` could represent a system of lakes.

`MultiPolygon` Assertions

- A `MultiPolygon` has no two `Polygon` elements with interiors that intersect.
- A `MultiPolygon` has no two `Polygon` elements that cross (crossing is also forbidden by the previous assertion), or that touch at an infinite number of points.
- A `MultiPolygon` may not have cut lines, spikes, or punctures. A `MultiPolygon` is a regular, closed point set.
- A `MultiPolygon` that has more than one `Polygon` has an interior that is not connected. The number of connected components of the interior of a `MultiPolygon` is equal to the number of `Polygon` values in the `MultiPolygon`.

`MultiPolygon` Properties

- A `MultiPolygon` is a two-dimensional geometry.
- A `MultiPolygon` boundary is a set of closed curves (`LineString` values) corresponding to the boundaries of its `Polygon` elements.
- Each `Curve` in the boundary of the `MultiPolygon` is in the boundary of exactly one `Polygon` element.
- Every `Curve` in the boundary of an `Polygon` element is in the boundary of the `MultiPolygon`.

11.17.3. Supported Spatial Data Formats

This section describes the standard spatial data formats that are used to represent geometry objects in queries. They are:

- Well-Known Text (WKT) format
- Well-Known Binary (WKB) format

Internally, MySQL stores geometry values in a format that is not identical to either WKT or WKB format.

11.17.3.1. Well-Known Text (WKT) Format

The Well-Known Text (WKT) representation of Geometry is designed to exchange geometry data in ASCII form. For a Backus-

Naur grammar that specifies the formal production rules for writing WKT values, see the OpenGIS specification document referenced in Section 11.17, “Spatial Extensions”.

Examples of WKT representations of geometry objects:

- A `Point`:

  ```
  POINT(15 20)
  ```

  Note that point coordinates are specified with no separating comma. This differs from the syntax for the SQL `POINT()` function, which requires a comma between the coordinates. Take care to use the syntax appropriate to the context of a given spatial operation. For example, the following statements both extract the X-coordinate from a `Point` object. The first produces the object directly using the `POINT()` function. The second uses a WKT representation converted to a `Point` with `GeomFromText()`.

  ```
  mysql> SELECT X(POINT(15, 20));
  +------------------+
  | X(POINT(15, 20)) |
  +------------------+
  |               15 |
  +------------------+

  mysql> SELECT X(GeomFromText('POINT(15 20)'));
  +---------------------------------+
  | X(GeomFromText('POINT(15 20)')) |
  +---------------------------------+
  |                              15 |
  +---------------------------------+
  ```

- A `LineString` with four points:

  ```
  LINESTRING(0 0, 10 10, 20 25, 50 60)
  ```

  Note that point coordinate pairs are separated by commas.

- A `Polygon` with one exterior ring and one interior ring:

  ```
  POLYGON((0 0,10 0,10 10,0 10,0 0),(5 5,7 5,7 7,5 7, 5 5))
  ```

- A `MultiPoint` with three `Point` values:

  ```
  MULTIPOINT(0 0, 20 20, 60 60)
  ```

- A `MultiLineString` with two `LineString` values:

  ```
  MULTILINESTRING((10 10, 20 20), (15 15, 30 15))
  ```

- A `MultiPolygon` with two `Polygon` values:

  ```
  MULTIPOLYGON(((0 0,10 0,10 10,0 10,0 0)),((5 5,7 5,7 7,5 7, 5 5)))
  ```

- A `GeometryCollection` consisting of two `Point` values and one `LineString`:

  ```
  GEOMETRYCOLLECTION(POINT(10 10), POINT(30 30), LINESTRING(15 15, 20 20))
  ```

11.17.3.2. Well-Known Binary (WKB) Format

The Well-Known Binary (WKB) representation for geometric values is defined by the OpenGIS specification. It is also defined in the ISO *SQL/MM Part 3: Spatial* standard.

WKB is used to exchange geometry data as binary streams represented by `BLOB` values containing geometric WKB information.

WKB uses one-byte unsigned integers, four-byte unsigned integers, and eight-byte double-precision numbers (IEEE 754 format). A byte is eight bits.

For example, a WKB value that corresponds to `POINT(1 1)` consists of this sequence of 21 bytes (each represented here by two hex digits):

```
0101000000000000000000F03F000000000000F03F
```

The sequence may be broken down into these components:

```
Byte order : 01
WKB type   : 01000000
X          : 000000000000F03F
Y          : 000000000000F03F
```

Component representation is as follows:

- The byte order may be either 1 or 0 to indicate little-endian or big-endian storage. The little-endian and big-endian byte orders are also known as Network Data Representation (NDR) and External Data Representation (XDR), respectively.
- The WKB type is a code that indicates the geometry type. Values from 1 through 7 indicate `Point`, `LineString`, `Polygon`, `MultiPoint`, `MultiLineString`, `MultiPolygon`, and `GeometryCollection`.
- A `Point` value has X and Y coordinates, each represented as a double-precision value.

WKB values for more complex geometry values are represented by more complex data structures, as detailed in the OpenGIS specification.

11.17.4. Creating a Spatially Enabled MySQL Database

This section describes the data types you can use for representing spatial data in MySQL, and the functions available for creating and retrieving spatial values.

11.17.4.1. MySQL Spatial Data Types

MySQL has data types that correspond to OpenGIS classes. Some of these types hold single geometry values:

- `GEOMETRY`
- `POINT`
- `LINESTRING`
- `POLYGON`

`GEOMETRY` can store geometry values of any type. The other single-value types (`POINT`, `LINESTRING`, and `POLYGON`) restrict their values to a particular geometry type.

The other data types hold collections of values:

- `MULTIPOINT`
- `MULTILINESTRING`
- `MULTIPOLYGON`
- `GEOMETRYCOLLECTION`

`GEOMETRYCOLLECTION` can store a collection of objects of any type. The other collection types (`MULTIPOINT`, `MULTILINESTRING`, `MULTIPOLYGON`, and `GEOMETRYCOLLECTION`) restrict collection members to those having a particular geometry type.

11.17.4.2. Creating Spatial Values

This section describes how to create spatial values using Well-Known Text and Well-Known Binary functions that are defined in the OpenGIS standard, and using MySQL-specific functions.

11.17.4.2.1. Creating Geometry Values Using WKT Functions

MySQL provides a number of functions that take as arguments a Well-Known Text representation and, optionally, a spatial reference system identifier (SRID). They return the corresponding geometry.

`GeomFromText()` accepts a WKT of any geometry type as its first argument. An implementation also provides type-specific construction functions for construction of geometry values of each geometry type.

- `GeomCollFromText(`*`wkt`*`[,`*`srid`*`])`, `GeometryCollectionFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a `GEOMETRYCOLLECTION` value using its WKT representation and SRID.

- `GeomFromText(`*`wkt`*`[,`*`srid`*`])`, `GeometryFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a geometry value of any type using its WKT representation and SRID.

- `LineFromText(`*`wkt`*`[,`*`srid`*`])`, `LineStringFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a `LINESTRING` value using its WKT representation and SRID.

- `MLineFromText(`*`wkt`*`[,`*`srid`*`])`, `MultiLineStringFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a `MULTILINESTRING` value using its WKT representation and SRID.

- `MPointFromText(`*`wkt`*`[,`*`srid`*`])`, `MultiPointFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a `MULTIPOINT` value using its WKT representation and SRID.

- `MPolyFromText(`*`wkt`*`[,`*`srid`*`])`, `MultiPolygonFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a `MULTIPOLYGON` value using its WKT representation and SRID.

- `PointFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a `POINT` value using its WKT representation and SRID.

- `PolyFromText(`*`wkt`*`[,`*`srid`*`])`, `PolygonFromText(`*`wkt`*`[,`*`srid`*`])`

  Constructs a `POLYGON` value using its WKT representation and SRID.

The OpenGIS specification also defines the following optional functions, which MySQL does not implement. These functions construct `Polygon` or `MultiPolygon` values based on the WKT representation of a collection of rings or closed `LineString` values. These values may intersect.

- `BdMPolyFromText(`*`wkt`*`,`*`srid`*`)`

  Constructs a `MultiPolygon` value from a `MultiLineString` value in WKT format containing an arbitrary collection of closed `LineString` values.

- `BdPolyFromText(`*`wkt`*`,`*`srid`*`)`

  Constructs a `Polygon` value from a `MultiLineString` value in WKT format containing an arbitrary collection of closed `LineString` values.

11.17.4.2.2. Creating Geometry Values Using WKB Functions

MySQL provides a number of functions that take as arguments a `BLOB` containing a Well-Known Binary representation and, optionally, a spatial reference system identifier (SRID). They return the corresponding geometry.

These functions also accept geometry objects for compatibility with the return value of the functions in Section 11.17.4.2.3, “Creating Geometry Values Using MySQL-Specific Functions”. Thus, those functions may be used to provide the first argument to the functions in this section.

- `GeomCollFromWKB(`*`wkb`*`[,`*`srid`*`])`, `GeometryCollectionFromWKB(`*`wkb`*`[,`*`srid`*`])`

  Constructs a `GEOMETRYCOLLECTION` value using its WKB representation and SRID.

- `GeomFromWKB(`*`wkb`*`[,`*`srid`*`])`, `GeometryFromWKB(`*`wkb`*`[,`*`srid`*`])`

  Constructs a geometry value of any type using its WKB representation and SRID.

- `LineFromWKB(`*`wkb`*`[,`*`srid`*`])`, `LineStringFromWKB(`*`wkb`*`[,`*`srid`*`])`

Constructs a `LINESTRING` value using its WKB representation and SRID.

- `MLineFromWKB(`*`wkb`*`[,`*`srid`*`])`, `MultiLineStringFromWKB(`*`wkb`*`[,`*`srid`*`])`

  Constructs a `MULTILINESTRING` value using its WKB representation and SRID.

- `MPointFromWKB(`*`wkb`*`[,`*`srid`*`])`, `MultiPointFromWKB(`*`wkb`*`[,`*`srid`*`])`

  Constructs a `MULTIPOINT` value using its WKB representation and SRID.

- `MPolyFromWKB(`*`wkb`*`[,`*`srid`*`])`, `MultiPolygonFromWKB(`*`wkb`*`[,`*`srid`*`])`

  Constructs a `MULTIPOLYGON` value using its WKB representation and SRID.

- `PointFromWKB(`*`wkb`*`[,`*`srid`*`])`

  Constructs a `POINT` value using its WKB representation and SRID.

- `PolyFromWKB(`*`wkb`*`[,`*`srid`*`])`, `PolygonFromWKB(`*`wkb`*`[,`*`srid`*`])`

  Constructs a `POLYGON` value using its WKB representation and SRID.

The OpenGIS specification also describes optional functions for constructing `Polygon` or `MultiPolygon` values based on the WKB representation of a collection of rings or closed `LineString` values. These values may intersect. MySQL does not implement these functions:

- `BdMPolyFromWKB(`*`wkb`*`,`*`srid`*`)`

  Constructs a `MultiPolygon` value from a `MultiLineString` value in WKB format containing an arbitrary collection of closed `LineString` values.

- `BdPolyFromWKB(`*`wkb`*`,`*`srid`*`)`

  Constructs a `Polygon` value from a `MultiLineString` value in WKB format containing an arbitrary collection of closed `LineString` values.

11.17.4.2.3. Creating Geometry Values Using MySQL-Specific Functions

MySQL provides a set of useful nonstandard functions for creating geometry values. The functions described in this section are MySQL extensions to the OpenGIS specification.

These functions produce geometry objects from either WKB values or geometry objects as arguments. If any argument is not a proper WKB or geometry representation of the proper object type, the return value is `NULL`.

For example, you can insert the geometry return value from `Point()` directly into a `Point` column:

```
INSERT INTO t1 (pt_col) VALUES(Point(1,2));
```

- `GeometryCollection(`*`g1`*`,`*`g2`*`,...)`

  Constructs a `GeometryCollection`.

- `LineString(`*`pt1`*`,`*`pt2`*`,...)`

  Constructs a `LineString` value from a number of `Point` or WKB `Point` arguments. If the number of arguments is less than two, the return value is `NULL`.

- `MultiLineString(`*`ls1`*`,`*`ls2`*`,...)`

  Constructs a `MultiLineString` value using `LineString` or WKB `LineString` arguments.

- `MultiPoint(`*`pt1`*`,`*`pt2`*`,...)`

  Constructs a `MultiPoint` value using `Point` or WKB `Point` arguments.

- `MultiPolygon(`*`poly1`*`,`*`poly2`*`,...)`

Constructs a `MultiPolygon` value from a set of `Polygon` or WKB `Polygon` arguments.

- `Point(x,y)`

  Constructs a `Point` using its coordinates.

- `Polygon(ls1,ls2,...)`

  Constructs a `Polygon` value from a number of `LineString` or WKB `LineString` arguments. If any argument does not represent a `LinearRing` (that is, not a closed and simple `LineString`), the return value is `NULL`.

11.17.4.3. Creating Spatial Columns

MySQL provides a standard way of creating spatial columns for geometry types, for example, with `CREATE TABLE` or `ALTER TABLE`. Currently, spatial columns are supported for `MyISAM`, `InnoDB`, `NDB`, and `ARCHIVE` tables. See also the annotations about spatial indexes under Section 11.17.6.1, “Creating Spatial Indexes”.

- Use the `CREATE TABLE` statement to create a table with a spatial column:

  ```
  CREATE TABLE geom (g GEOMETRY);
  ```

- Use the `ALTER TABLE` statement to add or drop a spatial column to or from an existing table:

  ```
  ALTER TABLE geom ADD pt POINT;
  ALTER TABLE geom DROP pt;
  ```

11.17.4.4. Populating Spatial Columns

After you have created spatial columns, you can populate them with spatial data.

Values should be stored in internal geometry format, but you can convert them to that format from either Well-Known Text (WKT) or Well-Known Binary (WKB) format. The following examples demonstrate how to insert geometry values into a table by converting WKT values into internal geometry format:

- Perform the conversion directly in the `INSERT` statement:

  ```
  INSERT INTO geom VALUES (GeomFromText('POINT(1 1)'));

  SET @g = 'POINT(1 1)';
  INSERT INTO geom VALUES (GeomFromText(@g));
  ```

- Perform the conversion prior to the `INSERT`:

  ```
  SET @g = GeomFromText('POINT(1 1)');
  INSERT INTO geom VALUES (@g);
  ```

The following examples insert more complex geometries into the table:

```
SET @g = 'LINESTRING(0 0,1 1,2 2)';
INSERT INTO geom VALUES (GeomFromText(@g));

SET @g = 'POLYGON((0 0,10 0,10 10,0 10,0 0),(5 5,7 5,7 7,5 7, 5 5))';
INSERT INTO geom VALUES (GeomFromText(@g));

SET @g =
'GEOMETRYCOLLECTION(POINT(1 1),LINESTRING(0 0,1 1,2 2,3 3,4 4))';
INSERT INTO geom VALUES (GeomFromText(@g));
```

The preceding examples all use `GeomFromText()` to create geometry values. You can also use type-specific functions:

```
SET @g = 'POINT(1 1)';
INSERT INTO geom VALUES (PointFromText(@g));

SET @g = 'LINESTRING(0 0,1 1,2 2)';
INSERT INTO geom VALUES (LineStringFromText(@g));

SET @g = 'POLYGON((0 0,10 0,10 10,0 10,0 0),(5 5,7 5,7 7,5 7, 5 5))';
INSERT INTO geom VALUES (PolygonFromText(@g));
```

```
SET @g =
'GEOMETRYCOLLECTION(POINT(1 1),LINESTRING(0 0,1 1,2 2,3 3,4 4))';
INSERT INTO geom VALUES (GeomCollFromText(@g));
```

Note that if a client application program wants to use WKB representations of geometry values, it is responsible for sending correctly formed WKB in queries to the server. However, there are several ways of satisfying this requirement. For example:

- Inserting a `POINT(1 1)` value with hex literal syntax:

  ```
  mysql> INSERT INTO geom VALUES
      -> (GeomFromWKB(0x0101000000000000000000F03F000000000000F03F));
  ```

- An ODBC application can send a WKB representation, binding it to a placeholder using an argument of `BLOB` type:

  ```
  INSERT INTO geom VALUES (GeomFromWKB(?))
  ```

  Other programming interfaces may support a similar placeholder mechanism.

- In a C program, you can escape a binary value using `mysql_real_escape_string()` and include the result in a query string that is sent to the server. See Section 20.9.3.53, “`mysql_real_escape_string()`”.

11.17.4.5. Fetching Spatial Data

Geometry values stored in a table can be fetched in internal format. You can also convert them into WKT or WKB format.

- Fetching spatial data in internal format:

  Fetching geometry values using internal format can be useful in table-to-table transfers:

  ```
  CREATE TABLE geom2 (g GEOMETRY) SELECT g FROM geom;
  ```

- Fetching spatial data in WKT format:

  The `AsText()` function converts a geometry from internal format into a WKT string.

  ```
  SELECT AsText(g) FROM geom;
  ```

- Fetching spatial data in WKB format:

  The `AsBinary()` function converts a geometry from internal format into a `BLOB` containing the WKB value.

  ```
  SELECT AsBinary(g) FROM geom;
  ```

11.17.5. Spatial Analysis Functions

After populating spatial columns with values, you are ready to query and analyze them. MySQL provides a set of functions to perform various operations on spatial data. These functions can be grouped into four major categories according to the type of operation they perform:

- Functions that convert geometries between various formats
- Functions that provide access to qualitative or quantitative properties of a geometry
- Functions that describe relations between two geometries
- Functions that create new geometries from existing ones

Spatial analysis functions can be used in many contexts, such as:

- Any interactive SQL program, such as `mysql`.
- Application programs written in any language that supports a MySQL client API

11.17.5.1. Geometry Format Conversion Functions

MySQL supports the following functions for converting geometry values between internal format and either WKT or WKB format:

- `AsBinary(g)`, `AsWKB(g)`

  Converts a value in internal geometry format to its WKB representation and returns the binary result.

  ```
  SELECT AsBinary(g) FROM geom;
  ```

- `AsText(g)`, `AsWKT(g)`

  Converts a value in internal geometry format to its WKT representation and returns the string result.

  ```
  mysql> SET @g = 'LineString(1 1,2 2,3 3)';
  mysql> SELECT AsText(GeomFromText(@g));
  +--------------------------+
  | AsText(GeomFromText(@g)) |
  +--------------------------+
  | LINESTRING(1 1,2 2,3 3)  |
  +--------------------------+
  ```

- `GeomFromText(wkt[,srid])`

  Converts a string value from its WKT representation into internal geometry format and returns the result. A number of type-specific functions are also supported, such as `PointFromText()` and `LineFromText()`. See Section 11.17.4.2.1, “Creating Geometry Values Using WKT Functions”.

- `GeomFromWKB(wkb[,srid])`

  Converts a binary value from its WKB representation into internal geometry format and returns the result. A number of type-specific functions are also supported, such as `PointFromWKB()` and `LineFromWKB()`. See Section 11.17.4.2.2, “Creating Geometry Values Using WKB Functions”.

11.17.5.2. `Geometry` Functions

Each function that belongs to this group takes a geometry value as its argument and returns some quantitative or qualitative property of the geometry. Some functions restrict their argument type. Such functions return `NULL` if the argument is of an incorrect geometry type. For example, `Area()` returns `NULL` if the object type is neither `Polygon` nor `MultiPolygon`.

11.17.5.2.1. General Geometry Functions

The functions listed in this section do not restrict their argument and accept a geometry value of any type.

- `Dimension(g)`

  Returns the inherent dimension of the geometry value *g*. The result can be –1, 0, 1, or 2. The meaning of these values is given in Section 11.17.2.2, “Class `Geometry`”.

  ```
  mysql> SELECT Dimension(GeomFromText('LineString(1 1,2 2)'));
  +------------------------------------------------+
  | Dimension(GeomFromText('LineString(1 1,2 2)')) |
  +------------------------------------------------+
  |                                              1 |
  +------------------------------------------------+
  ```

- `Envelope(g)`

  Returns the Minimum Bounding Rectangle (MBR) for the geometry value *g*. The result is returned as a `Polygon` value.

  The polygon is defined by the corner points of the bounding box:

  ```
  POLYGON((MINX MINY, MAXX MINY, MAXX MAXY, MINX MAXY, MINX MINY))
  ```

  ```
  mysql> SELECT AsText(Envelope(GeomFromText('LineString(1 1,2 2)')));
  +-------------------------------------------------------+
  | AsText(Envelope(GeomFromText('LineString(1 1,2 2)'))) |
  +-------------------------------------------------------+
  | POLYGON((1 1,2 1,2 2,1 2,1 1))                        |
  +-------------------------------------------------------+
  ```

- `GeometryType(g)`

  Returns as a string the name of the geometry type of which the geometry instance *`g`* is a member. The name corresponds to one of the instantiable `Geometry` subclasses.

  ```
  mysql> SELECT GeometryType(GeomFromText('POINT(1 1)'));
  +------------------------------------------+
  | GeometryType(GeomFromText('POINT(1 1)')) |
  +------------------------------------------+
  | POINT                                    |
  +------------------------------------------+
  ```

- `SRID(g)`

  Returns an integer indicating the Spatial Reference System ID for the geometry value *`g`*.

  In MySQL, the SRID value is just an integer associated with the geometry value. All calculations are done assuming Euclidean (planar) geometry.

  ```
  mysql> SELECT SRID(GeomFromText('LineString(1 1,2 2)',101));
  +-----------------------------------------------+
  | SRID(GeomFromText('LineString(1 1,2 2)',101)) |
  +-----------------------------------------------+
  |                                           101 |
  +-----------------------------------------------+
  ```

The OpenGIS specification also defines the following functions, which MySQL does not implement:

- `Boundary(g)`

  Returns a geometry that is the closure of the combinatorial boundary of the geometry value *`g`*.

- `IsEmpty(g)`

  Returns 1 if the geometry value *`g`* is the empty geometry, 0 if it is not empty, and –1 if the argument is `NULL`. If the geometry is empty, it represents the empty point set.

- `IsSimple(g)`

  Currently, this function is a placeholder and should not be used. If implemented, its behavior will be as described in the next paragraph.

  Returns 1 if the geometry value *`g`* has no anomalous geometric points, such as self-intersection or self-tangency. `IsSimple()` returns 0 if the argument is not simple, and –1 if it is `NULL`.

  The description of each instantiable geometric class given earlier in the chapter includes the specific conditions that cause an instance of that class to be classified as not simple. (See Section 11.17.2.1, “The Geometry Class Hierarchy”.)

11.17.5.2.2. `Point` Functions

A `Point` consists of X and Y coordinates, which may be obtained using the following functions:

- `X(p)`

  Returns the X-coordinate value for the `Point` object *`p`* as a double-precision number.

  ```
  mysql> SELECT X(POINT(56.7, 53.34));
  +-----------------------+
  | X(POINT(56.7, 53.34)) |
  +-----------------------+
  |                  56.7 |
  +-----------------------+
  ```

- `Y(p)`

  Returns the Y-coordinate value for the `Point` object *`p`* as a double-precision number.

  ```
  mysql> SELECT Y(POINT(56.7, 53.34));
  +-----------------------+
  | Y(POINT(56.7, 53.34)) |
  +-----------------------+
  |                 53.34 |
  ```

```
+-----------------------+
```

11.17.5.2.3. `LineString` Functions

A `LineString` consists of `Point` values. You can extract particular points of a `LineString`, count the number of points that it contains, or obtain its length.

- `EndPoint(ls)`

  Returns the `Point` that is the endpoint of the `LineString` value *`ls`*.

  ```
  mysql> SET @ls = 'LineString(1 1,2 2,3 3)';
  mysql> SELECT AsText(EndPoint(GeomFromText(@ls)));
  +-------------------------------------+
  | AsText(EndPoint(GeomFromText(@ls))) |
  +-------------------------------------+
  | POINT(3 3)                          |
  +-------------------------------------+
  ```

- `GLength(ls)`

  Returns as a double-precision number the length of the `LineString` value *`ls`* in its associated spatial reference.

  ```
  mysql> SET @ls = 'LineString(1 1,2 2,3 3)';
  mysql> SELECT GLength(GeomFromText(@ls));
  +----------------------------+
  | GLength(GeomFromText(@ls)) |
  +----------------------------+
  |            2.8284271247462 |
  +----------------------------+
  ```

  `GLength()` is a nonstandard name. It corresponds to the OpenGIS `Length()` function.

- `NumPoints(ls)`

  Returns the number of `Point` objects in the `LineString` value *`ls`*.

  ```
  mysql> SET @ls = 'LineString(1 1,2 2,3 3)';
  mysql> SELECT NumPoints(GeomFromText(@ls));
  +------------------------------+
  | NumPoints(GeomFromText(@ls)) |
  +------------------------------+
  |                            3 |
  +------------------------------+
  ```

- `PointN(ls,N)`

  Returns the *`N`*-th `Point` in the `Linestring` value *`ls`*. Points are numbered beginning with 1.

  ```
  mysql> SET @ls = 'LineString(1 1,2 2,3 3)';
  mysql> SELECT AsText(PointN(GeomFromText(@ls),2));
  +-------------------------------------+
  | AsText(PointN(GeomFromText(@ls),2)) |
  +-------------------------------------+
  | POINT(2 2)                          |
  +-------------------------------------+
  ```

- `StartPoint(ls)`

  Returns the `Point` that is the start point of the `LineString` value *`ls`*.

  ```
  mysql> SET @ls = 'LineString(1 1,2 2,3 3)';
  mysql> SELECT AsText(StartPoint(GeomFromText(@ls)));
  +---------------------------------------+
  | AsText(StartPoint(GeomFromText(@ls))) |
  +---------------------------------------+
  | POINT(1 1)                            |
  +---------------------------------------+
  ```

The OpenGIS specification also defines the following function, which MySQL does not implement:

- `IsRing(ls)`

Returns 1 if the `LineString` value *`ls`* is closed (that is, its `StartPoint()` and `EndPoint()` values are the same) and is simple (does not pass through the same point more than once). Returns 0 if *`ls`* is not a ring, and –1 if it is `NULL`.

11.17.5.2.4. `MultiLineString` Functions

These functions return properties of `MultiLineString` values.

- `GLength(`*`mls`*`)`

  Returns as a double-precision number the length of the `MultiLineString` value *`mls`*. The length of *`mls`* is equal to the sum of the lengths of its elements.

  ```
  mysql> SET @mls = 'MultiLineString((1 1,2 2,3 3),(4 4,5 5))';
  mysql> SELECT GLength(GeomFromText(@mls));
  +-----------------------------+
  | GLength(GeomFromText(@mls)) |
  +-----------------------------+
  |             4.2426406871193 |
  +-----------------------------+
  ```

  `GLength()` is a nonstandard name. It corresponds to the OpenGIS `Length()` function.

- `IsClosed(`*`mls`*`)`

  Returns 1 if the `MultiLineString` value *`mls`* is closed (that is, the `StartPoint()` and `EndPoint()` values are the same for each `LineString` in *`mls`*). Returns 0 if *`mls`* is not closed, and –1 if it is `NULL`.

  ```
  mysql> SET @mls = 'MultiLineString((1 1,2 2,3 3),(4 4,5 5))';
  mysql> SELECT IsClosed(GeomFromText(@mls));
  +------------------------------+
  | IsClosed(GeomFromText(@mls)) |
  +------------------------------+
  |                            0 |
  +------------------------------+
  ```

11.17.5.2.5. `Polygon` Functions

These functions return properties of `Polygon` values.

- `Area(`*`poly`*`)`

  Returns as a double-precision number the area of the `Polygon` value *`poly`*, as measured in its spatial reference system.

  ```
  mysql> SET @poly = 'Polygon((0 0,0 3,3 0,0 0),(1 1,1 2,2 1,1 1))';
  mysql> SELECT Area(GeomFromText(@poly));
  +---------------------------+
  | Area(GeomFromText(@poly)) |
  +---------------------------+
  |                         4 |
  +---------------------------+
  ```

- `ExteriorRing(`*`poly`*`)`

  Returns the exterior ring of the `Polygon` value *`poly`* as a `LineString`.

  ```
  mysql> SET @poly =
      -> 'Polygon((0 0,0 3,3 3,3 0,0 0),(1 1,1 2,2 2,2 1,1 1))';
  mysql> SELECT AsText(ExteriorRing(GeomFromText(@poly)));
  +-------------------------------------------+
  | AsText(ExteriorRing(GeomFromText(@poly))) |
  +-------------------------------------------+
  | LINESTRING(0 0,0 3,3 3,3 0,0 0)           |
  +-------------------------------------------+
  ```

- `InteriorRingN(`*`poly`*`,`*`N`*`)`

  Returns the *`N`*-th interior ring for the `Polygon` value *`poly`* as a `LineString`. Rings are numbered beginning with 1.

  ```
  mysql> SET @poly =
      -> 'Polygon((0 0,0 3,3 3,3 0,0 0),(1 1,1 2,2 2,2 1,1 1))';
  mysql> SELECT AsText(InteriorRingN(GeomFromText(@poly),1));
  +----------------------------------------------+
  | AsText(InteriorRingN(GeomFromText(@poly),1)) |
  ```

```
+-----------------------------------------------+
| LINESTRING(1 1,1 2,2 2,2 1,1 1)               |
+-----------------------------------------------+
```

- `NumInteriorRings(poly)`

  Returns the number of interior rings in the `Polygon` value *`poly`*.

  ```
  mysql> SET @poly =
      -> 'Polygon((0 0,0 3,3 3,3 0,0 0),(1 1,1 2,2 2,2 1,1 1))';
  mysql> SELECT NumInteriorRings(GeomFromText(@poly));
  +---------------------------------------+
  | NumInteriorRings(GeomFromText(@poly)) |
  +---------------------------------------+
  |                                     1 |
  +---------------------------------------+
  ```

11.17.5.2.6. `MultiPolygon` Functions

These functions return properties of `MultiPolygon` values.

- `Area(mpoly)`

  Returns as a double-precision number the area of the `MultiPolygon` value *`mpoly`*, as measured in its spatial reference system.

  ```
  mysql> SET @mpoly =
      -> 'MultiPolygon(((0 0,0 3,3 3,3 0,0 0),(1 1,1 2,2 2,2 1,1 1)))';
  mysql> SELECT Area(GeomFromText(@mpoly));
  +----------------------------+
  | Area(GeomFromText(@mpoly)) |
  +----------------------------+
  |                          8 |
  +----------------------------+
  ```

The OpenGIS specification also defines the following functions, which MySQL does not implement:

- `Centroid(mpoly)`

  Returns the mathematical centroid for the `MultiPolygon` value *`mpoly`* as a `Point`. The result is not guaranteed to be on the `MultiPolygon`.

- `PointOnSurface(mpoly)`

  Returns a `Point` value that is guaranteed to be on the `MultiPolygon` value *`mpoly`*.

11.17.5.2.7. `GeometryCollection` Functions

These functions return properties of `GeometryCollection` values.

- `GeometryN(gc,N)`

  Returns the *`N`*-th geometry in the `GeometryCollection` value *`gc`*. Geometries are numbered beginning with 1.

  ```
  mysql> SET @gc = 'GeometryCollection(Point(1 1),LineString(2 2, 3 3))';
  mysql> SELECT AsText(GeometryN(GeomFromText(@gc),1));
  +----------------------------------------+
  | AsText(GeometryN(GeomFromText(@gc),1)) |
  +----------------------------------------+
  | POINT(1 1)                             |
  +----------------------------------------+
  ```

- `NumGeometries(gc)`

  Returns the number of geometries in the `GeometryCollection` value *`gc`*.

  ```
  mysql> SET @gc = 'GeometryCollection(Point(1 1),LineString(2 2, 3 3))';
  mysql> SELECT NumGeometries(GeomFromText(@gc));
  +----------------------------------+
  | NumGeometries(GeomFromText(@gc)) |
  +----------------------------------+
  ```

```
|                                2 |
+----------------------------------+
```

11.17.5.3. Functions That Create New Geometries from Existing Ones

The following sections describe functions that take geometry values as arguments and return new geometry values.

11.17.5.3.1. Geometry Functions That Produce New Geometries

Section 11.17.5.2, "`Geometry` Functions", discusses several functions that construct new geometries from existing ones. See that section for descriptions of these functions:

- `Envelope(g)`
- `StartPoint(ls)`
- `EndPoint(ls)`
- `PointN(ls,N)`
- `ExteriorRing(poly)`
- `InteriorRingN(poly,N)`
- `GeometryN(gc,N)`

11.17.5.3.2. Spatial Operators

OpenGIS proposes a number of other functions that can produce geometries. They are designed to implement spatial operators.

These functions are not implemented in MySQL.

- `Buffer(g,d)`

  Returns a geometry that represents all points whose distance from the geometry value `g` is less than or equal to a distance of `d`.
- `ConvexHull(g)`

  Returns a geometry that represents the convex hull of the geometry value `g`.
- `Difference(g1,g2)`

  Returns a geometry that represents the point set difference of the geometry value `g1` with `g2`.
- `Intersection(g1,g2)`

  Returns a geometry that represents the point set intersection of the geometry values `g1` with `g2`.
- `SymDifference(g1,g2)`

  Returns a geometry that represents the point set symmetric difference of the geometry value `g1` with `g2`.
- `Union(g1,g2)`

  Returns a geometry that represents the point set union of the geometry values `g1` and `g2`.

11.17.5.4. Functions for Testing Spatial Relations Between Geometric Objects

The functions described in these sections take two geometries as input parameters and return a qualitative or quantitative relation between them.

11.17.5.4.1. Relations on Geometry Minimal Bounding Rectangles (MBRs)

MySQL provides several functions that test relations between minimal bounding rectangles of two geometries `g1` and `g2`. The return values 1 and 0 indicate true and false, respectively.

- `MBRContains(g1,g2)`

  Returns 1 or 0 to indicate whether the Minimum Bounding Rectangle of *`g1`* contains the Minimum Bounding Rectangle of *`g2`*. This tests the opposite relationship as `MBRWithin()`.

  ```
  mysql> SET @g1 = GeomFromText('Polygon((0 0,0 3,3 3,3 0,0 0))');
  mysql> SET @g2 = GeomFromText('Point(1 1)');
  mysql> SELECT MBRContains(@g1,@g2), MBRContains(@g2,@g1);
  ----------------------+----------------------+
  | MBRContains(@g1,@g2) | MBRContains(@g2,@g1) |
  +----------------------+----------------------+
  |                    1 |                    0 |
  +----------------------+----------------------+
  ```

- `MBRDisjoint(g1,g2)`

  Returns 1 or 0 to indicate whether the Minimum Bounding Rectangles of the two geometries *`g1`* and *`g2`* are disjoint (do not intersect).

- `MBREqual(g1,g2)`

  Returns 1 or 0 to indicate whether the Minimum Bounding Rectangles of the two geometries *`g1`* and *`g2`* are the same.

- `MBRIntersects(g1,g2)`

  Returns 1 or 0 to indicate whether the Minimum Bounding Rectangles of the two geometries *`g1`* and *`g2`* intersect.

- `MBROverlaps(g1,g2)`

  Returns 1 or 0 to indicate whether the Minimum Bounding Rectangles of the two geometries *`g1`* and *`g2`* overlap. The term *spatially overlaps* is used if two geometries intersect and their intersection results in a geometry of the same dimension but not equal to either of the given geometries.

- `MBRTouches(g1,g2)`

  Returns 1 or 0 to indicate whether the Minimum Bounding Rectangles of the two geometries *`g1`* and *`g2`* touch. Two geometries *spatially touch* if the interiors of the geometries do not intersect, but the boundary of one of the geometries intersects either the boundary or the interior of the other.

- `MBRWithin(g1,g2)`

  Returns 1 or 0 to indicate whether the Minimum Bounding Rectangle of *`g1`* is within the Minimum Bounding Rectangle of *`g2`*. This tests the opposite relationship as `MBRContains()`.

  ```
  mysql> SET @g1 = GeomFromText('Polygon((0 0,0 3,3 3,3 0,0 0))');
  mysql> SET @g2 = GeomFromText('Polygon((0 0,0 5,5 5,5 0,0 0))');
  mysql> SELECT MBRWithin(@g1,@g2), MBRWithin(@g2,@g1);
  +--------------------+--------------------+
  | MBRWithin(@g1,@g2) | MBRWithin(@g2,@g1) |
  +--------------------+--------------------+
  |                  1 |                  0 |
  +--------------------+--------------------+
  ```

11.17.5.4.2. Functions That Test Spatial Relationships Between Geometries

The OpenGIS specification defines the following functions. They test the relationship between two geometry values `g1` and `g2`.

The return values 1 and 0 indicate true and false, respectively.

> **Note**
>
> Currently, MySQL does not implement these functions according to the specification. Those that are implemented return the same result as the corresponding MBR-based functions.

- `Contains(g1,g2)`

  Returns 1 or 0 to indicate whether *`g1`* completely contains *`g2`*. This tests the opposite relationship as `Within()`.

- `Crosses(g1,g2)`

  Returns 1 if *`g1`* spatially crosses *`g2`*. Returns `NULL` if `g1` is a `Polygon` or a `MultiPolygon`, or if *`g2`* is a `Point` or a `MultiPoint`. Otherwise, returns 0.

The term *spatially crosses* denotes a spatial relation between two given geometries that has the following properties:

- The two geometries intersect
- Their intersection results in a geometry that has a dimension that is one less than the maximum dimension of the two given geometries
- Their intersection is not equal to either of the two given geometries

- `Disjoint(g1,g2)`

  Returns 1 or 0 to indicate whether `g1` is spatially disjoint from (does not intersect) `g2`.

- `Equals(g1,g2)`

  Returns 1 or 0 to indicate whether `g1` is spatially equal to `g2`.

- `Intersects(g1,g2)`

  Returns 1 or 0 to indicate whether `g1` spatially intersects `g2`.

- `Overlaps(g1,g2)`

  Returns 1 or 0 to indicate whether `g1` spatially overlaps `g2`. The term *spatially overlaps* is used if two geometries intersect and their intersection results in a geometry of the same dimension but not equal to either of the given geometries.

- `Touches(g1,g2)`

  Returns 1 or 0 to indicate whether `g1` spatially touches `g2`. Two geometries *spatially touch* if the interiors of the geometries do not intersect, but the boundary of one of the geometries intersects either the boundary or the interior of the other.

- `Within(g1,g2)`

  Returns 1 or 0 to indicate whether `g1` is spatially within `g2`. This tests the opposite relationship as `Contains()`.

11.17.6. Optimizing Spatial Analysis

For `MyISAM` tables, Search operations in nonspatial databases can be optimized using `SPATIAL` indexes. This is true for spatial databases as well. With the help of a great variety of multi-dimensional indexing methods that have previously been designed, it is possible to optimize spatial searches. The most typical of these are:

- Point queries that search for all objects that contain a given point
- Region queries that search for all objects that overlap a given region

MySQL uses **R-Trees with quadratic splitting** for `SPATIAL` indexes on spatial columns. A `SPATIAL` index is built using the MBR of a geometry. For most geometries, the MBR is a minimum rectangle that surrounds the geometries. For a horizontal or a vertical linestring, the MBR is a rectangle degenerated into the linestring. For a point, the MBR is a rectangle degenerated into the point.

It is also possible to create normal indexes on spatial columns. In a non-`SPATIAL` index, you must declare a prefix for any spatial column except for `POINT` columns.

`MyISAM` supports both `SPATIAL` and non-`SPATIAL` indexes. Other storage engines support non-`SPATIAL` indexes, as described in Section 12.1.11, “`CREATE INDEX` Syntax”.

11.17.6.1. Creating Spatial Indexes

For `MyISAM` tables, MySQL can create spatial indexes using syntax similar to that for creating regular indexes, but extended with the `SPATIAL` keyword. Currently, columns in spatial indexes must be declared `NOT NULL`. The following examples demonstrate how to create spatial indexes:

- With `CREATE TABLE`:

  ```
  CREATE TABLE geom (g GEOMETRY NOT NULL, SPATIAL INDEX(g)) ENGINE=MyISAM;
  ```

- With `ALTER TABLE`:

  ```
  ALTER TABLE geom ADD SPATIAL INDEX(g);
  ```

- With `CREATE INDEX`:

  ```
  CREATE SPATIAL INDEX sp_index ON geom (g);
  ```

For `MyISAM` tables, `SPATIAL INDEX` creates an R-tree index. For storage engines that support nonspatial indexing of spatial columns, the engine creates a B-tree index. A B-tree index on spatial values will be useful for exact-value lookups, but not for range scans.

For more information on indexing spatial columns, see Section 12.1.11, “`CREATE INDEX` Syntax”.

To drop spatial indexes, use `ALTER TABLE` or `DROP INDEX`:

- With `ALTER TABLE`:

  ```
  ALTER TABLE geom DROP INDEX g;
  ```

- With `DROP INDEX`:

  ```
  DROP INDEX sp_index ON geom;
  ```

Example: Suppose that a table `geom` contains more than 32,000 geometries, which are stored in the column `g` of type `GEOMETRY`. The table also has an `AUTO_INCREMENT` column `fid` for storing object ID values.

```
mysql> DESCRIBE geom;
+-------+----------+------+-----+---------+----------------+
| Field | Type     | Null | Key | Default | Extra          |
+-------+----------+------+-----+---------+----------------+
| fid   | int(11)  |      | PRI | NULL    | auto_increment |
| g     | geometry |      |     |         |                |
+-------+----------+------+-----+---------+----------------+
2 rows in set (0.00 sec)

mysql> SELECT COUNT(*) FROM geom;
+----------+
| count(*) |
+----------+
|    32376 |
+----------+
1 row in set (0.00 sec)
```

To add a spatial index on the column `g`, use this statement:

```
mysql> ALTER TABLE geom ADD SPATIAL INDEX(g);
Query OK, 32376 rows affected (4.05 sec)
Records: 32376  Duplicates: 0  Warnings: 0
```

11.17.6.2. Using a Spatial Index

The optimizer investigates whether available spatial indexes can be involved in the search for queries that use a function such as `MBRContains()` or `MBRWithin()` in the `WHERE` clause. The following query finds all objects that are in the given rectangle:

```
mysql> SET @poly =
    -> 'Polygon((30000 15000,
                 31000 15000,
                 31000 16000,
                 30000 16000,
                 30000 15000))';
mysql> SELECT fid,AsText(g) FROM geom WHERE
    -> MBRContains(GeomFromText(@poly),g);
+-----+---------------------------------------------------------------+
| fid | AsText(g)                                                     |
+-----+---------------------------------------------------------------+
|  21 | LINESTRING(30350.4 15828.8,30350.6 15845,30333.8 15845,30 ... |
|  22 | LINESTRING(30350.6 15871.4,30350.6 15887.8,30334 15887.8, ... |
|  23 | LINESTRING(30350.6 15914.2,30350.6 15930.4,30334 15930.4, ... |
|  24 | LINESTRING(30290.2 15823,30290.2 15839.4,30273.4 15839.4, ... |
|  25 | LINESTRING(30291.4 15866.2,30291.6 15882.4,30274.8 15882. ... |
|  26 | LINESTRING(30291.6 15918.2,30291.6 15934.4,30275 15934.4, ... |
| 249 | LINESTRING(30337.8 15938.6,30337.8 15946.8,30320.4 15946. ... |
|   1 | LINESTRING(30250.4 15129.2,30248.8 15138.4,30238.2 15136. ... |
|   2 | LINESTRING(30220.2 15122.8,30217.2 15137.8,30207.6 15136, ... |
|   3 | LINESTRING(30179 15114.4,30176.6 15129.4,30167 15128,3016 ... |
```

```
|   4 | LINESTRING(30155.2 15121.4,30140.4 15118.6,30142 15109,30 ... |
|   5 | LINESTRING(30192.4 15085,30177.6 15082.2,30179.2 15072.4, ... |
|   6 | LINESTRING(30244 15087,30229 15086.2,30229.4 15076.4,3024 ... |
|   7 | LINESTRING(30200.6 15059.4,30185.6 15058.6,30186 15048.8, ... |
|  10 | LINESTRING(30179.6 15017.8,30181 15002.8,30190.8 15003.6, ... |
|  11 | LINESTRING(30154.2 15000.4,30168.6 15004.8,30166 15014.2, ... |
|  13 | LINESTRING(30105 15065.8,30108.4 15050.8,30118 15053,3011 ... |
| 154 | LINESTRING(30276.2 15143.8,30261.4 15141,30263 15131.4,30 ... |
| 155 | LINESTRING(30269.8 15084,30269.4 15093.4,30258.6 15093,30 ... |
| 157 | LINESTRING(30128.2 15011,30113.2 15010.2,30113.6 15000.4, ... |
+-----+---------------------------------------------------------------+
20 rows in set (0.00 sec)
```

Use `EXPLAIN` to check the way this query is executed:

```
mysql> SET @poly =
    -> 'Polygon((30000 15000,
                               31000 15000,
                               31000 16000,
                               30000 16000,
                               30000 15000))';
mysql> EXPLAIN SELECT fid,AsText(g) FROM geom WHERE
    -> MBRContains(GeomFromText(@poly),g)\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: geom
         type: range
possible_keys: g
          key: g
      key_len: 32
          ref: NULL
         rows: 50
        Extra: Using where
1 row in set (0.00 sec)
```

Check what would happen without a spatial index:

```
mysql> SET @poly =
    -> 'Polygon((30000 15000,
                               31000 15000,
                               31000 16000,
                               30000 16000,
                               30000 15000))';
mysql> EXPLAIN SELECT fid,AsText(g) FROM g IGNORE INDEX (g) WHERE
    -> MBRContains(GeomFromText(@poly),g)\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: geom
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 32376
        Extra: Using where
1 row in set (0.00 sec)
```

Executing the `SELECT` statement without the spatial index yields the same result but causes the execution time to rise from 0.00 seconds to 0.46 seconds:

```
mysql> SET @poly =
    -> 'Polygon((30000 15000,
                               31000 15000,
                               31000 16000,
                               30000 16000,
                               30000 15000))';
mysql> SELECT fid,AsText(g) FROM geom IGNORE INDEX (g) WHERE
    -> MBRContains(GeomFromText(@poly),g);
+-----+---------------------------------------------------------------+
| fid | AsText(g)                                                     |
+-----+---------------------------------------------------------------+
|   1 | LINESTRING(30250.4 15129.2,30248.8 15138.4,30238.2 15136. ... |
|   2 | LINESTRING(30220.2 15122.8,30217.2 15137.8,30207.6 15136, ... |
|   3 | LINESTRING(30179 15114.4,30176.6 15129.4,30167 15128,3016 ... |
|   4 | LINESTRING(30155.2 15121.4,30140.4 15118.6,30142 15109,30 ... |
|   5 | LINESTRING(30192.4 15085,30177.6 15082.2,30179.2 15072.4, ... |
|   6 | LINESTRING(30244 15087,30229 15086.2,30229.4 15076.4,3024 ... |
|   7 | LINESTRING(30200.6 15059.4,30185.6 15058.6,30186 15048.8, ... |
|  10 | LINESTRING(30179.6 15017.8,30181 15002.8,30190.8 15003.6, ... |
|  11 | LINESTRING(30154.2 15000.4,30168.6 15004.8,30166 15014.2, ... |
|  13 | LINESTRING(30105 15065.8,30108.4 15050.8,30118 15053,3011 ... |
|  21 | LINESTRING(30350.4 15828.8,30350.6 15845,30333.8 15845,30 ... |
|  22 | LINESTRING(30350.6 15871.4,30350.6 15887.8,30334 15887.8, ... |
|  23 | LINESTRING(30350.6 15914.2,30350.6 15930.4,30334 15930.4, ... |
|  24 | LINESTRING(30290.2 15823,30290.2 15839.4,30273.4 15839.4, ... |
|  25 | LINESTRING(30291.4 15866.2,30291.6 15882.4,30274.8 15882. ... |
|  26 | LINESTRING(30291.6 15918.2,30291.6 15934.4,30275 15934.4, ... |
| 154 | LINESTRING(30276.2 15143.8,30261.4 15141,30263 15131.4,30 ... |
| 155 | LINESTRING(30269.8 15084,30269.4 15093.4,30258.6 15093,30 ... |
| 157 | LINESTRING(30128.2 15011,30113.2 15010.2,30113.6 15000.4, ... |
| 249 | LINESTRING(30337.8 15938.6,30337.8 15946.8,30320.4 15946. ... |
+-----+---------------------------------------------------------------+
20 rows in set (0.46 sec)
```

11.17.7. MySQL Conformance and Compatibility

MySQL does not yet implement the following GIS features:

- Additional Metadata Views

  OpenGIS specifications propose several additional metadata views. For example, a system view named `GEOMETRY_COLUMNS` contains a description of geometry columns, one row for each geometry column in the database.

- The OpenGIS function `Length()` on `LineString` and `MultiLineString` currently should be called in MySQL as `GLength()`

  The problem is that there is an existing SQL function `Length()` that calculates the length of string values, and sometimes it is not possible to distinguish whether the function is called in a textual or spatial context. We need either to solve this somehow, or decide on another function name.

11.18. Precision Math

MySQL 5.5 provides support for precision math: numeric value handling that results in extremely accurate results and a high degree control over invalid values. Precision math is based on these two features:

- SQL modes that control how strict the server is about accepting or rejecting invalid data.
- The MySQL library for fixed-point arithmetic.

These features have several implications for numeric operations and provide a high degree of compliance with standard SQL:

- **Precise calculations**: For exact-value numbers, calculations do not introduce floating-point errors. Instead, exact precision is used. For example, MySQL treats a number such as `.0001` as an exact value rather than as an approximation, and summing it 10,000 times produces a result of exactly `1`, not a value that is merely “close” to 1.
- **Well-defined rounding behavior**: For exact-value numbers, the result of `ROUND()` depends on its argument, not on environmental factors such as how the underlying C library works.
- **Platform independence**: Operations on exact numeric values are the same across different platforms such as Windows and Unix.
- **Control over handling of invalid values**: Overflow and division by zero are detectable and can be treated as errors. For example, you can treat a value that is too large for a column as an error rather than having the value truncated to lie within the range of the column's data type. Similarly, you can treat division by zero as an error rather than as an operation that produces a result of `NULL`. The choice of which approach to take is determined by the setting of the server SQL mode.

The following discussion covers several aspects of how precision math works, including possible incompatibilities with older applications. At the end, some examples are given that demonstrate how MySQL 5.5 handles numeric operations precisely. For information about controlling the SQL mode, see Section 5.1.6, “Server SQL Modes”.

11.18.1. Types of Numeric Values

The scope of precision math for exact-value operations includes the exact-value data types (`DECIMAL` and integer types) and exact-value numeric literals. Approximate-value data types and numeric literals are handled as floating-point numbers.

Exact-value numeric literals have an integer part or fractional part, or both. They may be signed. Examples: `1`, `.2`, `3.4`, `-5`, `-6.78`, `+9.10`.

Approximate-value numeric literals are represented in scientific notation with a mantissa and exponent. Either or both parts may be signed. Examples: `1.2E3`, `1.2E-3`, `-1.2E3`, `-1.2E-3`.

Two numbers that look similar may be treated differently. For example, `2.34` is an exact-value (fixed-point) number, whereas `2.34E0` is an approximate-value (floating-point) number.

The `DECIMAL` data type is a fixed-point type and calculations are exact. In MySQL, the `DECIMAL` type has several synonyms: `NUMERIC`, `DEC`, `FIXED`. The integer types also are exact-value types.

The `FLOAT` and `DOUBLE` data types are floating-point types and calculations are approximate. In MySQL, types that are synonymous with `FLOAT` or `DOUBLE` are `DOUBLE PRECISION` and `REAL`.

11.18.2. `DECIMAL` Data Type Changes

This section discusses the characteristics of the `DECIMAL` data type (and its synonyms) in MySQL 5.5, with particular regard to the following topics:

- Maximum number of digits
- Storage format
- Storage requirements
- The nonstandard MySQL extension to the upper range of `DECIMAL` columns

Possible incompatibilities with applications that are written for older versions of MySQL (prior to 5.0.3) are noted throughout this section.

The declaration syntax for a `DECIMAL` column is `DECIMAL(M,D)`. The ranges of values for the arguments in MySQL 5.5 are as follows:

- `M` is the maximum number of digits (the precision). It has a range of 1 to 65. (Older versions of MySQL permitted a range of 1 to 254.)
- `D` is the number of digits to the right of the decimal point (the scale). It has a range of 0 to 30 and must be no larger than `M`.

The maximum value of 65 for `M` means that calculations on `DECIMAL` values are accurate up to 65 digits. This limit of 65 digits of precision also applies to exact-value numeric literals, so the maximum range of such literals differs from before. (In older versions of MySQL, decimal values could have up to 254 digits. However, calculations were done using floating-point and thus were approximate, not exact.)

Values for `DECIMAL` columns in MySQL 5.5 are stored using a binary format that packs nine decimal digits into 4 bytes. The storage requirements for the integer and fractional parts of each value are determined separately. Each multiple of nine digits requires 4 bytes, and any remaining digits left over require some fraction of 4 bytes. The storage required for remaining digits is given by the following table.

Leftover Digits	**Number of Bytes**
0	0
1–2	1
3–4	2
5–6	3
7–9	4

For example, a `DECIMAL(18,9)` column has nine digits on either side of the decimal point, so the integer part and the fractional part each require 4 bytes. A `DECIMAL(20,6)` column has fourteen integer digits and six fractional digits. The integer digits require four bytes for nine of the digits and 3 bytes for the remaining five digits. The six fractional digits require 3 bytes.

Unlike some older versions of MySQL, `DECIMAL` columns in MySQL 5.5 do not store a leading `+` character or `-` character or leading `0` digits. If you insert `+0003.1` into a `DECIMAL(5,1)` column, it is stored as `3.1`. For negative numbers, a literal `-` character is not stored. Applications that rely on the older behavior must be modified to account for this change.

`DECIMAL` columns in MySQL 5.5 do not permit values larger than the range implied by the column definition. For example, a `DECIMAL(3,0)` column supports a range of `-999` to `999`. A `DECIMAL(M,D)` column permits at most `M` - `D` digits to the left of the decimal point. This is not compatible with applications relying on older versions of MySQL that permitted storing an extra digit in lieu of a `+` sign.

The SQL standard requires that the precision of `NUMERIC(M,D)` be *exactly* `M` digits. For `DECIMAL(M,D)`, the standard requires a precision of at least `M` digits but permits more. In MySQL, `DECIMAL(M,D)` and `NUMERIC(M,D)` are the same, and both have a precision of exactly `M` digits.

For more detailed information about porting applications that rely on the old treatment of the `DECIMAL` data type, see the *MySQL 5.0 Reference Manual*.

11.18.3. Expression Handling

With precision math, exact-value numbers are used as given whenever possible. For example, numbers in comparisons are used exactly as given without a change in value. In strict SQL mode, for `INSERT` into a column with an exact data type (`DECIMAL` or integer), a number is inserted with its exact value if it is within the column range. When retrieved, the value should be the same as what was inserted. (Without strict mode, truncation for `INSERT` is permissible.)

Handling of a numeric expression depends on what kind of values the expression contains:

- If any approximate values are present, the expression is approximate and is evaluated using floating-point arithmetic.
- If no approximate values are present, the expression contains only exact values. If any exact value contains a fractional part (a value following the decimal point), the expression is evaluated using `DECIMAL` exact arithmetic and has a precision of 65 digits. The term “exact” is subject to the limits of what can be represented in binary. For example, `1.0/3.0` can be approximated in decimal notation as `.333...`, but not written as an exact number, so `(1.0/3.0)*3.0` does not evaluate to exactly `1.0`.
- Otherwise, the expression contains only integer values. The expression is exact and is evaluated using integer arithmetic and has a precision the same as `BIGINT` (64 bits).

If a numeric expression contains any strings, they are converted to double-precision floating-point values and the expression is approximate.

Inserts into numeric columns are affected by the SQL mode, which is controlled by the `sql_mode` system variable. (See Section 5.1.6, “Server SQL Modes”.) The following discussion mentions strict mode (selected by the `STRICT_ALL_TABLES` or `STRICT_TRANS_TABLES` mode values) and `ERROR_FOR_DIVISION_BY_ZERO`. To turn on all restrictions, you can simply use `TRADITIONAL` mode, which includes both strict mode values and `ERROR_FOR_DIVISION_BY_ZERO`:

```
mysql> SET sql_mode='TRADITIONAL';
```

If a number is inserted into an exact type column (`DECIMAL` or integer), it is inserted with its exact value if it is within the column range.

If the value has too many digits in the fractional part, rounding occurs and a warning is generated. Rounding is done as described in Section 11.18.4, “Rounding Behavior”.

If the value has too many digits in the integer part, it is too large and is handled as follows:

- If strict mode is not enabled, the value is truncated to the nearest legal value and a warning is generated.
- If strict mode is enabled, an overflow error occurs.

Underflow is not detected, so underflow handing is undefined.

By default, division by zero produces a result of `NULL` and no warning. With the `ERROR_FOR_DIVISION_BY_ZERO` SQL mode enabled, MySQL handles division by zero differently:

- If strict mode is not enabled, a warning occurs.
- If strict mode is enabled, inserts and updates involving division by zero are prohibited, and an error occurs.

In other words, inserts and updates involving expressions that perform division by zero can be treated as errors, but this requires `ERROR_FOR_DIVISION_BY_ZERO` in addition to strict mode.

Suppose that we have this statement:

```
INSERT INTO t SET i = 1/0;
```

This is what happens for combinations of strict and `ERROR_FOR_DIVISION_BY_ZERO` modes.

`sql_mode` Value	Result
`''` (Default)	No warning, no error; `i` is set to `NULL`.
strict	No warning, no error; `i` is set to `NULL`.
`ERROR_FOR_DIVISION_BY_ZERO`	Warning, no error; `i` is set to `NULL`.
strict,`ERROR_FOR_DIVISION_BY_ZERO`	Error condition; no row is inserted.

For inserts of strings into numeric columns, conversion from string to number is handled as follows if the string has nonnumeric contents:

- A string that does not begin with a number cannot be used as a number and produces an error in strict mode, or a warning otherwise. This includes the empty string.
- A string that begins with a number can be converted, but the trailing nonnumeric portion is truncated. If the truncated portion contains anything other than spaces, this produces an error in strict mode, or a warning otherwise.

11.18.4. Rounding Behavior

This section discusses precision math rounding for the `ROUND()` function and for inserts into columns with exact-value types (`DECIMAL` and integer).

The `ROUND()` function rounds differently depending on whether its argument is exact or approximate:

- For exact-value numbers, `ROUND()` uses the “round half up” rule: A value with a fractional part of .5 or greater is rounded up to the next integer if positive or down to the next integer if negative. (In other words, it is rounded away from zero.) A value with a fractional part less than .5 is rounded down to the next integer if positive or up to the next integer if negative.
- For approximate-value numbers, the result depends on the C library. On many systems, this means that `ROUND()` uses the “round to nearest even” rule: A value with any fractional part is rounded to the nearest even integer.

The following example shows how rounding differs for exact and approximate values:

```
mysql> SELECT ROUND(2.5), ROUND(25E-1);
+------------+--------------+
| ROUND(2.5) | ROUND(25E-1) |
+------------+--------------+
| 3          |            2 |
+------------+--------------+
```

For inserts into a `DECIMAL` or integer column, the target is an exact data type, so rounding uses “round half up,” regardless of whether the value to be inserted is exact or approximate:

```
mysql> CREATE TABLE t (d DECIMAL(10,0));
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO t VALUES(2.5),(2.5E0);
Query OK, 2 rows affected, 2 warnings (0.00 sec)
Records: 2  Duplicates: 0  Warnings: 2

mysql> SELECT d FROM t;
+------+
| d    |
+------+
| 3    |
| 3    |
+------+
```

11.18.5. Precision Math Examples

This section provides some examples that show precision math query results in MySQL 5.5. These examples demonstrate the principles described in Section 11.18.3, “Expression Handling”, and Section 11.18.4, “Rounding Behavior”.

Example 1. Numbers are used with their exact value as given when possible:

```
mysql> SELECT (.1 + .2) = .3;
+----------------+
| (.1 + .2) = .3 |
+----------------+
|              1 |
+----------------+
```

For floating-point values, results are inexact:

```
mysql> SELECT (.1E0 + .2E0) = .3E0;
+----------------------+
| (.1E0 + .2E0) = .3E0 |
+----------------------+
|                    0 |
+----------------------+
```

Another way to see the difference in exact and approximate value handling is to add a small number to a sum many times. Consider the following stored procedure, which adds `.0001` to a variable 1,000 times.

```
CREATE PROCEDURE p ()
BEGIN
  DECLARE i INT DEFAULT 0;
  DECLARE d DECIMAL(10,4) DEFAULT 0;
  DECLARE f FLOAT DEFAULT 0;
  WHILE i < 10000 DO
    SET d = d + .0001;
    SET f = f + .0001E0;
    SET i = i + 1;
  END WHILE;
  SELECT d, f;
END;
```

The sum for both `d` and `f` logically should be 1, but that is true only for the decimal calculation. The floating-point calculation introduces small errors:

```
+--------+------------------+
| d      | f                |
+--------+------------------+
| 1.0000 | 0.99999999999991 |
+--------+------------------+
```

Example 2. Multiplication is performed with the scale required by standard SQL. That is, for two numbers *`X1`* and *`X2`* that have scale *`S1`* and *`S2`*, the scale of the result is *`S1 + S2`*:

```
mysql> SELECT .01 * .01;
+-----------+
| .01 * .01 |
+-----------+
| 0.0001    |
+-----------+
```

Example 3. Rounding behavior for exact-value numbers is well-defined:

Rounding behavior (for example, with the `ROUND()` function) is independent of the implementation of the underlying C library, which means that results are consistent from platform to platform.

- Rounding for exact-value columns (`DECIMAL` and integer) and exact-valued numbers uses the “round half up” rule. Values with a fractional part of .5 or greater are rounded away from zero to the nearest integer, as shown here:

  ```
  mysql> SELECT ROUND(2.5), ROUND(-2.5);
  +------------+-------------+
  | ROUND(2.5) | ROUND(-2.5) |
  +------------+-------------+
  | 3          | -3          |
  +------------+-------------+
  ```

- Rounding for floating-point values uses the C library, which on many systems uses the “round to nearest even” rule. Values with any fractional part on such systems are rounded to the nearest even integer:

  ```
  mysql> SELECT ROUND(2.5E0), ROUND(-2.5E0);
  +--------------+---------------+
  | ROUND(2.5E0) | ROUND(-2.5E0) |
  +--------------+---------------+
  |            2 |            -2 |
  +--------------+---------------+
  ```

Example 4. In strict mode, inserting a value that is out of range for a column causes an error, rather than truncation to a legal value.

When MySQL is not running in strict mode, truncation to a legal value occurs:

```
mysql> SET sql_mode='';
Query OK, 0 rows affected (0.00 sec)
```

```
mysql> CREATE TABLE t (i TINYINT);
Query OK, 0 rows affected (0.01 sec)

mysql> INSERT INTO t SET i = 128;
Query OK, 1 row affected, 1 warning (0.00 sec)

mysql> SELECT i FROM t;
+------+
| i    |
+------+
|  127 |
+------+
1 row in set (0.00 sec)
```

However, an error occurs if strict mode is in effect:

```
mysql> SET sql_mode='STRICT_ALL_TABLES';
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE TABLE t (i TINYINT);
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO t SET i = 128;
ERROR 1264 (22003): Out of range value adjusted for column 'i' at row 1

mysql> SELECT i FROM t;
Empty set (0.00 sec)
```

Example 5: In strict mode and with `ERROR_FOR_DIVISION_BY_ZERO` set, division by zero causes an error, not a result of `NULL`.

In nonstrict mode, division by zero has a result of `NULL`:

```
mysql> SET sql_mode='';
Query OK, 0 rows affected (0.01 sec)

mysql> CREATE TABLE t (i TINYINT);
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO t SET i = 1 / 0;
Query OK, 1 row affected (0.00 sec)

mysql> SELECT i FROM t;
+------+
| i    |
+------+
| NULL |
+------+
1 row in set (0.03 sec)
```

However, division by zero is an error if the proper SQL modes are in effect:

```
mysql> SET sql_mode='STRICT_ALL_TABLES,ERROR_FOR_DIVISION_BY_ZERO';
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE TABLE t (i TINYINT);
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO t SET i = 1 / 0;
ERROR 1365 (22012): Division by 0

mysql> SELECT i FROM t;
Empty set (0.01 sec)
```

Example 6. Exact-value literals are evaluated as exact values.

Prior to MySQL 5.0.3, exact-value and approximate-value literals both are evaluated as double-precision floating-point values:

```
mysql> SELECT VERSION();
+------------+
| VERSION()  |
+------------+
| 4.1.18-log |
+------------+
1 row in set (0.01 sec)

mysql> CREATE TABLE t SELECT 2.5 AS a, 25E-1 AS b;
Query OK, 1 row affected (0.07 sec)
Records: 1  Duplicates: 0  Warnings: 0

mysql> DESCRIBE t;
+-------+-------------+------+-----+---------+-------+
| Field | Type        | Null | Key | Default | Extra |
+-------+-------------+------+-----+---------+-------+
| a     | double(3,1) |      |     | 0.0     |       |
| b     | double      |      |     | 0       |       |
+-------+-------------+------+-----+---------+-------+
2 rows in set (0.04 sec)
```

As of MySQL 5.0.3, the approximate-value literal is evaluated using floating point, but the exact-value literal is handled as `DECIMAL`:

```
mysql> SELECT VERSION();
+-----------------+
| VERSION()       |
+-----------------+
| 5.1.6-alpha-log |
+-----------------+
1 row in set (0.11 sec)

mysql> CREATE TABLE t SELECT 2.5 AS a, 25E-1 AS b;
Query OK, 1 row affected (0.01 sec)
Records: 1  Duplicates: 0  Warnings: 0

mysql> DESCRIBE t;
+-------+-----------------------+------+-----+---------+-------+
| Field | Type                  | Null | Key | Default | Extra |
+-------+-----------------------+------+-----+---------+-------+
| a     | decimal(2,1) unsigned | NO   |     | 0.0     |       |
| b     | double                | NO   |     | 0       |       |
+-------+-----------------------+------+-----+---------+-------+
2 rows in set (0.01 sec)
```

Example 7. If the argument to an aggregate function is an exact numeric type, the result is also an exact numeric type, with a scale at least that of the argument.

Consider these statements:

```
mysql> CREATE TABLE t (i INT, d DECIMAL, f FLOAT);
mysql> INSERT INTO t VALUES(1,1,1);
mysql> CREATE TABLE y SELECT AVG(i), AVG(d), AVG(f) FROM t;
```

Before MySQL 5.0.3, the result is a double no matter the argument type:

```
mysql> DESCRIBE y;
+--------+--------------+------+-----+---------+-------+
| Field  | Type         | Null | Key | Default | Extra |
+--------+--------------+------+-----+---------+-------+
| AVG(i) | double(17,4) | YES  |     | NULL    |       |
| AVG(d) | double(17,4) | YES  |     | NULL    |       |
| AVG(f) | double       | YES  |     | NULL    |       |
+--------+--------------+------+-----+---------+-------+
```

As of MySQL 5.0.3, the result is a double only for the floating-point argument. For exact type arguments, the result is also an exact type:

```
mysql> DESCRIBE y;
+--------+---------------+------+-----+---------+-------+
| Field  | Type          | Null | Key | Default | Extra |
+--------+---------------+------+-----+---------+-------+
| AVG(i) | decimal(14,4) | YES  |     | NULL    |       |
| AVG(d) | decimal(14,4) | YES  |     | NULL    |       |
| AVG(f) | double        | YES  |     | NULL    |       |
+--------+---------------+------+-----+---------+-------+
```

The result is a double only for the floating-point argument. For exact type arguments, the result is also an exact type.

Chapter 12. SQL Statement Syntax

This chapter describes the syntax for the SQL statements supported by MySQL.

12.1. Data Definition Statements

12.1.1. `ALTER DATABASE` Syntax

```
ALTER {DATABASE | SCHEMA} [db_name]
    alter_specification ...
ALTER {DATABASE | SCHEMA} db_name
    UPGRADE DATA DIRECTORY NAME

alter_specification:
    [DEFAULT] CHARACTER SET [=] charset_name
  | [DEFAULT] COLLATE [=] collation_name
```

`ALTER DATABASE` enables you to change the overall characteristics of a database. These characteristics are stored in the `db.opt` file in the database directory. To use `ALTER DATABASE`, you need the `ALTER` privilege on the database. `ALTER SCHEMA` is a synonym for `ALTER DATABASE`.

The database name can be omitted from the first syntax, in which case the statement applies to the default database.

National Language Characteristics

The `CHARACTER SET` clause changes the default database character set. The `COLLATE` clause changes the default database collation. Section 9.1, "Character Set Support", discusses character set and collation names.

You can see what character sets and collations are available using, respectively, the `SHOW CHARACTER SET` and `SHOW COLLATION` statements. See Section 12.4.5.4, "`SHOW CHARACTER SET` Syntax", and Section 12.4.5.5, "`SHOW COLLATION` Syntax", for more information.

Upgrading from Versions Older than MySQL 5.1

The syntax that includes the `UPGRADE DATA DIRECTORY NAME` clause updates the name of the directory associated with the database to use the encoding implemented in MySQL 5.1 for mapping database names to database directory names (see Section 8.2.3, "Mapping of Identifiers to File Names"). This clause is for use under these conditions:

- It is intended when upgrading MySQL to 5.1 or later from older versions.
- It is intended to update a database directory name to the current encoding format if the name contains special characters that need encoding.
- The statement is used by `mysqlcheck` (as invoked by `mysql_upgrade`).

For example, if a database in MySQL 5.0 has the name `a-b-c`, the name contains instances of the `-` (dash) character. In MySQL 5.0, the database directory is also named `a-b-c`, which is not necessarily safe for all file systems. In MySQL 5.1 and later, the same database name is encoded as `a@002db@002dc` to produce a file system-neutral directory name.

When a MySQL installation is upgraded to MySQL 5.1 or later from an older version,the server displays a name such as `a-b-c` (which is in the old format) as `#mysql50#a-b-c`, and you must refer to the name using the `#mysql50#` prefix. Use `UPGRADE DATA DIRECTORY NAME` in this case to explicitly tell the server to re-encode the database directory name to the current encoding format:

```
ALTER DATABASE `#mysql50#a-b-c` UPGRADE DATA DIRECTORY NAME;
```

After executing this statement, you can refer to the database as `a-b-c` without the special `#mysql50#` prefix.

12.1.2. `ALTER EVENT` Syntax

```
ALTER
    [DEFINER = { user | CURRENT_USER }]
    EVENT event_name
    [ON SCHEDULE schedule]
    [ON COMPLETION [NOT] PRESERVE]
    [RENAME TO new_event_name]
    [ENABLE | DISABLE | DISABLE ON SLAVE]
    [COMMENT 'comment']
    [DO event_body]
```

The `ALTER EVENT` statement changes one or more of the characteristics of an existing event without the need to drop and recreate it. The syntax for each of the `DEFINER`, `ON SCHEDULE`, `ON COMPLETION`, `COMMENT`, `ENABLE` / `DISABLE`, and `DO` clauses is exactly the same as when used with `CREATE EVENT`. (See Section 12.1.9, "`CREATE EVENT` Syntax".)

Any user can alter an event defined on a database for which that user has the `EVENT` privilege. When a user executes a successful `ALTER EVENT` statement, that user becomes the definer for the affected event.

`ALTER EVENT` works only with an existing event:

```
mysql> ALTER EVENT no_such_event
     >     ON SCHEDULE
     >       EVERY '2:3' DAY_HOUR;
ERROR 1517 (HY000): Unknown event 'no_such_event'
```

In each of the following examples, assume that the event named `myevent` is defined as shown here:

```
CREATE EVENT myevent
    ON SCHEDULE
      EVERY 6 HOUR
    COMMENT 'A sample comment.'
    DO
      UPDATE myschema.mytable SET mycol = mycol + 1;
```

The following statement changes the schedule for `myevent` from once every six hours starting immediately to once every twelve hours, starting four hours from the time the statement is run:

```
ALTER EVENT myevent
    ON SCHEDULE
      EVERY 12 HOUR
    STARTS CURRENT_TIMESTAMP + INTERVAL 4 HOUR;
```

It is possible to change multiple characteristics of an event in a single statement. This example changes the SQL statement executed by `myevent` to one that deletes all records from `mytable`; it also changes the schedule for the event such that it executes once, one day after this `ALTER EVENT` statement is run.

```
ALTER TABLE myevent
    ON SCHEDULE
      AT CURRENT_TIMESTAMP + INTERVAL 1 DAY
    DO
      TRUNCATE TABLE myschema.mytable;
```

Specify the options in an `ALTER EVENT` statement only for those characteristics that you want to change; omitted options keep their existing values. This includes any default values for `CREATE EVENT` such as `ENABLE`.

To disable `myevent`, use this `ALTER EVENT` statement:

```
ALTER EVENT myevent
    DISABLE;
```

The `ON SCHEDULE` clause may use expressions involving built-in MySQL functions and user variables to obtain any of the *`timestamp`* or *`interval`* values which it contains. You cannot use stored routines or user-defined functions in such expressions, and you cannot use any table references; however, you can use `SELECT FROM DUAL`. This is true for both `ALTER EVENT` and `CREATE EVENT` statements. References to stored routines, user-defined functions, and tables in such cases are specifically not permitted, and fail with an error (see Bug #22830).

Although an `ALTER EVENT` statement that contains another `ALTER EVENT` statement in its `DO` clause appears to succeed, when the server attempts to execute the resulting scheduled event, the execution fails with an error.

To rename an event, use the `ALTER EVENT` statement's `RENAME TO` clause. This statement renames the event `myevent` to `yourevent`:

```
ALTER EVENT myevent
    RENAME TO yourevent;
```

You can also move an event to a different database using `ALTER EVENT ... RENAME TO ...` and *`db_name.event_name`* notation, as shown here:

```
ALTER EVENT olddb.myevent
    RENAME TO newdb.myevent;
```

To execute the previous statement, the user executing it must have the `EVENT` privilege on both the `olddb` and `newdb` databases.

> **Note**
>
> There is no `RENAME EVENT` statement.

The value `DISABLE ON SLAVE` is used on a replication slave instead of `ENABLED` or `DISABLED` to indicate an event that was created on the master and replicated to the slave, but that is not executed on the slave. Normally, `DISABLE ON SLAVE` is set automatically as required; however, there are some circumstances under which you may want or need to change it manually. See Section 15.4.1.8, “Replication of Invoked Features”, for more information.

12.1.3. `ALTER FUNCTION` Syntax

```
ALTER FUNCTION func_name [characteristic ...]

characteristic:
    { CONTAINS SQL | NO SQL | READS SQL DATA | MODIFIES SQL DATA }
  | SQL SECURITY { DEFINER | INVOKER }
  | COMMENT 'string'
```

This statement can be used to change the characteristics of a stored function. More than one change may be specified in an `ALTER FUNCTION` statement. However, you cannot change the parameters or body of a stored function using this statement; to make such changes, you must drop and re-create the function using `DROP FUNCTION` and `CREATE FUNCTION`.

You must have the `ALTER ROUTINE` privilege for the function. (That privilege is granted automatically to the function creator.) If binary logging is enabled, the `ALTER FUNCTION` statement might also require the `SUPER` privilege, as described in Section 17.7, “Binary Logging of Stored Programs”.

12.1.4. `ALTER PROCEDURE` Syntax

```
ALTER PROCEDURE proc_name [characteristic ...]

characteristic:
    COMMENT 'string'
  | { CONTAINS SQL | NO SQL | READS SQL DATA | MODIFIES SQL DATA }
  | SQL SECURITY { DEFINER | INVOKER }
```

This statement can be used to change the characteristics of a stored procedure. More than one change may be specified in an `ALTER PROCEDURE` statement. However, you cannot change the parameters or body of a stored procedure using this statement; to make such changes, you must drop and re-create the procedure using `DROP PROCEDURE` and `CREATE PROCEDURE`.

You must have the `ALTER ROUTINE` privilege for the procedure. By default, that privilege is granted automatically to the procedure creator. This behavior can be changed by disabling the `automatic_sp_privileges` system variable. See Section 17.2.2, “Stored Routines and MySQL Privileges”.

12.1.5. `ALTER SERVER` Syntax

```
ALTER SERVER  server_name
    OPTIONS (option [, option] ...)
```

Alters the server information for *`server_name`*, adjusting any of the options allowed in the `CREATE SERVER` statement. See Section 12.1.13, “`CREATE SERVER` Syntax”. The corresponding fields in the `mysql.servers` table are updated accordingly. This statement requires the `SUPER` privilege.

For example, to update the `USER` option:

```
ALTER SERVER s OPTIONS (USER 'sally');
```

`ALTER SERVER` does not cause an automatic commit.

12.1.6. `ALTER TABLE` Syntax

```
ALTER [IGNORE] TABLE tbl_name
    [alter_specification [, alter_specification] ...]
    [partition_options]

ALTER [IGNORE] TABLE tbl_name
    partition_options

alter_specification:
    table_options
  | ADD [COLUMN] col_name column_definition
        [FIRST | AFTER col_name ]
  | ADD [COLUMN] (col_name column_definition,...)
  | ADD {INDEX|KEY} [index_name]
```

```
        [index_type] (index_col_name,...) [index_option] ...
  | ADD [CONSTRAINT [symbol]] PRIMARY KEY
        [index_type] (index_col_name,...) [index_option] ...
  | ADD [CONSTRAINT [symbol]]
        UNIQUE [INDEX|KEY] [index_name]
        [index_type] (index_col_name,...) [index_option] ...
  | ADD FULLTEXT [INDEX|KEY] [index_name]
        (index_col_name,...) [index_option] ...
  | ADD SPATIAL [INDEX|KEY] [index_name]
        (index_col_name,...) [index_option] ...
  | ADD [CONSTRAINT [symbol]]
        FOREIGN KEY [index_name] (index_col_name,...)
        reference_definition
  | ALTER [COLUMN] col_name {SET DEFAULT literal | DROP DEFAULT}
  | CHANGE [COLUMN] old_col_name new_col_name column_definition
        [FIRST|AFTER col_name]
  | MODIFY [COLUMN] col_name column_definition
        [FIRST | AFTER col_name]
  | DROP [COLUMN] col_name
  | DROP PRIMARY KEY
  | DROP {INDEX|KEY} index_name
  | DROP FOREIGN KEY fk_symbol
  | DISABLE KEYS
  | ENABLE KEYS
  | RENAME [TO] new_tbl_name
  | ORDER BY col_name [, col_name] ...
  | CONVERT TO CHARACTER SET charset_name [COLLATE collation_name]
  | [DEFAULT] CHARACTER SET [=] charset_name [COLLATE [=] collation_name]
  | DISCARD TABLESPACE
  | IMPORT TABLESPACE
  | FORCE
  | ADD PARTITION (partition_definition)
  | DROP PARTITION partition_names
  | TRUNCATE PARTITION {partition_names | ALL }
  | COALESCE PARTITION number
  | REORGANIZE PARTITION partition_names INTO (partition_definitions)
  | ANALYZE PARTITION  {partition_names | ALL }
  | CHECK PARTITION  {partition_names | ALL }
  | OPTIMIZE PARTITION  {partition_names | ALL }
  | REBUILD PARTITION  {partition_names | ALL }
  | REPAIR PARTITION  {partition_names | ALL }
  | REMOVE PARTITIONING

index_col_name:
    col_name [(length)] [ASC | DESC]

index_type:
    USING {BTREE | HASH}

index_option:
    KEY_BLOCK_SIZE [=] value
  | index_type
  | WITH PARSER parser_name
  | COMMENT 'string'

table_options:
    table_option [[,] table_option] ...  (see CREATE TABLE options)

partition_options:
    (see CREATE TABLE options)
```

`ALTER TABLE` changes the structure of a table. For example, you can add or delete columns, create or destroy indexes, change the type of existing columns, or rename columns or the table itself. You can also change characteristics such as the storage engine used for the table or the table comment.

Partitioning-related clauses for `ALTER TABLE` can be used with partitioned tables for repartitioning, for adding, dropping, merging, and splitting partitions, and for performing partitioning maintenance. For more information, see Section 12.1.6.1, “`ALTER TABLE` Partition Operations”.

Following the table name, specify the alterations to be made. If none are given, `ALTER TABLE` does nothing.

The syntax for many of the permissible alterations is similar to clauses of the `CREATE TABLE` statement. See Section 12.1.14, “`CREATE TABLE` Syntax”, for more information.

Some operations may result in warnings if attempted on a table for which the storage engine does not support the operation. These warnings can be displayed with `SHOW WARNINGS`. See Section 12.4.5.41, “`SHOW WARNINGS` Syntax”.

For information on troubleshooting `ALTER TABLE`, see Section C.5.7.1, “Problems with `ALTER TABLE`”.

In most cases, `ALTER TABLE` makes a temporary copy of the original table. MySQL waits for other operations that are modifying the table, then proceeds. It incorporates the alteration into the copy, deletes the original table, and renames the new one. While `ALTER TABLE` is executing, the original table is readable by other sessions. Updates and writes to the table that begin after the `ALTER TABLE` operation begins are stalled until the new table is ready, then are automatically redirected to the new table without any failed updates. The temporary table is created in the database directory of the new table. This can differ from the database directory of the original table for `ALTER TABLE` operations that rename the table to a different database.

For `MyISAM` tables, you can speed up index re-creation (the slowest part of the alteration process) by setting the `myis-`

`am_sort_buffer_size` system variable to a high value.

For some operations, an in-place `ALTER TABLE` is possible that does not require a temporary table:

- For `ALTER TABLE` *`tbl_name`* `RENAME TO` *`new_tbl_name`* without any other options, MySQL simply renames any files that correspond to the table *`tbl_name`* without making a copy. (You can also use the `RENAME TABLE` statement to rename tables. See Section 12.1.26, "`RENAME TABLE` Syntax".) Any privileges granted specifically for the renamed table are not migrated to the new name. They must be changed manually.
- Alterations that modify only table metadata and not table data can be made immediately by altering the table's `.frm` file and not touching table contents. The following changes are fast alterations that can be made this way:
    - Renaming a column, except for the `InnoDB` storage engine.
    - Changing the default value of a column.
    - Changing the definition of an `ENUM` or `SET` column by adding new enumeration or set members to the *end* of the list of valid member values, as long as the storage side of the data type does not change. For example, adding a member to a `SET` column that has 8 members changes the required storage per value from 1 byte to 2 bytes; this will require a table copy. Adding members in the middle of the list causes renumbering of existing members, which requires a table copy.
- `ALTER TABLE ... ADD PARTITION` creates no temporary table. `ADD` or `DROP` operations for `RANGE` or `LIST` partitions are immediate operations or nearly so. `ADD` or `COALESCE` operations for `HASH` or `KEY` partitions copy data between changed partitions; unless `LINEAR HASH` or `LINEAR KEY` was used, this is much the same as creating a new table (although the operation is done partition by partition). `REORGANIZE` operations copy only changed partitions and do not touch unchanged ones.
- Renaming an index, except for `InnoDB`.
- Adding or dropping an index, for `InnoDB`.

You can force an `ALTER TABLE` operation that would otherwise not require a table copy to use the temporary table method (as supported in MySQL 5.0) by setting the `old_alter_table` system variable to `ON`.

As of MySQL 5.5.11, you can also use `ALTER TABLE` *`tbl_name`* `FORCE` to perform a "null" alter operation that rebuilds the table. Previously the `FORCE` option was recognized but ignored.

- To use `ALTER TABLE`, you need `ALTER`, `CREATE`, and `INSERT` privileges for the table. Renaming a table requires `ALTER` and `DROP` on the old table, `ALTER`, `CREATE`, and `INSERT` on the new table.
- `IGNORE` is a MySQL extension to standard SQL. It controls how `ALTER TABLE` works if there are duplicates on unique keys in the new table or if warnings occur when strict mode is enabled. If `IGNORE` is not specified, the copy is aborted and rolled back if duplicate-key errors occur. If `IGNORE` is specified, only the first row is used of rows with duplicates on a unique key. The other conflicting rows are deleted. Incorrect values are truncated to the closest matching acceptable value.
- Pending `INSERT DELAYED` statements are lost if a table is write locked and `ALTER TABLE` is used to modify the table structure.
- *`table_option`* signifies a table option of the kind that can be used in the `CREATE TABLE` statement, such as `ENGINE`, `AUTO_INCREMENT`, or `AVG_ROW_LENGTH`. (Section 12.1.14, "`CREATE TABLE` Syntax", lists all table options.) However, `ALTER TABLE` ignores the `DATA DIRECTORY` and `INDEX DIRECTORY` table options.

  For example, to convert a table to be an `InnoDB` table, use this statement:

  ```
  ALTER TABLE t1 ENGINE = InnoDB;
  ```

  When you specify an `ENGINE` clause, `ALTER TABLE` rebuilds the table. This is true even if the table already has the specified storage engine.

  The outcome of attempting to change a table's storage engine is affected by whether the desired storage engine is available and the setting of the `NO_ENGINE_SUBSTITUTION` SQL mode, as described in Section 5.1.6, "Server SQL Modes".

  To prevent inadvertent loss of data, `ALTER TABLE` cannot be used to change the storage engine of a table to `MERGE` or `BLACKHOLE`.

  To change the value of the `AUTO_INCREMENT` counter to be used for new rows, do this:

  ```
  ALTER TABLE t2 AUTO_INCREMENT = value;
  ```

You cannot reset the counter to a value less than or equal to any that have already been used. For `MyISAM`, if the value is less than or equal to the maximum value currently in the `AUTO_INCREMENT` column, the value is reset to the current maximum plus one. For `InnoDB`, *if the value is less than the current maximum value in the column, no error occurs and the current sequence value is not changed.*

- You can issue multiple `ADD`, `ALTER`, `DROP`, and `CHANGE` clauses in a single `ALTER TABLE` statement, separated by commas. This is a MySQL extension to standard SQL, which permits only one of each clause per `ALTER TABLE` statement. For example, to drop multiple columns in a single statement, do this:

  ```
  ALTER TABLE t2 DROP COLUMN c, DROP COLUMN d;
  ```

- `CHANGE col_name`, `DROP col_name`, and `DROP INDEX` are MySQL extensions to standard SQL.

- The word `COLUMN` is optional and can be omitted.

- `column_definition` clauses use the same syntax for `ADD` and `CHANGE` as for `CREATE TABLE`. See Section 12.1.14, "`CREATE TABLE` Syntax".

- You can rename a column using a `CHANGE old_col_name new_col_name column_definition` clause. To do so, specify the old and new column names and the definition that the column currently has. For example, to rename an `INTEGER` column from `a` to `b`, you can do this:

  ```
  ALTER TABLE t1 CHANGE a b INTEGER;
  ```

  If you want to change a column's type but not the name, `CHANGE` syntax still requires an old and new column name, even if they are the same. For example:

  ```
  ALTER TABLE t1 CHANGE b b BIGINT NOT NULL;
  ```

  You can also use `MODIFY` to change a column's type without renaming it:

  ```
  ALTER TABLE t1 MODIFY b BIGINT NOT NULL;
  ```

  `MODIFY` is an extension to `ALTER TABLE` for Oracle compatibility.

  When you use `CHANGE` or `MODIFY`, `column_definition` must include the data type and all attributes that should apply to the new column, other than index attributes such as `PRIMARY KEY` or `UNIQUE`. Attributes present in the original definition but not specified for the new definition are not carried forward. Suppose that a column `col1` is defined as `INT UNSIGNED DEFAULT 1 COMMENT 'my column'` and you modify the column as follows:

  ```
  ALTER TABLE t1 MODIFY col1 BIGINT;
  ```

  The resulting column will be defined as `BIGINT`, but will not include the attributes `UNSIGNED DEFAULT 1 COMMENT 'my column'`. To retain them, the statement should be:

  ```
  ALTER TABLE t1 MODIFY col1 BIGINT UNSIGNED DEFAULT 1 COMMENT 'my column';
  ```

- When you change a data type using `CHANGE` or `MODIFY`, MySQL tries to convert existing column values to the new type as well as possible.

  > **Warning**
  >
  > This conversion may result in alteration of data. For example, if you shorten a string column, values may be truncated. To prevent the operation from succeeding if conversions to the new data type would result in loss of data, enable strict SQL mode before using `ALTER TABLE` (see Section 5.1.6, "Server SQL Modes").

- To add a column at a specific position within a table row, use `FIRST` or `AFTER col_name`. The default is to add the column last. You can also use `FIRST` and `AFTER` in `CHANGE` or `MODIFY` operations to reorder columns within a table.

- `ALTER ... SET DEFAULT` or `ALTER ... DROP DEFAULT` specify a new default value for a column or remove the old default value, respectively. If the old default is removed and the column can be `NULL`, the new default is `NULL`. If the column cannot be `NULL`, MySQL assigns a default value as described in Section 10.1.4, "Data Type Default Values".

- `DROP INDEX` removes an index. This is a MySQL extension to standard SQL. See Section 12.1.20, "`DROP INDEX` Syntax". If you are unsure of the index name, use `SHOW INDEX FROM tbl_name`.

- If columns are dropped from a table, the columns are also removed from any index of which they are a part. If all columns that make up an index are dropped, the index is dropped as well. If you use `CHANGE` or `MODIFY` to shorten a column for which an index exists on the column, and the resulting column length is less than the index length, MySQL shortens the index automatically.

- If a table contains only one column, the column cannot be dropped. If what you intend is to remove the table, use `DROP TABLE` instead.

- `DROP PRIMARY KEY` drops the primary key. If there is no primary key, an error occurs.

  If you add a `UNIQUE INDEX` or `PRIMARY KEY` to a table, MySQL stores it before any nonunique index to permit detection of duplicate keys as early as possible.

- Some storage engines permit you to specify an index type when creating an index. The syntax for the *`index_type`* specifier is `USING` *`type_name`*. For details about `USING`, see Section 12.1.11, “`CREATE INDEX` Syntax”. The preferred position is after the column list. Support for use of the option before the column list will be removed in a future MySQL release.

  `index_option` values specify additional options for an index. `USING` is one such option. For details about permissible *`index_option`* values, see Section 12.1.11, “`CREATE INDEX` Syntax”.

- After an `ALTER TABLE` statement, it may be necessary to run `ANALYZE TABLE` to update index cardinality information. See Section 12.4.5.23, “`SHOW INDEX` Syntax”.

- `ORDER BY` enables you to create the new table with the rows in a specific order. Note that the table does not remain in this order after inserts and deletes. This option is useful primarily when you know that you are mostly to query the rows in a certain order most of the time. By using this option after major changes to the table, you might be able to get higher performance. In some cases, it might make sorting easier for MySQL if the table is in order by the column that you want to order it by later.

  `ORDER BY` syntax permits one or more column names to be specified for sorting, each of which optionally can be followed by `ASC` or `DESC` to indicate ascending or descending sort order, respectively. The default is ascending order. Only column names are permitted as sort criteria; arbitrary expressions are not permitted.

  `ORDER BY` does not make sense for `InnoDB` tables that contain a user-defined clustered index (`PRIMARY KEY` or `NOT NULL UNIQUE` index). `InnoDB` always orders table rows according to such an index if one is present.

  > **Note**
  >
  > When used on a partitioned table, `ALTER TABLE ... ORDER BY` orders rows within each partition only.

- If you use `ALTER TABLE` on a `MyISAM` table, all nonunique indexes are created in a separate batch (as for `REPAIR TABLE`). This should make `ALTER TABLE` much faster when you have many indexes.

  This feature can be activated explicitly for a `MyISAM` table. `ALTER TABLE ... DISABLE KEYS` tells MySQL to stop updating nonunique indexes. `ALTER TABLE ... ENABLE KEYS` then should be used to re-create missing indexes. MySQL does this with a special algorithm that is much faster than inserting keys one by one, so disabling keys before performing bulk insert operations should give a considerable speedup. Using `ALTER TABLE ... DISABLE KEYS` requires the `INDEX` privilege in addition to the privileges mentioned earlier.

  While the nonunique indexes are disabled, they are ignored for statements such as `SELECT` and `EXPLAIN` that otherwise would use them.

- If `ALTER TABLE` for an `InnoDB` table results in changes to column values (for example, because a column is truncated), `InnoDB`'s `FOREIGN KEY` constraint checks do not notice possible violations caused by changing the values.

- The `FOREIGN KEY` and `REFERENCES` clauses are supported by the `InnoDB` storage engine, which implements `ADD [CONSTRAINT [`*`symbol`*`]] FOREIGN KEY (...) REFERENCES ... (...)`. See Section 13.3.5.4, “`FOREIGN KEY` Constraints”. For other storage engines, the clauses are parsed but ignored. The `CHECK` clause is parsed but ignored by all storage engines. See Section 12.1.14, “`CREATE TABLE` Syntax”. The reason for accepting but ignoring syntax clauses is for compatibility, to make it easier to port code from other SQL servers, and to run applications that create tables with references. See Section 1.8.5, “MySQL Differences from Standard SQL”.

  > **Important**
  >
  > The inline `REFERENCES` specifications where the references are defined as part of the column specification are silently ignored by `InnoDB`. InnoDB only accepts `REFERENCES` clauses defined as part of a separate `FOREIGN KEY` specification.

  > **Note**
  >
  > Partitioned tables do not support foreign keys. See Section 16.5, “Restrictions and Limitations on Partitioning”, for more information.

- `InnoDB` supports the use of `ALTER TABLE` to drop foreign keys:

  ```
  ALTER TABLE tbl_name DROP FOREIGN KEY fk_symbol;
  ```

  For more information, see Section 13.3.5.4, “`FOREIGN KEY` Constraints”.

- You cannot add a foreign key and drop a foreign key in separate clauses of a single `ALTER TABLE` statement. You must use separate statements.

- For an `InnoDB` table that is created with its own tablespace in an `.ibd` file, that file can be discarded and imported. To discard the `.ibd` file, use this statement:

  ```
  ALTER TABLE tbl_name DISCARD TABLESPACE;
  ```

  This deletes the current `.ibd` file, so be sure that you have a backup first. Attempting to access the table while the tablespace file is discarded results in an error.

  To import the backup `.ibd` file back into the table, copy it into the database directory, and then issue this statement:

  ```
  ALTER TABLE tbl_name IMPORT TABLESPACE;
  ```

  The tablespace file must have been created on the server into which it is imported later.

  See Section 13.3.3, “Using Per-Table Tablespaces”.

- If you want to change the table default character set and all character columns (`CHAR`, `VARCHAR`, `TEXT`) to a new character set, use a statement like this:

  ```
  ALTER TABLE tbl_name CONVERT TO CHARACTER SET charset_name;
  ```

  For a column that has a data type of `VARCHAR` or one of the `TEXT` types, `CONVERT TO CHARACTER SET` will change the data type as necessary to ensure that the new column is long enough to store as many characters as the original column. For example, a `TEXT` column has two length bytes, which store the byte-length of values in the column, up to a maximum of 65,535. For a `latin1` `TEXT` column, each character requires a single byte, so the column can store up to 65,535 characters. If the column is converted to `utf8`, each character might require up to three bytes, for a maximum possible length of 3 × 65,535 = 196,605 bytes. That length will not fit in a `TEXT` column's length bytes, so MySQL will convert the data type to `MEDIUMTEXT`, which is the smallest string type for which the length bytes can record a value of 196,605. Similarly, a `VARCHAR` column might be converted to `MEDIUMTEXT`.

  To avoid data type changes of the type just described, do not use `CONVERT TO CHARACTER SET`. Instead, use `MODIFY` to change individual columns. For example:

  ```
  ALTER TABLE t MODIFY latin1_text_col TEXT CHARACTER SET utf8;
  ALTER TABLE t MODIFY latin1_varchar_col VARCHAR(M) CHARACTER SET utf8;
  ```

  If you specify `CONVERT TO CHARACTER SET binary`, the `CHAR`, `VARCHAR`, and `TEXT` columns are converted to their corresponding binary string types (`BINARY`, `VARBINARY`, `BLOB`). This means that the columns no longer will have a character set and a subsequent `CONVERT TO` operation will not apply to them.

  If *`charset_name`* is `DEFAULT`, the database character set is used.

  > **Warning**
  >
  > The `CONVERT TO` operation converts column values between the character sets. This is *not* what you want if you have a column in one character set (like `latin1`) but the stored values actually use some other, incompatible character set (like `utf8`). In this case, you have to do the following for each such column:
  >
  > ```
  > ALTER TABLE t1 CHANGE c1 c1 BLOB;
  > ALTER TABLE t1 CHANGE c1 c1 TEXT CHARACTER SET utf8;
  > ```
  >
  > The reason this works is that there is no conversion when you convert to or from `BLOB` columns.

  To change only the *default* character set for a table, use this statement:

  ```
  ALTER TABLE tbl_name DEFAULT CHARACTER SET charset_name;
  ```

  The word `DEFAULT` is optional. The default character set is the character set that is used if you do not specify the character set for columns that you add to a table later (for example, with `ALTER TABLE ... ADD column`).

With the `mysql_info()` C API function, you can find out how many rows were copied by `ALTER TABLE`, and (when `IGNORE` is used) how many rows were deleted due to duplication of unique key values. See Section 20.9.3.35, “`mysql_info()`”.

12.1.6.1. `ALTER TABLE` Partition Operations

Partitioning-related clauses for `ALTER TABLE` can be used with partitioned tables for repartitioning, for adding, dropping, merging, and splitting partitions, and for performing partitioning maintenance.

- Simply using a *`partition_options`* clause with `ALTER TABLE` on a partitioned table repartitions the table according to the partitioning scheme defined by the *`partition_options`*. This clause always begins with `PARTITION BY`, and follows the same syntax and other rules as apply to the *`partition_options`* clause for `CREATE TABLE` (see Section 12.1.14, “`CREATE TABLE` Syntax”, for more detailed information), and can also be used to partition an existing table that is not already partitioned. For example, consider a (nonpartitioned) table defined as shown here:

  ```
  CREATE TABLE t1 (
      id INT,
      year_col INT
  );
  ```

  This table can be partitioned by `HASH`, using the `id` column as the partitioning key, into 8 partitions by means of this statement:

  ```
  ALTER TABLE t1
      PARTITION BY HASH(id)
      PARTITIONS 8;
  ```

  The table that results from using an `ALTER TABLE ... PARTITION BY` statement must follow the same rules as one created using `CREATE TABLE ... PARTITION BY`. This includes the rules governing the relationship between any unique keys (including any primary key) that the table might have, and the column or columns used in the partitioning expression, as discussed in Section 16.5.1, “Partitioning Keys, Primary Keys, and Unique Keys”. The `CREATE TABLE ... PARTITION BY` rules for specifying the number of partitions also apply to `ALTER TABLE ... PARTITION BY`.

  The *`partition_definition`* clause for `ALTER TABLE ADD PARTITION` supports the same options as the clause of the same name for the `CREATE TABLE` statement. (See Section 12.1.14, “`CREATE TABLE` Syntax”, for the syntax and description.) Suppose that you have the partitioned table created as shown here:

  ```
  CREATE TABLE t1 (
      id INT,
      year_col INT
  )
  PARTITION BY RANGE (year_col) (
      PARTITION p0 VALUES LESS THAN (1991),
      PARTITION p1 VALUES LESS THAN (1995),
      PARTITION p2 VALUES LESS THAN (1999)
  );
  ```

  You can add a new partition `p3` to this table for storing values less than `2002` as follows:

  ```
  ALTER TABLE t1 ADD PARTITION (PARTITION p3 VALUES LESS THAN (2002));
  ```

  `DROP PARTITION` can be used to drop one or more `RANGE` or `LIST` partitions. This statement cannot be used with `HASH` or `KEY` partitions; instead, use `COALESCE PARTITION` (see below). Any data that was stored in the dropped partitions named in the *`partition_names`* list is discarded. For example, given the table `t1` defined previously, you can drop the partitions named `p0` and `p1` as shown here:

  ```
  ALTER TABLE t1 DROP PARTITION p0, p1;
  ```

  `ADD PARTITION` and `DROP PARTITION` do not currently support `IF [NOT] EXISTS`. It is also not possible to rename a partition or a partitioned table. Instead, if you wish to rename a partition, you must drop and re-create the partition; if you wish to rename a partitioned table, you must instead drop all partitions, rename the table, and then add back the partitions that were dropped.

  Beginning with MySQL 5.5.0, it is possible to delete rows from selected partitions using the `TRUNCATE PARTITION` option. This option takes a comma-separated list of one or more partition names. For example, consider the table `t1` as defined here:

  ```
  CREATE TABLE t1 (
      id INT,
      year_col INT
  )
  PARTITION BY RANGE (year_col) (
      PARTITION p0 VALUES LESS THAN (1991),
      PARTITION p1 VALUES LESS THAN (1995),
      PARTITION p2 VALUES LESS THAN (1999),
  ```

```
    PARTITION p3 VALUES LESS THAN (2003),
    PARTITION p4 VALUES LESS THAN (2007)
);
```

To delete all rows from partition `p0`, you can use the following statement:

```
ALTER TABLE t1 TRUNCATE PARTITION p0;
```

The statement just shown has the same effect as the following `DELETE` statement:

```
DELETE FROM t1 WHERE year_col < 1991;
```

When truncating multiple partitions, the partitions do not have to be contiguous: This can greatly simplify delete operations on partitioned tables that would otherwise require very complex `WHERE` conditions if done with `DELETE` statements. For example, this statement deletes all rows from partitions `p1` and `p3`:

```
ALTER TABLE t1 TRUNCATE PARTITION p1, p3;
```

An equivalent `DELETE` statement is shown here:

```
DELETE FROM t1 WHERE
    (year_col >= 1991 AND year_col < 1995)
    OR
    (year_col >= 2003 AND year_col < 2007);
```

You can also use the `ALL` keyword in place of the list of partition names; in this case, the statement acts on all partitions in the table.

`TRUNCATE PARTITION` merely deletes rows; it does not alter the definition of the table itself, or of any of its partitions.

> **Note**
>
> `TRUNCATE PARTITION` does not work with subpartitions.

You can verify that the rows were dropped by checking the `INFORMATION_SCHEMA.PARTITIONS` table, using a query such as this one:

```
SELECT PARTITION_NAME, TABLE_ROWS
    FROM INFORMATION_SCHEMA.PARTITIONS
    WHERE TABLE_NAME = 't1';
```

`TRUNCATE PARTITION` is supported only for partitioned tables that use the `MyISAM`, `InnoDB`, or `MEMORY` storage engine. It also works on `BLACKHOLE` tables (but has no effect). It is not supported for `ARCHIVE` tables.

`COALESCE PARTITION` can be used with a table that is partitioned by `HASH` or `KEY` to reduce the number of partitions by *`number`*. Suppose that you have created table `t2` using the following definition:

```
CREATE TABLE t2 (
    name VARCHAR (30),
    started DATE
)
PARTITION BY HASH( YEAR(started) )
PARTITIONS 6;
```

You can reduce the number of partitions used by `t2` from 6 to 4 using the following statement:

```
ALTER TABLE t2 COALESCE PARTITION 2;
```

The data contained in the last *`number`* partitions will be merged into the remaining partitions. In this case, partitions 4 and 5 will be merged into the first 4 partitions (the partitions numbered 0, 1, 2, and 3).

To change some but not all the partitions used by a partitioned table, you can use `REORGANIZE PARTITION`. This statement can be used in several ways:

- To merge a set of partitions into a single partition. This can be done by naming several partitions in the *`partition_names`* list and supplying a single definition for *`partition_definition`*.

- To split an existing partition into several partitions. You can accomplish this by naming a single partition for *`partition_names`* and providing multiple *`partition_definitions`*.

  - To change the ranges for a subset of partitions defined using `VALUES LESS THAN` or the value lists for a subset of partitions defined using `VALUES IN`.

    > **Note**
    >
    > For partitions that have not been explicitly named, MySQL automatically provides the default names `p0`, `p1`, `p2`, and so on. The same is true with regard to subpartitions.

  For more detailed information about and examples of `ALTER TABLE ... REORGANIZE PARTITION` statements, see Section 16.3.1, "Management of `RANGE` and `LIST` Partitions".

- Several additional options provide partition maintenance and repair functionality analogous to that implemented for nonpartitioned tables by statements such as `CHECK TABLE` and `REPAIR TABLE` (which are also supported for partitioned tables; see Section 12.4.2, "Table Maintenance Statements" for more information). These include `ANALYZE PARTITION`, `CHECK PARTITION`, `OPTIMIZE PARTITION`, `REBUILD PARTITION`, and `REPAIR PARTITION`. Each of these options takes a *`partition_names`* clause consisting of one or more names of partitions, separated by commas. The partitions must already exist in the table to be altered. You can also use the `ALL` keyword in place of *`partition_names`*, in which case the statement acts on all partitions in the table. For more information and examples, see Section 16.3.3, "Maintenance of Partitions".

  The `ANALYZE PARTITION`, `CHECK PARTITION`, `OPTIMIZE PARTITION`, and `REPAIR PARTITION` options are not permitted for tables which are not partitioned.

- `REMOVE PARTITIONING` enables you to remove a table's partitioning without otherwise affecting the table or its data. This option can be combined with other `ALTER TABLE` options such as those used to add, drop, or rename drop columns or indexes.

- Using the `ENGINE` option with `ALTER TABLE` changes the storage engine used by the table without affecting the partitioning.

Only a single instance of any one of the following options can be used in a given `ALTER TABLE` statement: `PARTITION BY`, `ADD PARTITION`, `DROP PARTITION`, `TRUNCATE PARTITION`, `REORGANIZE PARTITION`, or `COALESCE PARTITION`, `ANALYZE PARTITION`, `CHECK PARTITION`, `OPTIMIZE PARTITION`, `REBUILD PARTITION`, `REMOVE PARTITIONING`.

For example, the following two statements are invalid:

```
ALTER TABLE t1 ANALYZE PARTITION p1, ANALYZE PARTITION p2;

ALTER TABLE t1 ANALYZE PARTITION p1, CHECK PARTITION p2;
```

In the first case, you can analyze partitions `p1` and `p2` of table `t1` concurrently using a single statement with a single `ANALYZE PARTITION` option that lists both of the partitions to be analyzed, like this:

```
ALTER TABLE t1 ANALYZE PARTITION p1, p2;
```

In the second case, it is not possible to perform `ANALYZE` and `CHECK` operations on different partitions of the same table concurrently. Instead, you must issue two separate statements, like this:

```
ALTER TABLE t1 ANALYZE PARTITION p1;
ALTER TABLE t1 CHECK PARTITION p2;
```

12.1.6.2. `ALTER TABLE` Examples

Begin with a table `t1` that is created as shown here:

```
CREATE TABLE t1 (a INTEGER,b CHAR(10));
```

To rename the table from `t1` to `t2`:

```
ALTER TABLE t1 RENAME t2;
```

To change column `a` from `INTEGER` to `TINYINT NOT NULL` (leaving the name the same), and to change column `b` from `CHAR(10)` to `CHAR(20)` as well as renaming it from `b` to `c`:

```
ALTER TABLE t2 MODIFY a TINYINT NOT NULL, CHANGE b c CHAR(20);
```

To add a new `TIMESTAMP` column named `d`:

```
ALTER TABLE t2 ADD d TIMESTAMP;
```

To add an index on column `d` and a `UNIQUE` index on column `a`:

```
ALTER TABLE t2 ADD INDEX (d), ADD UNIQUE (a);
```

To remove column `c`:

```
ALTER TABLE t2 DROP COLUMN c;
```

To add a new `AUTO_INCREMENT` integer column named `c`:

```
ALTER TABLE t2 ADD c INT UNSIGNED NOT NULL AUTO_INCREMENT,
  ADD PRIMARY KEY (c);
```

We indexed `c` (as a `PRIMARY KEY`) because `AUTO_INCREMENT` columns must be indexed, and we declare `c` as `NOT NULL` because primary key columns cannot be `NULL`.

When you add an `AUTO_INCREMENT` column, column values are filled in with sequence numbers automatically. For `MyISAM` tables, you can set the first sequence number by executing `SET INSERT_ID=value` before `ALTER TABLE` or by using the `AUTO_INCREMENT=value` table option. See Section 5.1.3, “Server System Variables”.

With `MyISAM` tables, if you do not change the `AUTO_INCREMENT` column, the sequence number is not affected. If you drop an `AUTO_INCREMENT` column and then add another `AUTO_INCREMENT` column, the numbers are resequenced beginning with 1.

When replication is used, adding an `AUTO_INCREMENT` column to a table might not produce the same ordering of the rows on the slave and the master. This occurs because the order in which the rows are numbered depends on the specific storage engine used for the table and the order in which the rows were inserted. If it is important to have the same order on the master and slave, the rows must be ordered before assigning an `AUTO_INCREMENT` number. Assuming that you want to add an `AUTO_INCREMENT` column to the table `t1`, the following statements produce a new table `t2` identical to `t1` but with an `AUTO_INCREMENT` column:

```
CREATE TABLE t2 (id INT AUTO_INCREMENT PRIMARY KEY)
SELECT * FROM t1 ORDER BY col1, col2;
```

This assumes that the table `t1` has columns `col1` and `col2`.

This set of statements will also produce a new table `t2` identical to `t1`, with the addition of an `AUTO_INCREMENT` column:

```
CREATE TABLE t2 LIKE t1;
ALTER TABLE t2 ADD id INT AUTO_INCREMENT PRIMARY KEY;
INSERT INTO t2 SELECT * FROM t1 ORDER BY col1, col2;
```

> **Important**
>
> To guarantee the same ordering on both master and slave, *all* columns of `t1` must be referenced in the `ORDER BY` clause.

Regardless of the method used to create and populate the copy having the `AUTO_INCREMENT` column, the final step is to drop the original table and then rename the copy:

```
DROP t1;
ALTER TABLE t2 RENAME t1;
```

12.1.7. `ALTER VIEW` Syntax

```
ALTER
    [ALGORITHM = {UNDEFINED | MERGE | TEMPTABLE}]
    [DEFINER = { user | CURRENT_USER }]
    [SQL SECURITY { DEFINER | INVOKER }]
    VIEW view_name [(column_list)]
    AS select_statement
    [WITH [CASCADED | LOCAL] CHECK OPTION]
```

This statement changes the definition of a view, which must exist. The syntax is similar to that for `CREATE VIEW` and the effect is the same as for `CREATE OR REPLACE VIEW`. See Section 12.1.16, “`CREATE VIEW` Syntax”. This statement requires the `CREATE VIEW` and `DROP` privileges for the view, and some privilege for each column referred to in the `SELECT` statement. `ALTER VIEW` is permitted only to the definer or users with the `SUPER` privilege.

12.1.8. `CREATE DATABASE` Syntax

```
CREATE {DATABASE | SCHEMA} [IF NOT EXISTS] db_name
    [create_specification] ...

create_specification:
    [DEFAULT] CHARACTER SET [=] charset_name
  | [DEFAULT] COLLATE [=] collation_name
```

`CREATE DATABASE` creates a database with the given name. To use this statement, you need the `CREATE` privilege for the database. `CREATE SCHEMA` is a synonym for `CREATE DATABASE`.

An error occurs if the database exists and you did not specify `IF NOT EXISTS`.

As of MySQL 5.5.3, `CREATE DATABASE` is not permitted within a session that has an active `LOCK TABLES` statement.

`create_specification` options specify database characteristics. Database characteristics are stored in the `db.opt` file in the database directory. The `CHARACTER SET` clause specifies the default database character set. The `COLLATE` clause specifies the default database collation. Section 9.1, "Character Set Support", discusses character set and collation names.

A database in MySQL is implemented as a directory containing files that correspond to tables in the database. Because there are no tables in a database when it is initially created, the `CREATE DATABASE` statement creates only a directory under the MySQL data directory and the `db.opt` file. Rules for permissible database names are given in Section 8.2, "Schema Object Names". If a database name contains special characters, the name for the database directory contains encoded versions of those characters as described in Section 8.2.3, "Mapping of Identifiers to File Names".

If you manually create a directory under the data directory (for example, with `mkdir`), the server considers it a database directory and it shows up in the output of `SHOW DATABASES`.

You can also use the `mysqladmin` program to create databases. See Section 4.5.2, "`mysqladmin` — Client for Administering a MySQL Server".

12.1.9. `CREATE EVENT` Syntax

```
CREATE
    [DEFINER = { user | CURRENT_USER }]
    EVENT
    [IF NOT EXISTS]
    event_name
    ON SCHEDULE schedule
    [ON COMPLETION [NOT] PRESERVE]
    [ENABLE | DISABLE | DISABLE ON SLAVE]
    [COMMENT 'comment']
    DO event_body;

schedule:
    AT timestamp [+ INTERVAL interval] ...
  | EVERY interval
    [STARTS timestamp [+ INTERVAL interval] ...]
    [ENDS timestamp [+ INTERVAL interval] ...]

interval:
    quantity {YEAR | QUARTER | MONTH | DAY | HOUR | MINUTE |
              WEEK | SECOND | YEAR_MONTH | DAY_HOUR | DAY_MINUTE |
              DAY_SECOND | HOUR_MINUTE | HOUR_SECOND | MINUTE_SECOND}
```

This statement creates and schedules a new event. The event will not run unless the Event Scheduler is enabled. For information about checking Event Scheduler status and enabling it if necessary, see Section 17.4.2, "Event Scheduler Configuration".

`CREATE EVENT` requires the `EVENT` privilege for the schema in which the event is to be created. It might also require the `SUPER` privilege, depending on the `DEFINER` value, as described later in this section.

The minimum requirements for a valid `CREATE EVENT` statement are as follows:

- The keywords `CREATE EVENT` plus an event name, which uniquely identifies the event in a database schema.
- An `ON SCHEDULE` clause, which determines when and how often the event executes.
- A `DO` clause, which contains the SQL statement to be executed by an event.

This is an example of a minimal `CREATE EVENT` statement:

```
CREATE EVENT myevent
    ON SCHEDULE AT CURRENT_TIMESTAMP + INTERVAL 1 HOUR
    DO
      UPDATE myschema.mytable SET mycol = mycol + 1;
```

The previous statement creates an event named `myevent`. This event executes once—one hour following its creation—by running an SQL statement that increments the value of the `myschema.mytable` table's `mycol` column by 1.

The *`event_name`* must be a valid MySQL identifier with a maximum length of 64 characters. Event names are not case sensitive, so you cannot have two events named `myevent` and `MyEvent` in the same schema. In general, the rules governing event names are the same as those for names of stored routines. See Section 8.2, “Schema Object Names”.

An event is associated with a schema. If no schema is indicated as part of *`event_name`*, the default (current) schema is assumed. To create an event in a specific schema, qualify the event name with a schema using *`schema_name`*`.`*`event_name`* syntax.

The `DEFINER` clause specifies the MySQL account to be used when checking access privileges at event execution time. If a *`user`* value is given, it should be a MySQL account specified as `'`*`user_name`*`'@'`*`host_name`*`'` (the same format used in the `GRANT` statement), `CURRENT_USER`, or `CURRENT_USER()`. The default `DEFINER` value is the user who executes the `CREATE EVENT` statement. This is the same as specifying `DEFINER = CURRENT_USER` explicitly.

If you specify the `DEFINER` clause, these rules determine the legal `DEFINER` user values:

- If you do not have the `SUPER` privilege, the only legal *`user`* value is your own account, either specified literally or by using `CURRENT_USER`. You cannot set the definer to some other account.
- If you have the `SUPER` privilege, you can specify any syntactically legal account name. If the account does not actually exist, a warning is generated.
- Although it is possible to create an event with a nonexistent `DEFINER` account, an error occurs at event execution time if the account does not exist.

For more information about event security, see Section 17.6, “Access Control for Stored Programs and Views”.

Within an event, the `CURRENT_USER()` function returns the account used to check privileges at event execution time, which is the `DEFINER` user. For information about user auditing within events, see Section 5.5.10, “Auditing MySQL Account Activity”.

`IF NOT EXISTS` has the same meaning for `CREATE EVENT` as for `CREATE TABLE`: If an event named *`event_name`* already exists in the same schema, no action is taken, and no error results. (However, a warning is generated in such cases.)

The `ON SCHEDULE` clause determines when, how often, and for how long the *`event_body`* defined for the event repeats. This clause takes one of two forms:

- `AT` *`timestamp`* is used for a one-time event. It specifies that the event executes one time only at the date and time given by *`timestamp`*, which must include both the date and time, or must be an expression that resolves to a datetime value. You may use a value of either the `DATETIME` or `TIMESTAMP` type for this purpose. If the date is in the past, a warning occurs, as shown here:

```
mysql> SELECT NOW();
+---------------------+
| NOW()               |
+---------------------+
| 2006-02-10 23:59:01 |
+---------------------+
1 row in set (0.04 sec)

mysql> CREATE EVENT e_totals
    ->     ON SCHEDULE AT '2006-02-10 23:59:00'
    ->     DO INSERT INTO test.totals VALUES (NOW());
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> SHOW WARNINGS\G
*************************** 1. row ***************************
  Level: Note
   Code: 1588
Message: Event execution time is in the past and ON COMPLETION NOT
         PRESERVE is set. The event was dropped immediately after
         creation.
```

  `CREATE EVENT` statements which are themselves invalid—for whatever reason—fail with an error.

  You may use `CURRENT_TIMESTAMP` to specify the current date and time. In such a case, the event acts as soon as it is created.

  To create an event which occurs at some point in the future relative to the current date and time—such as that expressed by the phrase “three weeks from now”—you can use the optional clause `+ INTERVAL` *`interval`*. The *`interval`* portion consists of two parts, a quantity and a unit of time, and follows the same syntax rules that govern intervals used in the `DATE_ADD()` function (see Section 11.7, “Date and Time Functions”. The units keywords are also the same, except that you cannot use any units involving microseconds when defining an event. With some interval types, complex time units may be used. For example, “two minutes and ten seconds” can be expressed as `+ INTERVAL '2:10' MINUTE_SECOND`.

You can also combine intervals. For example, `AT CURRENT_TIMESTAMP + INTERVAL 3 WEEK + INTERVAL 2 DAY` is equivalent to “three weeks and two days from now”. Each portion of such a clause must begin with `+ INTERVAL`.

- To repeat actions at a regular interval, use an `EVERY` clause. The `EVERY` keyword is followed by an *`interval`* as described in the previous discussion of the `AT` keyword. (`+ INTERVAL` is *not* used with `EVERY`.) For example, `EVERY 6 WEEK` means “every six weeks”.

  Although `+ INTERVAL` clauses are not permitted in an `EVERY` clause, you can use the same complex time units permitted in a `+ INTERVAL`.

  An `EVERY` clause may contain an optional `STARTS` clause. `STARTS` is followed by a *`timestamp`* value that indicates when the action should begin repeating, and may also use `+ INTERVAL` *`interval`* to specify an amount of time “from now”. For example, `EVERY 3 MONTH STARTS CURRENT_TIMESTAMP + INTERVAL 1 WEEK` means “every three months, beginning one week from now”. Similarly, you can express “every two weeks, beginning six hours and fifteen minutes from now” as `EVERY 2 WEEK STARTS CURRENT_TIMESTAMP + INTERVAL '6:15' HOUR_MINUTE`. Not specifying `STARTS` is the same as using `STARTS CURRENT_TIMESTAMP`—that is, the action specified for the event begins repeating immediately upon creation of the event.

  An `EVERY` clause may contain an optional `ENDS` clause. The `ENDS` keyword is followed by a *`timestamp`* value that tells MySQL when the event should stop repeating. You may also use `+ INTERVAL` *`interval`* with `ENDS`; for instance, `EVERY 12 HOUR STARTS CURRENT_TIMESTAMP + INTERVAL 30 MINUTE ENDS CURRENT_TIMESTAMP + INTERVAL 4 WEEK` is equivalent to “every twelve hours, beginning thirty minutes from now, and ending four weeks from now”. Not using `ENDS` means that the event continues executing indefinitely.

  `ENDS` supports the same syntax for complex time units as `STARTS` does.

  You may use `STARTS`, `ENDS`, both, or neither in an `EVERY` clause.

  If a repeating event does not terminate within its scheduling interval, the result may be multiple instances of the event executing simultaneously. If this is undesirable, you should institute a mechanism to prevent simultaneous instances. For example, you could use the `GET_LOCK()` function, or row or table locking.

The `ON SCHEDULE` clause may use expressions involving built-in MySQL functions and user variables to obtain any of the *`timestamp`* or *`interval`* values which it contains. You may not use stored functions or user-defined functions in such expressions, nor may you use any table references; however, you may use `SELECT FROM DUAL`. This is true for both `CREATE EVENT` and `ALTER EVENT` statements. References to stored functions, user-defined functions, and tables in such cases are specifically not permitted, and fail with an error (see Bug #22830).

Times in the `ON SCHEDULE` clause are interpreted using the current session `time_zone` value. This becomes the event time zone; that is, the time zone that is used for event scheduling and is in effect within the event as it executes. These times are converted to UTC and stored along with the event time zone in the `mysql.event` table. This enables event execution to proceed as defined regardless of any subsequent changes to the server time zone or daylight saving time effects. For additional information about representation of event times, see Section 17.4.4, “Event Metadata”. See also Section 12.4.5.19, “`SHOW EVENTS` Syntax”, and Section 18.20, “The `INFORMATION_SCHEMA EVENTS` Table”.

Normally, once an event has expired, it is immediately dropped. You can override this behavior by specifying `ON COMPLETION PRESERVE`. Using `ON COMPLETION NOT PRESERVE` merely makes the default nonpersistent behavior explicit.

You can create an event but prevent it from being active using the `DISABLE` keyword. Alternatively, you can use `ENABLE` to make explicit the default status, which is active. This is most useful in conjunction with `ALTER EVENT` (see Section 12.1.2, “`ALTER EVENT` Syntax”).

A third value may also appear in place of `ENABLED` or `DISABLED`; `DISABLE ON SLAVE` is set for the status of an event on a replication slave to indicate that the event was created on the master and replicated to the slave, but is not executed on the slave. See Section 15.4.1.8, “Replication of Invoked Features”.

You may supply a comment for an event using a `COMMENT` clause. *`comment`* may be any string of up to 64 characters that you wish to use for describing the event. The comment text, being a string literal, must be surrounded by quotation marks.

The `DO` clause specifies an action carried by the event, and consists of an SQL statement. Nearly any valid MySQL statement that can be used in a stored routine can also be used as the action statement for a scheduled event. (See Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.) For example, the following event `e_hourly` deletes all rows from the `sessions` table once per hour, where this table is part of the `site_activity` schema:

```
CREATE EVENT e_hourly
    ON SCHEDULE
      EVERY 1 HOUR
    COMMENT 'Clears out sessions table each hour.'
    DO
```

```
      DELETE FROM site_activity.sessions;
```

MySQL stores the `sql_mode` system variable setting that is in effect at the time an event is created, and always executes the event with this setting in force, *regardless of the current server SQL mode*.

A `CREATE EVENT` statement that contains an `ALTER EVENT` statement in its `DO` clause appears to succeed; however, when the server attempts to execute the resulting scheduled event, the execution fails with an error.

> **Note**
>
> Statements such as `SELECT` or `SHOW` that merely return a result set have no effect when used in an event; the output from these is not sent to the MySQL Monitor, nor is it stored anywhere. However, you can use statements such as `SELECT ... INTO` and `INSERT INTO ... SELECT` that store a result. (See the next example in this section for an instance of the latter.)

The schema to which an event belongs is the default schema for table references in the `DO` clause. Any references to tables in other schemas must be qualified with the proper schema name.

As with stored routines, you can use compound-statement syntax in the `DO` clause by using the `BEGIN` and `END` keywords, as shown here:

```
delimiter |

CREATE EVENT e_daily
    ON SCHEDULE
      EVERY 1 DAY
    COMMENT 'Saves total number of sessions then clears the table each day'
    DO
      BEGIN
        INSERT INTO site_activity.totals (time, total)
          SELECT CURRENT_TIMESTAMP, COUNT(*)
            FROM site_activity.sessions;
        DELETE FROM site_activity.sessions;
      END |

delimiter ;
```

This example uses the `delimiter` command to change the statement delimiter. See Section 17.1, “Defining Stored Programs”.

More complex compound statements, such as those used in stored routines, are possible in an event. This example uses local variables, an error handler, and a flow control construct:

```
delimiter |

CREATE EVENT e
    ON SCHEDULE
      EVERY 5 SECOND
    DO
      BEGIN
        DECLARE v INTEGER;
        DECLARE CONTINUE HANDLER FOR SQLEXCEPTION BEGIN END;

        SET v = 0;

        WHILE v < 5 DO
          INSERT INTO t1 VALUES (0);
          UPDATE t2 SET s1 = s1 + 1;
          SET v = v + 1;
        END WHILE;
    END |

delimiter ;
```

There is no way to pass parameters directly to or from events; however, it is possible to invoke a stored routine with parameters within an event:

```
CREATE EVENT e_call_myproc
    ON SCHEDULE
      AT CURRENT_TIMESTAMP + INTERVAL 1 DAY
    DO CALL myproc(5, 27);
```

If an event's definer has the `SUPER` privilege, the event can read and write global variables. As granting this privilege entails a potential for abuse, extreme care must be taken in doing so.

Generally, any statements that are valid in stored routines may be used for action statements executed by events. For more information about statements permissible within stored routines, see Section 17.2.1, “Stored Routine Syntax”. You can create an event as part of a stored routine, but an event cannot be created by another event.

12.1.10. The `CREATE FUNCTION` Statement

The `CREATE FUNCTION` statement is used to create stored functions and user-defined functions (UDFs):

- For information about creating stored functions, see Section 12.1.12, “`CREATE PROCEDURE` and `CREATE FUNCTION` Syntax”.
- For information about creating user-defined functions, see Section 12.4.3.1, “`CREATE FUNCTION` Syntax for User-Defined Functions”.

12.1.11. `CREATE INDEX` Syntax

```
CREATE [UNIQUE|FULLTEXT|SPATIAL] INDEX index_name
    [index_type]
    ON tbl_name (index_col_name,...)
    [index_option] ...

index_col_name:
    col_name [(length)] [ASC | DESC]

index_type:
    USING {BTREE | HASH}

index_option:
    KEY_BLOCK_SIZE [=] value
  | index_type
  | WITH PARSER parser_name
  | COMMENT 'string'
```

`CREATE INDEX` is mapped to an `ALTER TABLE` statement to create indexes. See Section 12.1.6, “`ALTER TABLE` Syntax”. `CREATE INDEX` cannot be used to create a `PRIMARY KEY`; use `ALTER TABLE` instead. For more information about indexes, see Section 7.3.1, “How MySQL Uses Indexes”.

Normally, you create all indexes on a table at the time the table itself is created with `CREATE TABLE`. See Section 12.1.14, “`CREATE TABLE` Syntax”. This guideline is especially important for `InnoDB` tables, where the primary key determines the physical layout of rows in the data file. `CREATE INDEX` enables you to add indexes to existing tables.

A column list of the form `(col1,col2,...)` creates a multiple-column index. Index values are formed by concatenating the values of the given columns.

Indexes can be created that use only the leading part of column values, using `col_name(length)` syntax to specify an index prefix length:

- Prefixes can be specified for `CHAR`, `VARCHAR`, `BINARY`, and `VARBINARY` columns.
- `BLOB` and `TEXT` columns also can be indexed, but a prefix length *must* be given.
- Prefix lengths are given in characters for nonbinary string types and in bytes for binary string types. That is, index entries consist of the first `length` characters of each column value for `CHAR`, `VARCHAR`, and `TEXT` columns, and the first `length` bytes of each column value for `BINARY`, `VARBINARY`, and `BLOB` columns.
- For spatial columns, prefix values cannot be given, as described later in this section.

The statement shown here creates an index using the first 10 characters of the `name` column:

```
CREATE INDEX part_of_name ON customer (name(10));
```

If names in the column usually differ in the first 10 characters, this index should not be much slower than an index created from the entire `name` column. Also, using column prefixes for indexes can make the index file much smaller, which could save a lot of disk space and might also speed up `INSERT` operations.

Prefix support and lengths of prefixes (where supported) are storage engine dependent. For example, a prefix can be up to 1000 bytes long for `MyISAM` tables, and 767 bytes for `InnoDB` tables.

> **Note**
>
> Prefix limits are measured in bytes, whereas the prefix length in `CREATE INDEX` statements is interpreted as number of characters for nonbinary data types (`CHAR`, `VARCHAR`, `TEXT`). Take this into account when specifying a prefix length for a column that uses a multi-byte character set.

A `UNIQUE` index creates a constraint such that all values in the index must be distinct. An error occurs if you try to add a new row with a key value that matches an existing row. For all engines, a `UNIQUE` index permits multiple `NULL` values for columns that can contain `NULL`. If you specify a prefix value for a column in a `UNIQUE` index, the column values must be unique within the prefix.

`FULLTEXT` indexes are supported only for `MyISAM` tables and can include only `CHAR`, `VARCHAR`, and `TEXT` columns. Indexing always happens over the entire column; column prefix indexing is not supported and any prefix length is ignored if specified. See Section 11.9, "Full-Text Search Functions", for details of operation.

The `MyISAM`, `InnoDB`, `NDB`, and `ARCHIVE` storage engines support spatial columns such as (`POINT` and `GEOMETRY`. (Section 11.17, "Spatial Extensions", describes the spatial data types.) However, support for spatial column indexing varies among engines. Spatial and nonspatial indexes are available according to the following rules.

Spatial indexes (created using `SPATIAL INDEX`) have these characteristics:

- Available only for `MyISAM` tables. Specifying `SPATIAL INDEX` for other storage engines results in an error.
- Indexed columns must be `NOT NULL`.
- In MySQL 5.5, column prefix lengths are prohibited. The full width of each column is indexed.

Characteristics of nonspatial indexes (created with `INDEX`, `UNIQUE`, or `PRIMARY KEY`):

- Permitted for any storage engine that supports spatial columns except `ARCHIVE`.
- Columns can be `NULL` unless the index is a primary key.
- For each spatial column in a non-`SPATIAL` index except `POINT` columns, a column prefix length must be specified. (This is the same requirement as for indexed `BLOB` columns.) The prefix length is given in bytes.
- The index type for a non-`SPATIAL` index depends on the storage engine. Currently, B-tree is used.

In MySQL 5.5:

- You can add an index on a column that can have `NULL` values only if you are using the `MyISAM`, `InnoDB`, or `MEMORY` storage engine.
- You can add an index on a `BLOB` or `TEXT` column only if you are using the `MyISAM`, or `InnoDB` storage engine.

An *`index_col_name`* specification can end with `ASC` or `DESC`. These keywords are permitted for future extensions for specifying ascending or descending index value storage. Currently, they are parsed but ignored; index values are always stored in ascending order.

Following the index column list, index options can be given. An *`index_option`* value can be any of the following:

- `KEY_BLOCK_SIZE [=] value`

  This option provides a hint to the storage engine about the size in bytes to use for index key blocks. The engine is permitted to change the value if necessary. A value of 0 indicates that the default value should be used.

- *`index_type`*

  Some storage engines permit you to specify an index type when creating an index. The permissible index type values supported by different storage engines are shown in the following table. Where multiple index types are listed, the first one is the default when no index type specifier is given.

Storage Engine	Permissible Index Types
`MyISAM`	`BTREE`
`InnoDB`	`BTREE`
`MEMORY`/`HEAP`	`HASH`, `BTREE`
`NDB`	`HASH`, `BTREE` (see note in text)

Example:

```
CREATE TABLE lookup (id INT) ENGINE = MEMORY;
CREATE INDEX id_index ON lookup (id) USING BTREE;
```

The `index_type` clause cannot be used together with `SPATIAL INDEX`.

If you specify an index type that is not legal for a given storage engine, but there is another index type available that the engine can use without affecting query results, the engine uses the available type. The parser recognizes `RTREE` as a type name, but currently this cannot be specified for any storage engine.

Use of this option before the `ON tbl_name` clause is deprecated; support for use of the option in this position will be removed in a future MySQL release. If an `index_type` option is given in both the earlier and later positions, the final option applies.

`TYPE type_name` is recognized as a synonym for `USING type_name`. However, `USING` is the preferred form.

- `WITH PARSER parser_name`

  This option can be used only with `FULLTEXT` indexes. It associates a parser plugin with the index if full-text indexing and searching operations need special handling. See Section 21.2, “The MySQL Plugin API”, for details on creating plugins.

- `COMMENT 'string'`

  As of MySQL 5.5.3, index definitions can include an optional comment of up to 1024 characters.

12.1.12. `CREATE PROCEDURE` and `CREATE FUNCTION` Syntax

```
CREATE
    [DEFINER = { user | CURRENT_USER }]
    PROCEDURE sp_name ([proc_parameter[,...]])
    [characteristic ...] routine_body

CREATE
    [DEFINER = { user | CURRENT_USER }]
    FUNCTION sp_name ([func_parameter[,...]])
    RETURNS type
    [characteristic ...] routine_body

proc_parameter:
    [ IN | OUT | INOUT ] param_name type

func_parameter:
    param_name type

type:
    Any valid MySQL data type

characteristic:
    COMMENT 'string'
  | LANGUAGE SQL
  | [NOT] DETERMINISTIC
  | { CONTAINS SQL | NO SQL | READS SQL DATA | MODIFIES SQL DATA }
  | SQL SECURITY { DEFINER | INVOKER }

routine_body:
    Valid SQL routine statement
```

These statements create stored routines. By default, a routine is associated with the default database. To associate the routine explicitly with a given database, specify the name as `db_name.sp_name` when you create it.

The `CREATE FUNCTION` statement is also used in MySQL to support UDFs (user-defined functions). See Section 21.3, “Adding New Functions to MySQL”. A UDF can be regarded as an external stored function. Stored functions share their namespace with UDFs. See Section 8.2.4, “Function Name Parsing and Resolution”, for the rules describing how the server interprets references to different kinds of functions.

To invoke a stored procedure, use the `CALL` statement (see Section 12.2.1, “`CALL` Syntax”). To invoke a stored function, refer to it in an expression. The function returns a value during expression evaluation.

`CREATE PROCEDURE` and `CREATE FUNCTION` require the `CREATE ROUTINE` privilege. They might also require the `SUPER` privilege, depending on the `DEFINER` value, as described later in this section. If binary logging is enabled, `CREATE FUNCTION` might require the `SUPER` privilege, as described in Section 17.7, “Binary Logging of Stored Programs”.

By default, MySQL automatically grants the `ALTER ROUTINE` and `EXECUTE` privileges to the routine creator. This behavior can be changed by disabling the `automatic_sp_privileges` system variable. See Section 17.2.2, “Stored Routines and MySQL Privileges”.

The `DEFINER` and `SQL SECURITY` clauses specify the security context to be used when checking access privileges at routine execution time, as described later in this section.

If the routine name is the same as the name of a built-in SQL function, a syntax error occurs unless you use a space between the name and the following parenthesis when defining the routine or invoking it later. For this reason, avoid using the names of existing SQL functions for your own stored routines.

The `IGNORE_SPACE` SQL mode applies to built-in functions, not to stored routines. It is always permissible to have spaces after a stored routine name, regardless of whether `IGNORE_SPACE` is enabled.

The parameter list enclosed within parentheses must always be present. If there are no parameters, an empty parameter list of `()` should be used. Parameter names are not case sensitive.

Each parameter is an `IN` parameter by default. To specify otherwise for a parameter, use the keyword `OUT` or `INOUT` before the parameter name.

> **Note**
>
> Specifying a parameter as `IN`, `OUT`, or `INOUT` is valid only for a `PROCEDURE`. For a `FUNCTION`, parameters are always regarded as `IN` parameters.

An `IN` parameter passes a value into a procedure. The procedure might modify the value, but the modification is not visible to the caller when the procedure returns. An `OUT` parameter passes a value from the procedure back to the caller. Its initial value is `NULL` within the procedure, and its value is visible to the caller when the procedure returns. An `INOUT` parameter is initialized by the caller, can be modified by the procedure, and any change made by the procedure is visible to the caller when the procedure returns.

For each `OUT` or `INOUT` parameter, pass a user-defined variable in the `CALL` statement that invokes the procedure so that you can obtain its value when the procedure returns. If you are calling the procedure from within another stored procedure or function, you can also pass a routine parameter or local routine variable as an `IN` or `INOUT` parameter.

The following example shows a simple stored procedure that uses an `OUT` parameter:

```
mysql> delimiter //

mysql> CREATE PROCEDURE simpleproc (OUT param1 INT)
    -> BEGIN
    ->   SELECT COUNT(*) INTO param1 FROM t;
    -> END//
Query OK, 0 rows affected (0.00 sec)

mysql> delimiter ;

mysql> CALL simpleproc(@a);
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @a;
+------+
| @a   |
+------+
| 3    |
+------+
1 row in set (0.00 sec)
```

The example uses the `mysql` client `delimiter` command to change the statement delimiter from `;` to `//` while the procedure is being defined. This enables the `;` delimiter used in the procedure body to be passed through to the server rather than being interpreted by `mysql` itself. See Section 17.1, “Defining Stored Programs”.

The `RETURNS` clause may be specified only for a `FUNCTION`, for which it is mandatory. It indicates the return type of the function, and the function body must contain a `RETURN value` statement. If the `RETURN` statement returns a value of a different type, the value is coerced to the proper type. For example, if a function specifies an `ENUM` or `SET` value in the `RETURNS` clause, but the `RETURN` statement returns an integer, the value returned from the function is the string for the corresponding `ENUM` member of set of `SET` members.

The following example function takes a parameter, performs an operation using an SQL function, and returns the result. In this case, it is unnecessary to use `delimiter` because the function definition contains no internal `;` statement delimiters:

```
mysql> CREATE FUNCTION hello (s CHAR(20))
mysql> RETURNS CHAR(50) DETERMINISTIC
    -> RETURN CONCAT('Hello, ',s,'!');
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT hello('world');
+----------------+
| hello('world') |
+----------------+
| Hello, world!  |
+----------------+
1 row in set (0.00 sec)
```

Parameter types and function return types can be declared to use any valid data type, except that the `COLLATE` attribute cannot be used prior to MySQL 5.5.3. As of 5.5.3, `COLLATE` can be used if preceded by the `CHARACTER SET` attribute.

The *`routine_body`* consists of a valid SQL routine statement. This can be a simple statement such as `SELECT` or `INSERT`, or a compound statement written using `BEGIN` and `END`. Compound statements can contain declarations, loops, and other control structure statements. The syntax for these statements is described in Section 12.7, “MySQL Compound-Statement Syntax”.

MySQL permits routines to contain DDL statements, such as `CREATE` and `DROP`. MySQL also permits stored procedures (but not stored functions) to contain SQL transaction statements such as `COMMIT`. Stored functions may not contain statements that perform explicit or implicit commit or rollback. Support for these statements is not required by the SQL standard, which states that each DBMS vendor may decide whether to permit them.

Statements that return a result set can be used within a stored procedure but not within a stored function. This prohibition includes `SELECT` statements that do not have an `INTO` *`var_list`* clause and other statements such as `SHOW`, `EXPLAIN`, and `CHECK TABLE`. For statements that can be determined at function definition time to return a result set, a `Not allowed to return a result set from a function` error occurs (`ER_SP_NO_RETSET`). For statements that can be determined only at runtime to return a result set, a `PROCEDURE %s can't return a result set in the given context` error occurs (`ER_SP_BADSELECT`).

`USE` statements within stored routines are not permitted. When a routine is invoked, an implicit `USE` *`db_name`* is performed (and undone when the routine terminates). The causes the routine to have the given default database while it executes. References to objects in databases other than the routine default database should be qualified with the appropriate database name.

For additional information about statements that are not permitted in stored routines, see Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.

For information about invoking stored procedures from within programs written in a language that has a MySQL interface, see Section 12.2.1, “`CALL` Syntax”.

MySQL stores the `sql_mode` system variable setting that is in effect at the time a routine is created, and always executes the routine with this setting in force, *regardless of the server SQL mode in effect when the routine is invoked*.

The switch from the SQL mode of the invoker to that of the routine occurs after evaluation of arguments and assignment of the resulting values to routine parameters. If you define a routine in strict SQL mode but invoke it in nonstrict mode, assignment of arguments to routine parameters does not take place in strict mode. If you require that expressions passed to a routine be assigned in strict SQL mode, you should invoke the routine with strict mode in effect.

The `COMMENT` characteristic is a MySQL extension, and may be used to describe the stored routine. This information is displayed by the `SHOW CREATE PROCEDURE` and `SHOW CREATE FUNCTION` statements.

The `LANGUAGE` characteristic indicates the language in which the routine is written. The server ignores this characteristic; only SQL routines are supported.

A routine is considered “deterministic” if it always produces the same result for the same input parameters, and “not deterministic” otherwise. If neither `DETERMINISTIC` nor `NOT DETERMINISTIC` is given in the routine definition, the default is `NOT DETERMINISTIC`. To declare that a function is deterministic, you must specify `DETERMINISTIC` explicitly.

Assessment of the nature of a routine is based on the “honesty” of the creator: MySQL does not check that a routine declared `DETERMINISTIC` is free of statements that produce nondeterministic results. However, misdeclaring a routine might affect results or affect performance. Declaring a nondeterministic routine as `DETERMINISTIC` might lead to unexpected results by causing the optimizer to make incorrect execution plan choices. Declaring a deterministic routine as `NONDETERMINISTIC` might diminish performance by causing available optimizations not to be used.

If binary logging is enabled, the `DETERMINISTIC` characteristic affects which routine definitions MySQL accepts. See Section 17.7, “Binary Logging of Stored Programs”.

A routine that contains the `NOW()` function (or its synonyms) or `RAND()` is nondeterministic, but it might still be replication-safe. For `NOW()`, the binary log includes the timestamp and replicates correctly. `RAND()` also replicates correctly as long as it is called only a single time during the execution of a routine. (You can consider the routine execution timestamp and random number seed as implicit inputs that are identical on the master and slave.)

Several characteristics provide information about the nature of data use by the routine. In MySQL, these characteristics are advisory only. The server does not use them to constrain what kinds of statements a routine will be permitted to execute.

- `CONTAINS SQL` indicates that the routine does not contain statements that read or write data. This is the default if none of these characteristics is given explicitly. Examples of such statements are `SET @x = 1` or `DO RELEASE_LOCK('abc')`, which execute but neither read nor write data.

- `NO SQL` indicates that the routine contains no SQL statements.

- `READS SQL DATA` indicates that the routine contains statements that read data (for example, `SELECT`), but not statements that write data.
- `MODIFIES SQL DATA` indicates that the routine contains statements that may write data (for example, `INSERT` or `DELETE`).

The `SQL SECURITY` characteristic can be `DEFINER` or `INVOKER` to specify the security context; that is, whether the routine executes using the privileges of the account named in the routine `DEFINER` clause or the user who invokes it. This account must have permission to access the database with which the routine is associated. The default value is `DEFINER`. The user who invokes the routine must have the `EXECUTE` privilege for it, as must the `DEFINER` account if the routine executes in definer security context.

The `DEFINER` clause specifies the MySQL account to be used when checking access privileges at routine execution time for routines that have the `SQL SECURITY DEFINER` characteristic.

If a *`user`* value is given for the `DEFINER` clause, it should be a MySQL account specified as `'user_name'@'host_name'` (the same format used in the `GRANT` statement), `CURRENT_USER`, or `CURRENT_USER()`. The default `DEFINER` value is the user who executes the `CREATE PROCEDURE` or `CREATE FUNCTION` or statement. This is the same as specifying `DEFINER = CURRENT_USER` explicitly.

If you specify the `DEFINER` clause, these rules determine the legal `DEFINER` user values:

- If you do not have the `SUPER` privilege, the only legal *`user`* value is your own account, either specified literally or by using `CURRENT_USER`. You cannot set the definer to some other account.
- If you have the `SUPER` privilege, you can specify any syntactically legal account name. If the account does not actually exist, a warning is generated.
- Although it is possible to create a routine with a nonexistent `DEFINER` account, an error occurs at routine execution time if the `SQL SECURITY` value is `DEFINER` but the definer account does not exist.

For more information about stored routine security, see Section 17.6, “Access Control for Stored Programs and Views”.

Within a stored routine that is defined with the `SQL SECURITY DEFINER` characteristic, `CURRENT_USER` returns the routine's `DEFINER` value. For information about user auditing within stored routines, see Section 5.5.10, “Auditing MySQL Account Activity”.

Consider the following procedure, which displays a count of the number of MySQL accounts listed in the `mysql.user` table:

```
CREATE DEFINER = 'admin'@'localhost' PROCEDURE account_count()
BEGIN
  SELECT 'Number of accounts:', COUNT(*) FROM mysql.user;
END;
```

The procedure is assigned a `DEFINER` account of `'admin'@'localhost'` no matter which user defines it. It executes with the privileges of that account no matter which user invokes it (because the default security characteristic is `DEFINER`). The procedure succeeds or fails depending on whether invoker has the `EXECUTE` privilege for it and `'admin'@'localhost'` has the `SELECT` privilege for the `mysql.user` table.

Now suppose that the procedure is defined with the `SQL SECURITY INVOKER` characteristic:

```
CREATE DEFINER = 'admin'@'localhost' PROCEDURE account_count()
SQL SECURITY INVOKER
BEGIN
  SELECT 'Number of accounts:', COUNT(*) FROM mysql.user;
END;
```

The procedure still has a `DEFINER` of `'admin'@'localhost'`, but in this case, it executes with the privileges of the invoking user. Thus, the procedure succeeds or fails depending on whether the invoker has the `EXECUTE` privilege for it and the `SELECT` privilege for the `mysql.user` table.

The server handles the data type of a routine parameter, local routine variable created with `DECLARE`, or function return value as follows:

- Assignments are checked for data type mismatches and overflow. Conversion and overflow problems result in warnings, or errors in strict SQL mode.
- Only scalar values can be assigned. For example, a statement such as `SET x = (SELECT 1, 2)` is invalid.

- For character data types, if there is a `CHARACTER SET` attribute in the declaration, the specified character set and its default collation is used. If the `COLLATE` attribute is also present, that collation is used rather than the default collation. If there is no `CHARACTER SET` attribute, the database character set and collation in effect at routine creation time are used. (The database character set and collation are given by the value of the `character_set_database` and `collation_database` system variables.)

  Prior to MySQL 5.5.3, if there is a `CHARACTER SET` attribute in the declaration, the `COLLATE` attribute is not supported, and the character set's default collation is used. (This includes use of `BINARY`, which in this context specifies the binary collation of the character set.) If there is no `CHARACTER SET` attribute, the database character set and its default collation (rather than the database collation) are used.

12.1.13. `CREATE SERVER` Syntax

```
CREATE SERVER server_name
    FOREIGN DATA WRAPPER wrapper_name
    OPTIONS (option [, option] ...)

option:
  { HOST character-literal
  | DATABASE character-literal
  | USER character-literal
  | PASSWORD character-literal
  | SOCKET character-literal
  | OWNER character-literal
  | PORT numeric-literal }
```

This statement creates the definition of a server for use with the `FEDERATED` storage engine. The `CREATE SERVER` statement creates a new row within the `servers` table within the `mysql` database. This statement requires the `SUPER` privilege.

The *`server_name`* should be a unique reference to the server. Server definitions are global within the scope of the server, it is not possible to qualify the server definition to a specific database. *`server_name`* has a maximum length of 64 characters (names longer than 64 characters are silently truncated), and is case insensitive. You may specify the name as a quoted string.

The *`wrapper_name`* should be `mysql`, and may be quoted with single quotation marks. Other values for *`wrapper_name`* are not currently supported.

For each *`option`* you must specify either a character literal or numeric literal. Character literals are UTF-8, support a maximum length of 64 characters and default to a blank (empty) string. String literals are silently truncated to 64 characters. Numeric literals must be a number between 0 and 9999, default value is 0.

> **Note**
>
> Note that the `OWNER` option is currently not applied, and has no effect on the ownership or operation of the server connection that is created.

The `CREATE SERVER` statement creates an entry in the `mysql.servers` table that can later be used with the `CREATE TABLE` statement when creating a `FEDERATED` table. The options that you specify will be used to populate the columns in the `mysql.servers` table. The table columns are `Server_name`, `Host`, `Db`, `Username`, `Password`, `Port` and `Socket`.

For example:

```
CREATE SERVER s
FOREIGN DATA WRAPPER mysql
OPTIONS (USER 'Remote', HOST '192.168.1.106', DATABASE 'test');
```

The data stored in the table can be used when creating a connection to a `FEDERATED` table:

```
CREATE TABLE t (s1 INT) ENGINE=FEDERATED CONNECTION='s';
```

For more information, see Section 13.11, “The `FEDERATED` Storage Engine”.

`CREATE SERVER` does not cause an automatic commit.

12.1.14. `CREATE TABLE` Syntax

```
CREATE [TEMPORARY] TABLE [IF NOT EXISTS] tbl_name
    (create_definition,...)
    [table_options]
    [partition_options]
```

Or:

```
CREATE [TEMPORARY] TABLE [IF NOT EXISTS] tbl_name
    [(create_definition,...)]
    [table_options]
    [partition_options]
    select_statement
```

Or:

```
CREATE [TEMPORARY] TABLE [IF NOT EXISTS] tbl_name
    { LIKE old_tbl_name | (LIKE old_tbl_name) }
```

```
create_definition:
    col_name column_definition
  | [CONSTRAINT [symbol]] PRIMARY KEY [index_type] (index_col_name,...)
      [index_option] ...
  | {INDEX|KEY} [index_name] [index_type] (index_col_name,...)
      [index_option] ...
  | [CONSTRAINT [symbol]] UNIQUE [INDEX|KEY]
      [index_name] [index_type] (index_col_name,...)
      [index_option] ...
  | {FULLTEXT|SPATIAL} [INDEX|KEY] [index_name] (index_col_name,...)
      [index_option] ...
  | [CONSTRAINT [symbol]] FOREIGN KEY
      [index_name] (index_col_name,...) reference_definition
  | CHECK (expr)

column_definition:
    data_type [NOT NULL | NULL] [DEFAULT default_value]
      [AUTO_INCREMENT] [UNIQUE [KEY] | [PRIMARY] KEY]
      [COMMENT 'string']
      [COLUMN_FORMAT {FIXED|DYNAMIC|DEFAULT}]
      [reference_definition]

data_type:
    BIT[(length)]
  | TINYINT[(length)] [UNSIGNED] [ZEROFILL]
  | SMALLINT[(length)] [UNSIGNED] [ZEROFILL]
  | MEDIUMINT[(length)] [UNSIGNED] [ZEROFILL]
  | INT[(length)] [UNSIGNED] [ZEROFILL]
  | INTEGER[(length)] [UNSIGNED] [ZEROFILL]
  | BIGINT[(length)] [UNSIGNED] [ZEROFILL]
  | REAL[(length,decimals)] [UNSIGNED] [ZEROFILL]
  | DOUBLE[(length,decimals)] [UNSIGNED] [ZEROFILL]
  | FLOAT[(length,decimals)] [UNSIGNED] [ZEROFILL]
  | DECIMAL[(length[,decimals])] [UNSIGNED] [ZEROFILL]
  | NUMERIC[(length[,decimals])] [UNSIGNED] [ZEROFILL]
  | DATE
  | TIME
  | TIMESTAMP
  | DATETIME
  | YEAR
  | CHAR[(length)]
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | VARCHAR(length)
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | BINARY[(length)]
  | VARBINARY(length)
  | TINYBLOB
  | BLOB
  | MEDIUMBLOB
  | LONGBLOB
  | TINYTEXT [BINARY]
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | TEXT [BINARY]
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | MEDIUMTEXT [BINARY]
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | LONGTEXT [BINARY]
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | ENUM(value1,value2,value3,...)
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | SET(value1,value2,value3,...)
      [CHARACTER SET charset_name] [COLLATE collation_name]
  | spatial_type

index_col_name:
    col_name [(length)] [ASC | DESC]

index_type:
    USING {BTREE | HASH}

index_option:
    KEY_BLOCK_SIZE [=] value
  | index_type
  | WITH PARSER parser_name
  | COMMENT 'string'

reference_definition:
    REFERENCES tbl_name (index_col_name,...)
      [MATCH FULL | MATCH PARTIAL | MATCH SIMPLE]
      [ON DELETE reference_option]
      [ON UPDATE reference_option]
```

```
reference_option:
    RESTRICT | CASCADE | SET NULL | NO ACTION

table_options:
    table_option [[,] table_option] ...

table_option:
    ENGINE [=] engine_name
  | AUTO_INCREMENT [=] value
  | AVG_ROW_LENGTH [=] value
  | [DEFAULT] CHARACTER SET [=] charset_name
  | CHECKSUM [=] {0 | 1}
  | [DEFAULT] COLLATE [=] collation_name
  | COMMENT [=] 'string'
  | CONNECTION [=] 'connect_string'
  | DATA DIRECTORY [=] 'absolute path to directory'
  | DELAY_KEY_WRITE [=] {0 | 1}
  | INDEX DIRECTORY [=] 'absolute path to directory'
  | INSERT_METHOD [=] { NO | FIRST | LAST }
  | KEY_BLOCK_SIZE [=] value
  | MAX_ROWS [=] value
  | MIN_ROWS [=] value
  | PACK_KEYS [=] {0 | 1 | DEFAULT}
  | PASSWORD [=] 'string'
  | ROW_FORMAT [=] {DEFAULT|DYNAMIC|FIXED|COMPRESSED|REDUNDANT|COMPACT}
  | UNION [=] (tbl_name[,tbl_name]...)

partition_options:
    PARTITION BY
        { [LINEAR] HASH(expr)
        | [LINEAR] KEY(column_list)
        | RANGE{(expr) | COLUMNS(column_list)}
        | LIST{(expr) | COLUMNS(column_list)} }
    [PARTITIONS num]
    [SUBPARTITION BY
        { [LINEAR] HASH(expr)
        | [LINEAR] KEY(column_list) }
      [SUBPARTITIONS num]
    ]
    [(partition_definition [, partition_definition] ...)]

partition_definition:
    PARTITION partition_name
        [VALUES
            {LESS THAN {(expr | value_list) | MAXVALUE}
            |
            IN (value_list)}]
        [[STORAGE] ENGINE [=] engine_name]
        [COMMENT [=] 'comment_text' ]
        [DATA DIRECTORY [=] 'data_dir']
        [INDEX DIRECTORY [=] 'index_dir']
        [MAX_ROWS [=] max_number_of_rows]
        [MIN_ROWS [=] min_number_of_rows]
        [(subpartition_definition [, subpartition_definition] ...)]

subpartition_definition:
    SUBPARTITION logical_name
        [[STORAGE] ENGINE [=] engine_name]
        [COMMENT [=] 'comment_text' ]
        [DATA DIRECTORY [=] 'data_dir']
        [INDEX DIRECTORY [=] 'index_dir']
        [MAX_ROWS [=] max_number_of_rows]
        [MIN_ROWS [=] min_number_of_rows]

select_statement:
    [IGNORE | REPLACE] [AS] SELECT ...   (Some legal select statement)
```

`CREATE TABLE` creates a table with the given name. You must have the `CREATE` privilege for the table.

Rules for permissible table names are given in Section 8.2, “Schema Object Names”. By default, the table is created in the default database, using the `InnoDB` storage engine. An error occurs if the table exists, if there is no default database, or if the database does not exist.

The table name can be specified as *`db_name.tbl_name`* to create the table in a specific database. This works regardless of whether there is a default database, assuming that the database exists. If you use quoted identifiers, quote the database and table names separately. For example, write `` `mydb`.`mytbl` ``, not `` `mydb.mytbl` ``.

You can use the `TEMPORARY` keyword when creating a table. A `TEMPORARY` table is visible only to the current connection, and is dropped automatically when the connection is closed. This means that two different connections can use the same temporary table name without conflicting with each other or with an existing non-`TEMPORARY` table of the same name. (The existing table is hidden until the temporary table is dropped.) To create temporary tables, you must have the `CREATE TEMPORARY TABLES` privilege.

> **Note**
>
> `CREATE TABLE` does not automatically commit the current active transaction if you use the `TEMPORARY` keyword.

The keywords `IF NOT EXISTS` prevent an error from occurring if the table exists. However, there is no verification that the existing table has a structure identical to that indicated by the `CREATE TABLE` statement.

MySQL represents each table by an `.frm` table format (definition) file in the database directory. The storage engine for the table might create other files as well. In the case of `MyISAM` tables, the storage engine creates data and index files. Thus, for each `MyISAM` table *`tbl_name`*, there are three disk files.

File	Purpose
`tbl_name``.frm`	Table format (definition) file
`tbl_name``.MYD`	Data file
`tbl_name``.MYI`	Index file

Chapter 13, *Storage Engines*, describes what files each storage engine creates to represent tables. If a table name contains special characters, the names for the table files contain encoded versions of those characters as described in Section 8.2.3, "Mapping of Identifiers to File Names".

`data_type` represents the data type in a column definition. *`spatial_type`* represents a spatial data type. The data type syntax shown is representative only. For a full description of the syntax available for specifying column data types, as well as information about the properties of each type, see Chapter 10, *Data Types*, and Section 11.17, "Spatial Extensions".

Some attributes do not apply to all data types. `AUTO_INCREMENT` applies only to integer and floating-point types. `DEFAULT` does not apply to the `BLOB` or `TEXT` types.

- If neither `NULL` nor `NOT NULL` is specified, the column is treated as though `NULL` had been specified.
- An integer or floating-point column can have the additional attribute `AUTO_INCREMENT`. When you insert a value of `NULL` (recommended) or `0` into an indexed `AUTO_INCREMENT` column, the column is set to the next sequence value. Typically this is *`value`*`+1`, where *`value`* is the largest value for the column currently in the table. `AUTO_INCREMENT` sequences begin with `1`.

  To retrieve an `AUTO_INCREMENT` value after inserting a row, use the `LAST_INSERT_ID()` SQL function or the `mysql_insert_id()` C API function. See Section 11.14, "Information Functions", and Section 20.9.3.37, "`mysql_insert_id()`".

  If the `NO_AUTO_VALUE_ON_ZERO` SQL mode is enabled, you can store `0` in `AUTO_INCREMENT` columns as `0` without generating a new sequence value. See Section 5.1.6, "Server SQL Modes".

  > **Note**
  >
  > There can be only one `AUTO_INCREMENT` column per table, it must be indexed, and it cannot have a `DEFAULT` value. An `AUTO_INCREMENT` column works properly only if it contains only positive values. Inserting a negative number is regarded as inserting a very large positive number. This is done to avoid precision problems when numbers "wrap" over from positive to negative and also to ensure that you do not accidentally get an `AUTO_INCREMENT` column that contains `0`.

  For `MyISAM` tables, you can specify an `AUTO_INCREMENT` secondary column in a multiple-column key. See Section 3.6.9, "Using `AUTO_INCREMENT`".

  To make MySQL compatible with some ODBC applications, you can find the `AUTO_INCREMENT` value for the last inserted row with the following query:

  ```
  SELECT * FROM tbl_name WHERE auto_col IS NULL
  ```

  For information about `InnoDB` and `AUTO_INCREMENT`, see Section 13.3.5.3, "`AUTO_INCREMENT` Handling in `InnoDB`". For information about `AUTO_INCREMENT` and MySQL Replication, see Section 15.4.1.1, "Replication and `AUTO_INCREMENT`".
- Character data types (`CHAR`, `VARCHAR`, `TEXT`) can include `CHARACTER SET` and `COLLATE` attributes to specify the character set and collation for the column. For details, see Section 9.1, "Character Set Support". `CHARSET` is a synonym for `CHARACTER SET`. Example:

  ```
  CREATE TABLE t (c CHAR(20) CHARACTER SET utf8 COLLATE utf8_bin);
  ```

  MySQL 5.5 interprets length specifications in character column definitions in characters. (Versions before MySQL 4.1 interpreted them in bytes.) Lengths for `BINARY` and `VARBINARY` are in bytes.
- The `DEFAULT` clause specifies a default value for a column. With one exception, the default value must be a constant; it cannot be a function or an expression. This means, for example, that you cannot set the default for a date column to be the value of a

function such as `NOW()` or `CURRENT_DATE`. The exception is that you can specify `CURRENT_TIMESTAMP` as the default for a `TIMESTAMP` column. See Section 10.3.1.1, "`TIMESTAMP` Properties".

If a column definition includes no explicit `DEFAULT` value, MySQL determines the default value as described in Section 10.1.4, "Data Type Default Values".

`BLOB` and `TEXT` columns cannot be assigned a default value.

`CREATE TABLE` fails if a date-valued default is not correct according to the `NO_ZERO_IN_DATE` SQL mode, even if strict SQL mode is not enabled. For example, `c1 DATE DEFAULT '2010-00-00'` causes `CREATE TABLE` to fail with `Invalid default value for 'c1'`.

- A comment for a column can be specified with the `COMMENT` option, up to 1024 characters long (255 characters before MySQL 5.5.3). The comment is displayed by the `SHOW CREATE TABLE` and `SHOW FULL COLUMNS` statements.

- `KEY` is normally a synonym for `INDEX`. The key attribute `PRIMARY KEY` can also be specified as just `KEY` when given in a column definition. This was implemented for compatibility with other database systems.

- A `UNIQUE` index creates a constraint such that all values in the index must be distinct. An error occurs if you try to add a new row with a key value that matches an existing row. For all engines, a `UNIQUE` index permits multiple `NULL` values for columns that can contain `NULL`.

- A `PRIMARY KEY` is a unique index where all key columns must be defined as `NOT NULL`. If they are not explicitly declared as `NOT NULL`, MySQL declares them so implicitly (and silently). A table can have only one `PRIMARY KEY`. If you do not have a `PRIMARY KEY` and an application asks for the `PRIMARY KEY` in your tables, MySQL returns the first `UNIQUE` index that has no `NULL` columns as the `PRIMARY KEY`.

  In `InnoDB` tables, keep the `PRIMARY KEY` short to minimize storage overhead for secondary indexes. Each secondary index entry contains a copy of the primary key columns for the corresponding row. (See Section 13.3.11, "`InnoDB` Table and Index Structures".)

- In the created table, a `PRIMARY KEY` is placed first, followed by all `UNIQUE` indexes, and then the nonunique indexes. This helps the MySQL optimizer to prioritize which index to use and also more quickly to detect duplicated `UNIQUE` keys.

- A `PRIMARY KEY` can be a multiple-column index. However, you cannot create a multiple-column index using the `PRIMARY KEY` key attribute in a column specification. Doing so only marks that single column as primary. You must use a separate `PRIMARY KEY(index_col_name, ...)` clause.

- If a `PRIMARY KEY` or `UNIQUE` index consists of only one column that has an integer type, you can also refer to the column as `_rowid` in `SELECT` statements.

- In MySQL, the name of a `PRIMARY KEY` is `PRIMARY`. For other indexes, if you do not assign a name, the index is assigned the same name as the first indexed column, with an optional suffix (`_2`, `_3`, `...`) to make it unique. You can see index names for a table using `SHOW INDEX FROM tbl_name`. See Section 12.4.5.23, "`SHOW INDEX` Syntax".

- Some storage engines permit you to specify an index type when creating an index. The syntax for the *`index_type`* specifier is `USING type_name`.

  Example:

  ```
  CREATE TABLE lookup
    (id INT, INDEX USING BTREE (id))
    ENGINE = MEMORY;
  ```

  The preferred position is after the column list. Support for use of the option before the column list will be removed in a future MySQL release.

  `index_option` values specify additional options for an index. `USING` is one such option. For details about permissible *`index_option`* values, see Section 12.1.11, "`CREATE INDEX` Syntax".

  For more information about indexes, see Section 7.3.1, "How MySQL Uses Indexes".

- In MySQL 5.5, only the `MyISAM`, `InnoDB`, and `MEMORY` storage engines support indexes on columns that can have `NULL` values. In other cases, you must declare indexed columns as `NOT NULL` or an error results.

- For `CHAR`, `VARCHAR`, `BINARY`, and `VARBINARY` columns, indexes can be created that use only the leading part of column values, using `col_name(length)` syntax to specify an index prefix length. `BLOB` and `TEXT` columns also can be indexed, but a prefix length *must* be given. Prefix lengths are given in characters for nonbinary string types and in bytes for binary string types. That is, index entries consist of the first *`length`* characters of each column value for `CHAR`, `VARCHAR`, and `TEXT` columns, and the first *`length`* bytes of each column value for `BINARY`, `VARBINARY`, and `BLOB` columns. Indexing only a prefix of column values like this can make the index file much smaller. See Section 7.3.4, "Column Indexes".

Only the `MyISAM` and `InnoDB` storage engines support indexing on `BLOB` and `TEXT` columns. For example:

```
CREATE TABLE test (blob_col BLOB, INDEX(blob_col(10)));
```

Prefixes can be up to 1000 bytes long (767 bytes for `InnoDB` tables). Note that prefix limits are measured in bytes, whereas the prefix length in `CREATE TABLE` statements is interpreted as number of characters for nonbinary data types (`CHAR`, `VARCHAR`, `TEXT`). Take this into account when specifying a prefix length for a column that uses a multi-byte character set.

- An *`index_col_name`* specification can end with `ASC` or `DESC`. These keywords are permitted for future extensions for specifying ascending or descending index value storage. Currently, they are parsed but ignored; index values are always stored in ascending order.

- When you use `ORDER BY` or `GROUP BY` on a `TEXT` or `BLOB` column in a `SELECT`, the server sorts values using only the initial number of bytes indicated by the `max_sort_length` system variable. See Section 10.4.3, "The `BLOB` and `TEXT` Types".

- You can create special `FULLTEXT` indexes, which are used for full-text searches. Only the `MyISAM` storage engine supports `FULLTEXT` indexes. They can be created only from `CHAR`, `VARCHAR`, and `TEXT` columns. Indexing always happens over the entire column; column prefix indexing is not supported and any prefix length is ignored if specified. See Section 11.9, "Full-Text Search Functions", for details of operation. A `WITH PARSER` clause can be specified as an *`index_option`* value to associate a parser plugin with the index if full-text indexing and searching operations need special handling. This clause is legal only for `FULLTEXT` indexes. See Section 21.2, "The MySQL Plugin API", for details on creating plugins.

- You can create `SPATIAL` indexes on spatial data types. Spatial types are supported only for `MyISAM` tables and indexed columns must be declared as `NOT NULL`. See Section 11.17, "Spatial Extensions".

- As of MySQL 5.5.3, index definitions can include an optional comment of up to 1024 characters.

- `InnoDB` tables support checking of foreign key constraints. See Section 13.3, "The `InnoDB` Storage Engine". Note that the `FOREIGN KEY` syntax in `InnoDB` is more restrictive than the syntax presented for the `CREATE TABLE` statement at the beginning of this section: The columns of the referenced table must always be explicitly named. `InnoDB` supports both `ON DELETE` and `ON UPDATE` actions on foreign keys. For the precise syntax, see Section 13.3.5.4, "`FOREIGN KEY` Constraints".

  For other storage engines, MySQL Server parses and ignores the `FOREIGN KEY` and `REFERENCES` syntax in `CREATE TABLE` statements. The `CHECK` clause is parsed but ignored by all storage engines. See Section 1.8.5.4, "Foreign Key Differences".

  > **Important**
  >
  > For users familiar with the ANSI/ISO SQL Standard, please note that no storage engine, including `InnoDB`, recognizes or enforces the `MATCH` clause used in referential integrity constraint definitions. Use of an explicit `MATCH` clause will not have the specified effect, and also causes `ON DELETE` and `ON UPDATE` clauses to be ignored. For these reasons, specifying `MATCH` should be avoided.
  >
  > The `MATCH` clause in the SQL standard controls how `NULL` values in a composite (multiple-column) foreign key are handled when comparing to a primary key. `InnoDB` essentially implements the semantics defined by `MATCH SIMPLE`, which permit a foreign key to be all or partially `NULL`. In that case, the (child table) row containing such a foreign key is permitted to be inserted, and does not match any row in the referenced (parent) table. It is possible to implement other semantics using triggers.
  >
  > Additionally, MySQL and `InnoDB` require that the referenced columns be indexed for performance. However, the system does not enforce a requirement that the referenced columns be `UNIQUE` or be declared `NOT NULL`. The handling of foreign key references to nonunique keys or keys that contain `NULL` values is not well defined for operations such as `UPDATE` or `DELETE CASCADE`. You are advised to use foreign keys that reference only `UNIQUE` and `NOT NULL` keys.
  >
  > Furthermore, `InnoDB` does not recognize or support "inline `REFERENCES` specifications" (as defined in the SQL standard) where the references are defined as part of the column specification. `InnoDB` accepts `REFERENCES` clauses only when specified as part of a separate `FOREIGN KEY` specification. For other storage engines, MySQL Server parses and ignores foreign key specifications.

  > **Note**
  >
  > Partitioned tables do not support foreign keys. See Section 16.5, "Restrictions and Limitations on Partitioning", for more information.

- There is a hard limit of 4096 columns per table, but the effective maximum may be less for a given table and depends on the factors discussed in Section E.9.4, "Table Column-Count and Row-Size Limits".

The `ENGINE` table option specifies the storage engine for the table.

The `ENGINE` table option takes the storage engine names shown in the following table.

Storage Engine	**Description**
`InnoDB`	Transaction-safe tables with row locking and foreign keys. The default storage engine for new tables. See Section 13.3, "The `InnoDB` Storage Engine", and in particular Section 13.3.1, "InnoDB as the Default MySQL Storage Engine" if you have MySQL experience but are new to `InnoDB`.
`MyISAM`	The binary portable storage engine that is primarily used for read-only or read-mostly workloads. See Section 13.5, "The `MyISAM` Storage Engine".
`MEMORY`	The data for this storage engine is stored only in memory. See Section 13.6, "The `MEMORY` Storage Engine".
`CSV`	Tables that store rows in comma-separated values format. See Section 13.7, "The `CSV` Storage Engine".
`ARCHIVE`	The archiving storage engine. See Section 13.8, "The `ARCHIVE` Storage Engine".
`EXAMPLE`	An example engine. See Section 13.12, "The `EXAMPLE` Storage Engine".
`FEDERATED`	Storage engine that accesses remote tables. See Section 13.11, "The `FEDERATED` Storage Engine".
`HEAP`	This is a synonym for `MEMORY`.
`MERGE`	A collection of `MyISAM` tables used as one table. Also known as `MRG_MyISAM`. See Section 13.10, "The `MERGE` Storage Engine".
`ISAM` (*OBSOLETE*)	Not available in MySQL 5.5. If you are upgrading to MySQL 5.5 from a previous version, you should convert any existing `ISAM` tables to `MyISAM` *before* performing the upgrade.

If a storage engine is specified that is not available, MySQL uses the default engine instead. Normally, this is `MyISAM`. For example, if a table definition includes the `ENGINE=INNODB` option but the MySQL server does not support `INNODB` tables, the table is created as a `MyISAM` table. This makes it possible to have a replication setup where you have transactional tables on the master but tables created on the slave are nontransactional (to get more speed). In MySQL 5.5, a warning occurs if the storage engine specification is not honored.

Engine substitution can be controlled by the setting of the `NO_ENGINE_SUBSTITUTION` SQL mode, as described in Section 5.1.6, "Server SQL Modes".

> **Note**
>
> The older `TYPE` option was synonymous with `ENGINE`. `TYPE` was deprecated in MySQL 4.0 and removed in MySQL 5.5. *When upgrading to MySQL 5.5 or later, you must convert existing applications that rely on `TYPE` to use `ENGINE` instead.*

The other table options are used to optimize the behavior of the table. In most cases, you do not have to specify any of them. These options apply to all storage engines unless otherwise indicated. Options that do not apply to a given storage engine may be accepted and remembered as part of the table definition. Such options then apply if you later use `ALTER TABLE` to convert the table to use a different storage engine.

- `AUTO_INCREMENT`

  The initial `AUTO_INCREMENT` value for the table. In MySQL 5.5, this works for `MyISAM`, `MEMORY`, `InnoDB`, and `ARCHIVE` tables. To set the first auto-increment value for engines that do not support the `AUTO_INCREMENT` table option, insert a "dummy" row with a value one less than the desired value after creating the table, and then delete the dummy row.

  For engines that support the `AUTO_INCREMENT` table option in `CREATE TABLE` statements, you can also use `ALTER TABLE tbl_name AUTO_INCREMENT = N` to reset the `AUTO_INCREMENT` value. The value cannot be set lower than the maximum value currently in the column.

- `AVG_ROW_LENGTH`

  An approximation of the average row length for your table. You need to set this only for large tables with variable-size rows.

  When you create a `MyISAM` table, MySQL uses the product of the `MAX_ROWS` and `AVG_ROW_LENGTH` options to decide how big the resulting table is. If you don't specify either option, the maximum size for `MyISAM` data and index files is 256TB by default. (If your operating system does not support files that large, table sizes are constrained by the file size limit.) If you want to keep down the pointer sizes to make the index smaller and faster and you don't really need big files, you can decrease the default pointer size by setting the `myisam_data_pointer_size` system variable. (See Section 5.1.3, “Server System Variables”.) If you want all your tables to be able to grow above the default limit and are willing to have your tables slightly slower and larger than necessary, you can increase the default pointer size by setting this variable. Setting the value to 7 permits table sizes up to 65,536TB.

- `[DEFAULT] CHARACTER SET`

  Specify a default character set for the table. `CHARSET` is a synonym for `CHARACTER SET`. If the character set name is `DEFAULT`, the database character set is used.

- `CHECKSUM`

  Set this to 1 if you want MySQL to maintain a live checksum for all rows (that is, a checksum that MySQL updates automatically as the table changes). This makes the table a little slower to update, but also makes it easier to find corrupted tables. The `CHECKSUM TABLE` statement reports the checksum. (`MyISAM` only.)

- `[DEFAULT] COLLATE`

  Specify a default collation for the table.

- `COMMENT`

  A comment for the table, up to 2048 characters long (60 characters before MySQL 5.5.3).

- `CONNECTION`

  The connection string for a `FEDERATED` table.

  > **Note**
  >
  > Older versions of MySQL used a `COMMENT` option for the connection string.

- `DATA DIRECTORY`, `INDEX DIRECTORY`

  By using `DATA DIRECTORY='`*`directory`*`'` or `INDEX DIRECTORY='`*`directory`*`'` you can specify where the `MyISAM` storage engine should put a table's data file and index file. The directory must be the full path name to the directory, not a relative path.

  > **Important**
  >
  > Table-level `DATA DIRECTORY` and `INDEX DIRECTORY` options are ignored for partitioned tables. (Bug #32091)

  These options work only when you are not using the `--skip-symbolic-links` option. Your operating system must also have a working, thread-safe `realpath()` call. See Section 7.11.3.1.2, “Using Symbolic Links for Tables on Unix”, for more complete information.

  If a `MyISAM` table is created with no `DATA DIRECTORY` option, the `.MYD` file is created in the database directory. By default, if `MyISAM` finds an existing `.MYD` file in this case, it overwrites it. The same applies to `.MYI` files for tables created with no `INDEX DIRECTORY` option. To suppress this behavior, start the server with the `--keep_files_on_create` option, in which case `MyISAM` will not overwrite existing files and returns an error instead.

  If a `MyISAM` table is created with a `DATA DIRECTORY` or `INDEX DIRECTORY` option and an existing `.MYD` or `.MYI` file is found, MyISAM always returns an error. It will not overwrite a file in the specified directory.

  > **Important**
  >
  > You cannot use path names that contain the MySQL data directory with `DATA DIRECTORY` or `INDEX DIRECTORY`. This includes partitioned tables and individual table partitions. (See Bug #32167.)

- `DELAY_KEY_WRITE`

  Set this to 1 if you want to delay key updates for the table until the table is closed. See the description of the `delay_key_write` system variable in Section 5.1.3, “Server System Variables”. (`MyISAM` only.)

- `INSERT_METHOD`

  If you want to insert data into a `MERGE` table, you must specify with `INSERT_METHOD` the table into which the row should be inserted. `INSERT_METHOD` is an option useful for `MERGE` tables only. Use a value of `FIRST` or `LAST` to have inserts go to the first or last table, or a value of `NO` to prevent inserts. See Section 13.10, “The `MERGE` Storage Engine”.

- `KEY_BLOCK_SIZE`

This option provides a hint to the storage engine about the size in bytes to use for index key blocks. The engine is permitted to change the value if necessary. A value of 0 indicates that the default value should be used. Individual index definitions can specify a `KEY_BLOCK_SIZE` value of their own to override the table value.

- `MAX_ROWS`

  The maximum number of rows you plan to store in the table. This is not a hard limit, but rather a hint to the storage engine that the table must be able to store at least this many rows.

  The maximum `MAX_ROWS` value is 4294967295; larger values are truncated to this limit.

- `MIN_ROWS`

  The minimum number of rows you plan to store in the table. The `MEMORY` storage engine uses this option as a hint about memory use.

- `PACK_KEYS`

  `PACK_KEYS` takes effect only with `MyISAM` tables. Set this option to 1 if you want to have smaller indexes. This usually makes updates slower and reads faster. Setting the option to 0 disables all packing of keys. Setting it to `DEFAULT` tells the storage engine to pack only long `CHAR`, `VARCHAR`, `BINARY`, or `VARBINARY` columns.

  If you do not use `PACK_KEYS`, the default is to pack strings, but not numbers. If you use `PACK_KEYS=1`, numbers are packed as well.

  When packing binary number keys, MySQL uses prefix compression:

  - Every key needs one extra byte to indicate how many bytes of the previous key are the same for the next key.

  - The pointer to the row is stored in high-byte-first order directly after the key, to improve compression.

  This means that if you have many equal keys on two consecutive rows, all following “same” keys usually only take two bytes (including the pointer to the row). Compare this to the ordinary case where the following keys takes `storage_size_for_key + pointer_size` (where the pointer size is usually 4). Conversely, you get a significant benefit from prefix compression only if you have many numbers that are the same. If all keys are totally different, you use one byte more per key, if the key is not a key that can have `NULL` values. (In this case, the packed key length is stored in the same byte that is used to mark if a key is `NULL`.)

- `PASSWORD`

  This option is unused. If you have a need to scramble your `.frm` files and make them unusable to any other MySQL server, please contact our sales department.

- `RAID_TYPE`

  `RAID` support has been removed as of MySQL 5.0.

- `ROW_FORMAT`

  Defines how the rows should be stored. For `MyISAM` tables, the option value can be `FIXED` or `DYNAMIC` for static or variable-length row format. `myisampack` sets the type to `COMPRESSED`. See Section 13.5.3, “`MyISAM` Table Storage Formats”.

  For `InnoDB` tables, rows are stored in compact format (`ROW_FORMAT=COMPACT`) by default. The noncompact format used in older versions of MySQL can still be requested by specifying `ROW_FORMAT=REDUNDANT`.

  > **Note**
  >
  > When executing a `CREATE TABLE` statement, if you specify a row format which is not supported by the storage engine that is used for the table, the table is created using that storage engine's default row format. The information reported in this column in response to `SHOW TABLE STATUS` is the actual row format used. This may differ from the value in the `Create_options` column because the original `CREATE TABLE` definition is retained during creation.

- `UNION`

  `UNION` is used when you want to access a collection of identical `MyISAM` tables as one. This works only with `MERGE` tables. See Section 13.10, “The `MERGE` Storage Engine”.

  You must have `SELECT`, `UPDATE`, and `DELETE` privileges for the tables you map to a `MERGE` table.

  > **Note**

> Formerly, all tables used had to be in the same database as the `MERGE` table itself. This restriction no longer applies.

`partition_options` can be used to control partitioning of the table created with `CREATE TABLE`.

> **Important**
>
> Not all options shown in the syntax for `partition_options` at the beginning of this section are available for all partitioning types. Please see the listings for the following individual types for information specific to each type, and see Chapter 16, *Partitioning*, for more complete information about the workings of and uses for partitioning in MySQL, as well as additional examples of table creation and other statements relating to MySQL partitioning.

If used, a `partition_options` clause begins with `PARTITION BY`. This clause contains the function that is used to determine the partition; the function returns an integer value ranging from 1 to `num`, where `num` is the number of partitions. (The maximum number of user-defined partitions which a table may contain is 1024; the number of subpartitions—discussed later in this section—is included in this maximum.) The choices that are available for this function in MySQL 5.5 are shown in the following list:

- `HASH(expr)`: Hashes one or more columns to create a key for placing and locating rows. `expr` is an expression using one or more table columns. This can be any legal MySQL expression (including MySQL functions) that yields a single integer value. For example, these are both valid `CREATE TABLE` statements using `PARTITION BY HASH`:

  ```
  CREATE TABLE t1 (col1 INT, col2 CHAR(5))
      PARTITION BY HASH(col1);

  CREATE TABLE t1 (col1 INT, col2 CHAR(5), col3 DATETIME)
      PARTITION BY HASH ( YEAR(col3) );
  ```

  You may not use either `VALUES LESS THAN` or `VALUES IN` clauses with `PARTITION BY HASH`.

  `PARTITION BY HASH` uses the remainder of `expr` divided by the number of partitions (that is, the modulus). For examples and additional information, see Section 16.2.4, “HASH Partitioning”.

  The `LINEAR` keyword entails a somewhat different algorithm. In this case, the number of the partition in which a row is stored is calculated as the result of one or more logical `AND` operations. For discussion and examples of linear hashing, see Section 16.2.4.1, “`LINEAR HASH` Partitioning”.

- `KEY(column_list)`: This is similar to `HASH`, except that MySQL supplies the hashing function so as to guarantee an even data distribution. The `column_list` argument is simply a list of table columns. This example shows a simple table partitioned by key, with 4 partitions:

  ```
  CREATE TABLE tk (col1 INT, col2 CHAR(5), col3 DATE)
      PARTITION BY KEY(col3)
      PARTITIONS 4;
  ```

  For tables that are partitioned by key, you can employ linear partitioning by using the `LINEAR` keyword. This has the same effect as with tables that are partitioned by `HASH`. That is, the partition number is found using the `&` operator rather than the modulus (see Section 16.2.4.1, “`LINEAR HASH` Partitioning”, and Section 16.2.5, “`KEY` Partitioning”, for details). This example uses linear partitioning by key to distribute data between 5 partitions:

  ```
  CREATE TABLE tk (col1 INT, col2 CHAR(5), col3 DATE)
      PARTITION BY LINEAR KEY(col3)
      PARTITIONS 5;
  ```

  You may not use either `VALUES LESS THAN` or `VALUES IN` clauses with `PARTITION BY KEY`.

- `RANGE`: In this case, `expr` shows a range of values using a set of `VALUES LESS THAN` operators. When using range partitioning, you must define at least one partition using `VALUES LESS THAN`. You cannot use `VALUES IN` with range partitioning.

  When used with a table partitioned by `RANGE`, `VALUES LESS THAN` must be used with either an integer literal value or an expression that evaluates to a single integer value. In MySQL 5.5, this limitation can be overcome in a table that is defined using `PARTITION BY RANGE COLUMNS`, as described later in this section.

  Suppose that you have a table that you wish to partition on a column containing year values, according to the following scheme.

Partition Number:	Years Range:
0	1990 and earlier
1	1991 to 1994

Partition Number:	Years Range:
2	1995 to 1998
3	1999 to 2002
4	2003 to 2005
5	2006 and later

A table implementing such a partitioning scheme can be realized by the `CREATE TABLE` statement shown here:

```
CREATE TABLE t1 (
    year_col  INT,
    some_data INT
)
PARTITION BY RANGE (year_col) (
    PARTITION p0 VALUES LESS THAN (1991),
    PARTITION p1 VALUES LESS THAN (1995),
    PARTITION p2 VALUES LESS THAN (1999),
    PARTITION p3 VALUES LESS THAN (2002),
    PARTITION p4 VALUES LESS THAN (2006),
    PARTITION p5 VALUES LESS THAN MAXVALUE
);
```

`PARTITION ... VALUES LESS THAN ...` statements work in a consecutive fashion. `VALUES LESS THAN MAXVALUE` works to specify “leftover” values that are greater than the maximum value otherwise specified.

Note that `VALUES LESS THAN` clauses work sequentially in a manner similar to that of the `case` portions of a `switch ... case` block (as found in many programming languages such as C, Java, and PHP). That is, the clauses must be arranged in such a way that the upper limit specified in each successive `VALUES LESS THAN` is greater than that of the previous one, with the one referencing `MAXVALUE` coming last of all in the list.

- `RANGE COLUMNS(column_list)`: This variant on `RANGE` was introduced in MySQL 5.5.0 to facilitate partition pruning for queries using range conditions on multiple columns (that is, having conditions such as `WHERE a = 1 AND b < 10` or `WHERE a = 1 AND b = 10 AND c < 10`). It enables you to specify value ranges in multiple columns by using a list of columns in the `COLUMNS` clause and a set of column values in each `PARTITION ... VALUES LESS THAN (value_list)` partition definition clause. (In the simplest case, this set consists of a single column.) The maximum number of columns that can be referenced in the `column_list` and `value_list` is 16.

  The `column_list` used in the `COLUMNS` clause may contain only names of columns; each column in the list must be one of the following MySQL data types: the integer types; the string types; and time or date column types. Columns using `BLOB`, `TEXT`, `SET`, `ENUM`, `BIT`, or spatial data types are not permitted; columns that use floating-point number types are also not permitted. You also may not use functions or arithmetic expressions in the `COLUMNS` clause.

  The `VALUES LESS THAN` clause used in a partition definition must specify a literal value for each column that appears in the `COLUMNS()` clause; that is, the list of values used for each `VALUES LESS THAN` clause must contain the same number of values as there are columns listed in the `COLUMNS` clause. An attempt to use more or fewer values in a `VALUES LESS THAN` clause than there are in the `COLUMNS` clause causes the statement to fail with the error `INCONSISTENCY IN USAGE OF COLUMN LISTS FOR PARTITIONING....` You cannot use `NULL` for any value appearing in `VALUES LESS THAN`. It is possible to use `MAXVALUE` more than once for a given column other than the first, as shown in this example:

```
CREATE TABLE rc (
    a INT NOT NULL,
    b INT NOT NULL
)
PARTITION BY RANGE COLUMNS(a,b) (
    PARTITION p0 VALUES LESS THAN (10,5),
    PARTITION p1 VALUES LESS THAN (20,10),
    PARTITION p2 VALUES LESS THAN (MAXVALUE,15),
    PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE)
);
```

  Each value used in a `VALUES LESS THAN` value list must match the type of the corresponding column exactly; no conversion is made. For example, you cannot use the string `"1"` for a value that matches a column that uses an integer type (you must use the numeral `1` instead), nor can you use the numeral `1` for a value that matches a column that uses a string type (in such a case, you must use a quoted string: `"1"`).

  For more information, see Section 16.2.1, “RANGE Partitioning”, and Section 16.4, “Partition Pruning”.

- `LIST(expr)`: This is useful when assigning partitions based on a table column with a restricted set of possible values, such as a state or country code. In such a case, all rows pertaining to a certain state or country can be assigned to a single partition, or a partition can be reserved for a certain set of states or countries. It is similar to `RANGE`, except that only `VALUES IN` may be used to specify permissible values for each partition.

`VALUES IN` is used with a list of values to be matched. For instance, you could create a partitioning scheme such as the following:

```
CREATE TABLE client_firms (
    id   INT,
    name VARCHAR(35)
)
PARTITION BY LIST (id) (
    PARTITION r0 VALUES IN (1, 5, 9, 13, 17, 21),
    PARTITION r1 VALUES IN (2, 6, 10, 14, 18, 22),
    PARTITION r2 VALUES IN (3, 7, 11, 15, 19, 23),
    PARTITION r3 VALUES IN (4, 8, 12, 16, 20, 24)
);
```

When using list partitioning, you must define at least one partition using `VALUES IN`. You cannot use `VALUES LESS THAN` with `PARTITION BY LIST`.

> **Note**
>
> For tables partitioned by `LIST`, the value list used with `VALUES IN` must consist of integer values only. In MySQL 5.5, you can overcome this limitation using partitioning by `LIST COLUMNS`, which is described later in this section.

- `LIST COLUMNS(`*`column_list`*`)`: This variant on `LIST` was introduced in MySQL 5.5.0 to facilitate partition pruning for queries using comparison conditions on multiple columns (that is, having conditions such as `WHERE a = 5 AND b = 5` or `WHERE a = 1 AND b = 10 AND c = 5`). It enables you to specify values in multiple columns by using a list of columns in the `COLUMNS` clause and a set of column values in each `PARTITION ... VALUES IN (`*`value_list`*`)` partition definition clause.

  The rules governing regarding data types for the column list used in `LIST COLUMNS(`*`column_list`*`)` and the value list used in VALUES IN(*`value_list`*) are the as those for the column list used in `RANGE COLUMNS(`*`column_list`*`)` and the value list used in `VALUES LESS THAN(`*`value_list`*`)`, respectively, except that in the `VALUES IN` clause, `MAXVALUE` is not permitted, and you may use `NULL`.

  There is one important difference between the list of values used for `VALUES IN` with `PARTITION BY LIST COLUMNS` as opposed to when it is used with `PARTITION BY LIST`. When used with `PARTITION BY LIST COLUMNS`, each element in the `VALUES IN` clause must be a *set* of column values; the number of values in each set must be the same as the number of columns used in the *COLUMNS* clause, and the data types of these values must match those of the columns (and occur in the same order). In the simplest case, the set consists of a single column. The maximum number of columns that can be used in the *`column_list`* and in the elements making up the *`value_list`* is 16.

  The table defined by the following `CREATE TABLE` statement provides an example of a table using `LIST COLUMNS` partitioning:

```
CREATE TABLE lc (
    a INT NULL,
    b INT NULL
)
PARTITION BY LIST COLUMNS(a,b) (
    PARTITION p0 VALUES IN( (0,0), (NULL,NULL) ),
    PARTITION p1 VALUES IN( (0,1), (0,2), (0,3), (1,1), (1,2) ),
    PARTITION p2 VALUES IN( (1,0), (2,0), (2,1), (3,0), (3,1) ),
    PARTITION p3 VALUES IN( (1,3), (2,2), (2,3), (3,2), (3,3) )
);
```

- The number of partitions may optionally be specified with a `PARTITIONS` *`num`* clause, where *`num`* is the number of partitions. If both this clause *and* any `PARTITION` clauses are used, *`num`* must be equal to the total number of any partitions that are declared using `PARTITION` clauses.

  > **Note**
  >
  > Whether or not you use a `PARTITIONS` clause in creating a table that is partitioned by `RANGE` or `LIST`, you must still include at least one `PARTITION VALUES` clause in the table definition (see below).

- A partition may optionally be divided into a number of subpartitions. This can be indicated by using the optional `SUBPARTITION BY` clause. Subpartitioning may be done by `HASH` or `KEY`. Either of these may be `LINEAR`. These work in the same way as previously described for the equivalent partitioning types. (It is not possible to subpartition by `LIST` or `RANGE`.)

  The number of subpartitions can be indicated using the `SUBPARTITIONS` keyword followed by an integer value.

- Rigorous checking of the value used in `PARTITIONS` or `SUBPARTITIONS` clauses is applied and this value must adhere to the following rules:

  - The value must be a positive, nonzero integer.

- No leading zeros are permitted.
- The value must be an integer literal, and cannot not be an expression. For example, `PARTITIONS 0.2E+01` is not permitted, even though `0.2E+01` evaluates to `2`. (Bug #15890)

> **Note**
>
> The expression (*`expr`*) used in a `PARTITION BY` clause cannot refer to any columns not in the table being created; such references are specifically not permitted and cause the statement to fail with an error. (Bug #29444)

Each partition may be individually defined using a *`partition_definition`* clause. The individual parts making up this clause are as follows:

- `PARTITION` *`partition_name`*: This specifies a logical name for the partition.
- A `VALUES` clause: For range partitioning, each partition must include a `VALUES LESS THAN` clause; for list partitioning, you must specify a `VALUES IN` clause for each partition. This is used to determine which rows are to be stored in this partition. See the discussions of partitioning types in Chapter 16, *Partitioning*, for syntax examples.
- An optional `COMMENT` clause may be used to specify a string that describes the partition. Example:

  ```
  COMMENT = 'Data for the years previous to 1999'
  ```

- `DATA DIRECTORY` and `INDEX DIRECTORY` may be used to indicate the directory where, respectively, the data and indexes for this partition are to be stored. Both the *`data_dir`* and the *`index_dir`* must be absolute system path names. Example:

  ```
  CREATE TABLE th (id INT, name VARCHAR(30), adate DATE)
  PARTITION BY LIST(YEAR(adate))
  (
    PARTITION p1999 VALUES IN (1995, 1999, 2003)
      DATA DIRECTORY = '/var/appdata/95/data'
      INDEX DIRECTORY = '/var/appdata/95/idx',
    PARTITION p2000 VALUES IN (1996, 2000, 2004)
      DATA DIRECTORY = '/var/appdata/96/data'
      INDEX DIRECTORY = '/var/appdata/96/idx',
    PARTITION p2001 VALUES IN (1997, 2001, 2005)
      DATA DIRECTORY = '/var/appdata/97/data'
      INDEX DIRECTORY = '/var/appdata/97/idx',
    PARTITION p2000 VALUES IN (1998, 2002, 2006)
      DATA DIRECTORY = '/var/appdata/98/data'
      INDEX DIRECTORY = '/var/appdata/98/idx'
  );
  ```

  `DATA DIRECTORY` and `INDEX DIRECTORY` behave in the same way as in the `CREATE TABLE` statement's *`table_option`* clause as used for `MyISAM` tables.

  One data directory and one index directory may be specified per partition. If left unspecified, the data and indexes are stored by default in the table's database directory.

  On Windows, the `DATA DIRECTORY` and `INDEX DIRECTORY` options are not supported for individual partitions or subpartitions. These options are ignored on Windows, except that a warning is generated. (Bug #30459)

  > **Note**
  >
  > The `DATA DIRECTORY` and `INDEX DIRECTORY` options are ignored for creating partitioned tables if `NO_DIR_IN_CREATE` is in effect. (Bug #24633)

- `MAX_ROWS` and `MIN_ROWS` may be used to specify, respectively, the maximum and minimum number of rows to be stored in the partition. The values for *`max_number_of_rows`* and *`min_number_of_rows`* must be positive integers. As with the table-level options with the same names, these act only as “suggestions” to the server and are not hard limits.
- The partitioning handler accepts a `[STORAGE] ENGINE` option for both `PARTITION` and `SUBPARTITION`. Currently, the only way in which this can be used is to set all partitions or all subpartitions to the same storage engine, and an attempt to set different storage engines for partitions or subpartitions in the same table will give rise to the error `ERROR 1469 (HY000): THE MIX OF HANDLERS IN THE PARTITIONS IS NOT PERMITTED IN THIS VERSION OF MYSQL`. We expect to lift this restriction on partitioning in a future MySQL release.
- The partition definition may optionally contain one or more *`subpartition_definition`* clauses. Each of these consists at a minimum of the `SUBPARTITION` *`name`*, where *`name`* is an identifier for the subpartition. Except for the replacement of the `PARTITION` keyword with `SUBPARTITION`, the syntax for a subpartition definition is identical to that for a partition definition.

Subpartitioning must be done by `HASH` or `KEY`, and can be done only on `RANGE` or `LIST` partitions. See Section 16.2.6, “Subpartitioning”.

Partitions can be modified, merged, added to tables, and dropped from tables. For basic information about the MySQL statements to accomplish these tasks, see Section 12.1.6, “`ALTER TABLE` Syntax”. For more detailed descriptions and examples, see Section 16.3, “Partition Management”.

> **Important**
>
> The original `CREATE TABLE` statement, including all specifications and table options are stored by MySQL when the table is created. The information is retained so that if you change storage engines, collations or other settings using an `ALTER TABLE` statement, the original table options specified are retained. This enables you to change between `InnoDB` and `MyISAM` table types even though the row formats supported by the two engines are different.
>
> Because the text of the original statement is retained, but due to the way that certain values and options may be silently reconfigured (such as the `ROW_FORMAT`), the active table definition (accessible through `DESCRIBE` or with `SHOW TABLE STATUS`) and the table creation string (accessible through `SHOW CREATE TABLE`) will report different values.

You can create one table from another by adding a `SELECT` statement at the end of the `CREATE TABLE` statement:

```
CREATE TABLE new_tbl SELECT * FROM orig_tbl;
```

For more information, see Section 12.1.14.1, “`CREATE TABLE ... SELECT` Syntax”.

Use `LIKE` to create an empty table based on the definition of another table, including any column attributes and indexes defined in the original table:

```
CREATE TABLE new_tbl LIKE orig_tbl;
```

The copy is created using the same version of the table storage format as the original table. The `SELECT` privilege is required on the original table.

`LIKE` works only for base tables, not for views.

> **Important**
>
> Beginning with MySQL 5.5.3, you cannot execute `CREATE TABLE` or `CREATE TABLE ... LIKE` while a `LOCK TABLES` statement is in effect.
>
> Also as of MySQL 5.5.3, `CREATE TABLE ... LIKE` makes the same checks as `CREATE TABLE` and does not just copy the `.frm` file. This means that if the current SQL mode is different from the mode in effect when the original table was created, the table definition might be considered invalid for the new mode and the statement will fail.

`CREATE TABLE ... LIKE` does not preserve any `DATA DIRECTORY` or `INDEX DIRECTORY` table options that were specified for the original table, or any foreign key definitions.

If the original table is a `TEMPORARY` table, `CREATE TABLE ... LIKE` does not preserve `TEMPORARY`. To create a `TEMPORARY` destination table, use `CREATE TEMPORARY TABLE ... LIKE`.

12.1.14.1. `CREATE TABLE ... SELECT` Syntax

You can create one table from another by adding a `SELECT` statement at the end of the `CREATE TABLE` statement:

```
CREATE TABLE new_tbl SELECT * FROM orig_tbl;
```

MySQL creates new columns for all elements in the `SELECT`. For example:

```
mysql> CREATE TABLE test (a INT NOT NULL AUTO_INCREMENT,
    ->        PRIMARY KEY (a), KEY(b))
    ->        ENGINE=MyISAM SELECT b,c FROM test2;
```

This creates a `MyISAM` table with three columns, `a`, `b`, and `c`. Notice that the columns from the `SELECT` statement are appended to the right side of the table, not overlapped onto it. Take the following example:

```
mysql> SELECT * FROM foo;
+---+
| n |
+---+
| 1 |
+---+

mysql> CREATE TABLE bar (m INT) SELECT n FROM foo;
Query OK, 1 row affected (0.02 sec)
Records: 1  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM bar;
+------+---+
| m    | n |
+------+---+
| NULL | 1 |
+------+---+
1 row in set (0.00 sec)
```

For each row in table `foo`, a row is inserted in `bar` with the values from `foo` and default values for the new columns.

In a table resulting from `CREATE TABLE ... SELECT`, columns named only in the `CREATE TABLE` part come first. Columns named in both parts or only in the `SELECT` part come after that. The data type of `SELECT` columns can be overridden by also specifying the column in the `CREATE TABLE` part.

If any errors occur while copying the data to the table, it is automatically dropped and not created.

You can precede the `SELECT` by `IGNORE` or `REPLACE` to indicate how to handle rows that duplicate unique key values. With `IGNORE`, new rows that duplicate an existing row on a unique key value are discarded. With `REPLACE`, new rows replace rows that have the same unique key value. If neither `IGNORE` nor `REPLACE` is specified, duplicate unique key values result in an error.

`CREATE TABLE ... SELECT` does not automatically create any indexes for you. This is done intentionally to make the statement as flexible as possible. If you want to have indexes in the created table, you should specify these before the `SELECT` statement:

```
mysql> CREATE TABLE bar (UNIQUE (n)) SELECT n FROM foo;
```

Some conversion of data types might occur. For example, the `AUTO_INCREMENT` attribute is not preserved, and `VARCHAR` columns can become `CHAR` columns. Retrained attributes are `NULL` (or `NOT NULL`) and, for those columns that have them, `CHARACTER SET`, `COLLATION`, `COMMENT`, and the `DEFAULT` clause.

When creating a table with `CREATE TABLE ... SELECT`, make sure to alias any function calls or expressions in the query. If you do not, the `CREATE` statement might fail or result in undesirable column names.

```
CREATE TABLE artists_and_works
  SELECT artist.name, COUNT(work.artist_id) AS number_of_works
  FROM artist LEFT JOIN work ON artist.id = work.artist_id
  GROUP BY artist.id;
```

You can also explicitly specify the data type for a generated column:

```
CREATE TABLE foo (a TINYINT NOT NULL) SELECT b+1 AS a FROM bar;
```

For `CREATE TABLE ... SELECT`, if `IF NOT EXISTS` is given and the destination table already exists, the result is version dependent. Before MySQL 5.5.6, MySQL handles the statement as follows:

- The table definition given in the `CREATE TABLE` part is ignored. No error occurs, even if the definition does not match that of the existing table. MySQL attempts to insert the rows from the `SELECT` part anyway.
- If there is a mismatch between the number of columns in the table and the number of columns produced by the `SELECT` part, the selected values are assigned to the rightmost columns. For example, if the table contains *`n`* columns and the `SELECT` produces *`m`* columns, where $m < n$, the selected values are assigned to the *`m`* rightmost columns in the table. Each of the initial $n - m$ columns is assigned its default value, either that specified explicitly in the column definition or the implicit column data type default if the definition contains no default. If the `SELECT` part produces too many columns ($m > n$), an error occurs.
- If strict SQL mode is enabled and any of these initial columns do not have an explicit default value, the statement fails with an error.

The following example illustrates `IF NOT EXISTS` handling:

```
mysql> CREATE TABLE t1 (i1 INT DEFAULT 0, i2 INT, i3 INT, i4 INT);
Query OK, 0 rows affected (0.05 sec)

mysql> CREATE TABLE IF NOT EXISTS t1 (c1 CHAR(10)) SELECT 1, 2;
Query OK, 1 row affected, 1 warning (0.01 sec)
Records: 1  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM t1;
+------+------+------+------+
| i1   | i2   | i3   | i4   |
+------+------+------+------+
|    0 | NULL |    1 |    2 |
+------+------+------+------+
1 row in set (0.00 sec)
```

As of MySQL 5.5.6, handling of `CREATE TABLE IF NOT EXISTS ... SELECT` statements was changed for the case that the destination table already exists. This change also involves a change in MySQL 5.1 beginning with 5.1.51.

- Previously, for `CREATE TABLE IF NOT EXISTS ... SELECT`, MySQL produced a warning that the table exists, but inserted the rows and wrote the statement to the binary log anyway. By contrast, `CREATE TABLE ... SELECT` (without `IF NOT EXISTS`) failed with an error, but MySQL inserted no rows and did not write the statement to the binary log.
- MySQL now handles both statements the same way when the destination table exists, in that neither statement inserts rows or is written to the binary log. The difference between them is that MySQL produces a warning when `IF NOT EXISTS` is present and an error when it is not.

This change means that, for the preceding example, the `CREATE TABLE IF NOT EXISTS ... SELECT` statement inserts nothing into the destination table as of MySQL 5.5.6.

This change in handling of `IF NOT EXISTS` results in an incompatibility for statement-based replication from a MySQL 5.1 master with the original behavior and a MySQL 5.5 slave with the new behavior. Suppose that `CREATE TABLE IF NOT EXISTS ... SELECT` is executed on the master and the destination table exists. The result is that rows are inserted on the master but not on the slave. (Row-based replication does not have this problem.)

To address this issue, statement-based binary logging for `CREATE TABLE IF NOT EXISTS ... SELECT` is changed in MySQL 5.1 as of 5.1.51:

- If the destination table does not exist, there is no change: The statement is logged as is.
- If the destination table does exist, the statement is logged as the equivalent pair of `CREATE TABLE IF NOT EXISTS` and `INSERT ... SELECT` statements. (If the `SELECT` in the original statement is preceded by `IGNORE` or `REPLACE`, the `INSERT` becomes `INSERT IGNORE` or `REPLACE`, respectively.)

This change provides forward compatibility for statement-based replication from MySQL 5.1 to 5.5 because when the destination table exists, the rows will be inserted on both the master and slave. To take advantage of this compatibility measure, the 5.1 server must be at least 5.1.51 and the 5.5 server must be at least 5.5.6.

To upgrade an existing 5.1-to-5.5 replication scenario, upgrade the master first to 5.1.51 or higher. Note that this differs from the usual replication upgrade advice of upgrading the slave first.

A workaround for applications that wish to achieve the original effect (rows inserted regardless of whether the destination table exists) is to use `CREATE TABLE IF NOT EXISTS` and `INSERT ... SELECT` statements rather than `CREATE TABLE IF NOT EXISTS ... SELECT` statements.

Along with the change just described, the following related change was made: Previously, if an existing view was named as the destination table for `CREATE TABLE IF NOT EXISTS ... SELECT`, rows were inserted into the underlying base table and the statement was written to the binary log. As of MySQL 5.1.51 and 5.5.6, nothing is inserted or logged.

To ensure that the binary log can be used to re-create the original tables, MySQL does not permit concurrent inserts during `CREATE TABLE ... SELECT`.

12.1.14.2. Silent Column Specification Changes

In some cases, MySQL silently changes column specifications from those given in a `CREATE TABLE` or `ALTER TABLE` statement. These might be changes to a data type, to attributes associated with a data type, or to an index specification.

All changes are subject to the internal row-size limit of 65,535 bytes, which may cause some attempts at data type changes to fail. See Section E.9.4, “Table Column-Count and Row-Size Limits”.

- `TIMESTAMP` display sizes are discarded.

  Also note that `TIMESTAMP` columns are `NOT NULL` by default.
- Columns that are part of a `PRIMARY KEY` are made `NOT NULL` even if not declared that way.
- Trailing spaces are automatically deleted from `ENUM` and `SET` member values when the table is created.

- MySQL maps certain data types used by other SQL database vendors to MySQL types. See Section 10.8, “Using Data Types from Other Database Engines”.
- If you include a `USING` clause to specify an index type that is not legal for a given storage engine, but there is another index type available that the engine can use without affecting query results, the engine uses the available type.
- If strict SQL mode is not enabled, a `VARCHAR` column with a length specification greater than 65535 is converted to `TEXT`, and a `VARBINARY` column with a length specification greater than 65535 is converted to `BLOB`. Otherwise, an error occurs in either of these cases.
- Specifying the `CHARACTER SET binary` attribute for a character data type causes the column to be created as the corresponding binary data type: `CHAR` becomes `BINARY`, `VARCHAR` becomes `VARBINARY`, and `TEXT` becomes `BLOB`. For the `ENUM` and `SET` data types, this does not occur; they are created as declared. Suppose that you specify a table using this definition:

  ```
  CREATE TABLE t
  (
    c1 VARCHAR(10) CHARACTER SET binary,
    c2 TEXT CHARACTER SET binary,
    c3 ENUM('a','b','c') CHARACTER SET binary
  );
  ```

  The resulting table has this definition:

  ```
  CREATE TABLE t
  (
    c1 VARBINARY(10),
    c2 BLOB,
    c3 ENUM('a','b','c') CHARACTER SET binary
  );
  ```

To see whether MySQL used a data type other than the one you specified, issue a `DESCRIBE` or `SHOW CREATE TABLE` statement after creating or altering the table.

Certain other data type changes can occur if you compress a table using `myisampack`. See Section 13.5.3.3, “Compressed Table Characteristics”.

12.1.15. `CREATE TRIGGER` Syntax

```
CREATE
    [DEFINER = { user | CURRENT_USER }]
    TRIGGER trigger_name trigger_time trigger_event
    ON tbl_name FOR EACH ROW trigger_body
```

This statement creates a new trigger. A trigger is a named database object that is associated with a table, and that activates when a particular event occurs for the table. The trigger becomes associated with the table named *`tbl_name`*, which must refer to a permanent table. You cannot associate a trigger with a `TEMPORARY` table or a view.

`CREATE TRIGGER` requires the `TRIGGER` privilege for the table associated with the trigger. The statement might also require the `SUPER` privilege, depending on the `DEFINER` value, as described later in this section. If binary logging is enabled, `CREATE TRIGGER` might require the `SUPER` privilege, as described in Section 17.7, “Binary Logging of Stored Programs”.

The `DEFINER` clause determines the security context to be used when checking access privileges at trigger activation time. See later in this section for more information.

`trigger_time` is the trigger action time. It can be `BEFORE` or `AFTER` to indicate that the trigger activates before or after each row to be modified.

`trigger_event` indicates the kind of statement that activates the trigger. The *`trigger_event`* can be one of the following:

- `INSERT`: The trigger is activated whenever a new row is inserted into the table; for example, through `INSERT`, `LOAD DATA`, and `REPLACE` statements.
- `UPDATE`: The trigger is activated whenever a row is modified; for example, through `UPDATE` statements.
- `DELETE`: The trigger is activated whenever a row is deleted from the table; for example, through `DELETE` and `REPLACE` statements. However, `DROP TABLE` and `TRUNCATE TABLE` statements on the table do *not* activate this trigger, because they do not use `DELETE`. Dropping a partition does not activate `DELETE` triggers, either. See Section 12.1.27, “`TRUNCATE TABLE` Syntax”.

It is important to understand that the `trigger_event` does not represent a literal type of SQL statement that activates the trigger so much as it represents a type of table operation. For example, an `INSERT` trigger is activated by not only `INSERT` statements but also `LOAD DATA` statements because both statements insert rows into a table.

A potentially confusing example of this is the `INSERT INTO ... ON DUPLICATE KEY UPDATE ...` syntax: a `BEFORE INSERT` trigger will activate for every row, followed by either an `AFTER INSERT` trigger or both the `BEFORE UPDATE` and `AFTER UPDATE` triggers, depending on whether there was a duplicate key for the row.

There cannot be two triggers for a given table that have the same trigger action time and event. For example, you cannot have two `BEFORE UPDATE` triggers for a table. But you can have a `BEFORE UPDATE` and a `BEFORE INSERT` trigger, or a `BEFORE UPDATE` and an `AFTER UPDATE` trigger.

`trigger_body` is the statement to execute when the trigger activates. If you want to execute multiple statements, use the `BEGIN ... END` compound statement construct. This also enables you to use the same statements that are permissible within stored routines. See Section 12.7.1, “`BEGIN ... END` Compound Statement Syntax”. Some statements are not permitted in triggers; see Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.

You can refer to columns in the subject table (the table associated with the trigger) by using the aliases `OLD` and `NEW`. `OLD.col_name` refers to a column of an existing row before it is updated or deleted. `NEW.col_name` refers to the column of a new row to be inserted or an existing row after it is updated.

MySQL stores the `sql_mode` system variable setting that is in effect at the time a trigger is created, and always executes the trigger with this setting in force, *regardless of the server SQL mode in effect when the event begins executing*.

> **Note**
>
> Currently, cascaded foreign key actions do not activate triggers.

The `DEFINER` clause specifies the MySQL account to be used when checking access privileges at trigger activation time. If a `user` value is given, it should be a MySQL account specified as `'user_name'@'host_name'` (the same format used in the `GRANT` statement), `CURRENT_USER`, or `CURRENT_USER()`. The default `DEFINER` value is the user who executes the `CREATE TRIGGER` statement. This is the same as specifying `DEFINER = CURRENT_USER` explicitly.

If you specify the `DEFINER` clause, these rules determine the legal `DEFINER` user values:

- If you do not have the `SUPER` privilege, the only legal `user` value is your own account, either specified literally or by using `CURRENT_USER`. You cannot set the definer to some other account.
- If you have the `SUPER` privilege, you can specify any syntactically legal account name. If the account does not actually exist, a warning is generated.
- Although it is possible to create a trigger with a nonexistent `DEFINER` account, it is not a good idea for such triggers to be activated until the account actually does exist. Otherwise, the behavior with respect to privilege checking is undefined.

MySQL takes the `DEFINER` user into account when checking trigger privileges as follows:

- At `CREATE TRIGGER` time, the user who issues the statement must have the `TRIGGER` privilege.
- At trigger activation time, privileges are checked against the `DEFINER` user. This user must have these privileges:
  - The `TRIGGER` privilege.
  - The `SELECT` privilege for the subject table if references to table columns occur using `OLD.col_name` or `NEW.col_name` in the trigger definition.
  - The `UPDATE` privilege for the subject table if table columns are targets of `SET NEW.col_name = value` assignments in the trigger definition.
  - Whatever other privileges normally are required for the statements executed by the trigger.

For more information about trigger security, see Section 17.6, “Access Control for Stored Programs and Views”.

Within a trigger, the `CURRENT_USER()` function returns the account used to check privileges at trigger activation time. This is the `DEFINER` user, not the user whose actions caused the trigger to be activated. For information about user auditing within triggers, see Section 5.5.10, “Auditing MySQL Account Activity”.

If you use `LOCK TABLES` to lock a table that has triggers, the tables used within the trigger are also locked, as described in Section 12.3.5.2, “`LOCK TABLES` and Triggers”.

In MySQL 5.5, you can write triggers containing direct references to tables by name, such as the trigger named `testref` shown in this example:

```
CREATE TABLE test1(a1 INT);
CREATE TABLE test2(a2 INT);
CREATE TABLE test3(a3 INT NOT NULL AUTO_INCREMENT PRIMARY KEY);
CREATE TABLE test4(
  a4 INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
  b4 INT DEFAULT 0
);

delimiter |

CREATE TRIGGER testref BEFORE INSERT ON test1
  FOR EACH ROW BEGIN
    INSERT INTO test2 SET a2 = NEW.a1;
    DELETE FROM test3 WHERE a3 = NEW.a1;
    UPDATE test4 SET b4 = b4 + 1 WHERE a4 = NEW.a1;
  END;
|

delimiter ;

INSERT INTO test3 (a3) VALUES
  (NULL), (NULL), (NULL), (NULL), (NULL),
  (NULL), (NULL), (NULL), (NULL), (NULL);

INSERT INTO test4 (a4) VALUES
  (0), (0), (0), (0), (0), (0), (0), (0), (0), (0);
```

Suppose that you insert the following values into table `test1` as shown here:

```
mysql> INSERT INTO test1 VALUES
    -> (1), (3), (1), (7), (1), (8), (4), (4);
Query OK, 8 rows affected (0.01 sec)
Records: 8  Duplicates: 0  Warnings: 0
```

As a result, the data in the four tables will be as follows:

```
mysql> SELECT * FROM test1;
+------+
| a1   |
+------+
|    1 |
|    3 |
|    1 |
|    7 |
|    1 |
|    8 |
|    4 |
|    4 |
+------+
8 rows in set (0.00 sec)

mysql> SELECT * FROM test2;
+------+
| a2   |
+------+
|    1 |
|    3 |
|    1 |
|    7 |
|    1 |
|    8 |
|    4 |
|    4 |
+------+
8 rows in set (0.00 sec)

mysql> SELECT * FROM test3;
+----+
| a3 |
+----+
|  2 |
|  5 |
|  6 |
|  9 |
| 10 |
+----+
5 rows in set (0.00 sec)

mysql> SELECT * FROM test4;
+----+------+
| a4 | b4   |
+----+------+
|  1 |    3 |
|  2 |    0 |
|  3 |    1 |
|  4 |    2 |
|  5 |    0 |
|  6 |     0 |
|  7 |     1 |
|  8 |     1 |
|  9 |     0 |
| 10 |     0 |
+----+------+
10 rows in set (0.00 sec)
```

12.1.16. `CREATE VIEW` Syntax

```
CREATE
    [OR REPLACE]
    [ALGORITHM = {UNDEFINED | MERGE | TEMPTABLE}]
    [DEFINER = { user | CURRENT_USER }]
    [SQL SECURITY { DEFINER | INVOKER }]
    VIEW view_name [(column_list)]
    AS select_statement
    [WITH [CASCADED | LOCAL] CHECK OPTION]
```

The `CREATE VIEW` statement creates a new view, or replaces an existing one if the `OR REPLACE` clause is given. If the view does not exist, `CREATE OR REPLACE VIEW` is the same as `CREATE VIEW`. If the view does exist, `CREATE OR REPLACE VIEW` is the same as `ALTER VIEW`.

The *`select_statement`* is a `SELECT` statement that provides the definition of the view. (When you select from the view, you select in effect using the `SELECT` statement.) *`select_statement`* can select from base tables or other views.

The view definition is “frozen” at creation time, so changes to the underlying tables afterward do not affect the view definition. For example, if a view is defined as `SELECT *` on a table, new columns added to the table later do not become part of the view.

The `ALGORITHM` clause affects how MySQL processes the view. The `DEFINER` and `SQL SECURITY` clauses specify the security context to be used when checking access privileges at view invocation time. The `WITH CHECK OPTION` clause can be given to constrain inserts or updates to rows in tables referenced by the view. These clauses are described later in this section.

The `CREATE VIEW` statement requires the `CREATE VIEW` privilege for the view, and some privilege for each column selected by the `SELECT` statement. For columns used elsewhere in the `SELECT` statement you must have the `SELECT` privilege. If the `OR REPLACE` clause is present, you must also have the `DROP` privilege for the view. `CREATE VIEW` might also require the `SUPER` privilege, depending on the `DEFINER` value, as described later in this section.

When a view is referenced, privilege checking occurs as described later in this section.

A view belongs to a database. By default, a new view is created in the default database. To create the view explicitly in a given database, specify the name as *`db_name.view_name`* when you create it:

```
mysql> CREATE VIEW test.v AS SELECT * FROM t;
```

Within a database, base tables and views share the same namespace, so a base table and a view cannot have the same name.

Columns retrieved by the `SELECT` statement can be simple references to table columns. They can also be expressions that use functions, constant values, operators, and so forth.

Views must have unique column names with no duplicates, just like base tables. By default, the names of the columns retrieved by the `SELECT` statement are used for the view column names. To define explicit names for the view columns, the optional *`column_list`* clause can be given as a list of comma-separated identifiers. The number of names in *`column_list`* must be the same as the number of columns retrieved by the `SELECT` statement.

Unqualified table or view names in the `SELECT` statement are interpreted with respect to the default database. A view can refer to tables or views in other databases by qualifying the table or view name with the proper database name.

A view can be created from many kinds of `SELECT` statements. It can refer to base tables or other views. It can use joins, `UNION`, and subqueries. The `SELECT` need not even refer to any tables. The following example defines a view that selects two columns from another table, as well as an expression calculated from those columns:

```
mysql> CREATE TABLE t (qty INT, price INT);
mysql> INSERT INTO t VALUES(3, 50);
mysql> CREATE VIEW v AS SELECT qty, price, qty*price AS value FROM t;
mysql> SELECT * FROM v;
+------+-------+-------+
| qty  | price | value |
+------+-------+-------+
|    3 |    50 |   150 |
+------+-------+-------+
```

A view definition is subject to the following restrictions:

- The `SELECT` statement cannot contain a subquery in the `FROM` clause.
- The `SELECT` statement cannot refer to system or user variables.
- Within a stored program, the definition cannot refer to program parameters or local variables.
- The `SELECT` statement cannot refer to prepared statement parameters.
- Any table or view referred to in the definition must exist. However, after a view has been created, it is possible to drop a table or view that the definition refers to. In this case, use of the view results in an error. To check a view definition for problems of this kind, use the `CHECK TABLE` statement.
- The definition cannot refer to a `TEMPORARY` table, and you cannot create a `TEMPORARY` view.
- Any tables named in the view definition must exist at definition time.
- You cannot associate a trigger with a view.
- Aliases for column names in the `SELECT` statement are checked against the maximum column length of 64 characters (not the maximum alias length of 256 characters).

`ORDER BY` is permitted in a view definition, but it is ignored if you select from a view using a statement that has its own `ORDER BY`.

For other options or clauses in the definition, they are added to the options or clauses of the statement that references the view, but the effect is undefined. For example, if a view definition includes a `LIMIT` clause, and you select from the view using a statement that has its own `LIMIT` clause, it is undefined which limit applies. This same principle applies to options such as `ALL`, `DISTINCT`, or `SQL_SMALL_RESULT` that follow the `SELECT` keyword, and to clauses such as `INTO`, `FOR UPDATE`, `LOCK IN SHARE MODE`, and `PROCEDURE`.

If you create a view and then change the query processing environment by changing system variables, that may affect the results that you get from the view:

```
mysql> CREATE VIEW v (mycol) AS SELECT 'abc';
Query OK, 0 rows affected (0.01 sec)

mysql> SET sql_mode = '';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT "mycol" FROM v;
+-------+
| mycol |
+-------+
| mycol |
+-------+
1 row in set (0.01 sec)

mysql> SET sql_mode = 'ANSI_QUOTES';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT "mycol" FROM v;
+-------+
| mycol |
+-------+
| abc   |
+-------+
1 row in set (0.00 sec)
```

The `DEFINER` and `SQL SECURITY` clauses determine which MySQL account to use when checking access privileges for the view when a statement is executed that references the view. The legal `SQL SECURITY` characteristic values are `DEFINER` and `INVOKER`. These indicate that the required privileges must be held by the user who defined or invoked the view, respectively. The default `SQL SECURITY` value is `DEFINER`.

If a *`user`* value is given for the `DEFINER` clause, it should be a MySQL account specified as `'user_name'@'host_name'` (the same format used in the `GRANT` statement), `CURRENT_USER`, or `CURRENT_USER()`. The default `DEFINER` value is the user who executes the `CREATE VIEW` statement. This is the same as specifying `DEFINER = CURRENT_USER` explicitly.

If you specify the `DEFINER` clause, these rules determine the legal `DEFINER` user values:

- If you do not have the `SUPER` privilege, the only legal *`user`* value is your own account, either specified literally or by using `CURRENT_USER`. You cannot set the definer to some other account.
- If you have the `SUPER` privilege, you can specify any syntactically legal account name. If the account does not actually exist, a warning is generated.

- Although it is possible to create a view with a nonexistent `DEFINER` account, an error occurs when the view is referenced if the `SQL SECURITY` value is `DEFINER` but the definer account does not exist.

For more information about view security, see Section 17.6, “Access Control for Stored Programs and Views”.

Within a view definition, `CURRENT_USER` returns the view's `DEFINER` value by default. For views defined with the `SQL SECURITY INVOKER` characteristic, `CURRENT_USER` returns the account for the view's invoker. For information about user auditing within views, see Section 5.5.10, “Auditing MySQL Account Activity”.

Within a stored routine that is defined with the `SQL SECURITY DEFINER` characteristic, `CURRENT_USER` returns the routine's `DEFINER` value. This also affects a view defined within such a routine, if the view definition contains a `DEFINER` value of `CURRENT_USER`.

View privileges are checked like this:

- At view definition time, the view creator must have the privileges needed to use the top-level objects accessed by the view. For example, if the view definition refers to table columns, the creator must have some privilege for each column in the select list of the definition, and the `SELECT` privilege for each column used elsewhere in the definition. If the definition refers to a stored function, only the privileges needed to invoke the function can be checked. The privileges required at function invocation time can be checked only as it executes: For different invocations, different execution paths within the function might be taken.
- The user who references a view must have appropriate privileges to access it (`SELECT` to select from it, `INSERT` to insert into it, and so forth.)
- When a view has been referenced, privileges for objects accessed by the view are checked against the privileges held by the view `DEFINER` account or invoker, depending on whether the `SQL SECURITY` characteristic is `DEFINER` or `INVOKER`, respectively.
- If reference to a view causes execution of a stored function, privilege checking for statements executed within the function depend on whether the function `SQL SECURITY` characteristic is `DEFINER` or `INVOKER`. If the security characteristic is `DEFINER`, the function runs with the privileges of the `DEFINER` account. If the characteristic is `INVOKER`, the function runs with the privileges determined by the view's `SQL SECURITY` characteristic.

Example: A view might depend on a stored function, and that function might invoke other stored routines. For example, the following view invokes a stored function `f()`:

```
CREATE VIEW v AS SELECT * FROM t WHERE t.id = f(t.name);
```

Suppose that `f()` contains a statement such as this:

```
IF name IS NULL then
  CALL p1();
ELSE
  CALL p2();
END IF;
```

The privileges required for executing statements within `f()` need to be checked when `f()` executes. This might mean that privileges are needed for `p1()` or `p2()`, depending on the execution path within `f()`. Those privileges must be checked at runtime, and the user who must possess the privileges is determined by the `SQL SECURITY` values of the view `v` and the function `f()`.

The `DEFINER` and `SQL SECURITY` clauses for views are extensions to standard SQL. In standard SQL, views are handled using the rules for `SQL SECURITY DEFINER`. The standard says that the definer of the view, which is the same as the owner of the view's schema, gets applicable privileges on the view (for example, `SELECT`) and may grant them. MySQL has no concept of a schema “owner”, so MySQL adds a clause to identify the definer. The `DEFINER` clause is an extension where the intent is to have what the standard has; that is, a permanent record of who defined the view. This is why the default `DEFINER` value is the account of the view creator.

The optional `ALGORITHM` clause is a MySQL extension to standard SQL. It affects how MySQL processes the view. `ALGORITHM` takes three values: `MERGE`, `TEMPTABLE`, or `UNDEFINED`. The default algorithm is `UNDEFINED` if no `ALGORITHM` clause is present. For more information, see Section 17.5.2, “View Processing Algorithms”.

Some views are updatable. That is, you can use them in statements such as `UPDATE`, `DELETE`, or `INSERT` to update the contents of the underlying table. For a view to be updatable, there must be a one-to-one relationship between the rows in the view and the rows in the underlying table. There are also certain other constructs that make a view nonupdatable.

The `WITH CHECK OPTION` clause can be given for an updatable view to prevent inserts or updates to rows except those for which the `WHERE` clause in the *`select_statement`* is true.

In a `WITH CHECK OPTION` clause for an updatable view, the `LOCAL` and `CASCADED` keywords determine the scope of check testing when the view is defined in terms of another view. The `LOCAL` keyword restricts the `CHECK OPTION` only to the view being defined. `CASCADED` causes the checks for underlying views to be evaluated as well. When neither keyword is given, the default is `CASCADED`.

For more information about updatable views and the `WITH CHECK OPTION` clause, see Section 17.5.3, “Updatable and Insertable Views”.

12.1.17. `DROP DATABASE` Syntax

```
DROP {DATABASE | SCHEMA} [IF EXISTS] db_name
```

`DROP DATABASE` drops all tables in the database and deletes the database. Be *very* careful with this statement! To use `DROP DATABASE`, you need the `DROP` privilege on the database. `DROP SCHEMA` is a synonym for `DROP DATABASE`.

> **Important**
>
> When a database is dropped, user privileges on the database are *not* automatically dropped. See Section 12.4.1.3, “`GRANT` Syntax”.

`IF EXISTS` is used to prevent an error from occurring if the database does not exist.

If the default database is dropped, the default database is unset (the `DATABASE()` function returns `NULL`).

If you use `DROP DATABASE` on a symbolically linked database, both the link and the original database are deleted.

`DROP DATABASE` returns the number of tables that were removed. This corresponds to the number of `.frm` files removed.

The `DROP DATABASE` statement removes from the given database directory those files and directories that MySQL itself may create during normal operation:

- All files with the following extensions.

`.BAK`	`.DAT`	`.HSH`	`.MRG`
`.MYD`	`.MYI`	`.TRG`	`.TRN`
`.db`	`.frm`	`.ibd`	`.ndb`
`.par`			

- The `db.opt` file, if it exists.

If other files or directories remain in the database directory after MySQL removes those just listed, the database directory cannot be removed. In this case, you must remove any remaining files or directories manually and issue the `DROP DATABASE` statement again.

You can also drop databases with `mysqladmin`. See Section 4.5.2, “`mysqladmin` — Client for Administering a MySQL Server”.

12.1.18. `DROP EVENT` Syntax

```
DROP EVENT [IF EXISTS] event_name
```

This statement drops the event named *`event_name`*. The event immediately ceases being active, and is deleted completely from the server.

If the event does not exist, the error `ERROR 1517 (HY000): Unknown event 'event_name'` results. You can override this and cause the statement to generate a warning for nonexistent events instead using `IF EXISTS`.

This statement requires the `EVENT` privilege for the schema to which the event to be dropped belongs.

12.1.19. `DROP FUNCTION` Syntax

The `DROP FUNCTION` statement is used to drop stored functions and user-defined functions (UDFs):

- For information about dropping stored functions, see Section 12.1.21, “`DROP PROCEDURE` and `DROP FUNCTION` Syntax”.
- For information about dropping user-defined functions, see Section 12.4.3.2, “`DROP FUNCTION` Syntax”.

12.1.20. `DROP INDEX` Syntax

```
DROP INDEX index_name ON tbl_name
```

`DROP INDEX` drops the index named *`index_name`* from the table *`tbl_name`*. This statement is mapped to an `ALTER TABLE` statement to drop the index. See Section 12.1.6, “`ALTER TABLE` Syntax”.

12.1.21. `DROP PROCEDURE` and `DROP FUNCTION` Syntax

```
DROP {PROCEDURE | FUNCTION} [IF EXISTS] sp_name
```

This statement is used to drop a stored procedure or function. That is, the specified routine is removed from the server. You must have the `ALTER ROUTINE` privilege for the routine. (If the `automatic_sp_privileges` system variable is enabled, that privilege and `EXECUTE` are granted automatically to the routine creator when the routine is created and dropped from the creator when the routine is dropped. See Section 17.2.2, “Stored Routines and MySQL Privileges”.)

The `IF EXISTS` clause is a MySQL extension. It prevents an error from occurring if the procedure or function does not exist. A warning is produced that can be viewed with `SHOW WARNINGS`.

`DROP FUNCTION` is also used to drop user-defined functions (see Section 12.4.3.2, “`DROP FUNCTION` Syntax”).

12.1.22. `DROP SERVER` Syntax

```
DROP SERVER [ IF EXISTS ] server_name
```

Drops the server definition for the server named *`server_name`*. The corresponding row within the `mysql.servers` table will be deleted. This statement requires the `SUPER` privilege.

Dropping a server for a table does not affect any `FEDERATED` tables that used this connection information when they were created. See Section 12.1.13, “`CREATE SERVER` Syntax”.

`DROP SERVER` does not cause an automatic commit.

12.1.23. `DROP TABLE` Syntax

```
DROP [TEMPORARY] TABLE [IF EXISTS]
    tbl_name [, tbl_name] ...
    [RESTRICT | CASCADE]
```

`DROP TABLE` removes one or more tables. You must have the `DROP` privilege for each table. All table data and the table definition are *removed*, so *be careful* with this statement! If any of the tables named in the argument list do not exist, MySQL returns an error indicating by name which nonexisting tables it was unable to drop, but it also drops all of the tables in the list that do exist.

> **Important**
>
> When a table is dropped, user privileges on the table are *not* automatically dropped. See Section 12.4.1.3, “`GRANT` Syntax”.

Note that for a partitioned table, `DROP TABLE` permanently removes the table definition, all of its partitions, and all of the data which was stored in those partitions. It also removes the partitioning definition (`.par`) file associated with the dropped table.

Use `IF EXISTS` to prevent an error from occurring for tables that do not exist. A `NOTE` is generated for each nonexistent table when using `IF EXISTS`. See Section 12.4.5.41, “`SHOW WARNINGS` Syntax”.

`RESTRICT` and `CASCADE` are permitted to make porting easier. In MySQL 5.5, they do nothing.

> **Note**
>
> `DROP TABLE` automatically commits the current active transaction, unless you use the `TEMPORARY` keyword.

The `TEMPORARY` keyword has the following effects:

- The statement drops only `TEMPORARY` tables.
- The statement does not end an ongoing transaction.
- No access rights are checked. (A `TEMPORARY` table is visible only to the session that created it, so no check is necessary.)

Using `TEMPORARY` is a good way to ensure that you do not accidentally drop a non-`TEMPORARY` table.

12.1.24. `DROP TRIGGER` Syntax

```
DROP TRIGGER [IF EXISTS] [schema_name.]trigger_name
```

This statement drops a trigger. The schema (database) name is optional. If the schema is omitted, the trigger is dropped from the default schema. `DROP TRIGGER` requires the `TRIGGER` privilege for the table associated with the trigger.

Use `IF EXISTS` to prevent an error from occurring for a trigger that does not exist. A `NOTE` is generated for a nonexistent trigger when using `IF EXISTS`. See Section 12.4.5.41, "`SHOW WARNINGS` Syntax".

Triggers for a table are also dropped if you drop the table.

> **Note**
>
> When upgrading from a version of MySQL older than MySQL 5.0.10 to 5.0.10 or newer—including all MySQL 5.5 releases—you must drop all triggers and re-create them. Otherwise, `DROP TRIGGER` does not work for older triggers after the upgrade. See Upgrading from MySQL 4.1 to 5.0, for a suggested upgrade procedure.

12.1.25. `DROP VIEW` Syntax

```
DROP VIEW [IF EXISTS]
    view_name [, view_name] ...
    [RESTRICT | CASCADE]
```

`DROP VIEW` removes one or more views. You must have the `DROP` privilege for each view. If any of the views named in the argument list do not exist, MySQL returns an error indicating by name which nonexisting views it was unable to drop, but it also drops all of the views in the list that do exist.

The `IF EXISTS` clause prevents an error from occurring for views that don't exist. When this clause is given, a `NOTE` is generated for each nonexistent view. See Section 12.4.5.41, "`SHOW WARNINGS` Syntax".

`RESTRICT` and `CASCADE`, if given, are parsed and ignored.

12.1.26. `RENAME TABLE` Syntax

```
RENAME TABLE tbl_name TO new_tbl_name
    [, tbl_name2 TO new_tbl_name2] ...
```

This statement renames one or more tables.

The rename operation is done atomically, which means that no other session can access any of the tables while the rename is running. For example, if you have an existing table `old_table`, you can create another table `new_table` that has the same structure but is empty, and then replace the existing table with the empty one as follows (assuming that `backup_table` does not already exist):

```
CREATE TABLE new_table (...);
RENAME TABLE old_table TO backup_table, new_table TO old_table;
```

If the statement renames more than one table, renaming operations are done from left to right. If you want to swap two table names, you can do so like this (assuming that `tmp_table` does not already exist):

```
RENAME TABLE old_table TO tmp_table,
             new_table TO old_table,
             tmp_table TO new_table;
```

As long as two databases are on the same file system, you can use `RENAME TABLE` to move a table from one database to another:

```
RENAME TABLE current_db.tbl_name TO other_db.tbl_name;
```

If there are any triggers associated with a table which is moved to a different database using `RENAME TABLE`, then the statement fails with the error `TRIGGER IN WRONG SCHEMA`.

`RENAME TABLE` also works for views, as long as you do not try to rename a view into a different database.

Any privileges granted specifically for the renamed table or view are not migrated to the new name. They must be changed manually.

When you execute `RENAME`, you cannot have any locked tables or active transactions. You must also have the `ALTER` and `DROP` privileges on the original table, and the `CREATE` and `INSERT` privileges on the new table.

If MySQL encounters any errors in a multiple-table rename, it does a reverse rename for all renamed tables to return everything to its original state.

You cannot use `RENAME` to rename a `TEMPORARY` table. However, you can use `ALTER TABLE` instead:

```
mysql> ALTER TABLE orig_name RENAME new_name;
```

12.1.27. `TRUNCATE TABLE` Syntax

```
TRUNCATE [TABLE] tbl_name
```

`TRUNCATE TABLE` empties a table completely. It requires the `DROP` privilege.

Logically, `TRUNCATE TABLE` is similar to a `DELETE` statement that deletes all rows, or a sequence of `DROP TABLE` and `CREATE TABLE` statements. To achieve high performance, it bypasses the DML method of deleting data. Thus, it cannot be rolled back, it does not cause `ON DELETE` triggers to fire, and it cannot be performed for `InnoDB` tables with parent-child foreign key relationships.

Although `TRUNCATE TABLE` is similar to `DELETE`, it is classified as a DDL statement rather than a DML statement. It differs from `DELETE` in the following ways in MySQL 5.5:

- Truncate operations drop and re-create the table, which is much faster than deleting rows one by one, particularly for large tables.
- Truncate operations cause an implicit commit, and so cannot be rolled back.
- Truncation operations cannot be performed if the session holds an active table lock.
- `TRUNCATE TABLE` fails for an `InnoDB` table if there are any `FOREIGN KEY` constraints from other tables that reference the table. Foreign key constraints between columns of the same table are allowed.
- Truncation operations do not return a meaningful value for the number of deleted rows. The usual result is “0 rows affected,” which should be interpreted as “no information.”
- As long as the table format file `tbl_name.frm` is valid, the table can be re-created as an empty table with `TRUNCATE TABLE`, even if the data or index files have become corrupted.
- Any `AUTO_INCREMENT` value is reset to its start value. This is true even for `MyISAM` and `InnoDB`, which normally do not reuse sequence values.
- When used with partitioned tables, `TRUNCATE TABLE` preserves the partitioning; that is, the data and index files are dropped and re-created, while the partition definitions (`.par`) file is unaffected.
- The `TRUNCATE TABLE` statement does not invoke `ON DELETE` triggers.

`TRUNCATE TABLE` for a table closes all handlers for the table that were opened with `HANDLER OPEN`.

`TRUNCATE TABLE` is treated for purposes of binary logging and replication as `DROP TABLE` followed by `CREATE TABLE`—that is, as DDL rather than DML. This is due to the fact that, when using `InnoDB` and other transactional storage engines where the transaction isolation level does not permit statement-based logging (`READ COMMITTED` or `READ UNCOMMITTED`), the statement was not logged and replicated when using `STATEMENT` or `MIXED` logging mode. (Bug #36763) However, it is still applied on replication slaves using `InnoDB` in the manner described previously.

`TRUNCATE TABLE` can be used with Performance Schema summary tables, but the effect is to reset the summary columns to 0 or `NULL`, not to remove rows. See Section 19.7.4, “Performance Schema Summary Tables”.

12.2. Data Manipulation Statements

12.2.1. `CALL` Syntax

```
CALL sp_name([parameter[,...]])
CALL sp_name[()]
```

The `CALL` statement invokes a stored procedure that was defined previously with `CREATE PROCEDURE`.

Stored procedures that take no arguments can be invoked without parentheses. That is, `CALL p()` and `CALL p` are equivalent.

`CALL` can pass back values to its caller using parameters that are declared as `OUT` or `INOUT` parameters. When the procedure returns, a client program can also obtain the number of rows affected for the final statement executed within the routine: At the SQL level, call the `ROW_COUNT()` function; from the C API, call the `mysql_affected_rows()` function.

To get back a value from a procedure using an `OUT` or `INOUT` parameter, pass the parameter by means of a user variable, and then check the value of the variable after the procedure returns. (If you are calling the procedure from within another stored procedure or function, you can also pass a routine parameter or local routine variable as an `IN` or `INOUT` parameter.) For an `INOUT` parameter, initialize its value before passing it to the procedure. The following procedure has an `OUT` parameter that the procedure sets to the current server version, and an `INOUT` value that the procedure increments by one from its current value:

```
CREATE PROCEDURE p (OUT ver_param VARCHAR(25), INOUT incr_param INT)
BEGIN
  # Set value of OUT parameter
  SELECT VERSION() INTO ver_param;
  # Increment value of INOUT parameter
  SET incr_param = incr_param + 1;
END;
```

Before calling the procedure, initialize the variable to be passed as the `INOUT` parameter. After calling the procedure, the values of the two variables will have been set or modified:

```
mysql> SET @increment = 10;
mysql> CALL p(@version, @increment);
mysql> SELECT @version, @increment;
+--------------+------------+
| @version     | @increment |
+--------------+------------+
| 5.5.3-m3-log |         11 |
+--------------+------------+
```

In prepared `CALL` statements used with `PREPARE` and `EXECUTE`, placeholders can be used for `IN` parameters. For `OUT` and `INOUT` parameters, placeholder support is available as of MySQL 5.5.3. These types of parameters can be used as follows:

```
mysql> SET @increment = 10;
mysql> PREPARE s FROM 'CALL p(?, ?)';
mysql> EXECUTE s USING @version, @increment;
mysql> SELECT @version, @increment;
+--------------+------------+
| @version     | @increment |
+--------------+------------+
| 5.5.3-m3-log |         11 |
+--------------+------------+
```

Before MySQL 5.5.3, placeholder support is not available for `OUT` or `INOUT` parameters. To work around this limitation for `OUT` and `INOUT` parameters, forego the use of placeholders; instead, refer to user variables in the `CALL` statement itself and do not specify them in the `EXECUTE` statement:

```
mysql> SET @increment = 10;
mysql> PREPARE s FROM 'CALL p(@version, @increment)';
mysql> EXECUTE s;
mysql> SELECT @version, @increment;
+--------------+------------+
| @version     | @increment |
+--------------+------------+
| 5.5.0-m2-log |         11 |
+--------------+------------+
```

To write C programs that use the `CALL` SQL statement to execute stored procedures that produce result sets, the `CLIENT_MULTI_RESULTS` flag must be enabled. This is because each `CALL` returns a result to indicate the call status, in addition to any result sets that might be returned by statements executed within the procedure. `CLIENT_MULTI_RESULTS` must also be enabled if `CALL` is used to execute any stored procedure that contains prepared statements. It cannot be determined when such a procedure is loaded whether those statements will produce result sets, so it is necessary to assume that they will.

`CLIENT_MULTI_RESULTS` can be enabled when you call `mysql_real_connect()`, either explicitly by passing the `CLIENT_MULTI_RESULTS` flag itself, or implicitly by passing `CLIENT_MULTI_STATEMENTS` (which also enables `CLI-`

`ENT_MULTI_RESULTS`). As of MySQL 5.5.3, `CLIENT_MULTI_RESULTS` is enabled by default.

To process the result of a `CALL` statement executed using `mysql_query()` or `mysql_real_query()`, use a loop that calls `mysql_next_result()` to determine whether there are more results. For an example, see Section 20.9.13, "C API Support for Multiple Statement Execution".

For programs written in a language that provides a MySQL interface, there is no native method prior to MySQL 5.5.3 for directly retrieving the results of `OUT` or `INOUT` parameters from `CALL` statements. To get the parameter values, pass user-defined variables to the procedure in the `CALL` statement and then execute a `SELECT` statement to produce a result set containing the variable values. To handle an `INOUT` parameter, execute a statement prior to the `CALL` that sets the corresponding user variable to the value to be passed to the procedure.

The following example illustrates the technique (without error checking) for the stored procedure `p` described earlier that has an `OUT` parameter and an `INOUT` parameter:

```
mysql_query(mysql, "SET @increment = 10");
mysql_query(mysql, "CALL p(@version, @increment)");
mysql_query(mysql, "SELECT @version, @increment");
result = mysql_store_result(mysql);
row = mysql_fetch_row(result);
mysql_free_result(result);
```

After the preceding code executes, `row[0]` and `row[1]` contain the values of `@version` and `@increment`, respectively.

As of MySQL 5.5.3, C programs can use the prepared-statement interface to execute `CALL` statements and access `OUT` and `INOUT` parameters. This is done by processing the result of a `CALL` statement using a loop that calls `mysql_stmt_next_result()` to determine whether there are more results. For an example, see Section 20.9.16, "C API Support for Prepared `CALL` Statements". Languages that provide a MySQL interface can use prepared `CALL` statements to directly retrieve `OUT` and `INOUT` procedure parameters.

12.2.2. `DELETE` Syntax

Single-table syntax:

```
DELETE [LOW_PRIORITY] [QUICK] [IGNORE] FROM tbl_name
    [WHERE where_condition]
    [ORDER BY ...]
    [LIMIT row_count]
```

Multiple-table syntax:

```
DELETE [LOW_PRIORITY] [QUICK] [IGNORE]
    tbl_name[.*] [, tbl_name[.*]] ...
    FROM table_references
    [WHERE where_condition]
```

Or:

```
DELETE [LOW_PRIORITY] [QUICK] [IGNORE]
    FROM tbl_name[.*] [, tbl_name[.*]] ...
    USING table_references
    [WHERE where_condition]
```

For the single-table syntax, the `DELETE` statement deletes rows from *`tbl_name`* and returns a count of the number of deleted rows. This count can be obtained by calling the `ROW_COUNT()` function (see Section 11.14, "Information Functions"). The `WHERE` clause, if given, specifies the conditions that identify which rows to delete. With no `WHERE` clause, all rows are deleted. If the `ORDER BY` clause is specified, the rows are deleted in the order that is specified. The `LIMIT` clause places a limit on the number of rows that can be deleted.

For the multiple-table syntax, `DELETE` deletes from each *`tbl_name`* the rows that satisfy the conditions. In this case, `ORDER BY` and `LIMIT` cannot be used.

`where_condition` is an expression that evaluates to true for each row to be deleted. It is specified as described in Section 12.2.9, "`SELECT` Syntax".

Currently, you cannot delete from a table and select from the same table in a subquery.

You need the `DELETE` privilege on a table to delete rows from it. You need only the `SELECT` privilege for any columns that are only read, such as those named in the `WHERE` clause.

As stated, a `DELETE` statement with no `WHERE` clause deletes all rows. A faster way to do this, when you do not need to know the number of deleted rows, is to use `TRUNCATE TABLE`. However, within a transaction or if you have a lock on the table, `TRUNCATE TABLE` cannot be used whereas `DELETE` can. See Section 12.1.27, "`TRUNCATE TABLE` Syntax", and Section 12.3.5, `LOCK TABLES` and `UNLOCK TABLES` Syntax”.

If you delete the row containing the maximum value for an `AUTO_INCREMENT` column, the value is not reused for a `MyISAM` or `InnoDB` table. If you delete all rows in the table with `DELETE FROM tbl_name` (without a `WHERE` clause) in `autocommit` mode, the sequence starts over for all storage engines except `InnoDB` and `MyISAM`. There are some exceptions to this behavior for `InnoDB` tables, as discussed in Section 13.3.5.3, “`AUTO_INCREMENT` Handling in `InnoDB`”.

For `MyISAM` tables, you can specify an `AUTO_INCREMENT` secondary column in a multiple-column key. In this case, reuse of values deleted from the top of the sequence occurs even for `MyISAM` tables. See Section 3.6.9, “Using `AUTO_INCREMENT`”.

The `DELETE` statement supports the following modifiers:

- If you specify `LOW_PRIORITY`, the server delays execution of the `DELETE` until no other clients are reading from the table. This affects only storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`).
- For `MyISAM` tables, if you use the `QUICK` keyword, the storage engine does not merge index leaves during delete, which may speed up some kinds of delete operations.
- The `IGNORE` keyword causes MySQL to ignore all errors during the process of deleting rows. (Errors encountered during the parsing stage are processed in the usual manner.) Errors that are ignored due to the use of `IGNORE` are returned as warnings.

The speed of delete operations may also be affected by factors discussed in Section 7.2.2.3, “Speed of `DELETE` Statements”.

In `MyISAM` tables, deleted rows are maintained in a linked list and subsequent `INSERT` operations reuse old row positions. To reclaim unused space and reduce file sizes, use the `OPTIMIZE TABLE` statement or the `myisamchk` utility to reorganize tables. `OPTIMIZE TABLE` is easier to use, but `myisamchk` is faster. See Section 12.4.2.4, “`OPTIMIZE TABLE` Syntax”, and Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”.

The `QUICK` modifier affects whether index leaves are merged for delete operations. `DELETE QUICK` is most useful for applications where index values for deleted rows are replaced by similar index values from rows inserted later. In this case, the holes left by deleted values are reused.

`DELETE QUICK` is not useful when deleted values lead to underfilled index blocks spanning a range of index values for which new inserts occur again. In this case, use of `QUICK` can lead to wasted space in the index that remains unreclaimed. Here is an example of such a scenario:

1. Create a table that contains an indexed `AUTO_INCREMENT` column.
2. Insert many rows into the table. Each insert results in an index value that is added to the high end of the index.
3. Delete a block of rows at the low end of the column range using `DELETE QUICK`.

In this scenario, the index blocks associated with the deleted index values become underfilled but are not merged with other index blocks due to the use of `QUICK`. They remain underfilled when new inserts occur, because new rows do not have index values in the deleted range. Furthermore, they remain underfilled even if you later use `DELETE` without `QUICK`, unless some of the deleted index values happen to lie in index blocks within or adjacent to the underfilled blocks. To reclaim unused index space under these circumstances, use `OPTIMIZE TABLE`.

If you are going to delete many rows from a table, it might be faster to use `DELETE QUICK` followed by `OPTIMIZE TABLE`. This rebuilds the index rather than performing many index block merge operations.

The MySQL-specific `LIMIT row_count` option to `DELETE` tells the server the maximum number of rows to be deleted before control is returned to the client. This can be used to ensure that a given `DELETE` statement does not take too much time. You can simply repeat the `DELETE` statement until the number of affected rows is less than the `LIMIT` value.

If the `DELETE` statement includes an `ORDER BY` clause, rows are deleted in the order specified by the clause. This is useful primarily in conjunction with `LIMIT`. For example, the following statement finds rows matching the `WHERE` clause, sorts them by `timestamp_column`, and deletes the first (oldest) one:

```
DELETE FROM somelog WHERE user = 'jcole'
ORDER BY timestamp_column LIMIT 1;
```

`ORDER BY` may also be useful in some cases to delete rows in an order required to avoid referential integrity violations.

If you are deleting many rows from a large table, you may exceed the lock table size for an `InnoDB` table. To avoid this problem, or simply to minimize the time that the table remains locked, the following strategy (which does not use `DELETE` at all) might be helpful:

1. Select the rows *not* to be deleted into an empty table that has the same structure as the original table:

   ```
   INSERT INTO t_copy SELECT * FROM t WHERE ... ;
   ```

2. Use `RENAME TABLE` to atomically move the original table out of the way and rename the copy to the original name:

   ```
   RENAME TABLE t TO t_old, t_copy TO t;
   ```

3. Drop the original table:

   ```
   DROP TABLE t_old;
   ```

No other sessions can access the tables involved while `RENAME TABLE` executes, so the rename operation is not subject to concurrency problems. See Section 12.1.26, "`RENAME TABLE` Syntax".

You can specify multiple tables in a `DELETE` statement to delete rows from one or more tables depending on the particular condition in the `WHERE` clause. However, you cannot use `ORDER BY` or `LIMIT` in a multiple-table `DELETE`. The *`table_references`* clause lists the tables involved in the join. Its syntax is described in Section 12.2.9.1, "`JOIN` Syntax".

For the first multiple-table syntax, only matching rows from the tables listed before the `FROM` clause are deleted. For the second multiple-table syntax, only matching rows from the tables listed in the `FROM` clause (before the `USING` clause) are deleted. The effect is that you can delete rows from many tables at the same time and have additional tables that are used only for searching:

```
DELETE t1, t2 FROM t1 INNER JOIN t2 INNER JOIN t3
WHERE t1.id=t2.id AND t2.id=t3.id;
```

Or:

```
DELETE FROM t1, t2 USING t1 INNER JOIN t2 INNER JOIN t3
WHERE t1.id=t2.id AND t2.id=t3.id;
```

These statements use all three tables when searching for rows to delete, but delete matching rows only from tables `t1` and `t2`.

The preceding examples use `INNER JOIN`, but multiple-table `DELETE` statements can use other types of join permitted in `SELECT` statements, such as `LEFT JOIN`. For example, to delete rows that exist in `t1` that have no match in `t2`, use a `LEFT JOIN`:

```
DELETE t1 FROM t1 LEFT JOIN t2 ON t1.id=t2.id WHERE t2.id IS NULL;
```

The syntax permits `.*` after each *`tbl_name`* for compatibility with `Access`.

If you use a multiple-table `DELETE` statement involving `InnoDB` tables for which there are foreign key constraints, the MySQL optimizer might process tables in an order that differs from that of their parent/child relationship. In this case, the statement fails and rolls back. Instead, you should delete from a single table and rely on the `ON DELETE` capabilities that `InnoDB` provides to cause the other tables to be modified accordingly.

> **Note**
>
> If you declare an alias for a table, you must use the alias when referring to the table:
>
> ```
> DELETE t1 FROM test AS t1, test2 WHERE ...
> ```

Table aliases in a multiple-table `DELETE` should be declared only in the *`table_references`* part of the statement.

Correct:

```
DELETE a1, a2 FROM t1 AS a1 INNER JOIN t2 AS a2
WHERE a1.id=a2.id;

DELETE FROM a1, a2 USING t1 AS a1 INNER JOIN t2 AS a2
WHERE a1.id=a2.id;
```

Incorrect:

```
DELETE t1 AS a1, t2 AS a2 FROM t1 INNER JOIN t2
WHERE a1.id=a2.id;

DELETE FROM t1 AS a1, t2 AS a2 USING t1 INNER JOIN t2
WHERE a1.id=a2.id;
```

Declaration of aliases other than in the *`table_references`* part of the statement should be avoided because that can lead to ambiguous statements that have unexpected results such as deleting rows from the wrong table. This is such a statement:

```
DELETE t1 AS a2 FROM t1 AS a1 INNER JOIN t2 AS a2;
```

Before MySQL 5.5.3, alias declarations outside the *`table_references`* part of the statement are disallowed for the `USING` variant of multiple-table `DELETE` syntax. As of MySQL 5.5.3, alias declarations outside *`table_references`* are disallowed for all multiple-table `DELETE` statements.

Before MySQL 5.5.3, for alias references in the list of tables from which to delete rows in a multiple-table delete, the default database is used unless one is specified explicitly. For example, if the default database is `db1`, the following statement does not work because the unqualified alias reference `a2` is interpreted as having a database of `db1`:

```
DELETE a1, a2 FROM db1.t1 AS a1 INNER JOIN db2.t2 AS a2
WHERE a1.id=a2.id;
```

To correctly match an alias that refers to a table outside the default database, you must explicitly qualify the reference with the name of the proper database:

```
DELETE a1, db2.a2 FROM db1.t1 AS a1 INNER JOIN db2.t2 AS a2
WHERE a1.id=a2.id;
```

As of MySQL 5.5.3, alias resolution does not require qualification and alias references should not be qualified with the database name. Qualified names are interpreted as referring to tables, not aliases.

12.2.3. `DO` Syntax

```
DO expr [, expr] ...
```

`DO` executes the expressions but does not return any results. In most respects, `DO` is shorthand for `SELECT expr, ...`, but has the advantage that it is slightly faster when you do not care about the result.

`DO` is useful primarily with functions that have side effects, such as `RELEASE_LOCK()`.

12.2.4. `HANDLER` Syntax

```
HANDLER tbl_name OPEN [ [AS] alias]

HANDLER tbl_name READ index_name { = | <= | >= | < | > } (value1,value2,...)
    [ WHERE where_condition ] [LIMIT ... ]
HANDLER tbl_name READ index_name { FIRST | NEXT | PREV | LAST }
    [ WHERE where_condition ] [LIMIT ... ]
HANDLER tbl_name READ { FIRST | NEXT }
    [ WHERE where_condition ] [LIMIT ... ]

HANDLER tbl_name CLOSE
```

The `HANDLER` statement provides direct access to table storage engine interfaces. It is available for `MyISAM` and `InnoDB` tables.

The `HANDLER ... OPEN` statement opens a table, making it accessible using subsequent `HANDLER ... READ` statements. This table object is not shared by other sessions and is not closed until the session calls `HANDLER ... CLOSE` or the session terminates. If you open the table using an alias, further references to the open table with other `HANDLER` statements must use the alias rather than the table name.

The first `HANDLER ... READ` syntax fetches a row where the index specified satisfies the given values and the `WHERE` condition is met. If you have a multiple-column index, specify the index column values as a comma-separated list. Either specify values for all the columns in the index, or specify values for a leftmost prefix of the index columns. Suppose that an index `my_idx` includes three columns named `col_a`, `col_b`, and `col_c`, in that order. The `HANDLER` statement can specify values for all three columns in the index, or for the columns in a leftmost prefix. For example:

```
HANDLER ... READ my_idx = (col_a_val,col_b_val,col_c_val) ...
HANDLER ... READ my_idx = (col_a_val,col_b_val) ...
HANDLER ... READ my_idx = (col_a_val) ...
```

To employ the `HANDLER` interface to refer to a table's `PRIMARY KEY`, use the quoted identifier `` `PRIMARY` ``:

```
HANDLER tbl_name READ `PRIMARY` ...
```

The second `HANDLER ... READ` syntax fetches a row from the table in index order that matches the `WHERE` condition.

The third `HANDLER ... READ` syntax fetches a row from the table in natural row order that matches the `WHERE` condition. It is faster than `HANDLER tbl_name READ index_name` when a full table scan is desired. Natural row order is the order in which rows are stored in a `MyISAM` table data file. This statement works for `InnoDB` tables as well, but there is no such concept because there is no separate data file.

Without a `LIMIT` clause, all forms of `HANDLER ... READ` fetch a single row if one is available. To return a specific number of rows, include a `LIMIT` clause. It has the same syntax as for the `SELECT` statement. See Section 12.2.9, "`SELECT` Syntax".

`HANDLER ... CLOSE` closes a table that was opened with `HANDLER ... OPEN`.

There are several reasons to use the `HANDLER` interface instead of normal `SELECT` statements:

- `HANDLER` is faster than `SELECT`:
  - A designated storage engine handler object is allocated for the `HANDLER ... OPEN`. The object is reused for subsequent `HANDLER` statements for that table; it need not be reinitialized for each one.
  - There is less parsing involved.
  - There is no optimizer or query-checking overhead.
  - The table does not have to be locked between two handler requests.
  - The handler interface does not have to provide a consistent look of the data (for example, dirty reads are permitted), so the storage engine can use optimizations that `SELECT` does not normally permit.
- For applications that use a low-level `ISAM`-like interface, `HANDLER` makes it much easier to port them to MySQL.
- `HANDLER` enables you to traverse a database in a manner that is difficult (or even impossible) to accomplish with `SELECT`. The `HANDLER` interface is a more natural way to look at data when working with applications that provide an interactive user interface to the database.

`HANDLER` is a somewhat low-level statement. For example, it does not provide consistency. That is, `HANDLER ... OPEN` does *not* take a snapshot of the table, and does *not* lock the table. This means that after a `HANDLER ... OPEN` statement is issued, table data can be modified (by the current session or other sessions) and these modifications might be only partially visible to `HANDLER ... NEXT` or `HANDLER ... PREV` scans.

An open handler can be closed and marked for reopen, in which case the handler loses its position in the table. This occurs when both of the following circumstances are true:

- Any session executes `FLUSH TABLES` or DDL statements on the handler's table.
- The session in which the handler is open executes non-`HANDLER` statements that use tables.

`TRUNCATE TABLE` for a table closes all handlers for the table that were opened with `HANDLER OPEN`.

If a table is flushed with `FLUSH TABLES tbl_name WITH READ LOCK` was opened with `HANDLER`, the handler is implicitly flushed and loses its position.

12.2.5. `INSERT` Syntax

```
INSERT [LOW_PRIORITY | DELAYED | HIGH_PRIORITY] [IGNORE]
    [INTO] tbl_name [(col_name,...)]
    {VALUES | VALUE} ({expr | DEFAULT},...),(...),...
    [ ON DUPLICATE KEY UPDATE
      col_name=expr
        [, col_name=expr] ... ]
```

Or:

```
INSERT [LOW_PRIORITY | DELAYED | HIGH_PRIORITY] [IGNORE]
    [INTO] tbl_name
    SET col_name={expr | DEFAULT}, ...
    [ ON DUPLICATE KEY UPDATE
      col_name=expr
        [, col_name=expr] ... ]
```

Or:

```
INSERT [LOW_PRIORITY | HIGH_PRIORITY] [IGNORE]
    [INTO] tbl_name [(col_name,...)]
    SELECT ...
    [ ON DUPLICATE KEY UPDATE
      col_name=expr
        [, col_name=expr] ... ]
```

`INSERT` inserts new rows into an existing table. The `INSERT ... VALUES` and `INSERT ... SET` forms of the statement insert rows based on explicitly specified values. The `INSERT ... SELECT` form inserts rows selected from another table or tables. `INSERT ... SELECT` is discussed further in Section 12.2.5.1, "`INSERT ... SELECT` Syntax".

You can use `REPLACE` instead of `INSERT` to overwrite old rows. `REPLACE` is the counterpart to `INSERT IGNORE` in the treatment of new rows that contain unique key values that duplicate old rows: The new rows are used to replace the old rows rather than being discarded. See Section 12.2.8, "`REPLACE` Syntax".

`tbl_name` is the table into which rows should be inserted. The columns for which the statement provides values can be specified as follows:

- You can provide a comma-separated list of column names following the table name. In this case, a value for each named column must be provided by the `VALUES` list or the `SELECT` statement.
- If you do not specify a list of column names for `INSERT ... VALUES` or `INSERT ... SELECT`, values for every column in the table must be provided by the `VALUES` list or the `SELECT` statement. If you do not know the order of the columns in the table, use `DESCRIBE tbl_name` to find out.
- The `SET` clause indicates the column names explicitly.

Column values can be given in several ways:

- If you are not running in strict SQL mode, any column not explicitly given a value is set to its default (explicit or implicit) value. For example, if you specify a column list that does not name all the columns in the table, unnamed columns are set to their default values. Default value assignment is described in Section 10.1.4, "Data Type Default Values". See also Section 1.8.6.2, "Constraints on Invalid Data".

  If you want an `INSERT` statement to generate an error unless you explicitly specify values for all columns that do not have a default value, you should use strict mode. See Section 5.1.6, "Server SQL Modes".

- Use the keyword `DEFAULT` to set a column explicitly to its default value. This makes it easier to write `INSERT` statements that assign values to all but a few columns, because it enables you to avoid writing an incomplete `VALUES` list that does not include a value for each column in the table. Otherwise, you would have to write out the list of column names corresponding to each value in the `VALUES` list.

  You can also use `DEFAULT(col_name)` as a more general form that can be used in expressions to produce a given column's default value.

- If both the column list and the `VALUES` list are empty, `INSERT` creates a row with each column set to its default value:

  ```
  INSERT INTO tbl_name () VALUES();
  ```

  In strict mode, an error occurs if any column doesn't have a default value. Otherwise, MySQL uses the implicit default value for any column that does not have an explicitly defined default.

- You can specify an expression *`expr`* to provide a column value. This might involve type conversion if the type of the expression does not match the type of the column, and conversion of a given value can result in different inserted values depending on the data type. For example, inserting the string `'1999.0e-2'` into an `INT`, `FLOAT`, `DECIMAL(10,6)`, or `YEAR` column results in the values `1999`, `19.9921`, `19.992100`, and `1999` being inserted, respectively. The reason the value stored in the `INT` and `YEAR` columns is `1999` is that the string-to-integer conversion looks only at as much of the initial part of the string as may be considered a valid integer or year. For the floating-point and fixed-point columns, the string-to-floating-point conversion considers the entire string a valid floating-point value.

  An expression *`expr`* can refer to any column that was set earlier in a value list. For example, you can do this because the value for `col2` refers to `col1`, which has previously been assigned:

  ```
  INSERT INTO tbl_name (col1,col2) VALUES(15,col1*2);
  ```

  But the following is not legal, because the value for `col1` refers to `col2`, which is assigned after `col1`:

  ```
  INSERT INTO tbl_name (col1,col2) VALUES(col2*2,15);
  ```

One exception involves columns that contain `AUTO_INCREMENT` values. Because the `AUTO_INCREMENT` value is generated after other value assignments, any reference to an `AUTO_INCREMENT` column in the assignment returns a `0`.

`INSERT` statements that use `VALUES` syntax can insert multiple rows. To do this, include multiple lists of column values, each enclosed within parentheses and separated by commas. Example:

```
INSERT INTO tbl_name (a,b,c) VALUES(1,2,3),(4,5,6),(7,8,9);
```

The values list for each row must be enclosed within parentheses. The following statement is illegal because the number of values in the list does not match the number of column names:

```
INSERT INTO tbl_name (a,b,c) VALUES(1,2,3,4,5,6,7,8,9);
```

`VALUE` is a synonym for `VALUES` in this context. Neither implies anything about the number of values lists, and either may be used whether there is a single values list or multiple lists.

The affected-rows value for an `INSERT` can be obtained using the `ROW_COUNT()` function (see Section 11.14, "Information Functions"), or the `mysql_affected_rows()` C API function (see Section 20.9.3.1, "`mysql_affected_rows()`").

If you use an `INSERT ... VALUES` statement with multiple value lists or `INSERT ... SELECT`, the statement returns an information string in this format:

```
Records: 100 Duplicates: 0 Warnings: 0
```

`Records` indicates the number of rows processed by the statement. (This is not necessarily the number of rows actually inserted because `Duplicates` can be nonzero.) `Duplicates` indicates the number of rows that could not be inserted because they would duplicate some existing unique index value. `Warnings` indicates the number of attempts to insert column values that were problematic in some way. Warnings can occur under any of the following conditions:

- Inserting `NULL` into a column that has been declared `NOT NULL`. For multiple-row `INSERT` statements or `INSERT INTO ... SELECT` statements, the column is set to the implicit default value for the column data type. This is `0` for numeric types, the empty string (`''`) for string types, and the "zero" value for date and time types. `INSERT INTO ... SELECT` statements are handled the same way as multiple-row inserts because the server does not examine the result set from the `SELECT` to see whether it returns a single row. (For a single-row `INSERT`, no warning occurs when `NULL` is inserted into a `NOT NULL` column. Instead, the statement fails with an error.)
- Setting a numeric column to a value that lies outside the column's range. The value is clipped to the closest endpoint of the range.
- Assigning a value such as `'10.34 a'` to a numeric column. The trailing nonnumeric text is stripped off and the remaining numeric part is inserted. If the string value has no leading numeric part, the column is set to `0`.
- Inserting a string into a string column (`CHAR`, `VARCHAR`, `TEXT`, or `BLOB`) that exceeds the column's maximum length. The value is truncated to the column's maximum length.
- Inserting a value into a date or time column that is illegal for the data type. The column is set to the appropriate zero value for the type.

If you are using the C API, the information string can be obtained by invoking the `mysql_info()` function. See Section 20.9.3.35, "`mysql_info()`".

If `INSERT` inserts a row into a table that has an `AUTO_INCREMENT` column, you can find the value used for that column by using the SQL `LAST_INSERT_ID()` function. From within the C API, use the `mysql_insert_id()` function. However, you should note that the two functions do not always behave identically. The behavior of `INSERT` statements with respect to `AUTO_INCREMENT` columns is discussed further in Section 11.14, "Information Functions", and Section 20.9.3.37, "`mysql_insert_id()`".

The `INSERT` statement supports the following modifiers:

- If you use the `DELAYED` keyword, the server puts the row or rows to be inserted into a buffer, and the client issuing the `INSERT DELAYED` statement can then continue immediately. If the table is in use, the server holds the rows. When the table is free, the server begins inserting rows, checking periodically to see whether there are any new read requests for the table. If there are, the delayed row queue is suspended until the table becomes free again. See Section 12.2.5.2, "`INSERT DELAYED` Syntax".

`DELAYED` is ignored with `INSERT ... SELECT` or `INSERT ... ON DUPLICATE KEY UPDATE`.

`DELAYED` is also disregarded for an `INSERT` that uses functions accessing tables or triggers, or that is called from a function or a trigger.

- If you use the `LOW_PRIORITY` keyword, execution of the `INSERT` is delayed until no other clients are reading from the table. This includes other clients that began reading while existing clients are reading, and while the `INSERT LOW_PRIORITY` statement is waiting. It is possible, therefore, for a client that issues an `INSERT LOW_PRIORITY` statement to wait for a very long time (or even forever) in a read-heavy environment. (This is in contrast to `INSERT DELAYED`, which lets the client continue at once. Note that `LOW_PRIORITY` should normally not be used with `MyISAM` tables because doing so disables concurrent inserts. See Section 7.10.3, “Concurrent Inserts”.

  If you specify `HIGH_PRIORITY`, it overrides the effect of the `--low-priority-updates` option if the server was started with that option. It also causes concurrent inserts not to be used. See Section 7.10.3, “Concurrent Inserts”.

  `LOW_PRIORITY` and `HIGH_PRIORITY` affect only storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`).

- If you use the `IGNORE` keyword, errors that occur while executing the `INSERT` statement are treated as warnings instead. For example, without `IGNORE`, a row that duplicates an existing `UNIQUE` index or `PRIMARY KEY` value in the table causes a duplicate-key error and the statement is aborted. With `IGNORE`, the row still is not inserted, but no error is issued.

  `IGNORE` has a similar effect on inserts into partitioned tables where no partition matching a given value is found. Without `IGNORE`, such `INSERT` statements are aborted with an error; however, when `INSERT IGNORE` is used, the insert operation fails silently for the row containing the unmatched value, but any rows that are matched are inserted. For an example, see Section 16.2.2, “`LIST` Partitioning”.

  Data conversions that would trigger errors abort the statement if `IGNORE` is not specified. With `IGNORE`, invalid values are adjusted to the closest values and inserted; warnings are produced but the statement does not abort. You can determine with the `mysql_info()` C API function how many rows were actually inserted into the table.

- If you specify `ON DUPLICATE KEY UPDATE`, and a row is inserted that would cause a duplicate value in a `UNIQUE` index or `PRIMARY KEY`, an `UPDATE` of the old row is performed. The affected-rows value per row is 1 if the row is inserted as a new row and 2 if an existing row is updated. See Section 12.2.5.3, “`INSERT ... ON DUPLICATE KEY UPDATE` Syntax”.

Inserting into a table requires the `INSERT` privilege for the table. If the `ON DUPLICATE KEY UPDATE` clause is used and a duplicate key causes an `UPDATE` to be performed instead, the statement requires the `UPDATE` privilege for the columns to be updated. For columns that are read but not modified you need only the `SELECT` privilege (such as for a column referenced only on the right hand side of an *`col_name`*=*`expr`* assignment in an `ON DUPLICATE KEY UPDATE` clause).

12.2.5.1. `INSERT ... SELECT` Syntax

```
INSERT [LOW_PRIORITY | HIGH_PRIORITY] [IGNORE]
    [INTO] tbl_name [(col_name,...)]
    SELECT ...
    [ ON DUPLICATE KEY UPDATE col_name=expr, ... ]
```

With `INSERT ... SELECT`, you can quickly insert many rows into a table from one or many tables. For example:

```
INSERT INTO tbl_temp2 (fld_id)
  SELECT tbl_temp1.fld_order_id
  FROM tbl_temp1 WHERE tbl_temp1.fld_order_id > 100;
```

The following conditions hold for a `INSERT ... SELECT` statements:

- Specify `IGNORE` to ignore rows that would cause duplicate-key violations.

- `DELAYED` is ignored with `INSERT ... SELECT`.

- The target table of the `INSERT` statement may appear in the `FROM` clause of the `SELECT` part of the query. (This was not possible in some older versions of MySQL.) However, you cannot insert into a table and select from the same table in a subquery.

  When selecting from and inserting into a table at the same time, MySQL creates a temporary table to hold the rows from the `SELECT` and then inserts those rows into the target table. However, it remains true that you cannot use `INSERT INTO t ... SELECT ... FROM t` when `t` is a `TEMPORARY` table, because `TEMPORARY` tables cannot be referred to twice in the same statement (see Section C.5.7.2, “`TEMPORARY` Table Problems”).

- `AUTO_INCREMENT` columns work as usual.

- To ensure that the binary log can be used to re-create the original tables, MySQL does not permit concurrent inserts for `INSERT ... SELECT` statements.
- To avoid ambiguous column reference problems when the `SELECT` and the `INSERT` refer to the same table, provide a unique alias for each table used in the `SELECT` part, and qualify column names in that part with the appropriate alias.

In the values part of `ON DUPLICATE KEY UPDATE`, you can refer to columns in other tables, as long as you do not use `GROUP BY` in the `SELECT` part. One side effect is that you must qualify nonunique column names in the values part.

The order in which rows are returned by a `SELECT` statement with no `ORDER BY` clause is not determined. This means that, when using replication, there is no guarantee that such a `SELECT` returns rows in the same order on the master and the slave; this can lead to inconsistencies between them. To prevent this from occurring, you should always write `INSERT ... SELECT` statements that are to be replicated as `INSERT ... SELECT ... ORDER BY column`. The choice of `column` does not matter as long as the same order for returning the rows is enforced on both the master and the slave. See also Section 15.4.1.12, "Replication and `LIMIT`".

12.2.5.2. `INSERT DELAYED` Syntax

```
INSERT DELAYED ...
```

The `DELAYED` option for the `INSERT` statement is a MySQL extension to standard SQL that is very useful if you have clients that cannot or need not wait for the `INSERT` to complete. This is a common situation when you use MySQL for logging and you also periodically run `SELECT` and `UPDATE` statements that take a long time to complete.

When a client uses `INSERT DELAYED`, it gets an okay from the server at once, and the row is queued to be inserted when the table is not in use by any other thread.

Another major benefit of using `INSERT DELAYED` is that inserts from many clients are bundled together and written in one block. This is much faster than performing many separate inserts.

Note that `INSERT DELAYED` is slower than a normal `INSERT` if the table is not otherwise in use. There is also the additional overhead for the server to handle a separate thread for each table for which there are delayed rows. This means that you should use `INSERT DELAYED` only when you are really sure that you need it.

The queued rows are held only in memory until they are inserted into the table. This means that if you terminate `mysqld` forcibly (for example, with `kill -9`) or if `mysqld` dies unexpectedly, *any queued rows that have not been written to disk are lost*.

There are some constraints on the use of `DELAYED`:

- `INSERT DELAYED` works only with `MyISAM`, `MEMORY`, `ARCHIVE`, and `BLACKHOLE` tables. For engines that do not support `DELAYED`, an error occurs.
- An error occurs for `INSERT DELAYED` if used with a table that has been locked with `LOCK TABLES` because the insert must be handled by a separate thread, not by the session that holds the lock.
- For `MyISAM` tables, if there are no free blocks in the middle of the data file, concurrent `SELECT` and `INSERT` statements are supported. Under these circumstances, you very seldom need to use `INSERT DELAYED` with `MyISAM`.
- `INSERT DELAYED` should be used only for `INSERT` statements that specify value lists. The server ignores `DELAYED` for `INSERT ... SELECT` or `INSERT ... ON DUPLICATE KEY UPDATE` statements.
- Because the `INSERT DELAYED` statement returns immediately, before the rows are inserted, you cannot use `LAST_INSERT_ID()` to get the `AUTO_INCREMENT` value that the statement might generate.
- `DELAYED` rows are not visible to `SELECT` statements until they actually have been inserted.
- Prior to MySQL 5.5.7, `INSERT DELAYED` was treated as a normal `INSERT` if the statement inserted multiple rows, binary logging was enabled, and the global logging format was statement-based (that is, whenever `binlog_format` was set to `STATEMENT`). Beginning with MySQL 5.5.7, `INSERT DELAYED` is always handled as a simple `INSERT` (that is, without the `DELAYED` option) whenever the value of `binlog_format` is `STATEMENT` or `MIXED`. (In the latter case, the statement no longer triggers a switch to row-based logging, and so is logged using the statement-based format.)

  This does not apply when using row-based binary logging mode (`binlog_format` set to `ROW`), in which `INSERT DELAYED` statements are always executed using the `DELAYED` option as specified, and logged as row-update events.
- `DELAYED` is ignored on slave replication servers, so that `INSERT DELAYED` is treated as a normal `INSERT` on slaves. This is because `DELAYED` could cause the slave to have different data than the master.

- Pending `INSERT DELAYED` statements are lost if a table is write locked and `ALTER TABLE` is used to modify the table structure.
- `INSERT DELAYED` is not supported for views.
- `INSERT DELAYED` is not supported for partitioned tables.

The following describes in detail what happens when you use the `DELAYED` option to `INSERT` or `REPLACE`. In this description, the “thread” is the thread that received an `INSERT DELAYED` statement and “handler” is the thread that handles all `INSERT DELAYED` statements for a particular table.

- When a thread executes a `DELAYED` statement for a table, a handler thread is created to process all `DELAYED` statements for the table, if no such handler already exists.
- The thread checks whether the handler has previously acquired a `DELAYED` lock; if not, it tells the handler thread to do so. The `DELAYED` lock can be obtained even if other threads have a `READ` or `WRITE` lock on the table. However, the handler waits for all `ALTER TABLE` locks or `FLUSH TABLES` statements to finish, to ensure that the table structure is up to date.
- The thread executes the `INSERT` statement, but instead of writing the row to the table, it puts a copy of the final row into a queue that is managed by the handler thread. Any syntax errors are noticed by the thread and reported to the client program.
- The client cannot obtain from the server the number of duplicate rows or the `AUTO_INCREMENT` value for the resulting row, because the `INSERT` returns before the insert operation has been completed. (If you use the C API, the `mysql_info()` function does not return anything meaningful, for the same reason.)
- The binary log is updated by the handler thread when the row is inserted into the table. In case of multiple-row inserts, the binary log is updated when the first row is inserted.
- Each time that `delayed_insert_limit` rows are written, the handler checks whether any `SELECT` statements are still pending. If so, it permits these to execute before continuing.
- When the handler has no more rows in its queue, the table is unlocked. If no new `INSERT DELAYED` statements are received within `delayed_insert_timeout` seconds, the handler terminates.
- If more than `delayed_queue_size` rows are pending in a specific handler queue, the thread requesting `INSERT DELAYED` waits until there is room in the queue. This is done to ensure that `mysqld` does not use all memory for the delayed memory queue.
- The handler thread shows up in the MySQL process list with `delayed_insert` in the `Command` column. It is killed if you execute a `FLUSH TABLES` statement or kill it with `KILL` *`thread_id`*. However, before exiting, it first stores all queued rows into the table. During this time it does not accept any new `INSERT` statements from other threads. If you execute an `INSERT DELAYED` statement after this, a new handler thread is created.

  Note that this means that `INSERT DELAYED` statements have higher priority than normal `INSERT` statements if there is an `INSERT DELAYED` handler running. Other update statements have to wait until the `INSERT DELAYED` queue is empty, someone terminates the handler thread (with `KILL` *`thread_id`*), or someone executes a `FLUSH TABLES`.
- The following status variables provide information about `INSERT DELAYED` statements.

Status Variable	**Meaning**
`Delayed_insert_threads`	Number of handler threads
`Delayed_writes`	Number of rows written with `INSERT DELAYED`
`Not_flushed_delayed_rows`	Number of rows waiting to be written

  You can view these variables by issuing a `SHOW STATUS` statement or by executing a `mysqladmin extended-status` command.

12.2.5.3. `INSERT ... ON DUPLICATE KEY UPDATE` Syntax

If you specify `ON DUPLICATE KEY UPDATE`, and a row is inserted that would cause a duplicate value in a `UNIQUE` index or `PRIMARY KEY`, an `UPDATE` of the old row is performed. For example, if column `a` is declared as `UNIQUE` and contains the value `1`, the following two statements have identical effect:

```
INSERT INTO table (a,b,c) VALUES (1,2,3)
  ON DUPLICATE KEY UPDATE c=c+1;
```

```
UPDATE table SET c=c+1 WHERE a=1;
```

The `ON DUPLICATE KEY UPDATE` clause can contain multiple column assignments, separated by commas.

With `ON DUPLICATE KEY UPDATE`, the affected-rows value per row is 1 if the row is inserted as a new row and 2 if an existing row is updated.

If column `b` is also unique, the `INSERT` is equivalent to this `UPDATE` statement instead:

```
UPDATE table SET c=c+1 WHERE a=1 OR b=2 LIMIT 1;
```

If `a=1 OR b=2` matches several rows, only *one* row is updated. In general, you should try to avoid using an `ON DUPLICATE KEY UPDATE` clause on tables with multiple unique indexes.

You can use the `VALUES(col_name)` function in the `UPDATE` clause to refer to column values from the `INSERT` portion of the `INSERT ... ON DUPLICATE KEY UPDATE` statement. In other words, `VALUES(col_name)` in the `ON DUPLICATE KEY UPDATE` clause refers to the value of `col_name` that would be inserted, had no duplicate-key conflict occurred. This function is especially useful in multiple-row inserts. The `VALUES()` function is meaningful only in `INSERT ... UPDATE` statements and returns `NULL` otherwise. Example:

```
INSERT INTO table (a,b,c) VALUES (1,2,3),(4,5,6)
  ON DUPLICATE KEY UPDATE c=VALUES(a)+VALUES(b);
```

That statement is identical to the following two statements:

```
INSERT INTO table (a,b,c) VALUES (1,2,3)
  ON DUPLICATE KEY UPDATE c=3;
INSERT INTO table (a,b,c) VALUES (4,5,6)
  ON DUPLICATE KEY UPDATE c=9;
```

If a table contains an `AUTO_INCREMENT` column and `INSERT ... ON DUPLICATE KEY UPDATE` inserts or updates a row, the `LAST_INSERT_ID()` function returns the `AUTO_INCREMENT` value.

The `DELAYED` option is ignored when you use `ON DUPLICATE KEY UPDATE`.

12.2.6. `LOAD DATA INFILE` Syntax

```
LOAD DATA [LOW_PRIORITY | CONCURRENT] [LOCAL] INFILE 'file_name'
    [REPLACE | IGNORE]
    INTO TABLE tbl_name
    [CHARACTER SET charset_name]
    [{FIELDS | COLUMNS}
        [TERMINATED BY 'string']
        [[OPTIONALLY] ENCLOSED BY 'char']
        [ESCAPED BY 'char']
    ]
    [LINES
        [STARTING BY 'string']
        [TERMINATED BY 'string']
    ]
    [IGNORE number LINES]
    [(col_name_or_user_var,...)]
    [SET col_name = expr,...]
```

The `LOAD DATA INFILE` statement reads rows from a text file into a table at a very high speed. The file name must be given as a literal string.

`LOAD DATA INFILE` is the complement of `SELECT ... INTO OUTFILE`. (See Section 12.2.9, “`SELECT` Syntax”.) To write data from a table to a file, use `SELECT ... INTO OUTFILE`. To read the file back into a table, use `LOAD DATA INFILE`. The syntax of the `FIELDS` and `LINES` clauses is the same for both statements. Both clauses are optional, but `FIELDS` must precede `LINES` if both are specified.

For more information about the efficiency of `INSERT` versus `LOAD DATA INFILE` and speeding up `LOAD DATA INFILE`, see Section 7.2.2.1, “Speed of `INSERT` Statements”.

The character set indicated by the `character_set_database` system variable is used to interpret the information in the file. `SET NAMES` and the setting of `character_set_client` do not affect interpretation of input. If the contents of the input file use a character set that differs from the default, it is usually preferable to specify the character set of the file by using the `CHARACTER SET` clause. A character set of `binary` specifies “no conversion.”

`LOAD DATA INFILE` interprets all fields in the file as having the same character set, regardless of the data types of the columns into which field values are loaded. For proper interpretation of file contents, you must ensure that it was written with the correct character set. For example, if you write a data file with `mysqldump -T` or by issuing a `SELECT ... INTO OUTFILE` statement in `mysql`, be sure to use a `--default-character-set` option with `mysqldump` or `mysql` so that output is written in the character set to be used when the file is loaded with `LOAD DATA INFILE`.

> **Note**
>
> It is not possible to load data files that use the `ucs2`, `utf16`, or `utf32` character set.

The `character_set_filesystem` system variable controls the interpretation of the file name.

You can also load data files by using the `mysqlimport` utility; it operates by sending a `LOAD DATA INFILE` statement to the server. The `--local` option causes `mysqlimport` to read data files from the client host. You can specify the `--compress` option to get better performance over slow networks if the client and server support the compressed protocol. See Section 4.5.5, "`mysqlimport` — A Data Import Program".

If you use `LOW_PRIORITY`, execution of the `LOAD DATA` statement is delayed until no other clients are reading from the table. This affects only storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`).

If you specify `CONCURRENT` with a `MyISAM` table that satisfies the condition for concurrent inserts (that is, it contains no free blocks in the middle), other threads can retrieve data from the table while `LOAD DATA` is executing. Using this option affects the performance of `LOAD DATA` a bit, even if no other thread is using the table at the same time.

Prior to MySQL 5.5.1, `CONCURRENT` was not replicated when using statement-based replication (see Bug #34628). However, it is replicated when using row-based replication, regardless of the version. See Section 15.4.1.13, "Replication and `LOAD DATA INFILE`", for more information.

The `LOCAL` keyword, if specified, is interpreted with respect to the client end of the connection:

- If `LOCAL` is specified, the file is read by the client program on the client host and sent to the server. The file can be given as a full path name to specify its exact location. If given as a relative path name, the name is interpreted relative to the directory in which the client program was started.
- If `LOCAL` is not specified, the file must be located on the server host and is read directly by the server. The server uses the following rules to locate the file:
  - If the file name is an absolute path name, the server uses it as given.
  - If the file name is a relative path name with one or more leading components, the server searches for the file relative to the server's data directory.
  - If a file name with no leading components is given, the server looks for the file in the database directory of the default database.

Note that, in the non-`LOCAL` case, these rules mean that a file named as `./myfile.txt` is read from the server's data directory, whereas the file named as `myfile.txt` is read from the database directory of the default database. For example, if `db1` is the default database, the following `LOAD DATA` statement reads the file `data.txt` from the database directory for `db1`, even though the statement explicitly loads the file into a table in the `db2` database:

```
LOAD DATA INFILE 'data.txt' INTO TABLE db2.my_table;
```

Windows path names are specified using forward slashes rather than backslashes. If you do use backslashes, you must double them.

For security reasons, when reading text files located on the server, the files must either reside in the database directory or be readable by all. Also, to use `LOAD DATA INFILE` on server files, you must have the `FILE` privilege. See Section 5.4.1, "Privileges Provided by MySQL". For non-`LOCAL` load operations, if the `secure_file_priv` system variable is set to a nonempty directory name, the file to be loaded must be located in that directory.

Using `LOCAL` is a bit slower than letting the server access the files directly, because the contents of the file must be sent over the connection by the client to the server. On the other hand, you do not need the `FILE` privilege to load local files.

With `LOCAL`, the default duplicate-key handling behavior is the same as if `IGNORE` is specified; this is because the server has no way to stop transmission of the file in the middle of the operation. `IGNORE` is explained further later in this section.

`LOCAL` works only if your server and your client both have been configured to permit it. For example, if `mysqld` was started with `--local-infile=0`, `LOCAL` does not work. See Section 5.3.5, "Security Issues with `LOAD DATA LOCAL`".

On Unix, if you need `LOAD DATA` to read from a pipe, you can use the following technique (the example loads a listing of the `/` directory into the table `db1.t1`):

```
mkfifo /mysql/data/db1/ls.dat
chmod 666 /mysql/data/db1/ls.dat
```

```
find / -ls > /mysql/data/db1/ls.dat &
mysql -e "LOAD DATA INFILE 'ls.dat' INTO TABLE t1" db1
```

Note that you must run the command that generates the data to be loaded and the `mysql` commands either on separate terminals, or run the data generation process in the background (as shown in the preceding example). If you do not do this, the pipe will block until data is read by the `mysql` process.

The `REPLACE` and `IGNORE` keywords control handling of input rows that duplicate existing rows on unique key values:

- If you specify `REPLACE`, input rows replace existing rows. In other words, rows that have the same value for a primary key or unique index as an existing row. See Section 12.2.8, “`REPLACE` Syntax”.
- If you specify `IGNORE`, input rows that duplicate an existing row on a unique key value are skipped. If you do not specify either option, the behavior depends on whether the `LOCAL` keyword is specified. Without `LOCAL`, an error occurs when a duplicate key value is found, and the rest of the text file is ignored. With `LOCAL`, the default behavior is the same as if `IGNORE` is specified; this is because the server has no way to stop transmission of the file in the middle of the operation.

If you want to ignore foreign key constraints during the load operation, you can issue a `SET foreign_key_checks = 0` statement before executing `LOAD DATA`.

If you use `LOAD DATA INFILE` on an empty `MyISAM` table, all nonunique indexes are created in a separate batch (as for `REPAIR TABLE`). Normally, this makes `LOAD DATA INFILE` much faster when you have many indexes. In some extreme cases, you can create the indexes even faster by turning them off with `ALTER TABLE ... DISABLE KEYS` before loading the file into the table and using `ALTER TABLE ... ENABLE KEYS` to re-create the indexes after loading the file. See Section 7.2.2.1, “Speed of `INSERT` Statements”.

For both the `LOAD DATA INFILE` and `SELECT ... INTO OUTFILE` statements, the syntax of the `FIELDS` and `LINES` clauses is the same. Both clauses are optional, but `FIELDS` must precede `LINES` if both are specified.

If you specify a `FIELDS` clause, each of its subclauses (`TERMINATED BY`, `[OPTIONALLY] ENCLOSED BY`, and `ESCAPED BY`) is also optional, except that you must specify at least one of them.

If you specify no `FIELDS` or `LINES` clause, the defaults are the same as if you had written this:

```
FIELDS TERMINATED BY '\t' ENCLOSED BY '' ESCAPED BY '\\'
LINES TERMINATED BY '\n' STARTING BY ''
```

(Backslash is the MySQL escape character within strings in SQL statements, so to specify a literal backslash, you must specify two backslashes for the value to be interpreted as a single backslash. The escape sequences `'\t'` and `'\n'` specify tab and newline characters, respectively.)

In other words, the defaults cause `LOAD DATA INFILE` to act as follows when reading input:

- Look for line boundaries at newlines.
- Do not skip over any line prefix.
- Break lines into fields at tabs.
- Do not expect fields to be enclosed within any quoting characters.
- Interpret characters preceded by the escape character “`\`” as escape sequences. For example, “`\t`”, “`\n`”, and “`\\`” signify tab, newline, and backslash, respectively. See the discussion of `FIELDS ESCAPED BY` later for the full list of escape sequences.

Conversely, the defaults cause `SELECT ... INTO OUTFILE` to act as follows when writing output:

- Write tabs between fields.
- Do not enclose fields within any quoting characters.
- Use “`\`” to escape instances of tab, newline, or “`\`” that occur within field values.
- Write newlines at the ends of lines.

Note

> If you have generated the text file on a Windows system, you might have to use `LINES TERMINATED BY '\r\n'` to read the file properly, because Windows programs typically use two characters as a line terminator. Some programs, such as `WordPad`, might use `\r` as a line terminator when writing files. To read such files, use `LINES TERMINATED BY '\r'`.

If all the lines you want to read in have a common prefix that you want to ignore, you can use `LINES STARTING BY 'prefix_string'` to skip over the prefix, *and anything before it*. If a line does not include the prefix, the entire line is skipped. Suppose that you issue the following statement:

```
LOAD DATA INFILE '/tmp/test.txt' INTO TABLE test
  FIELDS TERMINATED BY ','  LINES STARTING BY 'xxx';
```

If the data file looks like this:

```
xxx"abc",1
something xxx"def",2
"ghi",3
```

The resulting rows will be `("abc",1)` and `("def",2)`. The third row in the file is skipped because it does not contain the prefix.

The `IGNORE number LINES` option can be used to ignore lines at the start of the file. For example, you can use `IGNORE 1 LINES` to skip over an initial header line containing column names:

```
LOAD DATA INFILE '/tmp/test.txt' INTO TABLE test IGNORE 1 LINES;
```

When you use `SELECT ... INTO OUTFILE` in tandem with `LOAD DATA INFILE` to write data from a database into a file and then read the file back into the database later, the field- and line-handling options for both statements must match. Otherwise, `LOAD DATA INFILE` will not interpret the contents of the file properly. Suppose that you use `SELECT ... INTO OUTFILE` to write a file with fields delimited by commas:

```
SELECT * INTO OUTFILE 'data.txt'
  FIELDS TERMINATED BY ','
  FROM table2;
```

To read the comma-delimited file back in, the correct statement would be:

```
LOAD DATA INFILE 'data.txt' INTO TABLE table2
  FIELDS TERMINATED BY ',';
```

If instead you tried to read in the file with the statement shown following, it wouldn't work because it instructs `LOAD DATA INFILE` to look for tabs between fields:

```
LOAD DATA INFILE 'data.txt' INTO TABLE table2
  FIELDS TERMINATED BY '\t';
```

The likely result is that each input line would be interpreted as a single field.

`LOAD DATA INFILE` can be used to read files obtained from external sources. For example, many programs can export data in comma-separated values (CSV) format, such that lines have fields separated by commas and enclosed within double quotation marks, with an initial line of column names. If the lines in such a file are terminated by carriage return/newline pairs, the statement shown here illustrates the field- and line-handling options you would use to load the file:

```
LOAD DATA INFILE 'data.txt' INTO TABLE tbl_name
  FIELDS TERMINATED BY ',' ENCLOSED BY '"'
  LINES TERMINATED BY '\r\n'
  IGNORE 1 LINES;
```

If the input values are not necessarily enclosed within quotation marks, use `OPTIONALLY` before the `ENCLOSED BY` keywords.

Any of the field- or line-handling options can specify an empty string (`''`). If not empty, the `FIELDS [OPTIONALLY] ENCLOSED BY` and `FIELDS ESCAPED BY` values must be a single character. The `FIELDS TERMINATED BY`, `LINES STARTING BY`, and `LINES TERMINATED BY` values can be more than one character. For example, to write lines that are terminated by carriage return/linefeed pairs, or to read a file containing such lines, specify a `LINES TERMINATED BY '\r\n'` clause.

To read a file containing jokes that are separated by lines consisting of `%%`, you can do this

```
CREATE TABLE jokes
  (a INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
  joke TEXT NOT NULL);
LOAD DATA INFILE '/tmp/jokes.txt' INTO TABLE jokes
```

```
  FIELDS TERMINATED BY ''
  LINES TERMINATED BY '\n%%\n' (joke);
```

`FIELDS [OPTIONALLY] ENCLOSED BY` controls quoting of fields. For output (`SELECT ... INTO OUTFILE`), if you omit the word `OPTIONALLY`, all fields are enclosed by the `ENCLOSED BY` character. An example of such output (using a comma as the field delimiter) is shown here:

```
"1","a string","100.20"
"2","a string containing a , comma","102.20"
"3","a string containing a \" quote","102.20"
"4","a string containing a \", quote and comma","102.20"
```

If you specify `OPTIONALLY`, the `ENCLOSED BY` character is used only to enclose values from columns that have a string data type (such as `CHAR`, `BINARY`, `TEXT`, or `ENUM`):

```
1,"a string",100.20
2,"a string containing a , comma",102.20
3,"a string containing a \" quote",102.20
4,"a string containing a \", quote and comma",102.20
```

Note that occurrences of the `ENCLOSED BY` character within a field value are escaped by prefixing them with the `ESCAPED BY` character. Also note that if you specify an empty `ESCAPED BY` value, it is possible to inadvertently generate output that cannot be read properly by `LOAD DATA INFILE`. For example, the preceding output just shown would appear as follows if the escape character is empty. Observe that the second field in the fourth line contains a comma following the quote, which (erroneously) appears to terminate the field:

```
1,"a string",100.20
2,"a string containing a , comma",102.20
3,"a string containing a " quote",102.20
4,"a string containing a ", quote and comma",102.20
```

For input, the `ENCLOSED BY` character, if present, is stripped from the ends of field values. (This is true regardless of whether `OPTIONALLY` is specified; `OPTIONALLY` has no effect on input interpretation.) Occurrences of the `ENCLOSED BY` character preceded by the `ESCAPED BY` character are interpreted as part of the current field value.

If the field begins with the `ENCLOSED BY` character, instances of that character are recognized as terminating a field value only if followed by the field or line `TERMINATED BY` sequence. To avoid ambiguity, occurrences of the `ENCLOSED BY` character within a field value can be doubled and are interpreted as a single instance of the character. For example, if `ENCLOSED BY '"'` is specified, quotation marks are handled as shown here:

```
"The ""BIG"" boss"  -> The "BIG" boss
The "BIG" boss      -> The "BIG" boss
The ""BIG"" boss    -> The ""BIG"" boss
```

`FIELDS ESCAPED BY` controls how to read or write special characters:

- For input, if the `FIELDS ESCAPED BY` character is not empty, occurrences of that character are stripped and the following character is taken literally as part of a field value. Some two-character sequences that are exceptions, where the first character is the escape character. These sequences are shown in the following table (using "`\`" for the escape character). The rules for `NULL` handling are described later in this section.

Character	Escape Sequence
`\0`	An ASCII NUL (`0x00`) character
`\b`	A backspace character
`\n`	A newline (linefeed) character
`\r`	A carriage return character
`\t`	A tab character.
`\Z`	ASCII 26 (Control+Z)
`\N`	NULL

  For more information about "`\`"-escape syntax, see Section 8.1.1, "Strings".

  If the `FIELDS ESCAPED BY` character is empty, escape-sequence interpretation does not occur.

- For output, if the `FIELDS ESCAPED BY` character is not empty, it is used to prefix the following characters on output:

- The `FIELDS ESCAPED BY` character
- The `FIELDS [OPTIONALLY] ENCLOSED BY` character
- The first character of the `FIELDS TERMINATED BY` and `LINES TERMINATED BY` values
- ASCII `0` (what is actually written following the escape character is ASCII “`0`”, not a zero-valued byte)

If the `FIELDS ESCAPED BY` character is empty, no characters are escaped and `NULL` is output as `NULL`, not `\N`. It is probably not a good idea to specify an empty escape character, particularly if field values in your data contain any of the characters in the list just given.

In certain cases, field- and line-handling options interact:

- If `LINES TERMINATED BY` is an empty string and `FIELDS TERMINATED BY` is nonempty, lines are also terminated with `FIELDS TERMINATED BY`.
- If the `FIELDS TERMINATED BY` and `FIELDS ENCLOSED BY` values are both empty (`''`), a fixed-row (nondelimited) format is used. With fixed-row format, no delimiters are used between fields (but you can still have a line terminator). Instead, column values are read and written using a field width wide enough to hold all values in the field. For `TINYINT`, `SMALLINT`, `MEDIUMINT`, `INT`, and `BIGINT`, the field widths are 4, 6, 8, 11, and 20, respectively, no matter what the declared display width is.

  `LINES TERMINATED BY` is still used to separate lines. If a line does not contain all fields, the rest of the columns are set to their default values. If you do not have a line terminator, you should set this to `''`. In this case, the text file must contain all fields for each row.

  Fixed-row format also affects handling of `NULL` values, as described later. Note that fixed-size format does not work if you are using a multi-byte character set.

Handling of `NULL` values varies according to the `FIELDS` and `LINES` options in use:

- For the default `FIELDS` and `LINES` values, `NULL` is written as a field value of `\N` for output, and a field value of `\N` is read as `NULL` for input (assuming that the `ESCAPED BY` character is “`\`”).
- If `FIELDS ENCLOSED BY` is not empty, a field containing the literal word `NULL` as its value is read as a `NULL` value. This differs from the word `NULL` enclosed within `FIELDS ENCLOSED BY` characters, which is read as the string `'NULL'`.
- If `FIELDS ESCAPED BY` is empty, `NULL` is written as the word `NULL`.
- With fixed-row format (which is used when `FIELDS TERMINATED BY` and `FIELDS ENCLOSED BY` are both empty), `NULL` is written as an empty string. Note that this causes both `NULL` values and empty strings in the table to be indistinguishable when written to the file because both are written as empty strings. If you need to be able to tell the two apart when reading the file back in, you should not use fixed-row format.

An attempt to load `NULL` into a `NOT NULL` column causes assignment of the implicit default value for the column's data type and a warning, or an error in strict SQL mode. Implicit default values are discussed in Section 10.1.4, “Data Type Default Values”.

Some cases are not supported by `LOAD DATA INFILE`:

- Fixed-size rows (`FIELDS TERMINATED BY` and `FIELDS ENCLOSED BY` both empty) and `BLOB` or `TEXT` columns.
- If you specify one separator that is the same as or a prefix of another, `LOAD DATA INFILE` cannot interpret the input properly. For example, the following `FIELDS` clause would cause problems:

  ```
  FIELDS TERMINATED BY '"' ENCLOSED BY '"'
  ```

- If `FIELDS ESCAPED BY` is empty, a field value that contains an occurrence of `FIELDS ENCLOSED BY` or `LINES TERMINATED BY` followed by the `FIELDS TERMINATED BY` value causes `LOAD DATA INFILE` to stop reading a field or line too early. This happens because `LOAD DATA INFILE` cannot properly determine where the field or line value ends.

The following example loads all columns of the `persondata` table:

```
LOAD DATA INFILE 'persondata.txt' INTO TABLE persondata;
```

By default, when no column list is provided at the end of the `LOAD DATA INFILE` statement, input lines are expected to contain a field for each table column. If you want to load only some of a table's columns, specify a column list:

```
LOAD DATA INFILE 'persondata.txt' INTO TABLE persondata (col1,col2,...);
```

You must also specify a column list if the order of the fields in the input file differs from the order of the columns in the table. Otherwise, MySQL cannot tell how to match input fields with table columns.

The column list can contain either column names or user variables. With user variables, the `SET` clause enables you to perform transformations on their values before assigning the result to columns.

User variables in the `SET` clause can be used in several ways. The following example uses the first input column directly for the value of `t1.column1`, and assigns the second input column to a user variable that is subjected to a division operation before being used for the value of `t1.column2`:

```
LOAD DATA INFILE 'file.txt'
  INTO TABLE t1
  (column1, @var1)
  SET column2 = @var1/100;
```

The `SET` clause can be used to supply values not derived from the input file. The following statement sets `column3` to the current date and time:

```
LOAD DATA INFILE 'file.txt'
  INTO TABLE t1
  (column1, column2)
  SET column3 = CURRENT_TIMESTAMP;
```

You can also discard an input value by assigning it to a user variable and not assigning the variable to a table column:

```
LOAD DATA INFILE 'file.txt'
  INTO TABLE t1
  (column1, @dummy, column2, @dummy, column3);
```

Use of the column/variable list and `SET` clause is subject to the following restrictions:

- Assignments in the `SET` clause should have only column names on the left hand side of assignment operators.
- You can use subqueries in the right hand side of `SET` assignments. A subquery that returns a value to be assigned to a column may be a scalar subquery only. Also, you cannot use a subquery to select from the table that is being loaded.
- Lines ignored by an `IGNORE` clause are not processed for the column/variable list or `SET` clause.
- User variables cannot be used when loading data with fixed-row format because user variables do not have a display width.

When processing an input line, `LOAD DATA` splits it into fields and uses the values according to the column/variable list and the `SET` clause, if they are present. Then the resulting row is inserted into the table. If there are `BEFORE INSERT` or `AFTER INSERT` triggers for the table, they are activated before or after inserting the row, respectively.

If an input line has too many fields, the extra fields are ignored and the number of warnings is incremented.

If an input line has too few fields, the table columns for which input fields are missing are set to their default values. Default value assignment is described in Section 10.1.4, “Data Type Default Values”.

An empty field value is interpreted differently than if the field value is missing:

- For string types, the column is set to the empty string.
- For numeric types, the column is set to `0`.
- For date and time types, the column is set to the appropriate “zero” value for the type. See Section 10.3, “Date and Time Types”.

These are the same values that result if you assign an empty string explicitly to a string, numeric, or date or time type explicitly in an `INSERT` or `UPDATE` statement.

`TIMESTAMP` columns are set to the current date and time only if there is a `NULL` value for the column (that is, `\N`) and the column is not declared to permit `NULL` values, or if the `TIMESTAMP` column's default value is the current timestamp and it is omitted from the field list when a field list is specified.

`LOAD DATA INFILE` regards all input as strings, so you cannot use numeric values for `ENUM` or `SET` columns the way you can with `INSERT` statements. All `ENUM` and `SET` values must be specified as strings.

`BIT` values cannot be loaded using binary notation (for example, `b'011010'`). To work around this, specify the values as regular integers and use the `SET` clause to convert them so that MySQL performs a numeric type conversion and loads them into the `BIT` column properly:

```
shell> cat /tmp/bit_test.txt
2
127
shell> mysql test
mysql> LOAD DATA INFILE '/tmp/bit_test.txt'
    -> INTO TABLE bit_test (@var1) SET b= CAST(@var1 AS UNSIGNED);
Query OK, 2 rows affected (0.00 sec)
Records: 2  Deleted: 0  Skipped: 0  Warnings: 0

mysql> SELECT BIN(b+0) FROM bit_test;
+----------+
| bin(b+0) |
+----------+
| 10       |
| 1111111  |
+----------+
2 rows in set (0.00 sec)
```

When the `LOAD DATA INFILE` statement finishes, it returns an information string in the following format:

```
Records: 1  Deleted: 0  Skipped: 0  Warnings: 0
```

If you are using the C API, you can get information about the statement by calling the `mysql_info()` function. See Section 20.9.3.35, “`mysql_info()`”.

Warnings occur under the same circumstances as when values are inserted using the `INSERT` statement (see Section 12.2.5, “`INSERT` Syntax”), except that `LOAD DATA INFILE` also generates warnings when there are too few or too many fields in the input row. The warnings are not stored anywhere; the number of warnings can be used only as an indication of whether everything went well.

You can use `SHOW WARNINGS` to get a list of the first `max_error_count` warnings as information about what went wrong. See Section 12.4.5.41, “`SHOW WARNINGS` Syntax”.

12.2.7. `LOAD XML` Syntax

```
LOAD XML [LOW_PRIORITY | CONCURRENT] [LOCAL] INFILE 'file_name'
[REPLACE | IGNORE]
INTO TABLE [db_name.]tbl_name
[CHARACTER SET charset_name]
[ROWS IDENTIFIED BY '<tagname>']
[IGNORE number [LINES | ROWS]]
[(column_or_user_var,...)]
[SET col_name = expr,...]
```

The `LOAD XML` statement reads data from an XML file into a table. The *`file_name`* must be given as a literal string. The *`tagname`* in the optional `ROWS IDENTIFIED BY` clause must also be given as a literal string, and must be surrounded by angle brackets (`<` and `>`).

`LOAD XML` acts as the complement of running the `mysql` client in XML output mode (that is, starting the client with the `--xml` option). To write data from a table to an XML file, use a command such as the following one from the system shell:

```
shell> mysql --xml -e 'SELECT * FROM mytable' > file.xml
```

To read the file back into a table, use `LOAD XML INFILE`. By default, the `<row>` element is considered to be the equivalent of a database table row; this can be changed using the `ROWS IDENTIFIED BY` clause.

This statement supports three different XML formats:

- Column names as attributes and column values as attribute values:

  ```
  <row column1="value1" column2="value2" .../>
  ```

- Column names as tags and column values as the content of these tags:

  ```
  <row>
    <column1>value1</column1>
    <column2>value2</column2>
  </row>
  ```

- Column names are the `name` attributes of `<field>` tags, and values are the contents of these tags:

  ```
  <row>
    <field name='column1'>value1</field>
    <field name='column2'>value2</field>
  </row>
  ```

  This is the format used by other MySQL tools, such as `mysqldump`.

All 3 formats can be used in the same XML file; the import routine automatically detects the format for each row and interprets it correctly. Tags are matched based on the tag or attribute name and the column name.

The following clauses work essentially the same way for `LOAD XML` as they do for `LOAD DATA`:

- `LOW_PRIORITY` or `CONCURRENT`
- `LOCAL`
- `REPLACE` or `IGNORE`
- `CHARACTER SET`
- *`(column_or_user_var,...)`*
- `SET`

See Section 12.2.6, “`LOAD DATA INFILE` Syntax”, for more information about these clauses.

The `IGNORE` *`number`* `LINES` or `IGNORE` *`number`* `ROWS` clause causes the first *`number`* rows in the XML file to be skipped. It is analogous to the `LOAD DATA` statement's `IGNORE ... LINES` clause.

To illustrate how this statement is used, suppose that we have a table created as follows:

```
USE test;

CREATE TABLE person (
    person_id INT NOT NULL PRIMARY KEY,
    fname VARCHAR(40) NULL,
    lname VARCHAR(40) NULL,
    created TIMESTAMP
);
```

Suppose further that this table is initially empty.

Now suppose that we have a simple XML file `person.xml`, whose contents are as shown here:

```
<?xml version="1.0"?>
<list>
  <person person_id="1" fname="Pekka" lname="Nousiainen"/>
  <person person_id="2" fname="Jonas" lname="Oreland"/>
  <person person_id="3"><fname>Mikael</fname><lname>Ronström</lname></person>
  <person person_id="4"><fname>Lars</fname><lname>Thalmann</lname></person>
  <person><field name="person_id">5</field><field name="fname">Tomas</field><field name="lname">Ulin</field></person>
  <person><field name="person_id">6</field><field name="fname">Martin</field><field name="lname">Sköld</field></person
</list>
```

Each of the permissible XML formats discussed previously is represented in this example file.

To import the data in `person.xml` into the `person` table, you can use this statement:

```
mysql> LOAD XML LOCAL INFILE 'person.xml'
    ->   INTO TABLE person
    ->   ROWS IDENTIFIED BY '<person>';

Query OK, 6 rows affected (0.00 sec)
Records: 6  Deleted: 0  Skipped: 0  Warnings: 0
```

Here, we assume that `person.xml` is located in the MySQL data directory. If the file cannot be found, the following error results:

```
ERROR 2 (HY000): File '/person.xml' not found (Errcode: 2)
```

The `ROWS IDENTIFIED BY '<person>'` clause means that each `<person>` element in the XML file is considered equivalent to a row in the table into which the data is to be imported. In this case, this is the `person` table in the `test` database.

As can be seen by the response from the server, 6 rows were imported into the `test.person` table. This can be verified by a simple `SELECT` statement:

```
mysql> SELECT * FROM person;
+-----------+--------+------------+---------------------+
| person_id | fname  | lname      | created             |
+-----------+--------+------------+---------------------+
|         1 | Pekka  | Nousiainen | 2007-07-13 16:18:47 |
|         2 | Jonas  | Oreland    | 2007-07-13 16:18:47 |
|         3 | Mikael | Ronström   | 2007-07-13 16:18:47 |
|         4 | Lars   | Thalmann   | 2007-07-13 16:18:47 |
|         5 | Tomas  | Ulin       | 2007-07-13 16:18:47 |
|         6 | Martin | Sköld      | 2007-07-13 16:18:47 |
+-----------+--------+------------+---------------------+
6 rows in set (0.00 sec)
```

This shows, as stated earlier in this section, that any or all of the 3 permitted XML formats may appear in a single file and be read in using `LOAD XML`.

The inverse of the above operation—that is, dumping MySQL table data into an XML file—can be accomplished using the mysql client from the system shell, as shown here:

Note

The `--xml` option causes the `mysql` client to use XML formatting for its output; the `-e` option causes the client to execute the SQL statement immediately following the option.

```
shell> mysql --xml -e "SELECT * FROM test.person" > person-dump.xml
shell> cat person-dump.xml
<?xml version="1.0"?>

<resultset statement="SELECT * FROM test.person" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <row>
        <field name="person_id">1</field>
        <field name="fname">Pekka</field>
        <field name="lname">Nousiainen</field>
        <field name="created">2007-07-13 16:18:47</field>
  </row>

  <row>
        <field name="person_id">2</field>
        <field name="fname">Jonas</field>
        <field name="lname">Oreland</field>
        <field name="created">2007-07-13 16:18:47</field>
  </row>

  <row>
        <field name="person_id">3</field>
        <field name="fname">Mikael</field>
        <field name="lname">Ronström</field>
        <field name="created">2007-07-13 16:18:47</field>
  </row>

  <row>
        <field name="person_id">4</field>
        <field name="fname">Lars</field>
        <field name="lname">Thalmann</field>
        <field name="created">2007-07-13 16:18:47</field>
  </row>

  <row>
        <field name="person_id">5</field>
        <field name="fname">Tomas</field>
        <field name="lname">Ulin</field>
        <field name="created">2007-07-13 16:18:47</field>
  </row>

  <row>
        <field name="person_id">6</field>
        <field name="fname">Martin</field>
        <field name="lname">Sköld</field>
        <field name="created">2007-07-13 16:18:47</field>
  </row>
</resultset>
```

You can verify that the dump is valid by creating a copy of the `person` and then importing the dump file into the new table, like this:

```
mysql> USE test;
mysql> CREATE TABLE person2 LIKE person;
Query OK, 0 rows affected (0.00 sec)

mysql> LOAD XML LOCAL INFILE 'person-dump.xml'
    ->   INTO TABLE person2;
Query OK, 6 rows affected (0.01 sec)
Records: 6  Deleted: 0  Skipped: 0  Warnings: 0

mysql> SELECT * FROM person2;
+-----------+--------+------------+---------------------+
| person_id | fname  | lname      | created             |
+-----------+--------+------------+---------------------+
|         1 | Pekka  | Nousiainen | 2007-07-13 16:18:47 |
|         2 | Jonas  | Oreland    | 2007-07-13 16:18:47 |
|         3 | Mikael | Ronström   | 2007-07-13 16:18:47 |
|         4 | Lars   | Thalmann   | 2007-07-13 16:18:47 |
|         5 | Tomas  | Ulin       | 2007-07-13 16:18:47 |
|         6 | Martin | Sköld      | 2007-07-13 16:18:47 |
+-----------+--------+------------+---------------------+
6 rows in set (0.00 sec)
```

Using a `ROWS IDENTIFIED BY '<tagname>'` clause, it is possible to import data from the same XML file into database tables with different definitions. For this example, suppose that you have a file named `address.xml` which contains the following XML:

```
<?xml version="1.0"?>

<list>
  <person person_id="1">
    <fname>Robert</fname>
    <lname>Jones</lname>
    <address address_id="1" street="Mill Creek Road" zip="45365" city="Sidney"/>
    <address address_id="2" street="Main Street" zip="28681" city="Taylorsville"/>
  </person>

  <person person_id="2">
    <fname>Mary</fname>
    <lname>Smith</lname>
    <address address_id="3" street="River Road" zip="80239" city="Denver"/>
    <!-- <address address_id="4" street="North Street" zip="37920" city="Knoxville"/> -->
  </person>

</list>
```

You can again use the `test.person` table as defined previously in this section, after clearing all the existing records from the table and then showing its structure as shown here:

```
mysql< TRUNCATE person;
Query OK, 0 rows affected (0.04 sec)

mysql< SHOW CREATE TABLE person\G
*************************** 1. row ***************************
       Table: person
Create Table: CREATE TABLE `person` (
  `person_id` int(11) NOT NULL,
  `fname` varchar(40) DEFAULT NULL,
  `lname` varchar(40) DEFAULT NULL,
  `created` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,
  PRIMARY KEY (`person_id`)
) ENGINE=MyISAM DEFAULT CHARSET=latin1
1 row in set (0.00 sec)
```

Now create an `address` table in the `test` database using the following `CREATE TABLE` statement:

```
CREATE TABLE address (
    address_id INT NOT NULL PRIMARY KEY,
    person_id INT NULL,
    street VARCHAR(40) NULL,
    zip INT NULL,
    city VARCHAR(40) NULL,
    created TIMESTAMP
);
```

To import the data from the XML file into the `person` table, execute the following `LOAD XML` statement, which specifies that rows are to be specified by the `<person>` element, as shown here;

```
mysql> LOAD XML LOCAL INFILE 'address.xml'
    ->   INTO TABLE person
    ->   ROWS IDENTIFIED BY '<person>';
Query OK, 2 rows affected (0.00 sec)
Records: 2  Deleted: 0  Skipped: 0  Warnings: 0
```

You can verify that the records were imported using a `SELECT` statement:

```
mysql> SELECT * FROM person;
+-----------+--------+-------+---------------------+
| person_id | fname  | lname | created             |
+-----------+--------+-------+---------------------+
|         1 | Robert | Jones | 2007-07-24 17:37:06 |
|         2 | Mary   | Smith | 2007-07-24 17:37:06 |
+-----------+--------+-------+---------------------+
2 rows in set (0.00 sec)
```

Since the `<address>` elements in the XML file have no corresponding columns in the `person` table, they are skipped.

To import the data from the `<address>` elements into the `address` table, use the `LOAD XML` statement shown here:

```
mysql> LOAD XML LOCAL INFILE 'address.xml'
    ->   INTO TABLE address
    ->   ROWS IDENTIFIED BY '<address>';
Query OK, 3 rows affected (0.00 sec)
Records: 3  Deleted: 0  Skipped: 0  Warnings: 0
```

You can see that the data was imported using a `SELECT` statement such as this one:

```
mysql> SELECT * FROM address;
+------------+-----------+-----------------+-------+--------------+---------------------+
| address_id | person_id | street          | zip   | city         | created             |
+------------+-----------+-----------------+-------+--------------+---------------------+
|          1 |         1 | Mill Creek Road | 45365 | Sidney       | 2007-07-24 17:37:37 |
|          2 |         1 | Main Street     | 28681 | Taylorsville | 2007-07-24 17:37:37 |
|          3 |         2 | River Road      | 80239 | Denver       | 2007-07-24 17:37:37 |
+------------+-----------+-----------------+-------+--------------+---------------------+
3 rows in set (0.00 sec)
```

The data from the `<address>` element that is enclosed in XML comments is not imported. However, since there is a `person_id` column in the `address` table, the value of the `person_id` attribute from the parent `<person>` element for each `<address>` *is* imported into the `address` table.

Security Considerations. As with the `LOAD DATA` statement, the transfer of the XML file from the client host to the server host is initiated by the MySQL server. In theory, a patched server could be built that would tell the client program to transfer a file of the server's choosing rather than the file named by the client in the `LOAD XML` statement. Such a server could access any file on the client host to which the client user has read access.

In a Web environment, clients usually connect to MySQL from a Web server. A user that can run any command against the MySQL server can use `LOAD XML LOCAL` to read any files to which the Web server process has read access. In this environment, the client with respect to the MySQL server is actually the Web server, not the remote program being run by the user who connects to the Web server.

You can disable loading of XML files from clients by starting the server with `--local-infile=0` or `--local-infile=OFF`. This option can also be used when starting the `mysql` client to disable `LOAD XML` for the duration of the client session.

To prevent a client from loading XML files from the server, do not grant the `FILE` privilege to the corresponding MySQL user account, or revoke this privilege if the client user account already has it.

> **Important**
>
> Revoking the `FILE` privilege (or not granting it in the first place) keeps the user only from executing the `LOAD XML INFILE` statement (as well as the `LOAD_FILE()` function; it does *not* prevent the user from executing `LOAD XML LOCAL INFILE`. To disallow this statement, you must start the server or the client with `--local-infile=OFF`.
>
> In other words, the `FILE` privilege affects only whether the client can read files on the server; it has no bearing on whether the client can read files on the local file system.

12.2.8. REPLACE Syntax

```
REPLACE [LOW_PRIORITY | DELAYED]
    [INTO] tbl_name [(col_name,...)]
    {VALUES | VALUE} ({expr | DEFAULT},...),(...),...
```

Or:

```
REPLACE [LOW_PRIORITY | DELAYED]
    [INTO] tbl_name
    SET col_name={expr | DEFAULT}, ...
```

Or:

```
REPLACE [LOW_PRIORITY | DELAYED]
    [INTO] tbl_name [(col_name,...)]
    SELECT ...
```

`REPLACE` works exactly like `INSERT`, except that if an old row in the table has the same value as a new row for a `PRIMARY KEY` or a `UNIQUE` index, the old row is deleted before the new row is inserted. See Section 12.2.5, “`INSERT` Syntax”.

`REPLACE` is a MySQL extension to the SQL standard. It either inserts, or *deletes* and inserts. For another MySQL extension to standard SQL—that either inserts or *updates*—see Section 12.2.5.3, “`INSERT ... ON DUPLICATE KEY UPDATE` Syntax”.

Note that unless the table has a `PRIMARY KEY` or `UNIQUE` index, using a `REPLACE` statement makes no sense. It becomes equivalent to `INSERT`, because there is no index to be used to determine whether a new row duplicates another.

Values for all columns are taken from the values specified in the `REPLACE` statement. Any missing columns are set to their default values, just as happens for `INSERT`. You cannot refer to values from the current row and use them in the new row. If you use an assignment such as `SET col_name = col_name + 1`, the reference to the column name on the right hand side is treated as `DEFAULT(col_name)`, so the assignment is equivalent to `SET col_name = DEFAULT(col_name) + 1`.

To use `REPLACE`, you must have both the `INSERT` and `DELETE` privileges for the table.

The `REPLACE` statement returns a count to indicate the number of rows affected. This is the sum of the rows deleted and inserted. If the count is 1 for a single-row `REPLACE`, a row was inserted and no rows were deleted. If the count is greater than 1, one or more old rows were deleted before the new row was inserted. It is possible for a single row to replace more than one old row if the table contains multiple unique indexes and the new row duplicates values for different old rows in different unique indexes.

The affected-rows count makes it easy to determine whether `REPLACE` only added a row or whether it also replaced any rows: Check whether the count is 1 (added) or greater (replaced).

If you are using the C API, the affected-rows count can be obtained using the `mysql_affected_rows()` function.

Currently, you cannot replace into a table and select from the same table in a subquery.

MySQL uses the following algorithm for `REPLACE` (and `LOAD DATA ... REPLACE`):

1. Try to insert the new row into the table
2. While the insertion fails because a duplicate-key error occurs for a primary key or unique index:
   a. Delete from the table the conflicting row that has the duplicate key value
   b. Try again to insert the new row into the table

It is possible that in the case of a duplicate-key error, a storage engine may perform the `REPLACE` as an update rather than a delete plus insert, but the semantics are the same. There are no user-visible effects other than a possible difference in how the storage engine increments `Handler_xxx` status variables.

12.2.9. `SELECT` Syntax

```
SELECT
    [ALL | DISTINCT | DISTINCTROW ]
      [HIGH_PRIORITY]
      [STRAIGHT_JOIN]
      [SQL_SMALL_RESULT] [SQL_BIG_RESULT] [SQL_BUFFER_RESULT]
      [SQL_CACHE | SQL_NO_CACHE] [SQL_CALC_FOUND_ROWS]
    select_expr [, select_expr ...]
    [FROM table_references
    [WHERE where_condition]
    [GROUP BY {col_name | expr | position}
      [ASC | DESC], ... [WITH ROLLUP]]
    [HAVING where_condition]
    [ORDER BY {col_name | expr | position}
      [ASC | DESC], ...]
    [LIMIT {[offset,] row_count | row_count OFFSET offset}]
    [PROCEDURE procedure_name(argument_list)]
    [INTO OUTFILE 'file_name'
        [CHARACTER SET charset_name]
        export_options
      | INTO DUMPFILE 'file_name'
      | INTO var_name [, var_name]]
    [FOR UPDATE | LOCK IN SHARE MODE]]
```

`SELECT` is used to retrieve rows selected from one or more tables, and can include `UNION` statements and subqueries. See Section 12.2.9.3, “`UNION` Syntax”, and Section 12.2.10, “Subquery Syntax”.

The most commonly used clauses of `SELECT` statements are these:

- Each *`select_expr`* indicates a column that you want to retrieve. There must be at least one *`select_expr`*.
- *`table_references`* indicates the table or tables from which to retrieve rows. Its syntax is described in Section 12.2.9.1, "`JOIN` Syntax".
- The `WHERE` clause, if given, indicates the condition or conditions that rows must satisfy to be selected. *`where_condition`* is an expression that evaluates to true for each row to be selected. The statement selects all rows if there is no `WHERE` clause.

  In the `WHERE` expression, you can use any of the functions and operators that MySQL supports, except for aggregate (summary) functions. See Section 8.5, "Expression Syntax", and Chapter 11, *Functions and Operators*.

`SELECT` can also be used to retrieve rows computed without reference to any table.

For example:

```
mysql> SELECT 1 + 1;
        -> 2
```

You are permitted to specify `DUAL` as a dummy table name in situations where no tables are referenced:

```
mysql> SELECT 1 + 1 FROM DUAL;
        -> 2
```

`DUAL` is purely for the convenience of people who require that all `SELECT` statements should have `FROM` and possibly other clauses. MySQL may ignore the clauses. MySQL does not require `FROM DUAL` if no tables are referenced.

In general, clauses used must be given in exactly the order shown in the syntax description. For example, a `HAVING` clause must come after any `GROUP BY` clause and before any `ORDER BY` clause. The exception is that the `INTO` clause can appear either as shown in the syntax description or immediately following the *`select_expr`* list.

The list of *`select_expr`* terms comprises the select list that indicates which columns to retrieve. Terms specify a column or expression or can use `*`-shorthand:

- A select list consisting only of a single unqualified `*` can be used as shorthand to select all columns from all tables:

  ```
  SELECT * FROM t1 INNER JOIN t2 ...
  ```

- *`tbl_name`*`.*` can be used as a qualified shorthand to select all columns from the named table:

  ```
  SELECT t1.*, t2.* FROM t1 INNER JOIN t2 ...
  ```

- Use of an unqualified `*` with other items in the select list may produce a parse error. To avoid this problem, use a qualified *`tbl_name`*`.*` reference

  ```
  SELECT AVG(score), t1.* FROM t1 ...
  ```

The following list provides additional information about other `SELECT` clauses:

- A *`select_expr`* can be given an alias using `AS` *`alias_name`*. The alias is used as the expression's column name and can be used in `GROUP BY`, `ORDER BY`, or `HAVING` clauses. For example:

  ```
  SELECT CONCAT(last_name,', ',first_name) AS full_name
    FROM mytable ORDER BY full_name;
  ```

  The `AS` keyword is optional when aliasing a *`select_expr`* with an identifier. The preceding example could have been written like this:

  ```
  SELECT CONCAT(last_name,', ',first_name) full_name
    FROM mytable ORDER BY full_name;
  ```

  However, because the `AS` is optional, a subtle problem can occur if you forget the comma between two *`select_expr`* expressions: MySQL interprets the second as an alias name. For example, in the following statement, `columnb` is treated as an alias name:

```
SELECT columna columnb FROM mytable;
```

For this reason, it is good practice to be in the habit of using `AS` explicitly when specifying column aliases.

It is not permissible to refer to a column alias in a `WHERE` clause, because the column value might not yet be determined when the `WHERE` clause is executed. See Section C.5.5.4, “Problems with Column Aliases”.

- The `FROM table_references` clause indicates the table or tables from which to retrieve rows. If you name more than one table, you are performing a join. For information on join syntax, see Section 12.2.9.1, “`JOIN` Syntax”. For each table specified, you can optionally specify an alias.

  ```
  tbl_name [[AS] alias] [index_hint]
  ```

  The use of index hints provides the optimizer with information about how to choose indexes during query processing. For a description of the syntax for specifying these hints, see Section 12.2.9.2, “Index Hint Syntax”.

  You can use `SET max_seeks_for_key=value` as an alternative way to force MySQL to prefer key scans instead of table scans. See Section 5.1.3, “Server System Variables”.

- You can refer to a table within the default database as `tbl_name`, or as `db_name.tbl_name` to specify a database explicitly. You can refer to a column as `col_name`, `tbl_name.col_name`, or `db_name.tbl_name.col_name`. You need not specify a `tbl_name` or `db_name.tbl_name` prefix for a column reference unless the reference would be ambiguous. See Section 8.2.1, “Identifier Qualifiers”, for examples of ambiguity that require the more explicit column reference forms.

- A table reference can be aliased using `tbl_name AS alias_name` or `tbl_name alias_name`:

  ```
  SELECT t1.name, t2.salary FROM employee AS t1, info AS t2
    WHERE t1.name = t2.name;

  SELECT t1.name, t2.salary FROM employee t1, info t2
    WHERE t1.name = t2.name;
  ```

- Columns selected for output can be referred to in `ORDER BY` and `GROUP BY` clauses using column names, column aliases, or column positions. Column positions are integers and begin with 1:

  ```
  SELECT college, region, seed FROM tournament
    ORDER BY region, seed;

  SELECT college, region AS r, seed AS s FROM tournament
    ORDER BY r, s;

  SELECT college, region, seed FROM tournament
    ORDER BY 2, 3;
  ```

  To sort in reverse order, add the `DESC` (descending) keyword to the name of the column in the `ORDER BY` clause that you are sorting by. The default is ascending order; this can be specified explicitly using the `ASC` keyword.

  If `ORDER BY` occurs within a subquery and also is applied in the outer query, the outermost `ORDER BY` takes precedence. For example, results for the following statement are sorted in descending order, not ascending order:

  ```
  (SELECT ... ORDER BY a) ORDER BY a DESC;
  ```

  Use of column positions is deprecated because the syntax has been removed from the SQL standard.

- If you use `GROUP BY`, output rows are sorted according to the `GROUP BY` columns as if you had an `ORDER BY` for the same columns. To avoid the overhead of sorting that `GROUP BY` produces, add `ORDER BY NULL`:

  ```
  SELECT a, COUNT(b) FROM test_table GROUP BY a ORDER BY NULL;
  ```

- MySQL extends the `GROUP BY` clause so that you can also specify `ASC` and `DESC` after columns named in the clause:

  ```
  SELECT a, COUNT(b) FROM test_table GROUP BY a DESC;
  ```

- MySQL extends the use of `GROUP BY` to permit selecting fields that are not mentioned in the `GROUP BY` clause. If you are not getting the results that you expect from your query, please read the description of `GROUP BY` found in Section 11.16, “Functions and Modifiers for Use with `GROUP BY` Clauses”.

- `GROUP BY` permits a `WITH ROLLUP` modifier. See Section 11.16.2, “`GROUP BY` Modifiers”.

- The `HAVING` clause is applied nearly last, just before items are sent to the client, with no optimization. (`LIMIT` is applied after

`HAVING`.)

The SQL standard requires that `HAVING` must reference only columns in the `GROUP BY` clause or columns used in aggregate functions. However, MySQL supports an extension to this behavior, and permits `HAVING` to refer to columns in the `SELECT` list and columns in outer subqueries as well.

If the `HAVING` clause refers to a column that is ambiguous, a warning occurs. In the following statement, `col2` is ambiguous because it is used as both an alias and a column name:

```
SELECT COUNT(col1) AS col2 FROM t GROUP BY col2 HAVING col2 = 2;
```

Preference is given to standard SQL behavior, so if a `HAVING` column name is used both in `GROUP BY` and as an aliased column in the output column list, preference is given to the column in the `GROUP BY` column.

- Do not use `HAVING` for items that should be in the `WHERE` clause. For example, do not write the following:

  ```
  SELECT col_name FROM tbl_name HAVING col_name > 0;
  ```

  Write this instead:

  ```
  SELECT col_name FROM tbl_name WHERE col_name > 0;
  ```

- The `HAVING` clause can refer to aggregate functions, which the `WHERE` clause cannot:

  ```
  SELECT user, MAX(salary) FROM users
    GROUP BY user HAVING MAX(salary) > 10;
  ```

  (This did not work in some older versions of MySQL.)

- MySQL permits duplicate column names. That is, there can be more than one *`select_expr`* with the same name. This is an extension to standard SQL. Because MySQL also permits `GROUP BY` and `HAVING` to refer to *`select_expr`* values, this can result in an ambiguity:

  ```
  SELECT 12 AS a, a FROM t GROUP BY a;
  ```

  In that statement, both columns have the name `a`. To ensure that the correct column is used for grouping, use different names for each *`select_expr`*.

- MySQL resolves unqualified column or alias references in `ORDER BY` clauses by searching in the *`select_expr`* values, then in the columns of the tables in the `FROM` clause. For `GROUP BY` or `HAVING` clauses, it searches the `FROM` clause before searching in the *`select_expr`* values. (For `GROUP BY` and `HAVING`, this differs from the pre-MySQL 5.0 behavior that used the same rules as for `ORDER BY`.)

- The `LIMIT` clause can be used to constrain the number of rows returned by the `SELECT` statement. `LIMIT` takes one or two numeric arguments, which must both be nonnegative integer constants, with these exceptions:

  - Within prepared statements, `LIMIT` parameters can be specified using `?` placeholder markers.
  - Within stored programs, `LIMIT` parameters can be specified using integer-valued routine parameters or local variables as of MySQL 5.5.6.

  With two arguments, the first argument specifies the offset of the first row to return, and the second specifies the maximum number of rows to return. The offset of the initial row is 0 (not 1):

  ```
  SELECT * FROM tbl LIMIT 5,10;  # Retrieve rows 6-15
  ```

  To retrieve all rows from a certain offset up to the end of the result set, you can use some large number for the second parameter. This statement retrieves all rows from the 96th row to the last:

  ```
  SELECT * FROM tbl LIMIT 95,18446744073709551615;
  ```

  With one argument, the value specifies the number of rows to return from the beginning of the result set:

  ```
  SELECT * FROM tbl LIMIT 5;     # Retrieve first 5 rows
  ```

  In other words, `LIMIT row_count` is equivalent to `LIMIT 0, row_count`.

  For prepared statements, you can use placeholders. The following statements will return one row from the `tbl` table:

```
SET @a=1;
PREPARE STMT FROM 'SELECT * FROM tbl LIMIT ?';
EXECUTE STMT USING @a;
```

The following statements will return the second to sixth row from the `tbl` table:

```
SET @skip=1; SET @numrows=5;
PREPARE STMT FROM 'SELECT * FROM tbl LIMIT ?, ?';
EXECUTE STMT USING @skip, @numrows;
```

For compatibility with PostgreSQL, MySQL also supports the `LIMIT` *`row_count`* `OFFSET` *`offset`* syntax.

If `LIMIT` occurs within a subquery and also is applied in the outer query, the outermost `LIMIT` takes precedence. For example, the following statement produces two rows, not one:

```
(SELECT ... LIMIT 1) LIMIT 2;
```

- A `PROCEDURE` clause names a procedure that should process the data in the result set. For an example, see Section 21.4.1, “`PROCEDURE ANALYSE`”, which describes `ANALYSE`, a procedure that can be used to obtain suggestions for optimal column data types that may help reduce table sizes.

- The `SELECT ... INTO OUTFILE '`*`file_name`*`'` form of `SELECT` writes the selected rows to a file. The file is created on the server host, so you must have the `FILE` privilege to use this syntax. *`file_name`* cannot be an existing file, which among other things prevents files such as `/etc/passwd` and database tables from being destroyed. The `character_set_filesystem` system variable controls the interpretation of the file name.

  The `SELECT ... INTO OUTFILE` statement is intended primarily to let you very quickly dump a table to a text file on the server machine. If you want to create the resulting file on some other host than the server host, you normally cannot use `SELECT ... INTO OUTFILE` since there is no way to write a path to the file relative to the server host's file system.

  However, if the MySQL client software is installed on the remote machine, you can instead use a client command such as `mysql -e "SELECT ..." >` *`file_name`* to generate the file on the client host.

  It is also possible to create the resulting file on a different host other than the server host, if the location of the file on the remote host can be accessed using a network-mapped path on the server's file system. In this case, the presence of `mysql` (or some other MySQL client program) is not required on the target host.

  `SELECT ... INTO OUTFILE` is the complement of `LOAD DATA INFILE`. Column values are written converted to the character set specified in the `CHARACTER SET` clause. If no such clause is present, values are dumped using the `binary` character set. In effect, there is no character set conversion. If a table contains columns in several character sets, the output data file will as well and you may not be able to reload the file correctly.

  The syntax for the *`export_options`* part of the statement consists of the same `FIELDS` and `LINES` clauses that are used with the `LOAD DATA INFILE` statement. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”, for information about the `FIELDS` and `LINES` clauses, including their default values and permissible values.

  `FIELDS ESCAPED BY` controls how to write special characters. If the `FIELDS ESCAPED BY` character is not empty, it is used as a prefix that precedes following characters on output:

  - The `FIELDS ESCAPED BY` character
  - The `FIELDS [OPTIONALLY] ENCLOSED BY` character
  - The first character of the `FIELDS TERMINATED BY` and `LINES TERMINATED BY` values
  - ASCII `NUL` (the zero-valued byte; what is actually written following the escape character is ASCII “`0`”, not a zero-valued byte)

  The `FIELDS TERMINATED BY`, `ENCLOSED BY`, `ESCAPED BY`, or `LINES TERMINATED BY` characters *must* be escaped so that you can read the file back in reliably. ASCII `NUL` is escaped to make it easier to view with some pagers.

  The resulting file does not have to conform to SQL syntax, so nothing else need be escaped.

  If the `FIELDS ESCAPED BY` character is empty, no characters are escaped and `NULL` is output as `NULL`, not `\N`. It is probably not a good idea to specify an empty escape character, particularly if field values in your data contain any of the characters in the list just given.

  Here is an example that produces a file in the comma-separated values (CSV) format used by many programs:

```
SELECT a,b,a+b INTO OUTFILE '/tmp/result.txt'
  FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"'
  LINES TERMINATED BY '\n'
  FROM test_table;
```

- If you use `INTO DUMPFILE` instead of `INTO OUTFILE`, MySQL writes only one row into the file, without any column or line termination and without performing any escape processing. This is useful if you want to store a `BLOB` value in a file.

- > **Note**
  >
  > Any file created by `INTO OUTFILE` or `INTO DUMPFILE` is writable by all users on the server host. The reason for this is that the MySQL server cannot create a file that is owned by anyone other than the user under whose account it is running. (You should *never* run `mysqld` as `root` for this and other reasons.) The file thus must be world-writable so that you can manipulate its contents.
  >
  > If the `secure_file_priv` system variable is set to a nonempty directory name, the file to be written must be located in that directory.

- The `INTO` clause can name a list of one or more variables, which can be user-defined variables, or parameters or local variables within a stored function or procedure body (see Section 12.7.3.3, “`SELECT ... INTO` Statement”). The selected values are assigned to the variables. The number of variables must match the number of columns. The query should return a single row. If the query returns no rows, a warning with error code 1329 occurs (`No data`), and the variable values remain unchanged. If the query returns multiple rows, error 1172 occurs (`Result consisted of more than one row`). If it is possible that the statement may retrieve multiple rows, you can use `LIMIT 1` to limit the result set to a single row.

  In the context of such statements that occur as part of events executed by the Event Scheduler, diagnostics messages (not only errors, but also warnings) are written to the error log, and, on Windows, to the application event log. For additional information, see Section 17.4.5, “Event Scheduler Status”.

- The `SELECT` syntax description at the beginning this section shows the `INTO` clause near the end of the statement. It is also possible to use `INTO` immediately following the *`select_expr`* list.

- An `INTO` clause should not be used in a nested `SELECT` because such a `SELECT` must return its result to the outer context.

- If you use `FOR UPDATE` with a storage engine that uses page or row locks, rows examined by the query are write-locked until the end of the current transaction. Using `LOCK IN SHARE MODE` sets a shared lock that permits other transactions to read the examined rows but not to update or delete them. See Section 13.3.9.3, “`SELECT ... FOR UPDATE` and `SELECT ... LOCK IN SHARE MODE` Locking Reads”.

Following the `SELECT` keyword, you can use a number of options that affect the operation of the statement. `HIGH_PRIORITY`, `STRAIGHT_JOIN`, and options beginning with `SQL_` are MySQL extensions to standard SQL.

- The `ALL` and `DISTINCT` options specify whether duplicate rows should be returned. `ALL` (the default) specifies that all matching rows should be returned, including duplicates. `DISTINCT` specifies removal of duplicate rows from the result set. It is an error to specify both options. `DISTINCTROW` is a synonym for `DISTINCT`.

- `HIGH_PRIORITY` gives the `SELECT` higher priority than a statement that updates a table. You should use this only for queries that are very fast and must be done at once. A `SELECT HIGH_PRIORITY` query that is issued while the table is locked for reading runs even if there is an update statement waiting for the table to be free. This affects only storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`).

  `HIGH_PRIORITY` cannot be used with `SELECT` statements that are part of a `UNION`.

- `STRAIGHT_JOIN` forces the optimizer to join the tables in the order in which they are listed in the `FROM` clause. You can use this to speed up a query if the optimizer joins the tables in nonoptimal order. `STRAIGHT_JOIN` also can be used in the *`table_references`* list. See Section 12.2.9.1, “`JOIN` Syntax”.

  `STRAIGHT_JOIN` does not apply to any table that the optimizer treats as a `const` or `system` table. Such a table produces a single row, is read during the optimization phase of query execution, and references to its columns are replaced with the appropriate column values before query execution proceeds. These tables will appear first in the query plan displayed by `EXPLAIN`. See Section 7.8.1, “Optimizing Queries with `EXPLAIN`”. This exception may not apply to `const` or `system` tables that are used on the `NULL`-complemented side of an outer join (that is, the right-side table of a `LEFT JOIN` or the left-side table of a `RIGHT JOIN`.

- `SQL_BIG_RESULT` or `SQL_SMALL_RESULT` can be used with `GROUP BY` or `DISTINCT` to tell the optimizer that the result set has many rows or is small, respectively. For `SQL_BIG_RESULT`, MySQL directly uses disk-based temporary tables if needed, and prefers sorting to using a temporary table with a key on the `GROUP BY` elements. For `SQL_SMALL_RESULT`, MySQL uses fast temporary tables to store the resulting table instead of using sorting. This should not normally be needed.

- `SQL_BUFFER_RESULT` forces the result to be put into a temporary table. This helps MySQL free the table locks early and helps in cases where it takes a long time to send the result set to the client. This option can be used only for top-level `SELECT` statements, not for subqueries or following `UNION`.

- `SQL_CALC_FOUND_ROWS` tells MySQL to calculate how many rows there would be in the result set, disregarding any `LIMIT` clause. The number of rows can then be retrieved with `SELECT FOUND_ROWS()`. See Section 11.14, "Information Functions".

- The `SQL_CACHE` and `SQL_NO_CACHE` options affect caching of query results in the query cache (see Section 7.9.3, "The MySQL Query Cache"). `SQL_CACHE` tells MySQL to store the result in the query cache if it is cacheable and the value of the `query_cache_type` system variable is `2` or `DEMAND`. `SQL_NO_CACHE` tells MySQL not to store the result in the query cache.

  For views, `SQL_NO_CACHE` applies if it appears in any `SELECT` in the query. For a cacheable query, `SQL_CACHE` applies if it appears in the first `SELECT` of a view referred to by the query.

  As of MySQL 5.5.3, these two options are mutually exclusive and an error occurs if they are both specified. Also, these options are not permitted in subqueries (including subqueries in the `FROM` clause), and `SELECT` statements in unions other than the first `SELECT`.

  Before MySQL 5.5.3, for a query that uses `UNION` or subqueries, the following rules apply:

  - `SQL_NO_CACHE` applies if it appears in any `SELECT` in the query.

  - For a cacheable query, `SQL_CACHE` applies if it appears in the first `SELECT` of the query.

12.2.9.1. `JOIN` Syntax

MySQL supports the following `JOIN` syntaxes for the *`table_references`* part of `SELECT` statements and multiple-table `DELETE` and `UPDATE` statements:

```
table_references:
    table_reference [, table_reference] ...

table_reference:
    table_factor
  | join_table

table_factor:
    tbl_name [[AS] alias] [index_hint_list]
  | table_subquery [AS] alias
  | ( table_references )
  | { OJ table_reference LEFT OUTER JOIN table_reference
        ON conditional_expr }

join_table:
    table_reference [INNER | CROSS] JOIN table_factor [join_condition]
  | table_reference STRAIGHT_JOIN table_factor
  | table_reference STRAIGHT_JOIN table_factor ON conditional_expr
  | table_reference {LEFT|RIGHT} [OUTER] JOIN table_reference join_condition
  | table_reference NATURAL [{LEFT|RIGHT} [OUTER]] JOIN table_factor

join_condition:
    ON conditional_expr
  | USING (column_list)

index_hint_list:
    index_hint [, index_hint] ...

index_hint:
    USE {INDEX|KEY}
      [{FOR {JOIN|ORDER BY|GROUP BY}] ([index_list])
  | IGNORE {INDEX|KEY}
      [{FOR {JOIN|ORDER BY|GROUP BY}] (index_list)
  | FORCE {INDEX|KEY}
      [{FOR {JOIN|ORDER BY|GROUP BY}] (index_list)

index_list:
    index_name [, index_name] ...
```

A table reference is also known as a join expression.

The syntax of *`table_factor`* is extended in comparison with the SQL Standard. The latter accepts only *`table_reference`*, not a list of them inside a pair of parentheses.

This is a conservative extension if we consider each comma in a list of *`table_reference`* items as equivalent to an inner join. For example:

```
SELECT * FROM t1 LEFT JOIN (t2, t3, t4)
                 ON (t2.a=t1.a AND t3.b=t1.b AND t4.c=t1.c)
```

is equivalent to:

```
SELECT * FROM t1 LEFT JOIN (t2 CROSS JOIN t3 CROSS JOIN t4)
                 ON (t2.a=t1.a AND t3.b=t1.b AND t4.c=t1.c)
```

In MySQL, `CROSS JOIN` is a syntactic equivalent to `INNER JOIN` (they can replace each other). In standard SQL, they are not equivalent. `INNER JOIN` is used with an `ON` clause, `CROSS JOIN` is used otherwise.

In general, parentheses can be ignored in join expressions containing only inner join operations. MySQL also supports nested joins (see Section 7.13.7, “Nested Join Optimization”).

Index hints can be specified to affect how the MySQL optimizer makes use of indexes. For more information, see Section 12.2.9.2, “Index Hint Syntax”.

The following list describes general factors to take into account when writing joins.

- A table reference can be aliased using `tbl_name AS alias_name` or `tbl_name alias_name`:

  ```
  SELECT t1.name, t2.salary
    FROM employee AS t1 INNER JOIN info AS t2 ON t1.name = t2.name;

  SELECT t1.name, t2.salary
    FROM employee t1 INNER JOIN info t2 ON t1.name = t2.name;
  ```

- A `table_subquery` is also known as a subquery in the `FROM` clause. Such subqueries *must* include an alias to give the subquery result a table name. A trivial example follows; see also Section 12.2.10.8, “Subqueries in the `FROM` Clause”.

  ```
  SELECT * FROM (SELECT 1, 2, 3) AS t1;
  ```

- `INNER JOIN` and `,` (comma) are semantically equivalent in the absence of a join condition: both produce a Cartesian product between the specified tables (that is, each and every row in the first table is joined to each and every row in the second table).

  However, the precedence of the comma operator is less than of `INNER JOIN`, `CROSS JOIN`, `LEFT JOIN`, and so on. If you mix comma joins with the other join types when there is a join condition, an error of the form `Unknown column 'col_name' in 'on clause'` may occur. Information about dealing with this problem is given later in this section.

- The `conditional_expr` used with `ON` is any conditional expression of the form that can be used in a `WHERE` clause. Generally, you should use the `ON` clause for conditions that specify how to join tables, and the `WHERE` clause to restrict which rows you want in the result set.

- If there is no matching row for the right table in the `ON` or `USING` part in a `LEFT JOIN`, a row with all columns set to `NULL` is used for the right table. You can use this fact to find rows in a table that have no counterpart in another table:

  ```
  SELECT left_tbl.*
    FROM left_tbl LEFT JOIN right_tbl ON left_tbl.id = right_tbl.id
    WHERE right_tbl.id IS NULL;
  ```

  This example finds all rows in `left_tbl` with an `id` value that is not present in `right_tbl` (that is, all rows in `left_tbl` with no corresponding row in `right_tbl`). This assumes that `right_tbl.id` is declared `NOT NULL`. See Section 7.13.5, “`LEFT JOIN` and `RIGHT JOIN` Optimization”.

- The `USING(column_list)` clause names a list of columns that must exist in both tables. If tables `a` and `b` both contain columns `c1`, `c2`, and `c3`, the following join compares corresponding columns from the two tables:

  ```
  a LEFT JOIN b USING (c1,c2,c3)
  ```

- The `NATURAL [LEFT] JOIN` of two tables is defined to be semantically equivalent to an `INNER JOIN` or a `LEFT JOIN` with a `USING` clause that names all columns that exist in both tables.

- `RIGHT JOIN` works analogously to `LEFT JOIN`. To keep code portable across databases, it is recommended that you use `LEFT JOIN` instead of `RIGHT JOIN`.

- The `{ OJ ... LEFT OUTER JOIN ...}` syntax shown in the join syntax description exists only for compatibility with ODBC. The curly braces in the syntax should be written literally; they are not metasyntax as used elsewhere in syntax descriptions.

  ```
  SELECT left_tbl.*
      FROM { OJ left_tbl LEFT OUTER JOIN right_tbl ON left_tbl.id = right_tbl.id }
      WHERE right_tbl.id IS NULL;
  ```

You can use other types of joins within `{ OJ ... }`, such as `INNER JOIN` or `RIGHT OUTER JOIN`. This helps with compatibility with some third-party applications, but is not official ODBC syntax.

- `STRAIGHT_JOIN` is similar to `JOIN`, except that the left table is always read before the right table. This can be used for those (few) cases for which the join optimizer puts the tables in the wrong order.

Some join examples:

```
SELECT * FROM table1, table2;

SELECT * FROM table1 INNER JOIN table2 ON table1.id=table2.id;

SELECT * FROM table1 LEFT JOIN table2 ON table1.id=table2.id;

SELECT * FROM table1 LEFT JOIN table2 USING (id);

SELECT * FROM table1 LEFT JOIN table2 ON table1.id=table2.id
  LEFT JOIN table3 ON table2.id=table3.id;
```

Join Processing Changes in MySQL 5.0.12

> **Note**
>
> Natural joins and joins with `USING`, including outer join variants, are processed according to the SQL:2003 standard. The goal was to align the syntax and semantics of MySQL with respect to `NATURAL JOIN` and `JOIN ... USING` according to SQL:2003. However, these changes in join processing can result in different output columns for some joins. Also, some queries that appeared to work correctly in older versions (prior to 5.0.12) must be rewritten to comply with the standard.

These changes have five main aspects:

- The way that MySQL determines the result columns of `NATURAL` or `USING` join operations (and thus the result of the entire `FROM` clause).
- Expansion of `SELECT *` and `SELECT tbl_name.*` into a list of selected columns.
- Resolution of column names in `NATURAL` or `USING` joins.
- Transformation of `NATURAL` or `USING` joins into `JOIN ... ON`.
- Resolution of column names in the `ON` condition of a `JOIN ... ON`.

The following list provides more detail about several effects of current join processing versus join processing in older versions. The term “previously” means “prior to MySQL 5.0.12.”

- The columns of a `NATURAL` join or a `USING` join may be different from previously. Specifically, redundant output columns no longer appear, and the order of columns for `SELECT *` expansion may be different from before.

  Consider this set of statements:

  ```
  CREATE TABLE t1 (i INT, j INT);
  CREATE TABLE t2 (k INT, j INT);
  INSERT INTO t1 VALUES(1,1);
  INSERT INTO t2 VALUES(1,1);
  SELECT * FROM t1 NATURAL JOIN t2;
  SELECT * FROM t1 JOIN t2 USING (j);
  ```

  Previously, the statements produced this output:

  ```
  +------+------+------+------+
  | i    | j    | k    | j    |
  +------+------+------+------+
  |    1 |    1 |    1 |    1 |
  +------+------+------+------+
  +------+------+------+------+
  | i    | j    | k    | j    |
  +------+------+------+------+
  |    1 |    1 |    1 |    1 |
  +------+------+------+------+
  ```

In the first `SELECT` statement, column `j` appears in both tables and thus becomes a join column, so, according to standard SQL, it should appear only once in the output, not twice. Similarly, in the second SELECT statement, column `j` is named in the `USING` clause and should appear only once in the output, not twice. But in both cases, the redundant column is not eliminated. Also, the order of the columns is not correct according to standard SQL.

Now the statements produce this output:

```
+------+------+------+
| j    | i    | k    |
+------+------+------+
|    1 |    1 |    1 |
+------+------+------+
+------+------+------+
| j    | i    | k    |
+------+------+------+
|    1 |    1 |    1 |
+------+------+------+
```

The redundant column is eliminated and the column order is correct according to standard SQL:

- First, coalesced common columns of the two joined tables, in the order in which they occur in the first table
- Second, columns unique to the first table, in order in which they occur in that table
- Third, columns unique to the second table, in order in which they occur in that table

The single result column that replaces two common columns is defined using the coalesce operation. That is, for two `t1.a` and `t2.a` the resulting single join column `a` is defined as `a = COALESCE(t1.a, t2.a)`, where:

```
COALESCE(x, y) = (CASE WHEN V1 IS NOT NULL THEN V1 ELSE V2 END)
```

If the join operation is any other join, the result columns of the join consists of the concatenation of all columns of the joined tables. This is the same as previously.

A consequence of the definition of coalesced columns is that, for outer joins, the coalesced column contains the value of the non-`NULL` column if one of the two columns is always `NULL`. If neither or both columns are `NULL`, both common columns have the same value, so it doesn't matter which one is chosen as the value of the coalesced column. A simple way to interpret this is to consider that a coalesced column of an outer join is represented by the common column of the inner table of a `JOIN`. Suppose that the tables `t1(a,b)` and `t2(a,c)` have the following contents:

```
t1    t2
----  ----
1 x   2 z
2 y   3 w
```

Then:

```
mysql> SELECT * FROM t1 NATURAL LEFT JOIN t2;
+------+------+------+
| a    | b    | c    |
+------+------+------+
|    1 | x    | NULL |
|    2 | y    | z    |
+------+------+------+
```

Here column `a` contains the values of `t1.a`.

```
mysql> SELECT * FROM t1 NATURAL RIGHT JOIN t2;
+------+------+------+
| a    | c    | b    |
+------+------+------+
|    2 | z    | y    |
|    3 | w    | NULL |
+------+------+------+
```

Here column `a` contains the values of `t2.a`.

Compare these results to the otherwise equivalent queries with `JOIN ... ON`:

```
mysql> SELECT * FROM t1 LEFT JOIN t2 ON (t1.a = t2.a);
+------+------+------+------+
| a    | b    | a    | c    |
+------+------+------+------+
|    1 | x    | NULL | NULL |
|    2 | y    |    2 | z    |
+------+------+------+------+
mysql> SELECT * FROM t1 RIGHT JOIN t2 ON (t1.a = t2.a);
+------+------+------+------+
| a    | b    | a    | c    |
+------+------+------+------+
|    2 | y    |    2 | z    |
| NULL | NULL |    3 | w    |
+------+------+------+------+
```

- Previously, a `USING` clause could be rewritten as an `ON` clause that compares corresponding columns. For example, the following two clauses were semantically identical:

  ```
  a LEFT JOIN b USING (c1,c2,c3)
  a LEFT JOIN b ON a.c1=b.c1 AND a.c2=b.c2 AND a.c3=b.c3
  ```

  Now the two clauses no longer are quite the same:

  - With respect to determining which rows satisfy the join condition, both joins remain semantically identical.
  - With respect to determining which columns to display for `SELECT *` expansion, the two joins are not semantically identical. The `USING` join selects the coalesced value of corresponding columns, whereas the `ON` join selects all columns from all tables. For the preceding `USING` join, `SELECT *` selects these values:

    ```
    COALESCE(a.c1,b.c1), COALESCE(a.c2,b.c2), COALESCE(a.c3,b.c3)
    ```

    For the `ON` join, `SELECT *` selects these values:

    ```
    a.c1, a.c2, a.c3, b.c1, b.c2, b.c3
    ```

    With an inner join, `COALESCE(a.c1,b.c1)` is the same as either `a.c1` or `b.c1` because both columns will have the same value. With an outer join (such as `LEFT JOIN`), one of the two columns can be `NULL`. That column will be omitted from the result.

- The evaluation of multi-way natural joins differs in a very important way that affects the result of `NATURAL` or `USING` joins and that can require query rewriting. Suppose that you have three tables `t1(a,b)`, `t2(c,b)`, and `t3(a,c)` that each have one row: `t1(1,2)`, `t2(10,2)`, and `t3(7,10)`. Suppose also that you have this `NATURAL JOIN` on the three tables:

  ```
  SELECT ... FROM t1 NATURAL JOIN t2 NATURAL JOIN t3;
  ```

  Previously, the left operand of the second join was considered to be `t2`, whereas it should be the nested join `(t1 NATURAL JOIN t2)`. As a result, the columns of `t3` are checked for common columns only in `t2`, and, if `t3` has common columns with `t1`, these columns are not used as equi-join columns. Thus, previously, the preceding query was transformed to the following equi-join:

  ```
  SELECT ... FROM t1, t2, t3
    WHERE t1.b = t2.b AND t2.c = t3.c;
  ```

  That join is missing one more equi-join predicate `(t1.a = t3.a)`. As a result, it produces one row, not the empty result that it should. The correct equivalent query is this:

  ```
  SELECT ... FROM t1, t2, t3
    WHERE t1.b = t2.b AND t2.c = t3.c AND t1.a = t3.a;
  ```

  If you require the same query result in current versions of MySQL as in older versions, rewrite the natural join as the first equi-join.

- Previously, the comma operator (`,`) and `JOIN` both had the same precedence, so the join expression `t1, t2 JOIN t3` was interpreted as `((t1, t2) JOIN t3)`. Now `JOIN` has higher precedence, so the expression is interpreted as `(t1, (t2 JOIN t3))`. This change affects statements that use an `ON` clause, because that clause can refer only to columns in the operands of the join, and the change in precedence changes interpretation of what those operands are.

  Example:

  ```
  CREATE TABLE t1 (i1 INT, j1 INT);
  CREATE TABLE t2 (i2 INT, j2 INT);
  CREATE TABLE t3 (i3 INT, j3 INT);
  INSERT INTO t1 VALUES(1,1);
  INSERT INTO t2 VALUES(1,1);
  INSERT INTO t3 VALUES(1,1);
  SELECT * FROM t1, t2 JOIN t3 ON (t1.i1 = t3.i3);
  ```

Previously, the `SELECT` was legal due to the implicit grouping of `t1,t2` as `(t1,t2)`. Now the `JOIN` takes precedence, so the operands for the `ON` clause are `t2` and `t3`. Because `t1.i1` is not a column in either of the operands, the result is an `Unknown column 't1.i1' in 'on clause'` error. To allow the join to be processed, group the first two tables explicitly with parentheses so that the operands for the `ON` clause are `(t1,t2)` and `t3`:

```
SELECT * FROM (t1, t2) JOIN t3 ON (t1.i1 = t3.i3);
```

Alternatively, avoid the use of the comma operator and use `JOIN` instead:

```
SELECT * FROM t1 JOIN t2 JOIN t3 ON (t1.i1 = t3.i3);
```

This change also applies to statements that mix the comma operator with `INNER JOIN`, `CROSS JOIN`, `LEFT JOIN`, and `RIGHT JOIN`, all of which now have higher precedence than the comma operator.

- Previously, the `ON` clause could refer to columns in tables named to its right. Now an `ON` clause can refer only to its operands.

  Example:

  ```
  CREATE TABLE t1 (i1 INT);
  CREATE TABLE t2 (i2 INT);
  CREATE TABLE t3 (i3 INT);
  SELECT * FROM t1 JOIN t2 ON (i1 = i3) JOIN t3;
  ```

  Previously, the `SELECT` statement was legal. Now the statement fails with an `Unknown column 'i3' in 'on clause'` error because `i3` is a column in `t3`, which is not an operand of the `ON` clause. The statement should be rewritten as follows:

  ```
  SELECT * FROM t1 JOIN t2 JOIN t3 ON (i1 = i3);
  ```

- Resolution of column names in `NATURAL` or `USING` joins is different than previously. For column names that are outside the `FROM` clause, MySQL now handles a superset of the queries compared to previously. That is, in cases when MySQL formerly issued an error that some column is ambiguous, the query now is handled correctly. This is due to the fact that MySQL now treats the common columns of `NATURAL` or `USING` joins as a single column, so when a query refers to such columns, the query compiler does not consider them as ambiguous.

  Example:

  ```
  SELECT * FROM t1 NATURAL JOIN t2 WHERE b > 1;
  ```

  Previously, this query would produce an error `ERROR 1052 (23000): Column 'b' in where clause is ambiguous`. Now the query produces the correct result:

  ```
  +------+------+------+
  | b    | c    | y    |
  +------+------+------+
  |    4 |    2 |    3 |
  +------+------+------+
  ```

  One extension of MySQL compared to the SQL:2003 standard is that MySQL enables you to qualify the common (coalesced) columns of `NATURAL` or `USING` joins (just as previously), while the standard disallows that.

12.2.9.2. Index Hint Syntax

You can provide hints to give the optimizer information about how to choose indexes during query processing. Section 12.2.9.1, “`JOIN` Syntax”, describes the general syntax for specifying tables in a `SELECT` statement. The syntax for an individual table, including that for index hints, looks like this:

```
tbl_name [[AS] alias] [index_hint_list]

index_hint_list:
    index_hint [, index_hint] ...

index_hint:
    USE {INDEX|KEY}
      [{FOR {JOIN|ORDER BY|GROUP BY}] ([index_list])
  | IGNORE {INDEX|KEY}
      [{FOR {JOIN|ORDER BY|GROUP BY}] (index_list)
  | FORCE {INDEX|KEY}
      [{FOR {JOIN|ORDER BY|GROUP BY}] (index_list)

index_list:
    index_name [, index_name] ...
```

By specifying `USE INDEX (index_list)`, you can tell MySQL to use only one of the named indexes to find rows in the table. The alternative syntax `IGNORE INDEX (index_list)` can be used to tell MySQL to not use some particular index or indexes. These hints are useful if `EXPLAIN` shows that MySQL is using the wrong index from the list of possible indexes.

You can also use `FORCE INDEX`, which acts like `USE INDEX (index_list)` but with the addition that a table scan is assumed to be *very* expensive. In other words, a table scan is used only if there is no way to use one of the given indexes to find rows in the table.

Each hint requires the names of *indexes*, not the names of columns. The name of a `PRIMARY KEY` is `PRIMARY`. To see the index names for a table, use `SHOW INDEX`.

An `index_name` value need not be a full index name. It can be an unambiguous prefix of an index name. If a prefix is ambiguous, an error occurs.

Examples:

```
SELECT * FROM table1 USE INDEX (col1_index,col2_index)
  WHERE col1=1 AND col2=2 AND col3=3;

SELECT * FROM table1 IGNORE INDEX (col3_index)
  WHERE col1=1 AND col2=2 AND col3=3;
```

The syntax for index hints has the following characteristics:

- It is syntactically valid to specify an empty `index_list` for `USE INDEX`, which means “use no indexes.” Specifying an empty `index_list` for `FORCE INDEX` or `IGNORE INDEX` is a syntax error.
- You can specify the scope of a index hint by adding a `FOR` clause to the hint. This provides more fine-grained control over the optimizer's selection of an execution plan for various phases of query processing. To affect only the indexes used when MySQL decides how to find rows in the table and how to process joins, use `FOR JOIN`. To influence index usage for sorting or grouping rows, use `FOR ORDER BY` or `FOR GROUP BY`. (However, if there is a covering index for the table and it is used to access the table, the optimizer will ignore `IGNORE INDEX FOR {ORDER BY|GROUP BY}` hints that disable that index.)
- You can specify multiple index hints:

  ```
  SELECT * FROM t1 USE INDEX (i1) IGNORE INDEX FOR ORDER BY (i2) ORDER BY a;
  ```

  It is not a error to name the same index in several hints (even within the same hint):

  ```
  SELECT * FROM t1 USE INDEX (i1) USE INDEX (i1,i1);
  ```

  However, it is an error to mix `USE INDEX` and `FORCE INDEX` for the same table:

  ```
  SELECT * FROM t1 USE INDEX FOR JOIN (i1) FORCE INDEX FOR JOIN (i2);
  ```

if you specify no `FOR` clause for an index hint, the hint by default applies to all parts of the statement. For example, this hint:

```
IGNORE INDEX (i1)
```

is equivalent to this combination of hints:

```
IGNORE INDEX FOR JOIN (i1)
IGNORE INDEX FOR ORDER BY (i1)
IGNORE INDEX FOR GROUP BY (i1)
```

To cause the server to use the older behavior for hint scope when no `FOR` clause is present (so that hints apply only to row retrieval), enable the `old` system variable at server startup. Take care about enabling this variable in a replication setup. With statement-based binary logging, having different modes for the master and slaves might lead to replication errors.

When index hints are processed, they are collected in a single list by type (`USE`, `FORCE`, `IGNORE`) and by scope (`FOR JOIN`, `FOR ORDER BY`, `FOR GROUP BY`). For example:

```
SELECT * FROM t1
  USE INDEX () IGNORE INDEX (i2) USE INDEX (i1) USE INDEX (i2);
```

is equivalent to:

```
SELECT * FROM t1
   USE INDEX (i1,i2) IGNORE INDEX (i2);
```

The index hints then are applied for each scope in the following order:

1. `{USE|FORCE} INDEX` is applied if present. (If not, the optimizer-determined set of indexes is used.)
2. `IGNORE INDEX` is applied over the result of the previous step. For example, the following two queries are equivalent:

   ```
   SELECT * FROM t1 USE INDEX (i1) IGNORE INDEX (i2) USE INDEX (i2);

   SELECT * FROM t1 USE INDEX (i1);
   ```

For `FULLTEXT` searches, index hints work as follows:

- For natural language mode searches, index hints are silently ignored. For example, `IGNORE INDEX(i)` is ignored with no warning and the index is still used.

  For boolean mode searches, index hints with `FOR ORDER BY` or `FOR GROUP BY` are silently ignored. Index hints with `FOR JOIN` or no `FOR` modifier are honored. In contrast to how hints apply for non-`FULLTEXT` searches, the hint is used for all phases of query execution (finding rows and retrieval, grouping, and ordering). This is true even if the hint is given for a non-`FULLTEXT` index.

For example, the following two queries are equivalent:

```
SELECT * FROM t
  USE INDEX (index1)
  IGNORE INDEX (index1) FOR ORDER BY
  IGNORE INDEX (index1) FOR GROUP BY
  WHERE ... IN BOOLEAN MODE ... ;

SELECT * FROM t
  USE INDEX (index1)
  WHERE ... IN BOOLEAN MODE ... ;
```

Index hints are accepted but ignored for `UPDATE` statements.

12.2.9.3. `UNION` Syntax

```
SELECT ...
UNION [ALL | DISTINCT] SELECT ...
[UNION [ALL | DISTINCT] SELECT ...]
```

`UNION` is used to combine the result from multiple `SELECT` statements into a single result set.

The column names from the first `SELECT` statement are used as the column names for the results returned. Selected columns listed in corresponding positions of each `SELECT` statement should have the same data type. (For example, the first column selected by the first statement should have the same type as the first column selected by the other statements.)

If the data types of corresponding `SELECT` columns do not match, the types and lengths of the columns in the `UNION` result take into account the values retrieved by all of the `SELECT` statements. For example, consider the following:

```
mysql> SELECT REPEAT('a',1) UNION SELECT REPEAT('b',10);
+---------------+
| REPEAT('a',1) |
+---------------+
| a             |
| bbbbbbbbbb    |
+---------------+
```

(In some earlier versions of MySQL, only the type and length from the first `SELECT` would have been used and the second row would have been truncated to a length of 1.)

The `SELECT` statements are normal select statements, but with the following restrictions:

- Only the last `SELECT` statement can use `INTO OUTFILE`. (However, the entire `UNION` result is written to the file.)
- `HIGH_PRIORITY` cannot be used with `SELECT` statements that are part of a `UNION`. If you specify it for the first `SELECT`, it has no effect. If you specify it for any subsequent `SELECT` statements, a syntax error results.

The default behavior for `UNION` is that duplicate rows are removed from the result. The optional `DISTINCT` keyword has no effect other than the default because it also specifies duplicate-row removal. With the optional `ALL` keyword, duplicate-row removal does not occur and the result includes all matching rows from all the `SELECT` statements.

You can mix `UNION ALL` and `UNION DISTINCT` in the same query. Mixed `UNION` types are treated such that a `DISTINCT` union overrides any `ALL` union to its left. A `DISTINCT` union can be produced explicitly by using `UNION DISTINCT` or implicitly by using `UNION` with no following `DISTINCT` or `ALL` keyword.

To apply `ORDER BY` or `LIMIT` to an individual `SELECT`, place the clause inside the parentheses that enclose the `SELECT`:

```
(SELECT a FROM t1 WHERE a=10 AND B=1 ORDER BY a LIMIT 10)
UNION
(SELECT a FROM t2 WHERE a=11 AND B=2 ORDER BY a LIMIT 10);
```

However, use of `ORDER BY` for individual `SELECT` statements implies nothing about the order in which the rows appear in the final result because `UNION` by default produces an unordered set of rows. Therefore, the use of `ORDER BY` in this context is typically in conjunction with `LIMIT`, so that it is used to determine the subset of the selected rows to retrieve for the `SELECT`, even though it does not necessarily affect the order of those rows in the final `UNION` result. If `ORDER BY` appears without `LIMIT` in a `SELECT`, it is optimized away because it will have no effect anyway.

To use an `ORDER BY` or `LIMIT` clause to sort or limit the entire `UNION` result, parenthesize the individual `SELECT` statements and place the `ORDER BY` or `LIMIT` after the last one. The following example uses both clauses:

```
(SELECT a FROM t1 WHERE a=10 AND B=1)
UNION
(SELECT a FROM t2 WHERE a=11 AND B=2)
ORDER BY a LIMIT 10;
```

A statement without parentheses is equivalent to one parenthesized as just shown.

This kind of `ORDER BY` cannot use column references that include a table name (that is, names in *`tbl_name`*.*`col_name`* format). Instead, provide a column alias in the first `SELECT` statement and refer to the alias in the `ORDER BY`. (Alternatively, refer to the column in the `ORDER BY` using its column position. However, use of column positions is deprecated.)

Also, if a column to be sorted is aliased, the `ORDER BY` clause *must* refer to the alias, not the column name. The first of the following statements will work, but the second will fail with an `Unknown column 'a' in 'order clause'` error:

```
(SELECT a AS b FROM t) UNION (SELECT ...) ORDER BY b;
(SELECT a AS b FROM t) UNION (SELECT ...) ORDER BY a;
```

To cause rows in a `UNION` result to consist of the sets of rows retrieved by each `SELECT` one after the other, select an additional column in each `SELECT` to use as a sort column and add an `ORDER BY` following the last `SELECT`:

```
(SELECT 1 AS sort_col, col1a, col1b, ... FROM t1)
UNION
(SELECT 2, col2a, col2b, ... FROM t2) ORDER BY sort_col;
```

To additionally maintain sort order within individual `SELECT` results, add a secondary column to the `ORDER BY` clause:

```
(SELECT 1 AS sort_col, col1a, col1b, ... FROM t1)
UNION
(SELECT 2, col2a, col2b, ... FROM t2) ORDER BY sort_col, col1a;
```

Use of an additional column also enables you to determine which `SELECT` each row comes from. Extra columns can provide other identifying information as well, such as a string that indicates a table name.

12.2.10. Subquery Syntax

A subquery is a `SELECT` statement within another statement.

Starting with MySQL 4.1, all subquery forms and operations that the SQL standard requires are supported, as well as a few features that are MySQL-specific.

Here is an example of a subquery:

```
SELECT * FROM t1 WHERE column1 = (SELECT column1 FROM t2);
```

In this example, `SELECT * FROM t1 ...` is the *outer query* (or *outer statement*), and `(SELECT column1 FROM t2)` is the *subquery*. We say that the subquery is *nested* within the outer query, and in fact it is possible to nest subqueries within other subqueries, to a considerable depth. A subquery must always appear within parentheses.

The main advantages of subqueries are:

- They allow queries that are *structured* so that it is possible to isolate each part of a statement.
- They provide alternative ways to perform operations that would otherwise require complex joins and unions.
- Many people find subqueries more readable than complex joins or unions. Indeed, it was the innovation of subqueries that gave people the original idea of calling the early SQL "Structured Query Language."

Here is an example statement that shows the major points about subquery syntax as specified by the SQL standard and supported in MySQL:

```
DELETE FROM t1
WHERE s11 > ANY
 (SELECT COUNT(*) /* no hint */ FROM t2
  WHERE NOT EXISTS
   (SELECT * FROM t3
    WHERE ROW(5*t2.s1,77)=
     (SELECT 50,11*s1 FROM t4 UNION SELECT 50,77 FROM
      (SELECT * FROM t5) AS t5)));
```

A subquery can return a scalar (a single value), a single row, a single column, or a table (one or more rows of one or more columns). These are called scalar, column, row, and table subqueries. Subqueries that return a particular kind of result often can be used only in certain contexts, as described in the following sections.

There are few restrictions on the type of statements in which subqueries can be used. A subquery can contain many of the keywords or clauses that an ordinary `SELECT` can contain: `DISTINCT`, `GROUP BY`, `ORDER BY`, `LIMIT`, joins, index hints, `UNION` constructs, comments, functions, and so on.

One restriction is that a subquery's outer statement must be one of: `SELECT`, `INSERT`, `UPDATE`, `DELETE`, `SET`, or `DO`. Another restriction is that currently you cannot modify a table and select from the same table in a subquery. This applies to statements such as `DELETE`, `INSERT`, `REPLACE`, `UPDATE`, and (because subqueries can be used in the `SET` clause) `LOAD DATA INFILE`.

A more comprehensive discussion of restrictions on subquery use, including performance issues for certain forms of subquery syntax, is given in Section E.4, "Restrictions on Subqueries".

12.2.10.1. The Subquery as Scalar Operand

In its simplest form, a subquery is a scalar subquery that returns a single value. A scalar subquery is a simple operand, and you can use it almost anywhere a single column value or literal is legal, and you can expect it to have those characteristics that all operands have: a data type, a length, an indication that it can be `NULL`, and so on. For example:

```
CREATE TABLE t1 (s1 INT, s2 CHAR(5) NOT NULL);
INSERT INTO t1 VALUES(100, 'abcde');
SELECT (SELECT s2 FROM t1);
```

The subquery in this `SELECT` returns a single value (`'abcde'`) that has a data type of `CHAR`, a length of 5, a character set and collation equal to the defaults in effect at `CREATE TABLE` time, and an indication that the value in the column can be `NULL`. Nullability of the value selected by a scalar subquery is not copied because if the subquery result is empty, the result is `NULL`. For the subquery just shown, if `t1` were empty, the result would be `NULL` even though `s2` is `NOT NULL`.

There are a few contexts in which a scalar subquery cannot be used. If a statement permits only a literal value, you cannot use a subquery. For example, `LIMIT` requires literal integer arguments, and `LOAD DATA INFILE` requires a literal string file name. You cannot use subqueries to supply these values.

When you see examples in the following sections that contain the rather spartan construct `(SELECT column1 FROM t1)`, imagine that your own code contains much more diverse and complex constructions.

Suppose that we make two tables:

```
CREATE TABLE t1 (s1 INT);
INSERT INTO t1 VALUES (1);
CREATE TABLE t2 (s1 INT);
INSERT INTO t2 VALUES (2);
```

Then perform a `SELECT`:

```
SELECT (SELECT s1 FROM t2) FROM t1;
```

The result is `2` because there is a row in `t2` containing a column `s1` that has a value of `2`.

A scalar subquery can be part of an expression, but remember the parentheses, even if the subquery is an operand that provides an argument for a function. For example:

```
SELECT UPPER((SELECT s1 FROM t1)) FROM t2;
```

12.2.10.2. Comparisons Using Subqueries

The most common use of a subquery is in the form:

```
non_subquery_operand comparison_operator (subquery)
```

Where *`comparison_operator`* is one of these operators:

```
=  >  <  >=  <=  <>  !=  <=>
```

For example:

```
... WHERE 'a' = (SELECT column1 FROM t1)
```

MySQL also permits this construct:

```
non_subquery_operand LIKE (subquery)
```

At one time the only legal place for a subquery was on the right side of a comparison, and you might still find some old DBMSs that insist on this.

Here is an example of a common-form subquery comparison that you cannot do with a join. It finds all the rows in table `t1` for which the `column1` value is equal to a maximum value in table `t2`:

```
SELECT * FROM t1
  WHERE column1 = (SELECT MAX(column2) FROM t2);
```

Here is another example, which again is impossible with a join because it involves aggregating for one of the tables. It finds all rows in table `t1` containing a value that occurs twice in a given column:

```
SELECT * FROM t1 AS t
  WHERE 2 = (SELECT COUNT(*) FROM t1 WHERE t1.id = t.id);
```

For a comparison of the subquery to a scalar, the subquery must return a scalar. For a comparison of the subquery to a row constructor, the subquery must be a row subquery that returns a row with the same number of values as the row constructor. See Section 12.2.10.5, “Row Subqueries”.

12.2.10.3. Subqueries with `ANY`, `IN`, or `SOME`

Syntax:

```
operand comparison_operator ANY (subquery)
operand IN (subquery)
operand comparison_operator SOME (subquery)
```

Where *`comparison_operator`* is one of these operators:

```
=  >  <  >=  <=  <>  !=
```

The `ANY` keyword, which must follow a comparison operator, means “return `TRUE` if the comparison is `TRUE` for `ANY` of the values in the column that the subquery returns.” For example:

```
SELECT s1 FROM t1 WHERE s1 > ANY (SELECT s1 FROM t2);
```

Suppose that there is a row in table `t1` containing `(10)`. The expression is `TRUE` if table `t2` contains `(21,14,7)` because there is a value `7` in `t2` that is less than `10`. The expression is `FALSE` if table `t2` contains `(20,10)`, or if table `t2` is empty. The expression is *unknown* (that is, `NULL`) if table `t2` contains `(NULL,NULL,NULL)`.

When used with a subquery, the word `IN` is an alias for `= ANY`. Thus, these two statements are the same:

```
SELECT s1 FROM t1 WHERE s1 = ANY (SELECT s1 FROM t2);
SELECT s1 FROM t1 WHERE s1 IN    (SELECT s1 FROM t2);
```

`IN` and `= ANY` are not synonyms when used with an expression list. `IN` can take an expression list, but `= ANY` cannot. See Section 11.3.2, “Comparison Functions and Operators”.

`NOT IN` is not an alias for `<> ANY`, but for `<> ALL`. See Section 12.2.10.4, “Subqueries with `ALL`”.

The word `SOME` is an alias for `ANY`. Thus, these two statements are the same:

```
SELECT s1 FROM t1 WHERE s1 <> ANY  (SELECT s1 FROM t2);
SELECT s1 FROM t1 WHERE s1 <> SOME (SELECT s1 FROM t2);
```

Use of the word `SOME` is rare, but this example shows why it might be useful. To most people, the English phrase “a is not equal to any b” means “there is no b which is equal to a,” but that is not what is meant by the SQL syntax. The syntax means “there is some b to which a is not equal.” Using `<> SOME` instead helps ensure that everyone understands the true meaning of the query.

12.2.10.4. Subqueries with `ALL`

Syntax:

```
operand comparison_operator ALL (subquery)
```

The word `ALL`, which must follow a comparison operator, means “return `TRUE` if the comparison is `TRUE` for `ALL` of the values in the column that the subquery returns.” For example:

```
SELECT s1 FROM t1 WHERE s1 > ALL (SELECT s1 FROM t2);
```

Suppose that there is a row in table `t1` containing `(10)`. The expression is `TRUE` if table `t2` contains `(-5,0,+5)` because `10` is greater than all three values in `t2`. The expression is `FALSE` if table `t2` contains `(12,6,NULL,-100)` because there is a single value `12` in table `t2` that is greater than `10`. The expression is *unknown* (that is, `NULL`) if table `t2` contains `(0,NULL,1)`.

Finally, the expression is `TRUE` if table `t2` is empty. So, the following expression is `TRUE` when table `t2` is empty:

```
SELECT * FROM t1 WHERE 1 > ALL (SELECT s1 FROM t2);
```

But this expression is `NULL` when table `t2` is empty:

```
SELECT * FROM t1 WHERE 1 > (SELECT s1 FROM t2);
```

In addition, the following expression is `NULL` when table `t2` is empty:

```
SELECT * FROM t1 WHERE 1 > ALL (SELECT MAX(s1) FROM t2);
```

In general, *tables containing `NULL` values* and *empty tables* are “edge cases.” When writing subqueries, always consider whether you have taken those two possibilities into account.

`NOT IN` is an alias for `<> ALL`. Thus, these two statements are the same:

```
SELECT s1 FROM t1 WHERE s1 <> ALL (SELECT s1 FROM t2);
SELECT s1 FROM t1 WHERE s1 NOT IN (SELECT s1 FROM t2);
```

12.2.10.5. Row Subqueries

The discussion to this point has been of scalar or column subqueries; that is, subqueries that return a single value or a column of values. A *row subquery* is a subquery variant that returns a single row and can thus return more than one column value. Legal operators for row subquery comparisons are:

```
=  >  <  >=  <=  <>  !=  <=>
```

Here are two examples:

```
SELECT * FROM t1
  WHERE (col1,col2) = (SELECT col3, col4 FROM t2 WHERE id = 10);
SELECT * FROM t1
  WHERE ROW(col1,col2) = (SELECT col3, col4 FROM t2 WHERE id = 10);
```

For both queries, if the table `t2` contains a single row with `id = 10`, the subquery returns a single row. If this row has `col3` and `col4` values equal to the `col1` and `col2` values of any rows in `t1`, the `WHERE` expression is `TRUE` and each query returns those `t1` rows. If the `t2` row `col3` and `col4` values are not equal the `col1` and `col2` values of any `t1` row, the expression is `FALSE` and the query returns an empty result set. The expression is *unknown* (that is, `NULL`) if the subquery produces no rows. An error occurs if the subquery produces multiple rows because a row subquery can return at most one row.

The expressions `(1,2)` and `ROW(1,2)` are sometimes called *row constructors*. The two are equivalent. The row constructor and the row returned by the subquery must contain the same number of values.

A row constructor is used for comparisons with subqueries that return two or more columns. When a subquery returns a single column, this is regarded as a scalar value and not as a row, so a row constructor cannot be used with a subquery that does not return at least two columns. Thus, the following query fails with a syntax error:

```
SELECT * FROM t1 WHERE ROW(1) = (SELECT column1 FROM t2)
```

Row constructors are legal in other contexts. For example, the following two statements are semantically equivalent (and are handled in the same way by the optimizer):

```
SELECT * FROM t1 WHERE (column1,column2) = (1,1);
SELECT * FROM t1 WHERE column1 = 1 AND column2 = 1;
```

The following query answers the request, “find all rows in table `t1` that also exist in table `t2`”:

```
SELECT column1,column2,column3
  FROM t1
  WHERE (column1,column2,column3) IN
         (SELECT column1,column2,column3 FROM t2);
```

12.2.10.6. Subqueries with `EXISTS` or `NOT EXISTS`

If a subquery returns any rows at all, `EXISTS` *`subquery`* is `TRUE`, and `NOT EXISTS` *`subquery`* is `FALSE`. For example:

```
SELECT column1 FROM t1 WHERE EXISTS (SELECT * FROM t2);
```

Traditionally, an `EXISTS` subquery starts with `SELECT *`, but it could begin with `SELECT 5` or `SELECT column1` or anything at all. MySQL ignores the `SELECT` list in such a subquery, so it makes no difference.

For the preceding example, if `t2` contains any rows, even rows with nothing but `NULL` values, the `EXISTS` condition is `TRUE`. This is actually an unlikely example because a `[NOT] EXISTS` subquery almost always contains correlations. Here are some more realistic examples:

- What kind of store is present in one or more cities?

  ```
  SELECT DISTINCT store_type FROM stores
    WHERE EXISTS (SELECT * FROM cities_stores
                  WHERE cities_stores.store_type = stores.store_type);
  ```

- What kind of store is present in no cities?

  ```
  SELECT DISTINCT store_type FROM stores
    WHERE NOT EXISTS (SELECT * FROM cities_stores
                      WHERE cities_stores.store_type = stores.store_type);
  ```

- What kind of store is present in all cities?

  ```
  SELECT DISTINCT store_type FROM stores s1
    WHERE NOT EXISTS (
      SELECT * FROM cities WHERE NOT EXISTS (
        SELECT * FROM cities_stores
         WHERE cities_stores.city = cities.city
         AND cities_stores.store_type = stores.store_type));
  ```

The last example is a double-nested `NOT EXISTS` query. That is, it has a `NOT EXISTS` clause within a `NOT EXISTS` clause. Formally, it answers the question “does a city exist with a store that is not in `Stores`”? But it is easier to say that a nested `NOT EXISTS` answers the question “is *`x`* `TRUE` for all *`y`*?”

12.2.10.7. Correlated Subqueries

A *correlated subquery* is a subquery that contains a reference to a table that also appears in the outer query. For example:

```
SELECT * FROM t1
  WHERE column1 = ANY (SELECT column1 FROM t2
                       WHERE t2.column2 = t1.column2);
```

Notice that the subquery contains a reference to a column of `t1`, even though the subquery's `FROM` clause does not mention a table `t1`. So, MySQL looks outside the subquery, and finds `t1` in the outer query.

Suppose that table `t1` contains a row where `column1 = 5` and `column2 = 6`; meanwhile, table `t2` contains a row where `column1 = 5` and `column2 = 7`. The simple expression `... WHERE column1 = ANY (SELECT column1 FROM t2)` would be `TRUE`, but in this example, the `WHERE` clause within the subquery is `FALSE` (because `(5,6)` is not equal to `(5,7)`), so the expression as a whole is `FALSE`.

Scoping rule: MySQL evaluates from inside to outside. For example:

```
SELECT column1 FROM t1 AS x
  WHERE x.column1 = (SELECT column1 FROM t2 AS x
    WHERE x.column1 = (SELECT column1 FROM t3
      WHERE x.column2 = t3.column1));
```

In this statement, `x.column2` must be a column in table `t2` because `SELECT column1 FROM t2 AS x ...` renames `t2`. It is not a column in table `t1` because `SELECT column1 FROM t1 ...` is an outer query that is *farther out*.

For subqueries in `HAVING` or `ORDER BY` clauses, MySQL also looks for column names in the outer select list.

For certain cases, a correlated subquery is optimized. For example:

```
val IN (SELECT key_val FROM tbl_name WHERE correlated_condition)
```

Otherwise, they are inefficient and likely to be slow. Rewriting the query as a join might improve performance.

Aggregate functions in correlated subqueries may contain outer references, provided the function contains nothing but outer references, and provided the function is not contained in another function or expression.

12.2.10.8. Subqueries in the `FROM` Clause

Subqueries are legal in a `SELECT` statement's `FROM` clause. The actual syntax is:

```
SELECT ... FROM (subquery) [AS] name ...
```

The `[AS] name` clause is mandatory, because every table in a `FROM` clause must have a name. Any columns in the `subquery` select list must have unique names.

For the sake of illustration, assume that you have this table:

```
CREATE TABLE t1 (s1 INT, s2 CHAR(5), s3 FLOAT);
```

Here is how to use a subquery in the `FROM` clause, using the example table:

```
INSERT INTO t1 VALUES (1,'1',1.0);
INSERT INTO t1 VALUES (2,'2',2.0);
SELECT sb1,sb2,sb3
  FROM (SELECT s1 AS sb1, s2 AS sb2, s3*2 AS sb3 FROM t1) AS sb
  WHERE sb1 > 1;
```

Result: `2, '2', 4.0`.

Here is another example: Suppose that you want to know the average of a set of sums for a grouped table. This does not work:

```
SELECT AVG(SUM(column1)) FROM t1 GROUP BY column1;
```

However, this query provides the desired information:

```
SELECT AVG(sum_column1)
  FROM (SELECT SUM(column1) AS sum_column1
        FROM t1 GROUP BY column1) AS t1;
```

Notice that the column name used within the subquery (`sum_column1`) is recognized in the outer query.

Subqueries in the `FROM` clause can return a scalar, column, row, or table. Subqueries in the `FROM` clause cannot be correlated subqueries, unless used within the `ON` clause of a `JOIN` operation.

Subqueries in the `FROM` clause are executed even for the `EXPLAIN` statement (that is, derived temporary tables are built). This occurs because upper-level queries need information about all tables during the optimization phase, and the table represented by a subquery in the `FROM` clause is unavailable unless the subquery is executed.

It is possible under certain circumstances to modify table data using `EXPLAIN SELECT`. This can occur if the outer query accesses any tables and an inner query invokes a stored function that changes one or more rows of a table. Suppose that there are two tables `t1` and `t2` in database `d1`, created as shown here:

```
mysql> CREATE DATABASE d1;
Query OK, 1 row affected (0.00 sec)

mysql> USE d1;
Database changed

mysql> CREATE TABLE t1 (c1 INT);
Query OK, 0 rows affected (0.15 sec)

mysql> CREATE TABLE t2 (c1 INT);
Query OK, 0 rows affected (0.08 sec)
```

Now we create a stored function `f1` which modifies `t2`:

```
mysql> DELIMITER //
mysql> CREATE FUNCTION f1(p1 INT) RETURNS INT
mysql>   BEGIN
mysql>     INSERT INTO t2 VALUES (p1);
mysql>     RETURN p1;
mysql>   END //
Query OK, 0 rows affected (0.01 sec)

mysql> DELIMITER ;
```

Referencing the function directly in an `EXPLAIN SELECT` does not have any effect on `t2`, as shown here:

```
mysql> SELECT * FROM t2;
Empty set (0.00 sec)

mysql> EXPLAIN SELECT f1(5);
+----+-------------+-------+------+---------------+------+---------+------+------+----------------+
| id | select_type | table | type | possible_keys | key  | key_len | ref  | rows | Extra          |
+----+-------------+-------+------+---------------+------+---------+------+------+----------------+
|  1 | SIMPLE      | NULL  | NULL | NULL          | NULL | NULL    | NULL | NULL | No tables used |
+----+-------------+-------+------+---------------+------+---------+------+------+----------------+
1 row in set (0.00 sec)

mysql> SELECT * FROM t2;
Empty set (0.00 sec)
```

This is because the `SELECT` statement did not reference any tables, as can be seen in the `table` and `Extra` columns of the output. This is also true of the following nested `SELECT`:

```
mysql> EXPLAIN SELECT NOW() AS a1, (SELECT f1(5)) AS a2;
+----+-------------+-------+------+---------------+------+---------+------+------+----------------+
| id | select_type | table | type | possible_keys | key  | key_len | ref  | rows | Extra          |
+----+-------------+-------+------+---------------+------+---------+------+------+----------------+
|  1 | PRIMARY     | NULL  | NULL | NULL          | NULL | NULL    | NULL | NULL | No tables used |
+----+-------------+-------+------+---------------+------+---------+------+------+----------------+
1 row in set, 1 warning (0.00 sec)

mysql> SHOW WARNINGS;
+-------+------+------------------------------------------+
| Level | Code | Message                                  |
+-------+------+------------------------------------------+
| Note  | 1249 | Select 2 was reduced during optimization |
+-------+------+------------------------------------------+
1 row in set (0.00 sec)

mysql> SELECT * FROM t2;
Empty set (0.00 sec)
```

However, if the outer `SELECT` references any tables, the optimizer executes the statement in the subquery as well:

```
mysql> EXPLAIN SELECT * FROM t1 AS a1, (SELECT f1(5)) AS a2;
+----+-------------+------------+--------+---------------+------+---------+------+------+---------------------+
| id | select_type | table      | type   | possible_keys | key  | key_len | ref  | rows | Extra               |
+----+-------------+------------+--------+---------------+------+---------+------+------+---------------------+
|  1 | PRIMARY     | a1         | system | NULL          | NULL | NULL    | NULL |    0 | const row not found |
|  1 | PRIMARY     | <derived2> | system | NULL          | NULL | NULL    | NULL |    1 |                     |
|  2 | DERIVED     | NULL       | NULL   | NULL          | NULL | NULL    | NULL | NULL | No tables used      |
+----+-------------+------------+--------+---------------+------+---------+------+------+---------------------+
3 rows in set (0.00 sec)

mysql> SELECT * FROM t2;
+------+
| c1   |
+------+
|    5 |
+------+
1 row in set (0.00 sec)
```

This also means that an `EXPLAIN SELECT` statement such as the one shown here may take a long time to execute because the `BENCHMARK()` function is executed once for each row in `t1`:

```
EXPLAIN SELECT * FROM t1 AS a1, (SELECT BENCHMARK(1000000, MD5(NOW())));
```

12.2.10.9. Subquery Errors

There are some errors that apply only to subqueries. This section describes them.

- Unsupported subquery syntax:

  ```
  ERROR 1235 (ER_NOT_SUPPORTED_YET)
  SQLSTATE = 42000
  Message = "This version of MySQL doesn't yet support
  'LIMIT & IN/ALL/ANY/SOME subquery'"
  ```

  This means that MySQL does not support statements of the following form:

  ```
  SELECT * FROM t1 WHERE s1 IN (SELECT s2 FROM t2 ORDER BY s1 LIMIT 1)
  ```

- Incorrect number of columns from subquery:

  ```
  ERROR 1241 (ER_OPERAND_COL)
  SQLSTATE = 21000
  Message = "Operand should contain 1 column(s)"
  ```

  This error occurs in cases like this:

  ```
  SELECT (SELECT column1, column2 FROM t2) FROM t1;
  ```

  You may use a subquery that returns multiple columns, if the purpose is row comparison. In other contexts, the subquery must be a scalar operand. See Section 12.2.10.5, “Row Subqueries”.

- Incorrect number of rows from subquery:

  ```
  ERROR 1242 (ER_SUBSELECT_NO_1_ROW)
  SQLSTATE = 21000
  Message = "Subquery returns more than 1 row"
  ```

  This error occurs for statements where the subquery must return at most one row but returns multiple rows. Consider the following example:

  ```
  SELECT * FROM t1 WHERE column1 = (SELECT column1 FROM t2);
  ```

  If `SELECT column1 FROM t2` returns just one row, the previous query will work. If the subquery returns more than one row, error 1242 will occur. In that case, the query should be rewritten as:

  ```
  SELECT * FROM t1 WHERE column1 = ANY (SELECT column1 FROM t2);
  ```

- Incorrectly used table in subquery:

  ```
  Error 1093 (ER_UPDATE_TABLE_USED)
  SQLSTATE = HY000
  Message = "You can't specify target table 'x'
  for update in FROM clause"
  ```

  This error occurs in cases such as the following, which attempts to modify a table and select from the same table in the subquery:

  ```
  UPDATE t1 SET column2 = (SELECT MAX(column1) FROM t1);
  ```

  You can use a subquery for assignment within an `UPDATE` statement because subqueries are legal in `UPDATE` and `DELETE` statements as well as in `SELECT` statements. However, you cannot use the same table (in this case, table `t1`) for both the subquery `FROM` clause and the update target.

For transactional storage engines, the failure of a subquery causes the entire statement to fail. For nontransactional storage engines, data modifications made before the error was encountered are preserved.

12.2.10.10. Optimizing Subqueries

Development is ongoing, so no optimization tip is reliable for the long term. The following list provides some interesting tricks that you might want to play with:

- Use subquery clauses that affect the number or order of the rows in the subquery. For example:

  ```
  SELECT * FROM t1 WHERE t1.column1 IN
    (SELECT column1 FROM t2 ORDER BY column1);
  SELECT * FROM t1 WHERE t1.column1 IN
    (SELECT DISTINCT column1 FROM t2);
  SELECT * FROM t1 WHERE EXISTS
    (SELECT * FROM t2 LIMIT 1);
  ```

- Replace a join with a subquery. For example, try this:

  ```
  SELECT DISTINCT column1 FROM t1 WHERE t1.column1 IN (
    SELECT column1 FROM t2);
  ```

  Instead of this:

  ```
  SELECT DISTINCT t1.column1 FROM t1, t2
    WHERE t1.column1 = t2.column1;
  ```

- Some subqueries can be transformed to joins for compatibility with older versions of MySQL that do not support subqueries. However, in some cases, converting a subquery to a join may improve performance. See Section 12.2.10.11, “Rewriting Subqueries as Joins”.

- Move clauses from outside to inside the subquery. For example, use this query:

  ```
  SELECT * FROM t1
    WHERE s1 IN (SELECT s1 FROM t1 UNION ALL SELECT s1 FROM t2);
  ```

  Instead of this query:

  ```
  SELECT * FROM t1
    WHERE s1 IN (SELECT s1 FROM t1) OR s1 IN (SELECT s1 FROM t2);
  ```

  For another example, use this query:

  ```
  SELECT (SELECT column1 + 5 FROM t1) FROM t2;
  ```

  Instead of this query:

  ```
  SELECT (SELECT column1 FROM t1) + 5 FROM t2;
  ```

- Use a row subquery instead of a correlated subquery. For example, use this query:

  ```
  SELECT * FROM t1
    WHERE (column1,column2) IN (SELECT column1,column2 FROM t2);
  ```

  Instead of this query:

  ```
  SELECT * FROM t1
    WHERE EXISTS (SELECT * FROM t2 WHERE t2.column1=t1.column1
                  AND t2.column2=t1.column2);
  ```

- Use `NOT (a = ANY (...))` rather than `a <> ALL (...)`.

- Use `x = ANY (table containing (1,2))` rather than `x=1 OR x=2`.

- Use `= ANY` rather than `EXISTS`.

- For uncorrelated subqueries that always return one row, `IN` is always slower than `=`. For example, use this query:

  ```
  SELECT * FROM t1
    WHERE t1.col_name = (SELECT a FROM t2 WHERE b = some_const);
  ```

  Instead of this query:

```
SELECT * FROM t1
  WHERE t1.col_name IN (SELECT a FROM t2 WHERE b = some_const);
```

These tricks might cause programs to go faster or slower. Using MySQL facilities like the `BENCHMARK()` function, you can get an idea about what helps in your own situation. See Section 11.14, "Information Functions".

Some optimizations that MySQL itself makes are:

- MySQL executes uncorrelated subqueries only once. Use `EXPLAIN` to make sure that a given subquery really is uncorrelated.
- MySQL rewrites `IN`, `ALL`, `ANY`, and `SOME` subqueries in an attempt to take advantage of the possibility that the select-list columns in the subquery are indexed.
- MySQL replaces subqueries of the following form with an index-lookup function, which `EXPLAIN` describes as a special join type (`unique_subquery` or `index_subquery`):

  ```
  ... IN (SELECT indexed_column FROM single_table ...)
  ```

- MySQL enhances expressions of the following form with an expression involving `MIN()` or `MAX()`, unless `NULL` values or empty sets are involved:

  ```
  value {ALL|ANY|SOME} {> | < | >= | <=} (uncorrelated subquery)
  ```

  For example, this `WHERE` clause:

  ```
  WHERE 5 > ALL (SELECT x FROM t)
  ```

  might be treated by the optimizer like this:

  ```
  WHERE 5 > (SELECT MAX(x) FROM t)
  ```

See also the MySQL Internals Manual chapter How MySQL Transforms Subqueries.

12.2.10.11. Rewriting Subqueries as Joins

Sometimes there are other ways to test membership in a set of values than by using a subquery. Also, on some occasions, it is not only possible to rewrite a query without a subquery, but it can be more efficient to make use of some of these techniques rather than to use subqueries. One of these is the `IN()` construct:

For example, this query:

```
SELECT * FROM t1 WHERE id IN (SELECT id FROM t2);
```

Can be rewritten as:

```
SELECT DISTINCT t1.* FROM t1, t2 WHERE t1.id=t2.id;
```

The queries:

```
SELECT * FROM t1 WHERE id NOT IN (SELECT id FROM t2);
SELECT * FROM t1 WHERE NOT EXISTS (SELECT id FROM t2 WHERE t1.id=t2.id);
```

Can be rewritten as:

```
SELECT table1.*
  FROM table1 LEFT JOIN table2 ON table1.id=table2.id
  WHERE table2.id IS NULL;
```

A `LEFT [OUTER] JOIN` can be faster than an equivalent subquery because the server might be able to optimize it better—a fact that is not specific to MySQL Server alone. Prior to SQL-92, outer joins did not exist, so subqueries were the only way to do certain things. Today, MySQL Server and many other modern database systems offer a wide range of outer join types.

MySQL Server supports multiple-table `DELETE` statements that can be used to efficiently delete rows based on information from one table or even from many tables at the same time. Multiple-table `UPDATE` statements are also supported. See Section 12.2.2, `DELETE` Syntax”, and Section 12.2.11, “`UPDATE` Syntax”.

12.2.11. `UPDATE` Syntax

Single-table syntax:

```
UPDATE [LOW_PRIORITY] [IGNORE] table_reference
    SET col_name1={expr1|DEFAULT} [, col_name2={expr2|DEFAULT}] ...
    [WHERE where_condition]
    [ORDER BY ...]
    [LIMIT row_count]
```

Multiple-table syntax:

```
UPDATE [LOW_PRIORITY] [IGNORE] table_references
    SET col_name1={expr1|DEFAULT} [, col_name2={expr2|DEFAULT}] ...
    [WHERE where_condition]
```

For the single-table syntax, the `UPDATE` statement updates columns of existing rows in the named table with new values. The `SET` clause indicates which columns to modify and the values they should be given. Each value can be given as an expression, or the keyword `DEFAULT` to set a column explicitly to its default value. The `WHERE` clause, if given, specifies the conditions that identify which rows to update. With no `WHERE` clause, all rows are updated. If the `ORDER BY` clause is specified, the rows are updated in the order that is specified. The `LIMIT` clause places a limit on the number of rows that can be updated.

For the multiple-table syntax, `UPDATE` updates rows in each table named in *`table_references`* that satisfy the conditions. In this case, `ORDER BY` and `LIMIT` cannot be used.

`where_condition` is an expression that evaluates to true for each row to be updated. For expression syntax, see Section 8.5, “Expression Syntax”.

`table_references` and *`where_condition`* are is specified as described in Section 12.2.9, “`SELECT` Syntax”.

You need the `UPDATE` privilege only for columns referenced in an `UPDATE` that are actually updated. You need only the `SELECT` privilege for any columns that are read but not modified.

The `UPDATE` statement supports the following modifiers:

- With the `LOW_PRIORITY` keyword, execution of the `UPDATE` is delayed until no other clients are reading from the table. This affects only storage engines that use only table-level locking (such as `MyISAM`, `MEMORY`, and `MERGE`).
- With the `IGNORE` keyword, the update statement does not abort even if errors occur during the update. Rows for which duplicate-key conflicts occur are not updated. Rows for which columns are updated to values that would cause data conversion errors are updated to the closest valid values instead.

If you access a column from the table to be updated in an expression, `UPDATE` uses the current value of the column. For example, the following statement sets `col1` to one more than its current value:

```
UPDATE t1 SET col1 = col1 + 1;
```

The second assignment in the following statement sets `col2` to the current (updated) `col1` value, not the original `col1` value. The result is that `col1` and `col2` have the same value. This behavior differs from standard SQL.

```
UPDATE t1 SET col1 = col1 + 1, col2 = col1;
```

Single-table `UPDATE` assignments are generally evaluated from left to right. For multiple-table updates, there is no guarantee that assignments are carried out in any particular order.

If you set a column to the value it currently has, MySQL notices this and does not update it.

If you update a column that has been declared `NOT NULL` by setting to `NULL`, an error occurs if strict SQL mode is enabled; otherwise, the column is set to the implicit default value for the column data type and the warning count is incremented. The implicit default value is `0` for numeric types, the empty string (`''`) for string types, and the “zero” value for date and time types. See Section 10.1.4, “Data Type Default Values”.

`UPDATE` returns the number of rows that were actually changed. The `mysql_info()` C API function returns the number of rows that were matched and updated and the number of warnings that occurred during the `UPDATE`.

You can use `LIMIT` *`row_count`* to restrict the scope of the `UPDATE`. A `LIMIT` clause is a rows-matched restriction. The statement stops as soon as it has found *`row_count`* rows that satisfy the `WHERE` clause, whether or not they actually were changed.

If an `UPDATE` statement includes an `ORDER BY` clause, the rows are updated in the order specified by the clause. This can be useful in certain situations that might otherwise result in an error. Suppose that a table `t` contains a column `id` that has a unique index. The following statement could fail with a duplicate-key error, depending on the order in which rows are updated:

```
UPDATE t SET id = id + 1;
```

For example, if the table contains 1 and 2 in the `id` column and 1 is updated to 2 before 2 is updated to 3, an error occurs. To avoid this problem, add an `ORDER BY` clause to cause the rows with larger `id` values to be updated before those with smaller values:

```
UPDATE t SET id = id + 1 ORDER BY id DESC;
```

You can also perform `UPDATE` operations covering multiple tables. However, you cannot use `ORDER BY` or `LIMIT` with a multiple-table `UPDATE`. The *`table_references`* clause lists the tables involved in the join. Its syntax is described in Section 12.2.9.1, “`JOIN` Syntax”. Here is an example:

```
UPDATE items,month SET items.price=month.price
WHERE items.id=month.id;
```

The preceding example shows an inner join that uses the comma operator, but multiple-table `UPDATE` statements can use any type of join permitted in `SELECT` statements, such as `LEFT JOIN`.

If you use a multiple-table `UPDATE` statement involving `InnoDB` tables for which there are foreign key constraints, the MySQL optimizer might process tables in an order that differs from that of their parent/child relationship. In this case, the statement fails and rolls back. Instead, update a single table and rely on the `ON UPDATE` capabilities that `InnoDB` provides to cause the other tables to be modified accordingly. See Section 13.3.5.4, “`FOREIGN KEY` Constraints”.

Currently, you cannot update a table and select from the same table in a subquery.

Index hints (see Section 12.2.9.2, “Index Hint Syntax”) are accepted but ignored for `UPDATE` statements.

12.3. MySQL Transactional and Locking Statements

MySQL supports local transactions (within a given client session) through statements such as `SET autocommit`, `START TRANSACTION`, `COMMIT`, and `ROLLBACK`. See Section 12.3.1, “`START TRANSACTION`, `COMMIT`, and `ROLLBACK` Syntax”. XA transaction support enables MySQL to participate in distributed transactions as well. See Section 12.3.7, “XA Transactions”.

12.3.1. `START TRANSACTION`, `COMMIT`, and `ROLLBACK` Syntax

```
START TRANSACTION [WITH CONSISTENT SNAPSHOT] | BEGIN [WORK]
COMMIT [WORK] [AND [NO] CHAIN] [[NO] RELEASE]
ROLLBACK [WORK] [AND [NO] CHAIN] [[NO] RELEASE]
SET autocommit = {0 | 1}
```

The `START TRANSACTION` or `BEGIN` statement begins a new transaction. `COMMIT` commits the current transaction, making its changes permanent. `ROLLBACK` rolls back the current transaction, canceling its changes. The `SET autocommit` statement disables or enables the default autocommit mode for the current session.

The optional `WORK` keyword is supported for `COMMIT` and `ROLLBACK`, as are the `CHAIN` and `RELEASE` clauses. `CHAIN` and `RELEASE` can be used for additional control over transaction completion. The value of the `completion_type` system variable determines the default completion behavior. See Section 5.1.3, “Server System Variables”.

> **Note**
>
> Within all stored programs (stored procedures and functions, triggers, and events), the parser treats `BEGIN [WORK]` as the beginning of a `BEGIN ... END` block. Begin a transaction in this context with `START TRANSACTION` instead.

The `AND CHAIN` clause causes a new transaction to begin as soon as the current one ends, and the new transaction has the same isolation level as the just-terminated transaction. The `RELEASE` clause causes the server to disconnect the current client session after terminating the current transaction. Including the `NO` keyword suppresses `CHAIN` or `RELEASE` completion, which can be useful if the `completion_type` system variable is set to cause chaining or release completion by default.

By default, MySQL runs with autocommit mode enabled. This means that as soon as you execute a statement that updates (modifies) a table, MySQL stores the update on disk to make it permanent. To disable autocommit mode, use the following statement:

```
SET autocommit=0;
```

After disabling autocommit mode by setting the `autocommit` variable to zero, changes to transaction-safe tables (such as those for `InnoDB` or `NDBCLUSTER`) are not made permanent immediately. You must use `COMMIT` to store your changes to disk or `ROLLBACK` to ignore the changes.

`autocommit` is a session variable and must be set for each session. If you want to disable autocommit mode for each new connection, see the description of the `autocommit` system variable at Section 5.1.3, "Server System Variables".

To disable autocommit mode for a single series of statements, use the `START TRANSACTION` statement:

```
START TRANSACTION;
SELECT @A:=SUM(salary) FROM table1 WHERE type=1;
UPDATE table2 SET summary=@A WHERE type=1;
COMMIT;
```

With `START TRANSACTION`, autocommit remains disabled until you end the transaction with `COMMIT` or `ROLLBACK`. The autocommit mode then reverts to its previous state.

`BEGIN` and `BEGIN WORK` are supported as aliases of `START TRANSACTION` for initiating a transaction. `START TRANSACTION` is standard SQL syntax and is the recommended way to start an ad-hoc transaction.

> **Important**
>
> Many APIs used for writing MySQL client applications (such as JDBC) provide their own methods for starting transactions that can (and sometimes should) be used instead of sending a `START TRANSACTION` statement from the client. See Chapter 20, *Connectors and APIs*, or the documentation for your API, for more information.

The `BEGIN` statement differs from the use of the `BEGIN` keyword that starts a `BEGIN ... END` compound statement. The latter does not begin a transaction. See Section 12.7.1, "`BEGIN ... END` Compound Statement Syntax".

You can also begin a transaction like this:

```
START TRANSACTION WITH CONSISTENT SNAPSHOT;
```

The `WITH CONSISTENT SNAPSHOT` clause starts a consistent read for storage engines that are capable of it. This applies only to `InnoDB`. The effect is the same as issuing a `START TRANSACTION` followed by a `SELECT` from any `InnoDB` table. See Section 13.3.9.2, "Consistent Nonlocking Reads". The `WITH CONSISTENT SNAPSHOT` clause does not change the current transaction isolation level, so it provides a consistent snapshot only if the current isolation level is one that permits consistent read (`REPEATABLE READ` or `SERIALIZABLE`).

Beginning a transaction causes any pending transaction to be committed. See Section 12.3.3, "Statements That Cause an Implicit Commit", for more information.

Beginning a transaction also causes table locks acquired with `LOCK TABLES` to be released, as though you had executed `UNLOCK TABLES`. Beginning a transaction does not release a global read lock acquired with `FLUSH TABLES WITH READ LOCK`.

For best results, transactions should be performed using only tables managed by a single transaction-safe storage engine. Otherwise, the following problems can occur:

- If you use tables from more than one transaction-safe storage engine (such as `InnoDB`), and the transaction isolation level is not `SERIALIZABLE`, it is possible that when one transaction commits, another ongoing transaction that uses the same tables will see only some of the changes made by the first transaction. That is, the atomicity of transactions is not guaranteed with mixed engines and inconsistencies can result. (If mixed-engine transactions are infrequent, you can use `SET TRANSACTION ISOLATION LEVEL` to set the isolation level to `SERIALIZABLE` on a per-transaction basis as necessary.)
- If you use tables that are not transaction-safe within a transaction, changes to those tables are stored at once, regardless of the status of autocommit mode.
- If you issue a `ROLLBACK` statement after updating a nontransactional table within a transaction, an `ER_WARNING_NOT_COMPLETE_ROLLBACK` warning occurs. Changes to transaction-safe tables are rolled back, but not changes to nontransaction-safe tables.

Each transaction is stored in the binary log in one chunk, upon `COMMIT`. Transactions that are rolled back are not logged. (**Exception**: Modifications to nontransactional tables cannot be rolled back. If a transaction that is rolled back includes modifications to nontransactional tables, the entire transaction is logged with a `ROLLBACK` statement at the end to ensure that modifications to the nontransactional tables are replicated.) See Section 5.2.4, "The Binary Log".

You can change the isolation level for transactions with `SET TRANSACTION ISOLATION LEVEL`. See Section 12.3.6, "`SET TRANSACTION` Syntax".

Rolling back can be a slow operation that may occur implicitly without the user having explicitly asked for it (for example, when an error occurs). Because of this, `SHOW PROCESSLIST` displays `Rolling back` in the `State` column for the session, not only for explicit rollbacks performed with the `ROLLBACK` statement but also for implicit rollbacks.

> **Note**
>
> In MySQL 5.5, `BEGIN`, `COMMIT`, and `ROLLBACK` are not affected by `--replicate-do-db` or `--replicate-ignore-db` rules.

12.3.2. Statements That Cannot Be Rolled Back

Some statements cannot be rolled back. In general, these include data definition language (DDL) statements, such as those that create or drop databases, those that create, drop, or alter tables or stored routines.

You should design your transactions not to include such statements. If you issue a statement early in a transaction that cannot be rolled back, and then another statement later fails, the full effect of the transaction cannot be rolled back in such cases by issuing a `ROLLBACK` statement.

12.3.3. Statements That Cause an Implicit Commit

The statements listed in this section (and any synonyms for them) implicitly end a transaction, as if you had done a `COMMIT` before executing the statement. As of MySQL 5.5.3, most of these statements also cause an implicit commit after executing; for additional details, see the end of this section.

- **Data definition language (DDL) statements that define or modify database objects.** `ALTER DATABASE ... UPGRADE DATA DIRECTORY NAME`, `ALTER EVENT`, `ALTER PROCEDURE`, `ALTER TABLE`, `ALTER VIEW`, `CREATE DATABASE`, `CREATE EVENT`, `CREATE INDEX`, `CREATE PROCEDURE`, `CREATE TABLE`, `CREATE TRIGGER`, `CREATE VIEW`, `DROP DATABASE`, `DROP EVENT`, `DROP INDEX`, `DROP PROCEDURE`, `DROP TABLE`, `DROP TRIGGER`, `DROP VIEW`, `RENAME TABLE`, `TRUNCATE TABLE`.

  `ALTER FUNCTION`, `CREATE FUNCTION` and `DROP FUNCTION` also cause an implicit commit when used with stored functions, but not with UDFs. (`ALTER FUNCTION` can only be used with stored functions.)

  `ALTER TABLE`, `CREATE TABLE`, and `DROP TABLE` do not commit a transaction if the `TEMPORARY` keyword is used. (This does not apply to other operations on temporary tables such as `CREATE INDEX`, which do cause a commit.) However, although no implicit commit occurs, neither can the statement be rolled back. Therefore, use of such statements will violate transaction atomicity: For example, if you use `CREATE TEMPORARY TABLE` and then roll back the transaction, the table remains in existence.

  The `CREATE TABLE` statement in `InnoDB` is processed as a single transaction. This means that a `ROLLBACK` from the user does not undo `CREATE TABLE` statements the user made during that transaction.

  `CREATE TABLE ... SELECT` causes an implicit commit before and after the statement is executed when you are creating nontemporary tables. (No commit occurs for `CREATE TEMPORARY TABLE ... SELECT`.) This is to prevent an issue during replication where the table could be created on the master after a rollback, but fail to be recorded in the binary log, and therefore not replicated to the slave. For more information, see Bug #22865.

- **Statements that implicitly use or modify tables in the `mysql` database.** `CREATE USER`, `DROP USER`, `GRANT`, `RENAME USER`, `REVOKE`, `SET PASSWORD`.

- **Transaction-control and locking statements.** `BEGIN`, `LOCK TABLES`, `SET autocommit = 1` (if the value is not already 1), `START TRANSACTION`, `UNLOCK TABLES`.

  `UNLOCK TABLES` commits a transaction only if any tables currently have been locked with `LOCK TABLES` to acquire nontransactional table locks. A commit does not occur for `UNLOCK TABLES` following `FLUSH TABLES WITH READ LOCK` because the latter statement does not acquire table-level locks.

  Transactions cannot be nested. This is a consequence of the implicit commit performed for any current transaction when you issue a `START TRANSACTION` statement or one of its synonyms.

  Statements that cause an implicit commit cannot be used in an XA transaction while the transaction is in an `ACTIVE` state.

  The `BEGIN` statement differs from the use of the `BEGIN` keyword that starts a `BEGIN ... END` compound statement. The latter does not cause an implicit commit. See Section 12.7.1, “`BEGIN ... END` Compound Statement Syntax”.

- **Data loading statements.** `LOAD DATA INFILE`. `LOAD DATA INFILE` causes an implicit commit only for tables using the `NDB` storage engine. For more information, see Bug #11151.

- **Administrative statements.** `ANALYZE TABLE`, `CACHE INDEX`, `CHECK TABLE`, `LOAD INDEX INTO CACHE`, `OPTIM-`

`IZE TABLE`, `REPAIR TABLE`.

As of MySQL 5.5.3, most statements that previously caused an implicit commit before executing also do so after executing. The intent is to handle each such statement in its own special transaction because it cannot be rolled back anyway. The following list provides additional details pertaining to this change:

- The `CREATE TABLE` variants (`CREATE TABLE` for `InnoDB` tables and `CREATE TABLE ... SELECT`) that previously were special cases no longer are so because `CREATE TABLE` uniformly causes an implicit commit before and after executing.
- The `FLUSH` and `RESET` statements cause an implicit commit.
- Transaction-control and locking statements behave as before.

12.3.4. `SAVEPOINT` and `ROLLBACK TO SAVEPOINT` Syntax

```
SAVEPOINT identifier
ROLLBACK [WORK] TO [SAVEPOINT] identifier
RELEASE SAVEPOINT identifier
```

`InnoDB` supports the SQL statements `SAVEPOINT`, `ROLLBACK TO SAVEPOINT`, `RELEASE SAVEPOINT` and the optional `WORK` keyword for `ROLLBACK`.

The `SAVEPOINT` statement sets a named transaction savepoint with a name of *`identifier`*. If the current transaction has a savepoint with the same name, the old savepoint is deleted and a new one is set.

The `ROLLBACK TO SAVEPOINT` statement rolls back a transaction to the named savepoint without terminating the transaction. Modifications that the current transaction made to rows after the savepoint was set are undone in the rollback, but `InnoDB` does *not* release the row locks that were stored in memory after the savepoint. (For a new inserted row, the lock information is carried by the transaction ID stored in the row; the lock is not separately stored in memory. In this case, the row lock is released in the undo.) Savepoints that were set at a later time than the named savepoint are deleted.

If the `ROLLBACK TO SAVEPOINT` statement returns the following error, it means that no savepoint with the specified name exists:

```
ERROR 1305 (42000): SAVEPOINT identifier does not exist
```

The `RELEASE SAVEPOINT` statement removes the named savepoint from the set of savepoints of the current transaction. No commit or rollback occurs. It is an error if the savepoint does not exist.

All savepoints of the current transaction are deleted if you execute a `COMMIT`, or a `ROLLBACK` that does not name a savepoint.

A new savepoint level is created when a stored function is invoked or a trigger is activated. The savepoints on previous levels become unavailable and thus do not conflict with savepoints on the new level. When the function or trigger terminates, any savepoints it created are released and the previous savepoint level is restored.

12.3.5. `LOCK TABLES` and `UNLOCK TABLES` Syntax

```
LOCK TABLES
    tbl_name [[AS] alias] lock_type
    [, tbl_name [[AS] alias] lock_type] ...

lock_type:
    READ [LOCAL]
  | [LOW_PRIORITY] WRITE

UNLOCK TABLES
```

MySQL enables client sessions to acquire table locks explicitly for the purpose of cooperating with other sessions for access to tables, or to prevent other sessions from modifying tables during periods when a session requires exclusive access to them. A session can acquire or release locks only for itself. One session cannot acquire locks for another session or release locks held by another session.

Locks may be used to emulate transactions or to get more speed when updating tables. This is explained in more detail later in this section.

`LOCK TABLES` explicitly acquires table locks for the current client session. Table locks can be acquired for base tables or views. You must have the `LOCK TABLES` privilege, and the `SELECT` privilege for each object to be locked.

For view locking, `LOCK TABLES` adds all base tables used in the view to the set of tables to be locked and locks them automatically. If you lock a table explicitly with `LOCK TABLES`, any tables used in triggers are also locked implicitly, as described in Section 12.3.5.2, "`LOCK TABLES` and Triggers".

`UNLOCK TABLES` explicitly releases any table locks held by the current session.

Another use for `UNLOCK TABLES` is to release the global read lock acquired with the `FLUSH TABLES WITH READ LOCK` statement, which enables you to lock all tables in all databases. See Section 12.4.6.3, "`FLUSH` Syntax". (This is a very convenient way to get backups if you have a file system such as Veritas that can take snapshots in time.)

A table lock protects only against inappropriate reads or writes by other sessions. The session holding the lock, even a read lock, can perform table-level operations such as `DROP TABLE`. Truncate operations are not transaction-safe, so an error occurs if the session attempts one during an active transaction or while holding a table lock.

The following discussion applies only to non-`TEMPORARY` tables. `LOCK TABLES` is permitted (but ignored) for a `TEMPORARY` table. The table can be accessed freely by the session within which it was created, regardless of what other locking may be in effect. No lock is necessary because no other session can see the table.

For information about other conditions on the use of `LOCK TABLES` and statements that cannot be used while `LOCK TABLES` is in effect, see Section 12.3.5.3, "Table-Locking Restrictions and Conditions"

Rules for Lock Acquisition

To acquire table locks within the current session, use the `LOCK TABLES` statement. The following lock types are available:

`READ [LOCAL]` lock:

- The session that holds the lock can read the table (but not write it).
- Multiple sessions can acquire a `READ` lock for the table at the same time.
- Other sessions can read the table without explicitly acquiring a `READ` lock.
- The `LOCAL` modifier enables nonconflicting `INSERT` statements (concurrent inserts) by other sessions to execute while the lock is held. (See Section 7.10.3, "Concurrent Inserts".) However, `READ LOCAL` cannot be used if you are going to manipulate the database using processes external to the server while you hold the lock. For `InnoDB` tables, `READ LOCAL` is the same as `READ`.

`[LOW_PRIORITY] WRITE` lock:

- The session that holds the lock can read and write the table.
- Only the session that holds the lock can access the table. No other session can access it until the lock is released.
- Lock requests for the table by other sessions block while the `WRITE` lock is held.
- The `LOW_PRIORITY` modifier affects lock scheduling if the `WRITE` lock request must wait, as described later.

If the `LOCK TABLES` statement must wait due to locks held by other sessions on any of the tables, it blocks until all locks can be acquired.

A session that requires locks must acquire all the locks that it needs in a single `LOCK TABLES` statement. While the locks thus obtained are held, the session can access only the locked tables. For example, in the following sequence of statements, an error occurs for the attempt to access `t2` because it was not locked in the `LOCK TABLES` statement:

```
mysql> LOCK TABLES t1 READ;
mysql> SELECT COUNT(*) FROM t1;
+----------+
| COUNT(*) |
+----------+
|        3 |
+----------+
mysql> SELECT COUNT(*) FROM t2;
ERROR 1100 (HY000): Table 't2' was not locked with LOCK TABLES
```

Tables in the `INFORMATION_SCHEMA` database are an exception. They can be accessed without being locked explicitly even while a session holds table locks obtained with `LOCK TABLES`.

You cannot refer to a locked table multiple times in a single query using the same name. Use aliases instead, and obtain a separate lock for the table and each alias:

```
mysql> LOCK TABLE t WRITE, t AS t1 READ;
mysql> INSERT INTO t SELECT * FROM t;
ERROR 1100: Table 't' was not locked with LOCK TABLES
mysql> INSERT INTO t SELECT * FROM t AS t1;
```

The error occurs for the first `INSERT` because there are two references to the same name for a locked table. The second `INSERT` succeeds because the references to the table use different names.

If your statements refer to a table by means of an alias, you must lock the table using that same alias. It does not work to lock the table without specifying the alias:

```
mysql> LOCK TABLE t READ;
mysql> SELECT * FROM t AS myalias;
ERROR 1100: Table 'myalias' was not locked with LOCK TABLES
```

Conversely, if you lock a table using an alias, you must refer to it in your statements using that alias:

```
mysql> LOCK TABLE t AS myalias READ;
mysql> SELECT * FROM t;
ERROR 1100: Table 't' was not locked with LOCK TABLES
mysql> SELECT * FROM t AS myalias;
```

`WRITE` locks normally have higher priority than `READ` locks to ensure that updates are processed as soon as possible. This means that if one session obtains a `READ` lock and then another session requests a `WRITE` lock, subsequent `READ` lock requests wait until the session that requested the `WRITE` lock has obtained the lock and released it. A request for a `LOW_PRIORITY WRITE` lock, by contrast, permits subsequent `READ` lock requests by other sessions to be satisfied first if they occur while the `LOW_PRIORITY WRITE` request is waiting. You should use `LOW_PRIORITY WRITE` locks only if you are sure that eventually there will be a time when no sessions have a `READ` lock. For `InnoDB` tables in transactional mode (autocommit = 0), a waiting `LOW_PRIORITY WRITE` lock acts like a regular `WRITE` lock and causes subsequent `READ` lock requests to wait.

`LOCK TABLES` acquires locks as follows:

1. Sort all tables to be locked in an internally defined order. From the user standpoint, this order is undefined.
2. If a table is to be locked with a read and a write lock, put the write lock request before the read lock request.
3. Lock one table at a time until the session gets all locks.

This policy ensures that table locking is deadlock free. There are, however, other things you need to be aware of about this policy: If you are using a `LOW_PRIORITY WRITE` lock for a table, it means only that MySQL waits for this particular lock until there are no other sessions that want a `READ` lock. When the session has gotten the `WRITE` lock and is waiting to get the lock for the next table in the lock table list, all other sessions wait for the `WRITE` lock to be released. If this becomes a serious problem with your application, you should consider converting some of your tables to transaction-safe tables.

Rules for Lock Release

When the table locks held by a session are released, they are all released at the same time. A session can release its locks explicitly, or locks may be released implicitly under certain conditions.

- A session can release its locks explicitly with `UNLOCK TABLES`.
- If a session issues a `LOCK TABLES` statement to acquire a lock while already holding locks, its existing locks are released implicitly before the new locks are granted.
- If a session begins a transaction (for example, with `START TRANSACTION`), an implicit `UNLOCK TABLES` is performed, which causes existing locks to be released. (For additional information about the interaction between table locking and transactions, see Section 12.3.5.1, “Interaction of Table Locking and Transactions”.)

If the connection for a client session terminates, whether normally or abnormally, the server implicitly releases all table locks held by the session (transactional and nontransactional). If the client reconnects, the locks will no longer be in effect. In addition, if the client had an active transaction, the server rolls back the transaction upon disconnect, and if reconnect occurs, the new session begins with autocommit enabled. For this reason, clients may wish to disable auto-reconnect. With auto-reconnect in effect, the client is not notified if reconnect occurs but any table locks or current transaction will have been lost. With auto-reconnect disabled, if the connection drops, an error occurs for the next statement issued. The client can detect the error and take appropriate action such as reacquiring the locks or redoing the transaction. See Section 20.9.12, “Controlling Automatic Reconnection Behavior”.

> **Note**
>
> If you use `ALTER TABLE` on a locked table, it may become unlocked. For example, if you attempt a second `ALTER TABLE` operation, the result may be an error `Table 'tbl_name' was not locked with LOCK TABLES`. To handle this, lock the table again prior to the second alteration. See also Section C.5.7.1, "Problems with `ALTER TABLE`".

12.3.5.1. Interaction of Table Locking and Transactions

`LOCK TABLES` and `UNLOCK TABLES` interact with the use of transactions as follows:

- `LOCK TABLES` is not transaction-safe and implicitly commits any active transaction before attempting to lock the tables.
- `UNLOCK TABLES` implicitly commits any active transaction, but only if `LOCK TABLES` has been used to acquire table locks. For example, in the following set of statements, `UNLOCK TABLES` releases the global read lock but does not commit the transaction because no table locks are in effect:

  ```
  FLUSH TABLES WITH READ LOCK;
  START TRANSACTION;
  SELECT ... ;
  UNLOCK TABLES;
  ```

- Beginning a transaction (for example, with `START TRANSACTION`) implicitly commits any current transaction and releases existing locks.
- Other statements that implicitly cause transactions to be committed do not release existing locks. For a list of such statements, see Section 12.3.3, "Statements That Cause an Implicit Commit".
- The correct way to use `LOCK TABLES` and `UNLOCK TABLES` with transactional tables, such as `InnoDB` tables, is to begin a transaction with `SET autocommit = 0` (not `START TRANSACTION`) followed by `LOCK TABLES`, and to not call `UNLOCK TABLES` until you commit the transaction explicitly. For example, if you need to write to table `t1` and read from table `t2`, you can do this:

  ```
  SET autocommit=0;
  LOCK TABLES t1 WRITE, t2 READ, ...;
  ... do something with tables t1 and t2 here ...
  COMMIT;
  UNLOCK TABLES;
  ```

  When you call `LOCK TABLES`, `InnoDB` internally takes its own table lock, and MySQL takes its own table lock. `InnoDB` releases its internal table lock at the next commit, but for MySQL to release its table lock, you have to call `UNLOCK TABLES`. You should not have `autocommit = 1`, because then `InnoDB` releases its internal table lock immediately after the call of `LOCK TABLES`, and deadlocks can very easily happen. `InnoDB` does not acquire the internal table lock at all if `autocommit = 1`, to help old applications avoid unnecessary deadlocks.
- `ROLLBACK` does not release table locks.
- `FLUSH TABLES WITH READ LOCK` acquires a global read lock and not table locks, so it is not subject to the same behavior as `LOCK TABLES` and `UNLOCK TABLES` with respect to table locking and implicit commits. See Section 12.4.6.3, "`FLUSH` Syntax".

12.3.5.2. `LOCK TABLES` and Triggers

If you lock a table explicitly with `LOCK TABLES`, any tables used in triggers are also locked implicitly:

- The locks are taken as the same time as those acquired explicitly with the `LOCK TABLES` statement.
- The lock on a table used in a trigger depends on whether the table is used only for reading. If so, a read lock suffices. Otherwise, a write lock is used.
- If a table is locked explicitly for reading with `LOCK TABLES`, but needs to be locked for writing because it might be modified within a trigger, a write lock is taken rather than a read lock. (That is, an implicit write lock needed due to the table's appearance within a trigger causes an explicit read lock request for the table to be converted to a write lock request.)

Suppose that you lock two tables, `t1` and `t2`, using this statement:

```
LOCK TABLES t1 WRITE, t2 READ;
```

If `t1` or `t2` have any triggers, tables used within the triggers will also be locked. Suppose that `t1` has a trigger defined like this:

```
CREATE TRIGGER t1_a_ins AFTER INSERT ON t1 FOR EACH ROW
BEGIN
  UPDATE t4 SET count = count+1
      WHERE id = NEW.id AND EXISTS (SELECT a FROM t3);
  INSERT INTO t2 VALUES(1, 2);
END;
```

The result of the `LOCK TABLES` statement is that `t1` and `t2` are locked because they appear in the statement, and `t3` and `t4` are locked because they are used within the trigger:

- `t1` is locked for writing per the `WRITE` lock request.
- `t2` is locked for writing, even though the request is for a `READ` lock. This occurs because `t2` is inserted into within the trigger, so the `READ` request is converted to a `WRITE` request.
- `t3` is locked for reading because it is only read from within the trigger.
- `t4` is locked for writing because it might be updated within the trigger.

12.3.5.3. Table-Locking Restrictions and Conditions

You can safely use `KILL` to terminate a session that is waiting for a table lock. See Section 12.4.6.4, “`KILL` Syntax”.

You should *not* lock any tables that you are using with `INSERT DELAYED`. An `INSERT DELAYED` in this case results in an error because the insert must be handled by a separate thread, not by the session which holds the lock.

`LOCK TABLES` and `UNLOCK TABLES` cannot be used within stored programs.

Tables in the `performance_schema` database cannot be locked with `LOCK TABLES`, except the `SETUP_`*`xxx`* tables.

The following statements are prohibited while a `LOCK TABLES` statement is in effect:

- As of MySQL 5.5.3, `CREATE TABLE`, `CREATE TABLE ... LIKE`, `CREATE VIEW`, `DROP VIEW`, and DDL statements on stored procedures and functions.
- As of MySQL 5.5.8, DDL statements on events

For some operations, system tables in the `mysql` database must be accessed. For example, the `HELP` statement requires the contents of the server-side help tables, and `CONVERT_TZ()` might need to read the time zone tables. The server implicitly locks the system tables for reading as necessary so that you need not lock them explicitly. These tables are treated as just described:

```
mysql.help_category
mysql.help_keyword
mysql.help_relation
mysql.help_topic
mysql.proc
mysql.time_zone
mysql.time_zone_leap_second
mysql.time_zone_name
mysql.time_zone_transition
mysql.time_zone_transition_type
```

If you want to explicitly place a `WRITE` lock on any of those tables with a `LOCK TABLES` statement, the table must be the only one locked; no other table can be locked with the same statement.

Normally, you do not need to lock tables, because all single `UPDATE` statements are atomic; no other session can interfere with any other currently executing SQL statement. However, there are a few cases when locking tables may provide an advantage:

- If you are going to run many operations on a set of `MyISAM` tables, it is much faster to lock the tables you are going to use. Locking `MyISAM` tables speeds up inserting, updating, or deleting on them because MySQL does not flush the key cache for the locked tables until `UNLOCK TABLES` is called. Normally, the key cache is flushed after each SQL statement.

  The downside to locking the tables is that no session can update a `READ`-locked table (including the one holding the lock) and no session can access a `WRITE`-locked table other than the one holding the lock.
- If you are using tables for a nontransactional storage engine, you must use `LOCK TABLES` if you want to ensure that no other session modifies the tables between a `SELECT` and an `UPDATE`. The example shown here requires `LOCK TABLES` to execute

safely:

```
LOCK TABLES trans READ, customer WRITE;
SELECT SUM(value) FROM trans WHERE customer_id=some_id;
UPDATE customer
  SET total_value=sum_from_previous_statement
  WHERE customer_id=some_id;
UNLOCK TABLES;
```

Without `LOCK TABLES`, it is possible that another session might insert a new row in the `trans` table between execution of the `SELECT` and `UPDATE` statements.

You can avoid using `LOCK TABLES` in many cases by using relative updates (`UPDATE customer SET value=value+new_value`) or the `LAST_INSERT_ID()` function. See Section 1.8.5.3, “Transaction and Atomic Operation Differences”.

You can also avoid locking tables in some cases by using the user-level advisory lock functions `GET_LOCK()` and `RELEASE_LOCK()`. These locks are saved in a hash table in the server and implemented with `pthread_mutex_lock()` and `pthread_mutex_unlock()` for high speed. See Section 11.15, “Miscellaneous Functions”.

See Section 7.10.1, “Internal Locking Methods”, for more information on locking policy.

12.3.6. `SET TRANSACTION` Syntax

```
SET [GLOBAL | SESSION] TRANSACTION ISOLATION LEVEL
  {
       READ UNCOMMITTED
     | READ COMMITTED
     | REPEATABLE READ
     | SERIALIZABLE
   }
```

This statement sets the transaction isolation level globally, for the current session, or for the next transaction:

- With the `GLOBAL` keyword, the statement sets the default transaction level globally for all subsequent sessions. Existing sessions are unaffected.
- With the `SESSION` keyword, the statement sets the default transaction level for all subsequent transactions performed within the current session.
- Without any `SESSION` or `GLOBAL` keyword, the statement sets the isolation level for the next (not started) transaction performed within the current session.

A change to the global default isolation level requires the `SUPER` privilege. Any session is free to change its session isolation level (even in the middle of a transaction), or the isolation level for its next transaction.

`SET TRANSACTION ISOLATION LEVEL` without `GLOBAL` or `SESSION` is not permitted while there is an active transaction:

```
mysql> START TRANSACTION;
Query OK, 0 rows affected (0.02 sec)

mysql> SET TRANSACTION ISOLATION LEVEL SERIALIZABLE;
ERROR 1568 (25001): Transaction isolation level can't be changed
while a transaction is in progress
```

To set the global default isolation level at server startup, use the `--transaction-isolation=level` option to `mysqld` on the command line or in an option file. Values of `level` for this option use dashes rather than spaces, so the permissible values are `READ-UNCOMMITTED`, `READ-COMMITTED`, `REPEATABLE-READ`, or `SERIALIZABLE`. For example, to set the default isolation level to `REPEATABLE READ`, use these lines in the `[mysqld]` section of an option file:

```
[mysqld]
transaction-isolation = REPEATABLE-READ
```

To determine the global and session transaction isolation levels at runtime, check the value of the `tx_isolation` system variable:

```
SELECT @@GLOBAL.tx_isolation, @@tx_isolation;
```

`InnoDB` supports each of the transaction isolation levels described here using different locking strategies. The default level is `REPEATABLE READ`. For additional information about `InnoDB` record-level locks and how it uses them to execute various types of statements, see Section 13.3.9.4, “`InnoDB` Record, Gap, and Next-Key Locks”, and Section 13.3.9.6, “Locks Set by Different SQL Statements in `InnoDB`”.

The following list describes how MySQL supports the different transaction levels:

- `READ UNCOMMITTED`

  `SELECT` statements are performed in a nonlocking fashion, but a possible earlier version of a row might be used. Thus, using this isolation level, such reads are not consistent. This is also called a “dirty read.” Otherwise, this isolation level works like `READ COMMITTED`.

- `READ COMMITTED`

  A somewhat Oracle-like isolation level with respect to consistent (nonlocking) reads: Each consistent read, even within the same transaction, sets and reads its own fresh snapshot. See Section 13.3.9.2, “Consistent Nonlocking Reads”.

  For locking reads (`SELECT` with `FOR UPDATE` or `LOCK IN SHARE MODE`), `InnoDB` locks only index records, not the gaps before them, and thus permits the free insertion of new records next to locked records. For `UPDATE` and `DELETE` statements, locking depends on whether the statement uses a unique index with a unique search condition (such as `WHERE id = 100`), or a range-type search condition (such as `WHERE id > 100`). For a unique index with a unique search condition, `InnoDB` locks only the index record found, not the gap before it. For range-type searches, `InnoDB` locks the index range scanned, using gap locks or next-key (gap plus index-record) locks to block insertions by other sessions into the gaps covered by the range. This is necessary because “phantom rows” must be blocked for MySQL replication and recovery to work.

  > **Note**
  >
  > In MySQL 5.5, if the `READ COMMITTED` isolation level is used or the `innodb_locks_unsafe_for_binlog` system variable is enabled, there is no `InnoDB` gap locking except for foreign-key constraint checking and duplicate-key checking. Also, record locks for nonmatching rows are released after MySQL has evaluated the `WHERE` condition.
  >
  > If you use `READ COMMITTED` or enable `innodb_locks_unsafe_for_binlog`, you *must* use row-based binary logging.

- `REPEATABLE READ`

  This is the default isolation level for `InnoDB`. For consistent reads, there is an important difference from the `READ COMMITTED` isolation level: All consistent reads within the same transaction read the snapshot established by the first read. This convention means that if you issue several plain (nonlocking) `SELECT` statements within the same transaction, these `SELECT` statements are consistent also with respect to each other. See Section 13.3.9.2, “Consistent Nonlocking Reads”.

  For locking reads (`SELECT` with `FOR UPDATE` or `LOCK IN SHARE MODE`), `UPDATE`, and `DELETE` statements, locking depends on whether the statement uses a unique index with a unique search condition, or a range-type search condition. For a unique index with a unique search condition, `InnoDB` locks only the index record found, not the gap before it. For other search conditions, `InnoDB` locks the index range scanned, using gap locks or next-key (gap plus index-record) locks to block insertions by other sessions into the gaps covered by the range.

- `SERIALIZABLE`

  This level is like `REPEATABLE READ`, but `InnoDB` implicitly converts all plain `SELECT` statements to `SELECT ... LOCK IN SHARE MODE` if autocommit is disabled. If autocommit is enabled, the `SELECT` is its own transaction. It therefore is known to be read only and can be serialized if performed as a consistent (nonlocking) read and need not block for other transactions. (This means that to force a plain `SELECT` to block if other transactions have modified the selected rows, you should disable autocommit.)

12.3.7. XA Transactions

Support for XA transactions is available for the `InnoDB` storage engine. The MySQL XA implementation is based on the X/Open CAE document *Distributed Transaction Processing: The XA Specification*. This document is published by The Open Group and available at http://www.opengroup.org/public/pubs/catalog/c193.htm. Limitations of the current XA implementation are described in Section E.6, “Restrictions on XA Transactions”.

On the client side, there are no special requirements. The XA interface to a MySQL server consists of SQL statements that begin with the `XA` keyword. MySQL client programs must be able to send SQL statements and to understand the semantics of the XA statement interface. They do not need be linked against a recent client library. Older client libraries also will work.

Currently, among the MySQL Connectors, MySQL Connector/J 5.0.0 supports XA directly (by means of a class interface that handles the Xan SQL statement interface for you).

XA supports distributed transactions; that is, the ability to permit multiple separate transactional resources to participate in a global transaction. Transactional resources often are RDBMSs but may be other kinds of resources.

A global transaction involves several actions that are transactional in themselves, but that all must either complete successfully as a group, or all be rolled back as a group. In essence, this extends ACID properties “up a level” so that multiple ACID transactions can be executed in concert as components of a global operation that also has ACID properties. (However, for a distributed transaction, you must use the `SERIALIZABLE` isolation level to achieve ACID properties. It is enough to use `REPEATABLE READ` for a nondistributed transaction, but not for a distributed transaction.)

Some examples of distributed transactions:

- An application may act as an integration tool that combines a messaging service with an RDBMS. The application makes sure that transactions dealing with message sending, retrieval, and processing that also involve a transactional database all happen in a global transaction. You can think of this as “transactional email.”
- An application performs actions that involve different database servers, such as a MySQL server and an Oracle server (or multiple MySQL servers), where actions that involve multiple servers must happen as part of a global transaction, rather than as separate transactions local to each server.
- A bank keeps account information in an RDBMS and distributes and receives money through automated teller machines (ATMs). It is necessary to ensure that ATM actions are correctly reflected in the accounts, but this cannot be done with the RDBMS alone. A global transaction manager integrates the ATM and database resources to ensure overall consistency of financial transactions.

Applications that use global transactions involve one or more Resource Managers and a Transaction Manager:

- A Resource Manager (RM) provides access to transactional resources. A database server is one kind of resource manager. It must be possible to either commit or roll back transactions managed by the RM.
- A Transaction Manager (TM) coordinates the transactions that are part of a global transaction. It communicates with the RMs that handle each of these transactions. The individual transactions within a global transaction are “branches” of the global transaction. Global transactions and their branches are identified by a naming scheme described later.

The MySQL implementation of XA MySQL enables a MySQL server to act as a Resource Manager that handles XA transactions within a global transaction. A client program that connects to the MySQL server acts as the Transaction Manager.

To carry out a global transaction, it is necessary to know which components are involved, and bring each component to a point when it can be committed or rolled back. Depending on what each component reports about its ability to succeed, they must all commit or roll back as an atomic group. That is, either all components must commit, or all components must roll back. To manage a global transaction, it is necessary to take into account that any component or the connecting network might fail.

The process for executing a global transaction uses two-phase commit (2PC). This takes place after the actions performed by the branches of the global transaction have been executed.

1. In the first phase, all branches are prepared. That is, they are told by the TM to get ready to commit. Typically, this means each RM that manages a branch records the actions for the branch in stable storage. The branches indicate whether they are able to do this, and these results are used for the second phase.
2. In the second phase, the TM tells the RMs whether to commit or roll back. If all branches indicated when they were prepared that they will be able to commit, all branches are told to commit. If any branch indicated when it was prepared that it will not be able to commit, all branches are told to roll back.

In some cases, a global transaction might use one-phase commit (1PC). For example, when a Transaction Manager finds that a global transaction consists of only one transactional resource (that is, a single branch), that resource can be told to prepare and commit at the same time.

12.3.7.1. XA Transaction SQL Syntax

To perform XA transactions in MySQL, use the following statements:

```
XA {START|BEGIN} xid [JOIN|RESUME]

XA END xid [SUSPEND [FOR MIGRATE]]

XA PREPARE xid

XA COMMIT xid [ONE PHASE]
XA ROLLBACK xid

XA RECOVER
```

For `XA START`, the `JOIN` and `RESUME` clauses are not supported.

For `XA END` the `SUSPEND [FOR MIGRATE]` clause is not supported.

Each XA statement begins with the `XA` keyword, and most of them require an *`xid`* value. An *`xid`* is an XA transaction identifier. It indicates which transaction the statement applies to. *`xid`* values are supplied by the client, or generated by the MySQL server. An *`xid`* value has from one to three parts:

```
xid: gtrid [, bqual [, formatID ]]
```

`gtrid` is a global transaction identifier, *`bqual`* is a branch qualifier, and *`formatID`* is a number that identifies the format used by the *`gtrid`* and *`bqual`* values. As indicated by the syntax, *`bqual`* and *`formatID`* are optional. The default *`bqual`* value is `''` if not given. The default *`formatID`* value is 1 if not given.

`gtrid` and *`bqual`* must be string literals, each up to 64 bytes (not characters) long. *`gtrid`* and *`bqual`* can be specified in several ways. You can use a quoted string (`'ab'`), hex string (`0x6162`, `X'ab'`), or bit value (`b'nnnn'`).

`formatID` is an unsigned integer.

The *`gtrid`* and *`bqual`* values are interpreted in bytes by the MySQL server's underlying XA support routines. However, while an SQL statement containing an XA statement is being parsed, the server works with some specific character set. To be safe, write *`gtrid`* and *`bqual`* as hex strings.

`xid` values typically are generated by the Transaction Manager. Values generated by one TM must be different from values generated by other TMs. A given TM must be able to recognize its own *`xid`* values in a list of values returned by the `XA RECOVER` statement.

`XA START xid` starts an XA transaction with the given *`xid`* value. Each XA transaction must have a unique *`xid`* value, so the value must not currently be used by another XA transaction. Uniqueness is assessed using the *`gtrid`* and *`bqual`* values. All following XA statements for the XA transaction must be specified using the same *`xid`* value as that given in the `XA START` statement. If you use any of those statements but specify an *`xid`* value that does not correspond to some existing XA transaction, an error occurs.

One or more XA transactions can be part of the same global transaction. All XA transactions within a given global transaction must use the same *`gtrid`* value in the *`xid`* value. For this reason, *`gtrid`* values must be globally unique so that there is no ambiguity about which global transaction a given XA transaction is part of. The *`bqual`* part of the *`xid`* value must be different for each XA transaction within a global transaction. (The requirement that *`bqual`* values be different is a limitation of the current MySQL XA implementation. It is not part of the XA specification.)

The `XA RECOVER` statement returns information for those XA transactions on the MySQL server that are in the `PREPARED` state. (See Section 12.3.7.2, “XA Transaction States”.) The output includes a row for each such XA transaction on the server, regardless of which client started it.

`XA RECOVER` output rows look like this (for an example *`xid`* value consisting of the parts `'abc'`, `'def'`, and `7`):

```
mysql> XA RECOVER;
+----------+--------------+--------------+--------+
| formatID | gtrid_length | bqual_length | data   |
+----------+--------------+--------------+--------+
|        7 |            3 |            3 | abcdef |
+----------+--------------+--------------+--------+
```

The output columns have the following meanings:

- `formatID` is the *`formatID`* part of the transaction *`xid`*
- `gtrid_length` is the length in bytes of the *`gtrid`* part of the *`xid`*
- `bqual_length` is the length in bytes of the *`bqual`* part of the *`xid`*
- `data` is the concatenation of the *`gtrid`* and *`bqual`* parts of the *`xid`*

12.3.7.2. XA Transaction States

An XA transaction progresses through the following states:

1. Use `XA START` to start an XA transaction and put it in the `ACTIVE` state.
2. For an `ACTIVE` XA transaction, issue the SQL statements that make up the transaction, and then issue an `XA END` statement. `XA END` puts the transaction in the `IDLE` state.
3. For an `IDLE` XA transaction, you can issue either an `XA PREPARE` statement or an `XA COMMIT ... ONE PHASE` statement:
    - `XA PREPARE` puts the transaction in the `PREPARED` state. An `XA RECOVER` statement at this point will include the transaction's *`xid`* value in its output, because `XA RECOVER` lists all XA transactions that are in the `PREPARED` state.
    - `XA COMMIT ... ONE PHASE` prepares and commits the transaction. The *`xid`* value will not be listed by `XA RECOVER` because the transaction terminates.
4. For a `PREPARED` XA transaction, you can issue an `XA COMMIT` statement to commit and terminate the transaction, or `XA ROLLBACK` to roll back and terminate the transaction.

Here is a simple XA transaction that inserts a row into a table as part of a global transaction:

```
mysql> XA START 'xatest';
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO mytable (i) VALUES(10);
Query OK, 1 row affected (0.04 sec)

mysql> XA END 'xatest';
Query OK, 0 rows affected (0.00 sec)

mysql> XA PREPARE 'xatest';
Query OK, 0 rows affected (0.00 sec)

mysql> XA COMMIT 'xatest';
Query OK, 0 rows affected (0.00 sec)
```

Within the context of a given client connection, XA transactions and local (non-XA) transactions are mutually exclusive. For example, if `XA START` has been issued to begin an XA transaction, a local transaction cannot be started until the XA transaction has been committed or rolled back. Conversely, if a local transaction has been started with `START TRANSACTION`, no XA statements can be used until the transaction has been committed or rolled back.

Note that if an XA transaction is in the `ACTIVE` state, you cannot issue any statements that cause an implicit commit. That would violate the XA contract because you could not roll back the XA transaction. You will receive the following error if you try to execute such a statement:

```
ERROR 1399 (XAE07): XAER_RMFAIL: The command cannot be executed
when global transaction is in the ACTIVE state
```

Statements to which the preceding remark applies are listed at Section 12.3.3, “Statements That Cause an Implicit Commit”.

12.4. Database Administration Statements

12.4.1. Account Management Statements

MySQL account information is stored in the tables of the `mysql` database. This database and the access control system are discussed extensively in Chapter 5, *MySQL Server Administration*, which you should consult for additional details.

> **Important**
>
> Some releases of MySQL introduce changes to the structure of the grant tables to add new privileges or features. Whenever you update to a new version of MySQL, you should update your grant tables to make sure that they have the current structure so that you can take advantage of any new capabilities. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

12.4.1.1. `CREATE USER` Syntax

```
CREATE USER user_specification
    [, user_specification] ...

user_specification:
    user
    [
        IDENTIFIED BY [PASSWORD] 'password'
      | IDENTIFIED WITH auth_plugin [AS 'auth_string']
    ]
```

The `CREATE USER` statement creates new MySQL accounts. To use it, you must have the global `CREATE USER` privilege or the `INSERT` privilege for the `mysql` database. For each account, `CREATE USER` creates a new row in the `mysql.user` table and assigns the account no privileges. An error occurs if the account already exists.

Each account name uses the format described in Section 5.4.3, “Specifying Account Names”. For example:

```
CREATE USER 'jeffrey'@'localhost' IDENTIFIED BY 'mypass';
```

If you specify only the user name part of the account name, a host name part of `'%'` is used.

The user specification may indicate how the user should authenticate when connecting to the server:

- To enable the user to connect with no password (which is *insecure*), include no `IDENTIFIED BY` clause:

  ```
  CREATE USER 'jeffrey'@'localhost';
  ```

  In this case, the server uses built-in authentication and clients must provide no password.

- To assign a password, use `IDENTIFIED BY` with the literal plaintext password value:

  ```
  CREATE USER 'jeffrey'@'localhost' IDENTIFIED BY 'mypass';
  ```

  The server uses built-in authentication and clients must match the given password.

- To avoid specifying the plaintext password if you know its hash value (the value that `PASSWORD()` would return for the password), specify the hash value preceded by the keyword `PASSWORD`:

  ```
  CREATE USER 'jeffrey'@'localhost'
  IDENTIFIED BY PASSWORD '*90E462C37378CED12064BB3388827D2BA3A9B689';
  ```

  The server uses built-in authentication and clients must match the given password.

- To authenticate the account using a specific authentication plugin, use `IDENTIFIED WITH`, where *`auth_plugin`* is the plugin name. It can be an unquoted name or a quoted string literal. *`'auth_string'`* is an optional quoted string literal to pass to the plugin. The plugin interprets the meaning of the string.

  ```
  CREATE USER 'jeffrey'@'localhost'
  IDENTIFIED WITH my_auth_plugin;
  ```

  For connections that use this account, the server invokes the named plugin and clients must provide credentials as required for the authentication method that the plugin implements. If the server cannot find the plugin, either at account-creation time or connect time, an error occurs. `IDENTIFIED WITH` can be used as of MySQL 5.5.7.

The `IDENTIFIED BY` and `IDENTIFIED WITH` clauses are mutually exclusive, so at most one of them can be specified for a given user.

For additional information about setting passwords, see Section 5.5.5, “Assigning Account Passwords”.

> **Important**
>
> `CREATE USER` may be recorded in server logs or in a history file such as `~/.mysql_history`, which means that plaintext passwords may be read by anyone having read access to that information. See Section 5.3.2, “Password Security in MySQL”.

> **Important**
>
> Some releases of MySQL introduce changes to the structure of the grant tables to add new privileges or features. Whenever you update to a new version of MySQL, you should update your grant tables to make sure that they have the current structure so that you can take advantage of any new capabilities. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

12.4.1.2. `DROP USER` Syntax

```
DROP USER user [, user] ...
```

The `DROP USER` statement removes one or more MySQL accounts and their privileges. It removes privilege rows for the account from all grant tables. To use this statement, you must have the global `CREATE USER` privilege or the `DELETE` privilege for the `mysql` database. Each account name uses the format described in Section 5.4.3, “Specifying Account Names”. For example:

```
DROP USER 'jeffrey'@'localhost';
```

If you specify only the user name part of the account name, a host name part of `'%'` is used.

> **Important**
>
> `DROP USER` does not automatically close any open user sessions. Rather, in the event that a user with an open session is dropped, the statement does not take effect until that user's session is closed. Once the session is closed, the user is dropped, and that user's next attempt to log in will fail. *This is by design*.

`DROP USER` does not automatically drop or invalidate databases or objects within them that the old user created. This includes stored programs or views for which the `DEFINER` attribute names the dropped user. Attempts to access such objects may produce an error if they execute in definer security context. (For information about security context, see Section 17.6, “Access Control for Stored Programs and Views”.)

12.4.1.3. `GRANT` Syntax

```
GRANT
    priv_type [(column_list)]
      [, priv_type [(column_list)]] ...
    ON [object_type] priv_level
    TO user_specification [, user_specification] ...
    [REQUIRE {NONE | ssl_option [[AND] ssl_option] ...}]
    [WITH with_option ...]

GRANT PROXY ON user_specification
    TO user_specification [, user_specification] ...
    [WITH GRANT OPTION]

object_type:
    TABLE
  | FUNCTION
  | PROCEDURE

priv_level:
    *
  | *.*
  | db_name.*
  | db_name.tbl_name
  | tbl_name
  | db_name.routine_name

user_specification:
    user
    [
        IDENTIFIED BY [PASSWORD] 'password'
      | IDENTIFIED WITH auth_plugin [AS 'auth_string']
    ]

ssl_option:
    SSL
  | X509
  | CIPHER 'cipher'
  | ISSUER 'issuer'
  | SUBJECT 'subject'

with_option:
    GRANT OPTION
  | MAX_QUERIES_PER_HOUR count
  | MAX_UPDATES_PER_HOUR count
  | MAX_CONNECTIONS_PER_HOUR count
  | MAX_USER_CONNECTIONS count
```

The `GRANT` statement grants privileges to MySQL user accounts. `GRANT` also serves to specify other account characteristics such as use of secure connections and limits on access to server resources. To use `GRANT`, you must have the `GRANT OPTION` privilege, and you must have the privileges that you are granting.

Normally, a database administrator first uses `CREATE USER` to create an account, then `GRANT` to define its privileges and characteristics. For example:

```
CREATE USER 'jeffrey'@'localhost' IDENTIFIED BY 'mypass';
GRANT ALL ON db1.* TO 'jeffrey'@'localhost';
GRANT SELECT ON db2.invoice TO 'jeffrey'@'localhost';
GRANT USAGE ON *.* TO 'jeffrey'@'localhost' WITH MAX_QUERIES_PER_HOUR 90;
```

However, if an account named in a `GRANT` statement does not already exist, `GRANT` may create it under the conditions described later in the discussion of the `NO_AUTO_CREATE_USER` SQL mode.

The `REVOKE` statement is related to `GRANT` and enables administrators to remove account privileges. See Section 12.4.1.5, “`REVOKE` Syntax”.

To determine what privileges an account has, use `SHOW GRANTS`. See Section 12.4.5.22, “`SHOW GRANTS` Syntax”.

There are several aspects to the `GRANT` statement, described under the following topics in this section:

- Privileges Supported by MySQL
- Global Privileges
- Database Privileges
- Table Privileges
- Column Privileges
- Stored Routine Privileges
- Proxy User Privileges
- Account Names and Passwords
- Other Account Characteristics
- MySQL and Standard SQL Versions of `GRANT`

> **Important**
>
> Some releases of MySQL introduce changes to the structure of the grant tables to add new privileges or features. Whenever you update to a new version of MySQL, you should update your grant tables to make sure that they have the current structure so that you can take advantage of any new capabilities. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

Privileges Supported by MySQL

The following table summarizes the permissible *`priv_type`* privilege types that can be specified for the `GRANT` and `REVOKE` statements. For additional information about these privileges, see Section 5.4.1, “Privileges Provided by MySQL”.

Table 12.1. Permissible Privileges for `GRANT` and `REVOKE`

Privilege	Meaning
`ALL [PRIVILEGES]`	Grant all privileges at specified access level except `GRANT OPTION`
`ALTER`	Enable use of `ALTER TABLE`
`ALTER ROUTINE`	Enable stored routines to be altered or dropped
`CREATE`	Enable database and table creation
`CREATE ROUTINE`	Enable stored routine creation
`CREATE TABLESPACE`	Enable tablespaces and log file groups to be created, altered, or dropped
`CREATE TEMPORARY TABLES`	Enable use of `CREATE TEMPORARY TABLE`
`CREATE USER`	Enable use of `CREATE USER`, `DROP USER`, `RENAME USER`, and `REVOKE ALL PRIVILEGES`
`CREATE VIEW`	Enable views to be created or altered
`DELETE`	Enable use of `DELETE`
`DROP`	Enable databases, tables, and views to be dropped
`EVENT`	Enable use of events for the Event Scheduler
`EXECUTE`	Enable the user to execute stored routines
`FILE`	Enable the user to cause the server to read or write files
`GRANT OPTION`	Enable privileges to be granted to or removed from other accounts
`INDEX`	Enable indexes to be created or dropped
`INSERT`	Enable use of `INSERT`
`LOCK TABLES`	Enable use of `LOCK TABLES` on tables for which you have the `SELECT` privilege
`PROCESS`	Enable the user to see all processes with `SHOW PROCESSLIST`

Privilege	**Meaning**
`PROXY`	Enable user proxying
`REFERENCES`	Not implemented
`RELOAD`	Enable use of `FLUSH` operations
`REPLICATION CLIENT`	Enable the user to ask where master or slave servers are
`REPLICATION SLAVE`	Enable replication slaves to read binary log events from the master
`SELECT`	Enable use of `SELECT`
`SHOW DATABASES`	Enable `SHOW DATABASES` to show all databases
`SHOW VIEW`	Enable use of `SHOW CREATE VIEW`
`SHUTDOWN`	Enable use of `mysqladmin shutdown`
`SUPER`	Enable use of other administrative operations such as `CHANGE MASTER TO`, `KILL`, `PURGE BINARY LOGS`, `SET GLOBAL`, and `mysqladmin debug` command
`TRIGGER`	Enable trigger operations
`UPDATE`	Enable use of `UPDATE`
`USAGE`	Synonym for “no privileges”

The `PROXY` privilege was added in MySQL 5.5.7.

A trigger is associated with a table, so to create or drop a trigger, you must have the `TRIGGER` privilege for the table, not the trigger.

In `GRANT` statements, the `ALL [PRIVILEGES]` or `PROXY` privilege must be named by itself and cannot be specified along with other privileges. `ALL [PRIVILEGES]` stands for all privileges available for the level at which privileges are to be granted except for the `GRANT OPTION` and `PROXY` privileges.

`USAGE` can be specified to create a user that has no privileges, or to specify the `REQUIRE` or `WITH` clauses for an account without changing its existing privileges.

MySQL account information is stored in the tables of the `mysql` database. This database and the access control system are discussed extensively in Section 5.4, “The MySQL Access Privilege System”, which you should consult for additional details.

If the grant tables hold privilege rows that contain mixed-case database or table names and the `lower_case_table_names` system variable is set to a nonzero value, `REVOKE` cannot be used to revoke these privileges. It will be necessary to manipulate the grant tables directly. (`GRANT` will not create such rows when `lower_case_table_names` is set, but such rows might have been created prior to setting that variable.)

Privileges can be granted at several levels, depending on the syntax used for the `ON` clause. For `REVOKE`, the same `ON` syntax specifies which privileges to take away. The examples shown here include no `IDENTIFIED BY '*password*'` clause for brevity, but you should include one if the account does not already exist, to avoid creating an insecure account that has no password.

Global Privileges

Global privileges are administrative or apply to all databases on a given server. To assign global privileges, use `ON *.*` syntax:

```
GRANT ALL ON *.* TO 'someuser'@'somehost';
GRANT SELECT, INSERT ON *.* TO 'someuser'@'somehost';
```

The `CREATE TABLESPACE`, `CREATE USER`, `FILE`, `PROCESS`, `RELOAD`, `REPLICATION CLIENT`, `REPLICATION SLAVE`, `SHOW DATABASES`, `SHUTDOWN`, and `SUPER` privileges are administrative and can only be granted globally.

Other privileges can be granted globally or at more specific levels.

MySQL stores global privileges in the `mysql.user` table.

Database Privileges

Database privileges apply to all objects in a given database. To assign database-level privileges, use `ON *db_name*.*` syntax:

```
GRANT ALL ON mydb.* TO 'someuser'@'somehost';
GRANT SELECT, INSERT ON mydb.* TO 'someuser'@'somehost';
```

If you use `ON *` syntax (rather than `ON *.*` and you have selected a default database, privileges are assigned at the database level for the default database. An error occurs if there is no default database.

The `CREATE`, `DROP`, `EVENT`, and `GRANT OPTION` privileges can be specified at the database level. Table or routine privileges also can be specified at the database level, in which case they apply to all tables or routines in the database.

MySQL stores database privileges in the `mysql.db` table.

Table Privileges

Table privileges apply to all columns in a given table. To assign table-level privileges, use `ON` *`db_name.tbl_name`* syntax:

```
GRANT ALL ON mydb.mytbl TO 'someuser'@'somehost';
GRANT SELECT, INSERT ON mydb.mytbl TO 'someuser'@'somehost';
```

If you specify *`tbl_name`* rather than *`db_name.tbl_name`*, the statement applies to *`tbl_name`* in the default database. An error occurs if there is no default database.

The permissible column-level *`priv_type`* values are `ALTER`, `CREATE VIEW`, `CREATE`, `DELETE`, `DROP`, `GRANT OPTION`, `INDEX`, `INSERT`, `SELECT`, `SHOW VIEW`, `TRIGGER`, and `UPDATE`.

MySQL stores table privileges in the `mysql.tables_priv` table.

Column Privileges

Column privileges apply to single columns in a given table. Each privilege to be granted at the column level must be followed by the column or columns, enclosed within parentheses.

```
GRANT SELECT (col1), INSERT (col1,col2) ON mydb.mytbl TO 'someuser'@'somehost';
```

The permissible *`priv_type`* values for a column (that is, when you use a *`column_list`* clause) are `INSERT`, `SELECT`, and `UPDATE`.

MySQL stores column privileges in the `mysql.columns_priv` table.

Stored Routine Privileges

The `ALTER ROUTINE`, `CREATE ROUTINE`, `EXECUTE`, and `GRANT OPTION` privileges apply to stored routines (procedures and functions). They can be granted at the global and database levels. Except for `CREATE ROUTINE`, these privileges can be granted at the routine level for individual routines.

```
GRANT CREATE ROUTINE ON mydb.* TO 'someuser'@'somehost';
GRANT EXECUTE ON PROCEDURE mydb.myproc TO 'someuser'@'somehost';
```

The permissible *`priv_type`* values at the routine level are `ALTER ROUTINE`, `EXECUTE`, and `GRANT OPTION`. `CREATE ROUTINE` is not a routine-level privilege because you must have this privilege to create a routine in the first place.

MySQL stores routine-level privileges in the `mysql.procs_priv` table.

Proxy User Privileges

The `PROXY` privilege enables one user to be a proxy for another. The proxy user impersonates or takes the identity of the proxied user.

```
GRANT PROXY ON 'localuser'@'localhost' TO 'externaluser'@'somehost';
```

When `PROXY` is granted, it must be the only privilege named in the `GRANT` statement, the `REQUIRE` clause cannot be given, and the only permitted `WITH` option is `WITH GRANT OPTION`.

Proxying requires that the proxy user authenticate through a plugin that returns the name of the proxied user to the server when the proxy user connects, and that the proxy user have the `PROXY` privilege for the proxied user. For details and examples, see Section 5.5.7, "Proxy Users".

MySQL stores proxy privileges in the `mysql.proxies_priv` table.

For the global, database, table, and routine levels, `GRANT ALL` assigns only the privileges that exist at the level you are granting. For example, `GRANT ALL ON` *`db_name`*`.*` is a database-level statement, so it does not grant any global-only privileges such as `FILE`. Granting `ALL` does not assign the `PROXY` privilege.

The *`object_type`* clause, if present, should be specified as `TABLE`, `FUNCTION`, or `PROCEDURE` when the following object is a table, a stored function, or a stored procedure.

The privileges for a database, table, column, or routine are formed additively as the logical `OR` of the privileges at each of the privilege levels. For example, if a user has a global `SELECT` privilege, the privilege cannot be denied by an absence of the privilege at the database, table, or column level. Details of the privilege-checking procedure are presented in Section 5.4.5, "Access Control, Stage 2: Request Verification".

MySQL enables you to grant privileges on databases or tables that do not exist. For tables, the privileges to be granted must include the `CREATE` privilege. *This behavior is by design*, and is intended to enable the database administrator to prepare user accounts and privileges for databases or tables that are to be created at a later time.

> **Important**
>
> *MySQL does not automatically revoke any privileges when you drop a database or table*. However, if you drop a routine, any routine-level privileges granted for that routine are revoked.

Account Names and Passwords

The *`user`* value indicates the MySQL account to which the `GRANT` statement applies. To accommodate granting rights to users from arbitrary hosts, MySQL supports specifying the *`user`* value in the form *`user_name@host_name`*. If a *`user_name`* or *`host_name`* value is legal as an unquoted identifier, you need not quote it. However, quotation marks are necessary to specify a *`user_name`* string containing special characters (such as "`-`"), or a *`host_name`* string containing special characters or wildcard characters (such as "`%`"); for example, `'test-user'@'%.com'`. Quote the user name and host name separately.

You can specify wildcards in the host name. For example, `user_name@'%.example.com'` applies to *`user_name`* for any host in the `example.com` domain, and `user_name@'192.168.1.%'` applies to *`user_name`* for any host in the `192.168.1` class C subnet.

The simple form *`user_name`* is a synonym for `user_name@'%'`.

MySQL does not support wildcards in user names. To refer to an anonymous user, specify an account with an empty user name with the `GRANT` statement:

```
GRANT ALL ON test.* TO ''@'localhost' ...
```

In this case, any user who connects from the local host with the correct password for the anonymous user will be permitted access, with the privileges associated with the anonymous-user account.

For additional information about user name and host name values in account names, see Section 5.4.3, "Specifying Account Names".

To specify quoted values, quote database, table, column, and routine names as identifiers. Quote user names and host names as identifiers or as strings. Quote passwords as strings. For string-quoting and identifier-quoting guidelines, see Section 8.1.1, "Strings", and Section 8.2, "Schema Object Names".

The "`_`" and "`%`" wildcards are permitted when specifying database names in `GRANT` statements that grant privileges at the global or database levels. This means, for example, that if you want to use a "`_`" character as part of a database name, you should specify it as "`\_`" in the `GRANT` statement, to prevent the user from being able to access additional databases matching the wildcard pattern; for example, ``GRANT ... ON `foo\_bar`.* TO ...``.

> **Warning**
>
> If you permit anonymous users to connect to the MySQL server, you should also grant privileges to all local users as `user_name@localhost`. Otherwise, the anonymous user account for `localhost` in the `mysql.user` table (created during MySQL installation) is used when named users try to log in to the MySQL server from the local machine. For details, see Section 5.4.4, "Access Control, Stage 1: Connection Verification".

To determine whether the preceding warning applies to you, execute the following query, which lists any anonymous users:

```
SELECT Host, User FROM mysql.user WHERE User='';
```

To avoid the problem just described, delete the local anonymous user account using this statement:

```
DROP USER ''@'localhost';
```

`GRANT` supports host names up to 60 characters long. Database, table, column, and routine names can be up to 64 characters. User names can be up to 16 characters.

> **Warning**
>
> *The permissible length for user names cannot be changed by altering the `mysql.user` table. Attempting to do so*

> *results in unpredictable behavior which may even make it impossible for users to log in to the MySQL server*. You should never alter any of the tables in the `mysql` database in any manner whatsoever except by means of the procedure described in Section 4.4.7, "`mysql_upgrade` — Check Tables for MySQL Upgrade".

The user specification may indicate how the user should authenticate when connecting to the server, through inclusion of an `IDENTIFIED BY` or `IDENTIFIED WITH` clause. The syntax is the same as for the `CREATE USER` statement. See Section 12.4.1.1, "`CREATE USER` Syntax".

When the `IDENTIFIED BY` clause is present and you have global grant privileges, the password becomes the new password for the account, even if the account exists and already has a password. With no `IDENTIFIED BY` clause, the account password remains unchanged.

If the `NO_AUTO_CREATE_USER` SQL mode is not enabled and the account named in a `GRANT` statement does not exist in the `mysql.user` table, `GRANT` creates it. If you specify no `IDENTIFIED BY` clause or provide an empty password, the user has no password. *This is very insecure.*

If `NO_AUTO_CREATE_USER` is enabled and the account does not exist, `GRANT` fails and does not create the account unless the `IDENTIFIED BY` clause is given to provide a nonempty password.

The `NO_AUTO_CREATE_USER` SQL mode has no effect for `GRANT` statements that include an `IDENTIFIED WITH` clause. That is, `GRANT ... IDENTIFIED WITH` creates nonexistent users regardless of the mode setting.

> **Important**
>
> `GRANT` may be recorded in server logs or in a history file such as `~/.mysql_history`, which means that plaintext passwords may be read by anyone having read access to that information. See Section 5.3.2, "Password Security in MySQL".

Other Account Characteristics

The `WITH` clause is used for several purposes:

- To enable a user to grant privileges to other users
- To specify resource limits for a user
- To specify whether and how a user must use secure connections to the server

The `WITH GRANT OPTION` clause gives the user the ability to give to other users any privileges the user has at the specified privilege level. You should be careful to whom you give the `GRANT OPTION` privilege because two users with different privileges may be able to combine privileges!

You cannot grant another user a privilege which you yourself do not have; the `GRANT OPTION` privilege enables you to assign only those privileges which you yourself possess.

Be aware that when you grant a user the `GRANT OPTION` privilege at a particular privilege level, any privileges the user possesses (or may be given in the future) at that level can also be granted by that user to other users. Suppose that you grant a user the `INSERT` privilege on a database. If you then grant the `SELECT` privilege on the database and specify `WITH GRANT OPTION`, that user can give to other users not only the `SELECT` privilege, but also `INSERT`. If you then grant the `UPDATE` privilege to the user on the database, the user can grant `INSERT`, `SELECT`, and `UPDATE`.

For a nonadministrative user, you should not grant the `ALTER` privilege globally or for the `mysql` database. If you do that, the user can try to subvert the privilege system by renaming tables!

For additional information about security risks associated with particular privileges, see Section 5.4.1, "Privileges Provided by MySQL".

Several `WITH` clause options specify limits on use of server resources by an account:

- The `MAX_QUERIES_PER_HOUR` *`count`*, `MAX_UPDATES_PER_HOUR` *`count`*, and `MAX_CONNECTIONS_PER_HOUR` *`count`* limits restrict the number of queries, updates, and connections to the server permitted to this account during any given one-hour period. (Queries for which results are served from the query cache do not count against the `MAX_QUERIES_PER_HOUR` limit.) If *`count`* is `0` (the default), this means that there is no limitation for the account.

- The `MAX_USER_CONNECTIONS` *`count`* limit restricts the maximum number of simultaneous connections to the server by the account. A nonzero *`count`* specifies the limit for the account explicitly. If *`count`* is `0` (the default), the server determines the number of simultaneous connections for the account from the global value of the `max_user_connections` system variable. If `max_user_connections` is also zero, there is no limit for the account.

To specify resource limits for an existing user without affecting existing privileges, use `GRANT USAGE` at the global level (`ON *.*`) and name the limits to be changed. For example:

```
GRANT USAGE ON *.* TO ...
  WITH MAX_QUERIES_PER_HOUR 500 MAX_UPDATES_PER_HOUR 100;
```

Limits not specified retain their current values.

For more information on restricting access to server resources, see Section 5.5.4, “Setting Account Resource Limits”.

MySQL can check X509 certificate attributes in addition to the usual authentication that is based on the user name and password. To specify SSL-related options for a MySQL account, use the `REQUIRE` clause of the `GRANT` statement. (For background information on the use of SSL with MySQL, see Section 5.5.8, “Using SSL for Secure Connections”.)

There are a number of different possibilities for limiting connection types for a given account:

- `REQUIRE NONE` indicates that the account has no SSL or X509 requirements. This is the default if no SSL-related `REQUIRE` options are specified. Unencrypted connections are permitted if the user name and password are valid. However, encrypted connections can also be used, at the client's option, if the client has the proper certificate and key files. That is, the client need not specify any SSL command options, in which case the connection will be unencrypted. To use an encrypted connection, the client must specify either the `--ssl-ca` option, or all three of the `--ssl-ca`, `--ssl-key`, and `--ssl-cert` options.

- The `REQUIRE SSL` option tells the server to permit only SSL-encrypted connections for the account.

  ```
  GRANT ALL PRIVILEGES ON test.* TO 'root'@'localhost'
    IDENTIFIED BY 'goodsecret' REQUIRE SSL;
  ```

  To connect, the client must specify the `--ssl-ca` option, and may additionally specify the `--ssl-key` and `--ssl-cert` options.

- `REQUIRE X509` means that the client must have a valid certificate but that the exact certificate, issuer, and subject do not matter. The only requirement is that it should be possible to verify its signature with one of the CA certificates.

  ```
  GRANT ALL PRIVILEGES ON test.* TO 'root'@'localhost'
    IDENTIFIED BY 'goodsecret' REQUIRE X509;
  ```

  To connect, the client must specify the `--ssl-ca`, `--ssl-key`, and `--ssl-cert` options. This is also true for `ISSUER` and `SUBJECT` because those `REQUIRE` options imply `X509`.

- `REQUIRE ISSUER 'issuer'` places the restriction on connection attempts that the client must present a valid X509 certificate issued by CA `'issuer'`. If the client presents a certificate that is valid but has a different issuer, the server rejects the connection. Use of X509 certificates always implies encryption, so the `SSL` option is unnecessary in this case.

  ```
  GRANT ALL PRIVILEGES ON test.* TO 'root'@'localhost'
    IDENTIFIED BY 'goodsecret'
    REQUIRE ISSUER '/C=FI/ST=Some-State/L=Helsinki/
      O=MySQL Finland AB/CN=Tonu Samuel/emailAddress=tonu@example.com';
  ```

  The `'issuer'` value should be entered as a single string.

  > **Note**
  >
  > If MySQL is linked against a version of OpenSSL older than 0.9.6h, use `Email` rather than `emailAddress` in the `'issuer'` value.

- `REQUIRE SUBJECT 'subject'` places the restriction on connection attempts that the client must present a valid X509 certificate containing the subject *subject*. If the client presents a certificate that is valid but has a different subject, the server rejects the connection.

  ```
  GRANT ALL PRIVILEGES ON test.* TO 'root'@'localhost'
    IDENTIFIED BY 'goodsecret'
    REQUIRE SUBJECT '/C=EE/ST=Some-State/L=Tallinn/
      O=MySQL demo client certificate/
      CN=Tonu Samuel/emailAddress=tonu@example.com';
  ```

  The `'subject'` value should be entered as a single string.

  > **Note**
  >
  > Regarding `emailAddress`, see the note in the description of `REQUIRE ISSUER`.

- `REQUIRE CIPHER 'cipher'` is needed to ensure that ciphers and key lengths of sufficient strength are used. SSL itself can be weak if old algorithms using short encryption keys are used. Using this option, you can ask that a specific cipher method is used for a connection.

  ```
  GRANT ALL PRIVILEGES ON test.* TO 'root'@'localhost'
    IDENTIFIED BY 'goodsecret'
    REQUIRE CIPHER 'EDH-RSA-DES-CBC3-SHA';
  ```

The `SUBJECT`, `ISSUER`, and `CIPHER` options can be combined in the `REQUIRE` clause like this:

```
GRANT ALL PRIVILEGES ON test.* TO 'root'@'localhost'
  IDENTIFIED BY 'goodsecret'
  REQUIRE SUBJECT '/C=EE/ST=Some-State/L=Tallinn/
    O=MySQL demo client certificate/
    CN=Tonu Samuel/emailAddress=tonu@example.com'
  AND ISSUER '/C=FI/ST=Some-State/L=Helsinki/
    O=MySQL Finland AB/CN=Tonu Samuel/emailAddress=tonu@example.com'
  AND CIPHER 'EDH-RSA-DES-CBC3-SHA';
```

The order of the options does not matter, but no option can be specified twice. The `AND` keyword is optional between `REQUIRE` options.

If you are using table, column, or routine privileges for even one user, the server examines table, column, and routine privileges for all users and this slows down MySQL a bit. Similarly, if you limit the number of queries, updates, or connections for any users, the server must monitor these values.

MySQL and Standard SQL Versions of `GRANT`

The biggest differences between the MySQL and standard SQL versions of `GRANT` are:

- MySQL associates privileges with the combination of a host name and user name and not with only a user name.
- Standard SQL does not have global or database-level privileges, nor does it support all the privilege types that MySQL supports.
- MySQL does not support the standard SQL `UNDER` privilege.
- Standard SQL privileges are structured in a hierarchical manner. If you remove a user, all privileges the user has been granted are revoked. This is also true in MySQL if you use `DROP USER`. See Section 12.4.1.2, “`DROP USER` Syntax”.
- In standard SQL, when you drop a table, all privileges for the table are revoked. In standard SQL, when you revoke a privilege, all privileges that were granted based on that privilege are also revoked. In MySQL, privileges can be dropped only with explicit `DROP USER` or `REVOKE` statements or by manipulating the MySQL grant tables directly.
- In MySQL, it is possible to have the `INSERT` privilege for only some of the columns in a table. In this case, you can still execute `INSERT` statements on the table, provided that you insert values only for those columns for which you have the `INSERT` privilege. The omitted columns are set to their implicit default values if strict SQL mode is not enabled. In strict mode, the statement is rejected if any of the omitted columns have no default value. (Standard SQL requires you to have the `INSERT` privilege on all columns.) Section 5.1.6, “Server SQL Modes”, discusses strict mode. Section 10.1.4, “Data Type Default Values”, discusses implicit default values.

12.4.1.4. `RENAME USER` Syntax

```
RENAME USER old_user TO new_user
    [, old_user TO new_user] ...
```

The `RENAME USER` statement renames existing MySQL accounts. To use it, you must have the global `CREATE USER` privilege or the `UPDATE` privilege for the `mysql` database. An error occurs if any old account does not exist or any new account exists. Each account name uses the format described in Section 5.4.3, “Specifying Account Names”. For example:

```
RENAME USER 'jeffrey'@'localhost' TO 'jeff'@'127.0.0.1';
```

If you specify only the user name part of the account name, a host name part of `'%'` is used.

`RENAME USER` causes the privileges held by the old user to be those held by the new user. However, `RENAME USER` does not automatically drop or invalidate databases or objects within them that the old user created. This includes stored programs or views for which the `DEFINER` attribute names the old user. Attempts to access such objects may produce an error if they execute in definer security context. (For information about security context, see Section 17.6, “Access Control for Stored Programs and

Views”.)

The privilege changes take effect as indicated in Section 5.4.6, “When Privilege Changes Take Effect”.

12.4.1.5. `REVOKE` Syntax

```
REVOKE
    priv_type [(column_list)]
      [, priv_type [(column_list)]] ...
    ON [object_type] priv_level
    FROM user [, user] ...

REVOKE ALL PRIVILEGES, GRANT OPTION
    FROM user [, user] ...

REVOKE PROXY ON user
    FROM user [, user] ...
```

The `REVOKE` statement enables system administrators to revoke privileges from MySQL accounts. Each account name uses the format described in Section 5.4.3, “Specifying Account Names”. For example:

```
REVOKE INSERT ON *.* FROM 'jeffrey'@'localhost';
```

If you specify only the user name part of the account name, a host name part of `'%'` is used.

For details on the levels at which privileges exist, the permissible *`priv_type`* and *`priv_level`* values, and the syntax for specifying users and passwords, see Section 12.4.1.3, “`GRANT` Syntax”

To use the first `REVOKE` syntax, you must have the `GRANT OPTION` privilege, and you must have the privileges that you are revoking.

To revoke all privileges, use the second syntax, which drops all global, database, table, column, and routine privileges for the named user or users:

```
REVOKE ALL PRIVILEGES, GRANT OPTION FROM user [, user] ...
```

To use this `REVOKE` syntax, you must have the global `CREATE USER` privilege or the `UPDATE` privilege for the `mysql` database.

`REVOKE` removes privileges, but does not drop `mysql.user` table entries. To remove a user account entirely, use `DROP USER` (see Section 12.4.1.2, “`DROP USER` Syntax”) or `DELETE`.

If the grant tables hold privilege rows that contain mixed-case database or table names and the `lower_case_table_names` system variable is set to a nonzero value, `REVOKE` cannot be used to revoke these privileges. It will be necessary to manipulate the grant tables directly. (`GRANT` will not create such rows when `lower_case_table_names` is set, but such rows might have been created prior to setting the variable.)

To verify an account's privileges after a `REVOKE` operation, use `SHOW GRANTS`. See Section 12.4.5.22, “`SHOW GRANTS` Syntax”.

12.4.1.6. `SET PASSWORD` Syntax

```
SET PASSWORD [FOR user] =
    {
        PASSWORD('some password')
      | OLD_PASSWORD('some password')
      | 'encrypted password'
    }
```

The `SET PASSWORD` statement assigns a password to an existing MySQL user account.

If the password is specified using the `PASSWORD()` or `OLD_PASSWORD()` function, the literal text of the password should be given. If the password is specified without using either function, the password should be the already-encrypted password value as returned by `PASSWORD()`.

With no `FOR` clause, this statement sets the password for the current user. Any client that has connected to the server using a non-anonymous account can change the password for that account.

In MySQL 5.1 and later, when the `read_only` system variable is enabled, the `SUPER` privilege is required to use `SET PASSWORD`.

With a `FOR` clause, this statement sets the password for a specific account on the current server host. Only clients that have the `UPDATE` privilege for the `mysql` database can do this. The *`user`* value should be given in *`user_name@host_name`* format, where *`user_name`* and *`host_name`* are exactly as they are listed in the `User` and `Host` columns of the `mysql.user` table entry. For example, if you had an entry with `User` and `Host` column values of `'bob'` and `'%.loc.gov'`, you would write the statement like this:

```
SET PASSWORD FOR 'bob'@'%.loc.gov' = PASSWORD('newpass');
```

That is equivalent to the following statements:

```
UPDATE mysql.user SET Password=PASSWORD('newpass')
  WHERE User='bob' AND Host='%.loc.gov';
FLUSH PRIVILEGES;
```

Another way to set the password is to use `GRANT`:

```
GRANT USAGE ON *.* TO 'bob'@'%.loc.gov' IDENTIFIED BY 'newpass';
```

Important

`SET PASSWORD` may be recorded in server logs or in a history file such as `~/.mysql_history`, which means that plaintext passwords may be read by anyone having read access to that information. See Section 5.3.2, "Password Security in MySQL".

Note

If you are connecting to a MySQL 4.1 or later server using a pre-4.1 client program, do not use the preceding `SET PASSWORD` or `UPDATE` statement without reading Section 5.3.2.3, "Password Hashing in MySQL", first. The password format changed in MySQL 4.1, and under certain circumstances it is possible that if you change your password, you might not be able to connect to the server afterward.

To see which account the server authenticated you as, invoke the `CURRENT_USER()` function.

For more information about setting passwords, see Section 5.5.5, "Assigning Account Passwords"

12.4.2. Table Maintenance Statements

12.4.2.1. `ANALYZE TABLE` Syntax

```
ANALYZE [NO_WRITE_TO_BINLOG | LOCAL] TABLE
    tbl_name [, tbl_name] ...
```

`ANALYZE TABLE` analyzes and stores the key distribution for a table. During the analysis, the table is locked with a read lock for `MyISAM` and `InnoDB`. This statement works with `MyISAM` and `InnoDB` tables. For `MyISAM` tables, this statement is equivalent to using `myisamchk --analyze`.

For more information on how the analysis works within `InnoDB`, see Section 13.3.15, "Limits on `InnoDB` Tables".

MySQL uses the stored key distribution to decide the order in which tables should be joined when you perform a join on something other than a constant. In addition, key distributions can be used when deciding which indexes to use for a specific table within a query.

This statement requires `SELECT` and `INSERT` privileges for the table.

`ANALYZE TABLE` is supported for partitioned tables, and you can use `ALTER TABLE ... ANALYZE PARTITION` to analyze one or more partitions; for more information, see Section 12.1.6, "`ALTER TABLE` Syntax", and Section 16.3.3, "Maintenance of Partitions".

`ANALYZE TABLE` returns a result set with the following columns.

Column	Value
`Table`	The table name
`Op`	Always `analyze`
`Msg_type`	`status`, `error`, `info`, `note`, or `warning`
`Msg_text`	An informational message

You can check the stored key distribution with the `SHOW INDEX` statement. See Section 12.4.5.23, "`SHOW INDEX` Syntax".

If the table has not changed since the last `ANALYZE TABLE` statement, the table is not analyzed again.

By default, `ANALYZE TABLE` statements are written to the binary log so that they will be replicated to replication slaves. Logging can be suppressed with the optional `NO_WRITE_TO_BINLOG` keyword or its alias `LOCAL`.

12.4.2.2. `CHECK TABLE` Syntax

```
CHECK TABLE tbl_name [, tbl_name] ... [option] ...

option = {FOR UPGRADE | QUICK | FAST | MEDIUM | EXTENDED | CHANGED}
```

`CHECK TABLE` checks a table or tables for errors. `CHECK TABLE` works for `MyISAM`, `InnoDB`, `ARCHIVE`, and `CSV` tables. For `MyISAM` tables, the key statistics are updated as well.

To check a table, you must have some privilege for it.

`CHECK TABLE` can also check views for problems, such as tables that are referenced in the view definition that no longer exist.

`CHECK TABLE` is supported for partitioned tables, and you can use `ALTER TABLE ... CHECK PARTITION` to check one or more partitions; for more information, see Section 12.1.6, “`ALTER TABLE` Syntax”, and Section 16.3.3, “Maintenance of Partitions”.

`CHECK TABLE` returns a result set with the following columns.

Column	Value
`Table`	The table name
`Op`	Always `check`
`Msg_type`	`status`, `error`, `info`, `note`, or `warning`
`Msg_text`	An informational message

Note that the statement might produce many rows of information for each checked table. The last row has a `Msg_type` value of `status` and the `Msg_text` normally should be `OK`. If you don't get `OK`, or `Table is already up to date` you should normally run a repair of the table. See Section 6.6, “`MyISAM` Table Maintenance and Crash Recovery”. `Table is already up to date` means that the storage engine for the table indicated that there was no need to check the table.

The `FOR UPGRADE` option checks whether the named tables are compatible with the current version of MySQL. With `FOR UPGRADE`, the server checks each table to determine whether there have been any incompatible changes in any of the table's data types or indexes since the table was created. If not, the check succeeds. Otherwise, if there is a possible incompatibility, the server runs a full check on the table (which might take some time). If the full check succeeds, the server marks the table's `.frm` file with the current MySQL version number. Marking the `.frm` file ensures that further checks for the table with the same version of the server will be fast.

Incompatibilities might occur because the storage format for a data type has changed or because its sort order has changed. Our aim is to avoid these changes, but occasionally they are necessary to correct problems that would be worse than an incompatibility between releases.

Currently, `FOR UPGRADE` discovers these incompatibilities:

- The indexing order for end-space in `TEXT` columns for `InnoDB` and `MyISAM` tables changed between MySQL 4.1 and 5.0.
- The storage method of the new `DECIMAL` data type changed between MySQL 5.0.3 and 5.0.5.
- If your table was created by a different version of the MySQL server than the one you are currently running, `FOR UPGRADE` indicates that the table has an `.frm` file with an incompatible version. In this case, the result set returned by `CHECK TABLE` contains a line with a `Msg_type` value of `error` and a `Msg_text` value of `Table upgrade required. Please do "REPAIR TABLE `tbl_name`" to fix it!`
- Changes are sometimes made to character sets or collations that require table indexes to be rebuilt. For details about these changes and when `FOR UPGRADE` detects them, see Section 2.11.3, “Checking Whether Tables or Indexes Must Be Rebuilt”.

The other check options that can be given are shown in the following table. These options are passed to the storage engine, which may use them or not. `MyISAM` uses them; they are ignored for `InnoDB` tables and views.

Type	Meaning
`QUICK`	Do not scan the rows to check for incorrect links.
`FAST`	Check only tables that have not been closed properly.

Type	Meaning
`CHANGED`	Check only tables that have been changed since the last check or that have not been closed properly.
`MEDIUM`	Scan rows to verify that deleted links are valid. This also calculates a key checksum for the rows and verifies this with a calculated checksum for the keys.
`EXTENDED`	Do a full key lookup for all keys for each row. This ensures that the table is 100% consistent, but takes a long time.

If none of the options `QUICK`, `MEDIUM`, or `EXTENDED` are specified, the default check type for dynamic-format `MyISAM` tables is `MEDIUM`. This has the same result as running `myisamchk --medium-check tbl_name` on the table. The default check type also is `MEDIUM` for static-format `MyISAM` tables, unless `CHANGED` or `FAST` is specified. In that case, the default is `QUICK`. The row scan is skipped for `CHANGED` and `FAST` because the rows are very seldom corrupted.

You can combine check options, as in the following example that does a quick check on the table to determine whether it was closed properly:

```
CHECK TABLE test_table FAST QUICK;
```

> **Note**
>
> In some cases, `CHECK TABLE` changes the table. This happens if the table is marked as “corrupted” or “not closed properly” but `CHECK TABLE` does not find any problems in the table. In this case, `CHECK TABLE` marks the table as okay.

If a table is corrupted, it is most likely that the problem is in the indexes and not in the data part. All of the preceding check types check the indexes thoroughly and should thus find most errors.

If you just want to check a table that you assume is okay, you should use no check options or the `QUICK` option. The latter should be used when you are in a hurry and can take the very small risk that `QUICK` does not find an error in the data file. (In most cases, under normal usage, MySQL should find any error in the data file. If this happens, the table is marked as “corrupted” and cannot be used until it is repaired.)

`FAST` and `CHANGED` are mostly intended to be used from a script (for example, to be executed from `cron`) if you want to check tables from time to time. In most cases, `FAST` is to be preferred over `CHANGED`. (The only case when it is not preferred is when you suspect that you have found a bug in the `MyISAM` code.)

`EXTENDED` is to be used only after you have run a normal check but still get strange errors from a table when MySQL tries to update a row or find a row by key. This is very unlikely if a normal check has succeeded.

Use of `CHECK TABLE ... EXTENDED` might influence the execution plan generated by the query optimizer.

Some problems reported by `CHECK TABLE` cannot be corrected automatically:

- `Found row where the auto_increment column has the value 0`.

  This means that you have a row in the table where the `AUTO_INCREMENT` index column contains the value 0. (It is possible to create a row where the `AUTO_INCREMENT` column is 0 by explicitly setting the column to 0 with an `UPDATE` statement.)

  This is not an error in itself, but could cause trouble if you decide to dump the table and restore it or do an `ALTER TABLE` on the table. In this case, the `AUTO_INCREMENT` column changes value according to the rules of `AUTO_INCREMENT` columns, which could cause problems such as a duplicate-key error.

  To get rid of the warning, simply execute an `UPDATE` statement to set the column to some value other than 0.

- If `CHECK TABLE` finds a problem for an `InnoDB` table, the server shuts down to prevent error propagation. Details of the error will be written to the error log.

12.4.2.3. `CHECKSUM TABLE` Syntax

```
CHECKSUM TABLE tbl_name [, tbl_name] ... [ QUICK | EXTENDED ]
```

`CHECKSUM TABLE` reports a table checksum. This statement requires the `SELECT` privilege for the table.

With `QUICK`, the live table checksum is reported if it is available, or `NULL` otherwise. This is very fast. A live checksum is enabled by specifying the `CHECKSUM=1` table option when you create the table; currently, this is supported only for `MyISAM` tables. See Section 12.1.14, “`CREATE TABLE` Syntax”.

With `EXTENDED`, the entire table is read row by row and the checksum is calculated. This can be very slow for large tables.

If neither `QUICK` nor `EXTENDED` is specified, MySQL returns a live checksum if the table storage engine supports it and scans the table otherwise.

For a nonexistent table, `CHECKSUM TABLE` returns `NULL` and generates a warning.

The checksum value depends on the table row format. If the row format changes, the checksum also changes. For example, the storage format for `VARCHAR` changed between MySQL 4.1 and 5.0, so if a 4.1 table is upgraded to MySQL 5.0, the checksum value may change.

> **Important**
>
> If the checksums for two tables are different, then it is almost certain that the tables are different in some way. However, because the hashing function used by `CHECKSUM TABLE` is not guaranteed to be collision-free, there is a slight chance that two tables which are not identical can produce the same checksum.

12.4.2.4. `OPTIMIZE TABLE` Syntax

```
OPTIMIZE [NO_WRITE_TO_BINLOG | LOCAL] TABLE
    tbl_name [, tbl_name] ...
```

`OPTIMIZE TABLE` should be used if you have deleted a large part of a table or if you have made many changes to a table with variable-length rows (tables that have `VARCHAR`, `VARBINARY`, `BLOB`, or `TEXT` columns). Deleted rows are maintained in a linked list and subsequent `INSERT` operations reuse old row positions. You can use `OPTIMIZE TABLE` to reclaim the unused space and to defragment the data file. After extensive changes to a table, this statement may also improve performance of statements that use the table, sometimes significantly.

This statement requires `SELECT` and `INSERT` privileges for the table.

`OPTIMIZE TABLE` is supported for partitioned tables, and you can use `ALTER TABLE ... OPTIMIZE PARTITION` to optimize one or more partitions; for more information, see Section 12.1.6, “`ALTER TABLE` Syntax”, and Section 16.3.3, “Maintenance of Partitions”.

`OPTIMIZE TABLE` works *only* for `MyISAM`, `InnoDB`, and `ARCHIVE` tables. It does *not* work for tables created using any other storage engine.

For `MyISAM` tables, `OPTIMIZE TABLE` works as follows:

1. If the table has deleted or split rows, repair the table.
2. If the index pages are not sorted, sort them.
3. If the table's statistics are not up to date (and the repair could not be accomplished by sorting the index), update them.

For `InnoDB` tables, `OPTIMIZE TABLE` is mapped to `ALTER TABLE`, which rebuilds the table to update index statistics and free unused space in the clustered index. This is displayed in the output of `OPTIMIZE TABLE` when you run it on an `InnoDB` table, as shown here:

```
mysql> OPTIMIZE TABLE foo;
+----------+----------+----------+-------------------------------------------------------------------+
| Table    | Op       | Msg_type | Msg_text                                                          |
+----------+----------+----------+-------------------------------------------------------------------+
| test.foo | optimize | note     | Table does not support optimize, doing recreate + analyze instead |
| test.foo | optimize | status   | OK                                                                |
+----------+----------+----------+-------------------------------------------------------------------+
```

You can make `OPTIMIZE TABLE` work on other storage engines by starting `mysqld` with the `--skip-new` or `--safe-mode` option. In this case, `OPTIMIZE TABLE` is just mapped to `ALTER TABLE`.

`OPTIMIZE TABLE` returns a result set with the following columns.

Column	Value
`Table`	The table name
`Op`	Always `optimize`
`Msg_type`	`status`, `error`, `info`, `note`, or `warning`
`Msg_text`	An informational message

Note that MySQL locks the table during the time `OPTIMIZE TABLE` is running.

By default, `OPTIMIZE TABLE` statements are written to the binary log so that they will be replicated to replication slaves. Logging can be suppressed with the optional `NO_WRITE_TO_BINLOG` keyword or its alias `LOCAL`.

`OPTIMIZE TABLE` does not sort R-tree indexes, such as spatial indexes on `POINT` columns. (Bug #23578)

12.4.2.5. REPAIR TABLE Syntax

```
REPAIR [NO_WRITE_TO_BINLOG | LOCAL] TABLE
    tbl_name [, tbl_name] ...
    [QUICK] [EXTENDED] [USE_FRM]
```

`REPAIR TABLE` repairs a possibly corrupted table. By default, it has the same effect as `myisamchk --recover tbl_name`. `REPAIR TABLE` works for `MyISAM`, `ARCHIVE`, and `CSV` tables. See Section 13.5, “The `MyISAM` Storage Engine”, and Section 13.8, “The `ARCHIVE` Storage Engine”, and Section 13.7, “The `CSV` Storage Engine”

This statement requires `SELECT` and `INSERT` privileges for the table.

`REPAIR TABLE` is supported for partitioned tables. However, the `USE_FRM` option cannot be used with this statement on a partitioned table.

You can use `ALTER TABLE ... REPAIR PARTITION` to repair one or more partitions; for more information, see Section 12.1.6, “`ALTER TABLE` Syntax”, and Section 16.3.3, “Maintenance of Partitions”.

Normally, you should never have to run `REPAIR TABLE`. However, if disaster strikes, this statement is very likely to get back all your data from a `MyISAM` table. If your tables become corrupted often, you should try to find the reason for it, to eliminate the need to use `REPAIR TABLE`. See Section C.5.4.2, “What to Do If MySQL Keeps Crashing”, and Section 13.5.4, “`MyISAM` Table Problems”.

> **Caution**
>
> It is best to make a backup of a table before performing a table repair operation; under some circumstances the operation might cause data loss. Possible causes include but are not limited to file system errors. See Chapter 6, *Backup and Recovery*.

> **Warning**
>
> If the server crashes during a `REPAIR TABLE` operation, it is essential after restarting it that you immediately execute another `REPAIR TABLE` statement for the table before performing any other operations on it. In the worst case, you might have a new clean index file without information about the data file, and then the next operation you perform could overwrite the data file. This is an unlikely but possible scenario that underscores the value of making a backup first.

`REPAIR TABLE` returns a result set with the following columns.

Column	Value
`Table`	The table name
`Op`	Always `repair`
`Msg_type`	`status`, `error`, `info`, `note`, or `warning`
`Msg_text`	An informational message

The `REPAIR TABLE` statement might produce many rows of information for each repaired table. The last row has a `Msg_type` value of `status` and `Msg_test` normally should be `OK`. If you do not get `OK` for a `MyISAM` table, you should try repairing it with `myisamchk --safe-recover`. (`REPAIR TABLE` does not implement all the options of `myisamchk`.) With `myisamchk --safe-recover`, you can also use options that `REPAIR TABLE` does not support, such as `--max-record-length`.

If you use the `QUICK` option, `REPAIR TABLE` tries to repair only the index file, and not the data file. This type of repair is like that done by `myisamchk --recover --quick`.

If you use the `EXTENDED` option, MySQL creates the index row by row instead of creating one index at a time with sorting. This type of repair is like that done by `myisamchk --safe-recover`.

The `USE_FRM` option is available for use if the `.MYI` index file is missing or if its header is corrupted. This option tells MySQL not to trust the information in the `.MYI` file header and to re-create it using information from the `.frm` file. This kind of repair cannot be done with `myisamchk`.

Note

Use the `USE_FRM` option *only* if you cannot use regular `REPAIR` modes! Telling the server to ignore the `.MYI` file makes important table metadata stored in the `.MYI` unavailable to the repair process, which can have deleterious consequences:

- The current `AUTO_INCREMENT` value is lost.
- The link to deleted records in the table is lost, which means that free space for deleted records will remain unoccupied thereafter.
- The `.MYI` header indicates whether the table is compressed. If the server ignores this information, it cannot tell that a table is compressed and repair can cause change or loss of table contents. This means that `USE_FRM` should not be used with compressed tables. That should not be necessary, anyway: Compressed tables are read only, so they should not become corrupt.

Caution

If you use `USE_FRM` for a table that was created by a different version of the MySQL server than the one you are currently running, `REPAIR TABLE` will not attempt to repair the table. In this case, the result set returned by `REPAIR TABLE` contains a line with a `Msg_type` value of `error` and a `Msg_text` value of `Failed repairing incompatible .FRM file`.

If `USE_FRM` is *not* used, `REPAIR TABLE` checks the table to see whether an upgrade is required. If so, it performs the upgrade, following the same rules as `CHECK TABLE ... FOR UPGRADE`. See Section 12.4.2.2, “`CHECK TABLE` Syntax”, for more information. `REPAIR TABLE` without `USE_FRM` upgrades the `.frm` file to the current version.

By default, `REPAIR TABLE` statements are written to the binary log so that they will be replicated to replication slaves. Logging can be suppressed with the optional `NO_WRITE_TO_BINLOG` keyword or its alias `LOCAL`.

Important

In the event that a table on the master becomes corrupted and you run `REPAIR TABLE` on it, any resulting changes to the original table are *not* propagated to slaves.

You may be able to increase `REPAIR TABLE` performance by setting certain system variables. See Section 7.6.3, “Speed of `REPAIR TABLE` Statements”.

12.4.3. Plugin and User-Defined Function Statements

12.4.3.1. `CREATE FUNCTION` Syntax for User-Defined Functions

```
CREATE [AGGREGATE] FUNCTION function_name RETURNS {STRING|INTEGER|REAL|DECIMAL}
    SONAME shared_library_name
```

A user-defined function (UDF) is a way to extend MySQL with a new function that works like a native (built-in) MySQL function such as `ABS()` or `CONCAT()`.

`function_name` is the name that should be used in SQL statements to invoke the function. The `RETURNS` clause indicates the type of the function's return value. `DECIMAL` is a legal value after `RETURNS`, but currently `DECIMAL` functions return string values and should be written like `STRING` functions.

`shared_library_name` is the basename of the shared object file that contains the code that implements the function. The file must be located in the plugin directory. This directory is given by the value of the `plugin_dir` system variable. For more information, see Section 21.3.2.5, “Compiling and Installing User-Defined Functions”.

To create a function, you must have the `INSERT` privilege for the `mysql` database. This is necessary because `CREATE FUNCTION` adds a row to the `mysql.func` system table that records the function's name, type, and shared library name. If you do not have this table, you should run the `mysql_upgrade` command to create it. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

An active function is one that has been loaded with `CREATE FUNCTION` and not removed with `DROP FUNCTION`. All active functions are reloaded each time the server starts, unless you start `mysqld` with the `--skip-grant-tables` option. In this case, UDF initialization is skipped and UDFs are unavailable.

For instructions on writing user-defined functions, see Section 21.3.2, “Adding a New User-Defined Function”. For the UDF mechanism to work, functions must be written in C or C++ (or another language that can use C calling conventions), your operating system must support dynamic loading and you must have compiled `mysqld` dynamically (not statically).

An `AGGREGATE` function works exactly like a native MySQL aggregate (summary) function such as `SUM` or `COUNT()`. For `AGGREGATE` to work, your `mysql.func` table must contain a `type` column. If your `mysql.func` table does not have this column, you should run the `mysql_upgrade` program to create it (see Section 4.4.7, "`mysql_upgrade` — Check Tables for MySQL Upgrade").

> **Note**
>
> To upgrade the shared library associated with a UDF, issue a `DROP FUNCTION` statement, upgrade the shared library, and then issue a `CREATE FUNCTION` statement. If you upgrade the shared library first and then use `DROP FUNCTION`, the server may crash.

12.4.3.2. `DROP FUNCTION` Syntax

```
DROP FUNCTION function_name
```

This statement drops the user-defined function (UDF) named *`function_name`*.

To drop a function, you must have the `DELETE` privilege for the `mysql` database. This is because `DROP FUNCTION` removes a row from the `mysql.func` system table that records the function's name, type, and shared library name.

> **Note**
>
> To upgrade the shared library associated with a UDF, issue a `DROP FUNCTION` statement, upgrade the shared library, and then issue a `CREATE FUNCTION` statement. If you upgrade the shared library first and then use `DROP FUNCTION`, the server may crash.

`DROP FUNCTION` is also used to drop stored functions (see Section 12.1.21, "`DROP PROCEDURE` and `DROP FUNCTION` Syntax").

12.4.3.3. `INSTALL PLUGIN` Syntax

```
INSTALL PLUGIN plugin_name SONAME 'shared_library_name'
```

This statement installs a server plugin. It requires the `INSERT privilege` for the `mysql.plugin` table.

`plugin_name` is the name of the plugin as defined in the plugin descriptor structure contained in the library file (see Section 21.2.4.2, "Plugin Data Structures"). Plugin names are not case sensitive. For maximal compatibility, plugin names should be limited to ASCII letters, digits, and underscore because they are used in C source files, shell command lines, M4 and Bourne shell scripts, and SQL environments.

`shared_library_name` is the name of the shared library that contains the plugin code. The name includes the file name extension (for example, `libmyplugin.so`, `libmyplugin.dll`, or `libmyplugin.dylib`).

The shared library must be located in the plugin directory (the directory named by the `plugin_dir` system variable). The library must be in the plugin directory itself, not in a subdirectory. By default, `plugin_dir` is the `plugin` directory under the directory named by the `pkglibdir` configuration variable, but it can be changed by setting the value of `plugin_dir` at server startup. For example, set its value in a `my.cnf` file:

```
[mysqld]
plugin_dir=/path/to/plugin/directory
```

If the value of `plugin_dir` is a relative path name, it is taken to be relative to the MySQL base directory (the value of the `basedir` system variable).

`INSTALL PLUGIN` loads and initializes the plugin code to make the plugin available for use. A plugin is initialized by executing its initialization function, which handles any setup that the plugin must perform before it can be used. When the server shuts down, it executes the deinitialization function for each plugin that is loaded so that the plugin has a change to perform any final cleanup.

`INSTALL PLUGIN` also registers the plugin by adding a line that indicates the plugin name and library file name to the `mysql.plugin` table. At server startup, the server loads and initializes any plugin that is listed in the `mysql.plugin` table. This means that a plugin is installed with `INSTALL PLUGIN` only once, not every time the server starts. Plugin loading at startup does not occur if the server is started with the `--skip-grant-tables` option.

A plugin library can contain multiple plugins. For each of them to be installed, use a separate `INSTALL PLUGIN` statement. Each statement names a different plugin, but all of them specify the same library name.

`INSTALL PLUGIN` causes the server to read option (`my.cnf`) files just as during server startup. This enables the plugin to pick up any relevant options from those files. It is possible to add plugin options to an option file even before loading a plugin (if the `loose` prefix is used). It is also possible to uninstall a plugin, edit `my.cnf`, and install the plugin again. Restarting the plugin this way enables it to the new option values without a server restart.

For options that control individual plugin loading at server startup, see Section 5.1.7.1, "Installing and Uninstalling Plugins". If you need to load plugins for a single server startup when the `--skip-grant-tables` option is given (which tells the server not to read system tables), use the `--plugin-load` option. See Section 5.1.2, "Server Command Options".

To remove a plugin, use the `UNINSTALL PLUGIN` statement.

For additional information about plugin loading, see Section 5.1.7.1, "Installing and Uninstalling Plugins".

To see what plugins are installed, use the `SHOW PLUGINS` statement or query the `INFORMATION_SCHEMA.PLUGINS` table.

If you recompile a plugin library and need to reinstall it, you can use either of the following methods:

- Use `UNINSTALL PLUGIN` to uninstall all plugins in the library, install the new plugin library file in the plugin directory, and then use `INSTALL PLUGIN` to install all plugins in the library. This procedure has the advantage that it can be used without stopping the server. However, if the plugin library contains many plugins, you must issue many `INSTALL PLUGIN` and `UNINSTALL PLUGIN` statements.
- Stop the server, install the new plugin library file in the plugin directory, and restart the server.

12.4.3.4. `UNINSTALL PLUGIN` Syntax

```
UNINSTALL PLUGIN plugin_name
```

This statement removes an installed server plugin. It requires the `DELETE` privilege for the `mysql.plugin` table.

`plugin_name` must be the name of some plugin that is listed in the `mysql.plugin` table. The server executes the plugin's deinitialization function and removes the row for the plugin from the `mysql.plugin` table, so that subsequent server restarts will not load and initialize the plugin. `UNINSTALL PLUGIN` does not remove the plugin's shared library file.

You cannot uninstall a plugin if any table that uses it is open.

Plugin removal has implications for the use of associated tables. For example, if a full-text parser plugin is associated with a `FULLTEXT` index on the table, uninstalling the plugin makes the table unusable. Any attempt to access the table results in an error. The table cannot even be opened, so you cannot drop an index for which the plugin is used. This means that uninstalling a plugin is something to do with care unless you do not care about the table contents. If you are uninstalling a plugin with no intention of reinstalling it later and you care about the table contents, you should dump the table with `mysqldump` and remove the `WITH PARSER` clause from the dumped `CREATE TABLE` statement so that you can reload the table later. If you do not care about the table, `DROP TABLE` can be used even if any plugins associated with the table are missing.

For additional information about plugin loading, see Section 5.1.7.1, "Installing and Uninstalling Plugins".

12.4.4. `SET` Syntax

```
SET variable_assignment [, variable_assignment] ...

variable_assignment:
      user_var_name = expr
    | [GLOBAL | SESSION] system_var_name = expr
    | [@@global. | @@session. | @@]system_var_name = expr
```

The `SET` statement assigns values to different types of variables that affect the operation of the server or your client. Older versions of MySQL employed `SET OPTION`, but this syntax is deprecated in favor of `SET` without `OPTION`.

This section describes use of `SET` for assigning values to system variables or user variables. For general information about these types of variables, see Section 5.1.3, "Server System Variables", and Section 8.4, "User-Defined Variables". System variables also can be set at server startup, as described in Section 5.1.4, "Using System Variables".

Some variants of `SET` syntax are used in other contexts:

- `SET CHARACTER SET` and `SET NAMES` assign values to character set and collation variables associated with the connection to the server. `SET ONESHOT` is used for replication. These variants are described later in this section.
- `SET PASSWORD` assigns account passwords. See Section 12.4.1.6, "`SET PASSWORD` Syntax".
- `SET TRANSACTION ISOLATION LEVEL` sets the isolation level for transaction processing. See Section 12.3.6, "`SET TRANSACTION` Syntax".

- `SET` is used within stored routines to assign values to local routine variables. See Section 12.7.3.2, “Variable `SET` Statement”.

The following discussion shows the different `SET` syntaxes that you can use to set variables. The examples use the `=` assignment operator, but you can also use the `:=` assignment operator for this purpose.

A user variable is written as `@var_name` and can be set as follows:

```
SET @var_name = expr;
```

Many system variables are dynamic and can be changed while the server runs by using the `SET` statement. For a list, see Section 5.1.4.2, “Dynamic System Variables”. To change a system variable with `SET`, refer to it as `var_name`, optionally preceded by a modifier:

- To indicate explicitly that a variable is a global variable, precede its name by `GLOBAL` or `@@global.`. The `SUPER` privilege is required to set global variables.
- To indicate explicitly that a variable is a session variable, precede its name by `SESSION`, `@@session.`, or `@@`. Setting a session variable requires no special privilege, but a client can change only its own session variables, not those of any other client.
- `LOCAL` and `@@local.` are synonyms for `SESSION` and `@@session.`.
- If no modifier is present, `SET` changes the session variable.

A `SET` statement can contain multiple variable assignments, separated by commas. If you set several system variables, the most recent `GLOBAL` or `SESSION` modifier in the statement is used for following variables that have no modifier specified.

Examples:

```
SET sort_buffer_size=10000;
SET @@local.sort_buffer_size=10000;
SET GLOBAL sort_buffer_size=1000000, SESSION sort_buffer_size=1000000;
SET @@sort_buffer_size=1000000;
SET @@global.sort_buffer_size=1000000, @@local.sort_buffer_size=1000000;
```

The `@@var_name` syntax for system variables is supported for compatibility with some other database systems.

If you change a session system variable, the value remains in effect until your session ends or until you change the variable to a different value. The change is not visible to other clients.

If you change a global system variable, the value is remembered and used for new connections until the server restarts. (To make a global system variable setting permanent, you should set it in an option file.) The change is visible to any client that accesses that global variable. However, the change affects the corresponding session variable only for clients that connect after the change. The global variable change does not affect the session variable for any client that is currently connected (not even that of the client that issues the `SET GLOBAL` statement).

To prevent incorrect usage, MySQL produces an error if you use `SET GLOBAL` with a variable that can only be used with `SET SESSION` or if you do not specify `GLOBAL` (or `@@global.`) when setting a global variable.

To set a `SESSION` variable to the `GLOBAL` value or a `GLOBAL` value to the compiled-in MySQL default value, use the `DEFAULT` keyword. For example, the following two statements are identical in setting the session value of `max_join_size` to the global value:

```
SET max_join_size=DEFAULT;
SET @@session.max_join_size=@@global.max_join_size;
```

Not all system variables can be set to `DEFAULT`. In such cases, use of `DEFAULT` results in an error.

You can refer to the values of specific global or session system variables in expressions by using one of the `@@`-modifiers. For example, you can retrieve values in a `SELECT` statement like this:

```
SELECT @@global.sql_mode, @@session.sql_mode, @@sql_mode;
```

When you refer to a system variable in an expression as `@@var_name` (that is, when you do not specify `@@global.` or `@@session.`), MySQL returns the session value if it exists and the global value otherwise. (This differs from `SET @@var_name = value`, which always refers to the session value.)

Note

> Some variables displayed by `SHOW VARIABLES` may not be available using `SELECT @@var_name` syntax; an `Unknown system variable` occurs. As a workaround in such cases, you can use `SHOW VARIABLES LIKE 'var_name'`.

Suffixes for specifying a value multiplier can be used when setting a variable at server startup, but not to set the value with `SET` at runtime. On the other hand, with `SET` you can assign a variable's value using an expression, which is not true when you set a variable at server startup. For example, the first of the following lines is legal at server startup, but the second is not:

```
shell> mysql --max_allowed_packet=16M
shell> mysql --max_allowed_packet=16*1024*1024
```

Conversely, the second of the following lines is legal at runtime, but the first is not:

```
mysql> SET GLOBAL max_allowed_packet=16M;
mysql> SET GLOBAL max_allowed_packet=16*1024*1024;
```

To display system variables names and values, use the `SHOW VARIABLES` statement. (See Section 12.4.5.40, "`SHOW VARIABLES` Syntax".)

The following list describes `SET` options that have nonstandard syntax (that is, options that are not set with `name = value` syntax).

- `CHARACTER SET {charset_name | DEFAULT}`

  This maps all strings from and to the client with the given mapping. You can add new mappings by editing `sql/convert.cc` in the MySQL source distribution. `SET CHARACTER SET` sets three session system variables: `character_set_client` and `character_set_results` are set to the given character set, and `character_set_connection` to the value of `character_set_database`. See Section 9.1.4, "Connection Character Sets and Collations".

  The default mapping can be restored by using the value `DEFAULT`. The default depends on the server configuration.

  `ucs2`, `utf16`, and `utf32` cannot be used as a client character set, which means that they do not work for `SET CHARACTER SET`.

- `NAMES {'charset_name' [COLLATE 'collation_name'] | DEFAULT}`

  `SET NAMES` sets the three session system variables `character_set_client`, `character_set_connection`, and `character_set_results` to the given character set. Setting `character_set_connection` to `charset_name` also sets `collation_connection` to the default collation for `charset_name`. The optional `COLLATE` clause may be used to specify a collation explicitly. See Section 9.1.4, "Connection Character Sets and Collations".

  The default mapping can be restored by using a value of `DEFAULT`. The default depends on the server configuration.

  `ucs2`, `utf16`, and `utf32` cannot be used as a client character set, which means that they do not work for `SET NAMES`.

- `ONE_SHOT`

  This option is a modifier, not a variable. It is *only* for internal use for replication: `mysqlbinlog` uses `SET ONE_SHOT` to modify temporarily the values of character set, collation, and time zone variables to reflect at rollforward what they were originally. `ONE_SHOT` is for internal use only and is deprecated for MySQL 5.0 and up.

  `ONE_SHOT` is intended for use only with the permitted set of variables. It changes the variables as requested, but only for the next non-`SET` statement. After that, the server resets all character set, collation, and time zone-related system variables to their previous values. Example:

```
mysql> SET ONE_SHOT character_set_connection = latin5;

mysql> SET ONE_SHOT collation_connection = latin5_turkish_ci;

mysql> SHOW VARIABLES LIKE '%_connection';
+--------------------------+-------------------+
| Variable_name            | Value             |
+--------------------------+-------------------+
| character_set_connection | latin5            |
| collation_connection     | latin5_turkish_ci |
+--------------------------+-------------------+

mysql> SHOW VARIABLES LIKE '%_connection';
+--------------------------+-------------------+
| Variable_name            | Value             |
+--------------------------+-------------------+
| character_set_connection | latin1            |
| collation_connection     | latin1_swedish_ci |
+--------------------------+-------------------+
```

12.4.5. `SHOW` Syntax

`SHOW` has many forms that provide information about databases, tables, columns, or status information about the server. This section describes those following:

```
SHOW AUTHORS
SHOW {BINARY | MASTER} LOGS
SHOW BINLOG EVENTS [IN 'log_name'] [FROM pos] [LIMIT [offset,] row_count]
SHOW CHARACTER SET [like_or_where]
SHOW COLLATION [like_or_where]
SHOW [FULL] COLUMNS FROM tbl_name [FROM db_name] [like_or_where]
SHOW CONTRIBUTORS
SHOW CREATE DATABASE db_name
SHOW CREATE EVENT event_name
SHOW CREATE FUNCTION func_name
SHOW CREATE PROCEDURE proc_name
SHOW CREATE TABLE tbl_name
SHOW CREATE TRIGGER trigger_name
SHOW CREATE VIEW view_name
SHOW DATABASES [like_or_where]
SHOW ENGINE engine_name {STATUS | MUTEX}
SHOW [STORAGE] ENGINES
SHOW ERRORS [LIMIT [offset,] row_count]
SHOW EVENTS
SHOW FUNCTION CODE func_name
SHOW FUNCTION STATUS [like_or_where]
SHOW GRANTS FOR user
SHOW INDEX FROM tbl_name [FROM db_name]
SHOW MASTER STATUS
SHOW OPEN TABLES [FROM db_name] [like_or_where]
SHOW PLUGINS
SHOW PROCEDURE CODE proc_name
SHOW PROCEDURE STATUS [like_or_where]
SHOW PRIVILEGES
SHOW [FULL] PROCESSLIST
SHOW PROFILE [types] [FOR QUERY n] [OFFSET n] [LIMIT n]
SHOW PROFILES
SHOW SLAVE HOSTS
SHOW SLAVE STATUS
SHOW [GLOBAL | SESSION] STATUS [like_or_where]
SHOW TABLE STATUS [FROM db_name] [like_or_where]
SHOW [FULL] TABLES [FROM db_name] [like_or_where]
SHOW TRIGGERS [FROM db_name] [like_or_where]
SHOW [GLOBAL | SESSION] VARIABLES [like_or_where]
SHOW WARNINGS [LIMIT [offset,] row_count]

like_or_where:
    LIKE 'pattern'
  | WHERE expr
```

If the syntax for a given `SHOW` statement includes a `LIKE 'pattern'` part, `'pattern'` is a string that can contain the SQL "`%`" and "`_`" wildcard characters. The pattern is useful for restricting statement output to matching values.

Several `SHOW` statements also accept a `WHERE` clause that provides more flexibility in specifying which rows to display. See Section 18.31, "Extensions to `SHOW` Statements".

Many MySQL APIs (such as PHP) enable you to treat the result returned from a `SHOW` statement as you would a result set from a `SELECT`; see Chapter 20, *Connectors and APIs*, or your API documentation for more information. In addition, you can work in SQL with results from queries on tables in the `INFORMATION_SCHEMA` database, which you cannot easily do with results from `SHOW` statements. See Chapter 18, *`INFORMATION_SCHEMA` Tables*.

12.4.5.1. `SHOW AUTHORS` Syntax

```
SHOW AUTHORS
```

The `SHOW AUTHORS` statement displays information about the people who work on MySQL. For each author, it displays `Name`, `Location`, and `Comment` values.

12.4.5.2. `SHOW BINARY LOGS` Syntax

```
SHOW BINARY LOGS
SHOW MASTER LOGS
```

Lists the binary log files on the server. This statement is used as part of the procedure described in Section 12.5.1.1, "`PURGE BINARY LOGS` Syntax", that shows how to determine which logs can be purged.

```
mysql> SHOW BINARY LOGS;
+---------------+-----------+
| Log_name      | File_size |
+---------------+-----------+
| binlog.000015 |    724935 |
| binlog.000016 |    733481 |
+---------------+-----------+
```

`SHOW MASTER LOGS` is equivalent to `SHOW BINARY LOGS`.

12.4.5.3. `SHOW BINLOG EVENTS` Syntax

```
SHOW BINLOG EVENTS
   [IN 'log_name'] [FROM pos] [LIMIT [offset,] row_count]
```

Shows the events in the binary log. If you do not specify `'log_name'`, the first binary log is displayed.

The `LIMIT` clause has the same syntax as for the `SELECT` statement. See Section 12.2.9, “`SELECT` Syntax”.

> **Note**
>
> Issuing a `SHOW BINLOG EVENTS` with no `LIMIT` clause could start a very time- and resource-consuming process because the server returns to the client the complete contents of the binary log (which includes all statements executed by the server that modify data). As an alternative to `SHOW BINLOG EVENTS`, use the `mysqlbinlog` utility to save the binary log to a text file for later examination and analysis. See Section 4.6.7, “`mysqlbinlog` — Utility for Processing Binary Log Files”.

> **Note**
>
> Some events relating to the setting of user and system variables are not included in the output from `SHOW BINLOG EVENTS`. To get complete coverage of events within a binary log, use `mysqlbinlog`.

> **Note**
>
> `SHOW BINLOG EVENTS` does *not* work with relay log files. You can use `SHOW RELAYLOG EVENTS` for this purpose.

12.4.5.4. `SHOW CHARACTER SET` Syntax

```
SHOW CHARACTER SET
    [LIKE 'pattern' | WHERE expr]
```

The `SHOW CHARACTER SET` statement shows all available character sets. The `LIKE` clause, if present, indicates which character set names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”. For example:

```
mysql> SHOW CHARACTER SET LIKE 'latin%';
+---------+-----------------------------+-------------------+--------+
| Charset | Description                 | Default collation | Maxlen |
+---------+-----------------------------+-------------------+--------+
| latin1  | cp1252 West European        | latin1_swedish_ci |      1 |
| latin2  | ISO 8859-2 Central European | latin2_general_ci |      1 |
| latin5  | ISO 8859-9 Turkish          | latin5_turkish_ci |      1 |
| latin7  | ISO 8859-13 Baltic          | latin7_general_ci |      1 |
+---------+-----------------------------+-------------------+--------+
```

The `Maxlen` column shows the maximum number of bytes required to store one character.

12.4.5.5. `SHOW COLLATION` Syntax

```
SHOW COLLATION
    [LIKE 'pattern' | WHERE expr]
```

This statement lists collations supported by the server. By default, the output from `SHOW COLLATION` includes all available collations. The `LIKE` clause, if present, indicates which collation names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”. For example:

```
mysql> SHOW COLLATION LIKE 'latin1%';
+-------------------+---------+----+---------+----------+---------+
| Collation         | Charset | Id | Default | Compiled | Sortlen |
+-------------------+---------+----+---------+----------+---------+
| latin1_german1_ci | latin1  |  5 |         |          |       0 |
| latin1_swedish_ci | latin1  |  8 | Yes     | Yes      |       0 |
| latin1_danish_ci  | latin1  | 15 |         |          |       0 |
| latin1_german2_ci | latin1  | 31 |         | Yes      |       2 |
| latin1_bin        | latin1  | 47 |         | Yes      |       0 |
| latin1_general_ci | latin1  | 48 |         |          |       0 |
| latin1_general_cs | latin1  | 49 |         |          |       0 |
| latin1_spanish_ci | latin1  | 94 |         |          |       0 |
+-------------------+---------+----+---------+----------+---------+
```

The `Collation` and `Charset` columns indicate the names of the collation and the character set with which it is associated. `Id` is the collation ID. `Default` indicates whether the collation is the default for its character set. `Compiled` indicates whether the character set is compiled into the server. `Sortlen` is related to the amount of memory required to sort strings expressed in the character set.

To see the default collation for each character set, use the following statement. `Default` is a reserved word, so to use it as an identifier, it must be quoted as such:

```
mysql> SHOW COLLATION WHERE `Default` = 'Yes';
+---------------------+----------+----+---------+----------+---------+
| Collation           | Charset  | Id | Default | Compiled | Sortlen |
+---------------------+----------+----+---------+----------+---------+
| big5_chinese_ci     | big5     |  1 | Yes     | Yes      |       1 |
| dec8_swedish_ci     | dec8     |  3 | Yes     | Yes      |       1 |
| cp850_general_ci    | cp850    |  4 | Yes     | Yes      |       1 |
| hp8_english_ci      | hp8      |  6 | Yes     | Yes      |       1 |
| koi8r_general_ci    | koi8r    |  7 | Yes     | Yes      |       1 |
| latin1_swedish_ci   | latin1   |  8 | Yes     | Yes      |       1 |
...
```

12.4.5.6. `SHOW COLUMNS` Syntax

```
SHOW [FULL] COLUMNS {FROM | IN} tbl_name [{FROM | IN} db_name]
    [LIKE 'pattern' | WHERE expr]
```

`SHOW COLUMNS` displays information about the columns in a given table. It also works for views. The `LIKE` clause, if present, indicates which column names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

`SHOW COLUMNS` displays information only for those columns for which you have some privilege.

```
mysql> SHOW COLUMNS FROM City;
+------------+----------+------+-----+---------+----------------+
| Field      | Type     | Null | Key | Default | Extra          |
+------------+----------+------+-----+---------+----------------+
| Id         | int(11)  | NO   | PRI | NULL    | auto_increment |
| Name       | char(35) | NO   |     |         |                |
| Country    | char(3)  | NO   | UNI |         |                |
| District   | char(20) | YES  | MUL |         |                |
| Population | int(11)  | NO   |     | 0       |                |
+------------+----------+------+-----+---------+----------------+
5 rows in set (0.00 sec)
```

If the data types differ from what you expect them to be based on a `CREATE TABLE` statement, note that MySQL sometimes changes data types when you create or alter a table. The conditions under which this occurs are described in Section 12.1.14.2, “Silent Column Specification Changes”.

The `FULL` keyword causes the output to include the column collation and comments, as well as the privileges you have for each column.

You can use *`db_name.tbl_name`* as an alternative to the *`tbl_name`* `FROM` *`db_name`* syntax. In other words, these two statements are equivalent:

```
mysql> SHOW COLUMNS FROM mytable FROM mydb;
mysql> SHOW COLUMNS FROM mydb.mytable;
```

`SHOW COLUMNS` displays the following values for each table column:

`Field` indicates the column name.

`Type` indicates the column data type.

`Collation` indicates the collation for nonbinary string columns, or `NULL` for other columns. This value is displayed only if you use the `FULL` keyword.

The `Null` field contains `YES` if `NULL` values can be stored in the column, `NO` if not.

The `Key` field indicates whether the column is indexed:

- If `Key` is empty, the column either is not indexed or is indexed only as a secondary column in a multiple-column, nonunique index.

- If `Key` is `PRI`, the column is a `PRIMARY KEY` or is one of the columns in a multiple-column `PRIMARY KEY`.
- If `Key` is `UNI`, the column is the first column of a `UNIQUE` index. (A `UNIQUE` index permits multiple `NULL` values, but you can tell whether the column permits `NULL` by checking the `Null` field.)
- If `Key` is `MUL`, the column is the first column of a nonunique index in which multiple occurrences of a given value are permitted within the column.

If more than one of the `Key` values applies to a given column of a table, `Key` displays the one with the highest priority, in the order `PRI`, `UNI`, `MUL`.

A `UNIQUE` index may be displayed as `PRI` if it cannot contain `NULL` values and there is no `PRIMARY KEY` in the table. A `UNIQUE` index may display as `MUL` if several columns form a composite `UNIQUE` index; although the combination of the columns is unique, each column can still hold multiple occurrences of a given value.

The `Default` field indicates the default value that is assigned to the column.

The `Extra` field contains any additional information that is available about a given column. The value is `auto_increment` if the column was created with the `AUTO_INCREMENT` keyword and empty otherwise.

`Privileges` indicates the privileges you have for the column. This value is displayed only if you use the `FULL` keyword.

`Comment` indicates any comment the column has. This value is displayed only if you use the `FULL` keyword.

`SHOW FIELDS` is a synonym for `SHOW COLUMNS`. You can also list a table's columns with the `mysqlshow db_name tbl_name` command.

The `DESCRIBE` statement provides information similar to `SHOW COLUMNS`. See Section 12.8.1, “`DESCRIBE` Syntax”.

The `SHOW CREATE TABLE`, `SHOW TABLE STATUS`, and `SHOW INDEX` statements also provide information about tables. See Section 12.4.5, “`SHOW` Syntax”.

12.4.5.7. `SHOW CONTRIBUTORS` Syntax

```
SHOW CONTRIBUTORS
```

The `SHOW CONTRIBUTORS` statement displays information about the people who contribute to MySQL source or to causes that we support. For each contributor, it displays `Name`, `Location`, and `Comment` values.

12.4.5.8. `SHOW CREATE DATABASE` Syntax

```
SHOW CREATE {DATABASE | SCHEMA} db_name
```

Shows the `CREATE DATABASE` statement that creates the given database. `SHOW CREATE SCHEMA` is a synonym for `SHOW CREATE DATABASE`.

```
mysql> SHOW CREATE DATABASE test\G
*************************** 1. row ***************************
       Database: test
Create Database: CREATE DATABASE `test`
                 /*!40100 DEFAULT CHARACTER SET latin1 */

mysql> SHOW CREATE SCHEMA test\G
*************************** 1. row ***************************
       Database: test
Create Database: CREATE DATABASE `test`
                 /*!40100 DEFAULT CHARACTER SET latin1 */
```

`SHOW CREATE DATABASE` quotes table and column names according to the value of the `sql_quote_show_create` option. See Section 5.1.3, “Server System Variables”.

12.4.5.9. `SHOW CREATE EVENT` Syntax

```
SHOW CREATE EVENT event_name
```

This statement displays the `CREATE EVENT` statement needed to re-create a given event. For example (using the same event `e_daily` defined and then altered in Section 12.4.5.19, “`SHOW EVENTS` Syntax”):

```
mysql> SHOW CREATE EVENT test.e_daily\G
*************************** 1. row ***************************
               Event: e_daily
```

```
            sql_mode:
           time_zone: SYSTEM
        Create Event: CREATE EVENT `e_daily`
                        ON SCHEDULE EVERY 1 DAY
                        STARTS CURRENT_TIMESTAMP + INTERVAL 6 HOUR
                        ON COMPLETION NOT PRESERVE
                        ENABLE
                        COMMENT 'Saves total number of sessions then
                                clears the table each day'
                        DO BEGIN
                          INSERT INTO site_activity.totals (time, total)
                            SELECT CURRENT_TIMESTAMP, COUNT(*)
                            FROM site_activity.sessions;
                          DELETE FROM site_activity.sessions;
                        END
character_set_client: latin1
collation_connection: latin1_swedish_ci
  Database Collation: latin1_swedish_ci
```

`character_set_client` is the session value of the `character_set_client` system variable when the event was created. `collation_connection` is the session value of the `collation_connection` system variable when the event was created. `Database Collation` is the collation of the database with which the event is associated.

Note that the output reflects the current status of the event (`ENABLE`) rather than the status with which it was created.

12.4.5.10. `SHOW CREATE FUNCTION` Syntax

```
SHOW CREATE FUNCTION func_name
```

This statement is similar to `SHOW CREATE PROCEDURE` but for stored functions. See Section 12.4.5.11, “`SHOW CREATE PROCEDURE` Syntax”.

12.4.5.11. `SHOW CREATE PROCEDURE` Syntax

```
SHOW CREATE PROCEDURE proc_name
```

This statement is a MySQL extension. It returns the exact string that can be used to re-create the named stored procedure. A similar statement, `SHOW CREATE FUNCTION`, displays information about stored functions (see Section 12.4.5.10, “`SHOW CREATE FUNCTION` Syntax”).

Both statements require that you be the owner of the routine or have `SELECT` access to the `mysql.proc` table. If you do not have privileges for the routine itself, the value displayed for the `Create Procedure` or `Create Function` field will be `NULL`.

```
mysql> SHOW CREATE PROCEDURE test.simpleproc\G
*************************** 1. row ***************************
           Procedure: simpleproc
            sql_mode:
    Create Procedure: CREATE PROCEDURE `simpleproc`(OUT param1 INT)
                      BEGIN
                      SELECT COUNT(*) INTO param1 FROM t;
                      END
character_set_client: latin1
collation_connection: latin1_swedish_ci
  Database Collation: latin1_swedish_ci

mysql> SHOW CREATE FUNCTION test.hello\G
*************************** 1. row ***************************
            Function: hello
            sql_mode:
     Create Function: CREATE FUNCTION `hello`(s CHAR(20))
                      RETURNS CHAR(50)
                      RETURN CONCAT('Hello, ',s,'!')
character_set_client: latin1
collation_connection: latin1_swedish_ci
  Database Collation: latin1_swedish_ci
```

`character_set_client` is the session value of the `character_set_client` system variable when the routine was created. `collation_connection` is the session value of the `collation_connection` system variable when the routine was created. `Database Collation` is the collation of the database with which the routine is associated.

12.4.5.12. `SHOW CREATE TABLE` Syntax

```
SHOW CREATE TABLE tbl_name
```

Shows the `CREATE TABLE` statement that creates the given table. To use this statement, you must have some privilege for the table. This statement also works with views.

```
mysql> SHOW CREATE TABLE t\G
```

```
*************************** 1. row ***************************
       Table: t
Create Table: CREATE TABLE t (
  id INT(11) default NULL auto_increment,
  s char(60) default NULL,
  PRIMARY KEY (id)
) ENGINE=MyISAM
```

`SHOW CREATE TABLE` quotes table and column names according to the value of the `sql_quote_show_create` option. See Section 5.1.3, “Server System Variables”.

12.4.5.13. SHOW CREATE TRIGGER Syntax

```
SHOW CREATE TRIGGER trigger_name
```

This statement shows a `CREATE TRIGGER` statement that creates the given trigger.

```
mysql> SHOW CREATE TRIGGER ins_sum\G
*************************** 1. row ***************************
               Trigger: ins_sum
              sql_mode:
SQL Original Statement: CREATE DEFINER=`bob`@`localhost` TRIGGER ins_sum
                        BEFORE INSERT ON account
                        FOR EACH ROW SET @sum = @sum + NEW.amount
  character_set_client: latin1
  collation_connection: latin1_swedish_ci
    Database Collation: latin1_swedish_ci
```

You can also obtain information about trigger objects from `INFORMATION_SCHEMA`, which contains a `TRIGGERS` table. See Section 18.16, “The `INFORMATION_SCHEMA TRIGGERS` Table”.

12.4.5.14. SHOW CREATE VIEW Syntax

```
SHOW CREATE VIEW view_name
```

This statement shows a `CREATE VIEW` statement that creates the given view.

```
mysql> SHOW CREATE VIEW v\G
*************************** 1. row ***************************
                View: v
         Create View: CREATE ALGORITHM=UNDEFINED
                      DEFINER=`bob`@`localhost`
                      SQL SECURITY DEFINER VIEW
                      `v` AS select 1 AS `a`,2 AS `b`
character_set_client: latin1
collation_connection: latin1_swedish_ci
```

`character_set_client` is the session value of the `character_set_client` system variable when the view was created. `collation_connection` is the session value of the `collation_connection` system variable when the view was created.

Use of `SHOW CREATE VIEW` requires the `SHOW VIEW` privilege and the `SELECT` privilege for the view in question.

You can also obtain information about view objects from `INFORMATION_SCHEMA`, which contains a `VIEWS` table. See Section 18.15, “The `INFORMATION_SCHEMA VIEWS` Table”.

MySQL lets you use different `sql_mode` settings to tell the server the type of SQL syntax to support. For example, you might use the `ANSI` SQL mode to ensure MySQL correctly interprets the standard SQL concatenation operator, the double bar (`||`), in your queries. If you then create a view that concatenates items, you might worry that changing the `sql_mode` setting to a value different from `ANSI` could cause the view to become invalid. But this is not the case. No matter how you write out a view definition, MySQL always stores it the same way, in a canonical form. Here is an example that shows how the server changes a double bar concatenation operator to a `CONCAT()` function:

```
mysql> SET sql_mode = 'ANSI';
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE VIEW test.v AS SELECT 'a' || 'b' as col1;
Query OK, 0 rows affected (0.01 sec)

mysql> SHOW CREATE VIEW test.v\G
*************************** 1. row ***************************
                View: v
         Create View: CREATE VIEW "v" AS select concat('a','b') AS "col1"
...
1 row in set (0.00 sec)
```

The advantage of storing a view definition in canonical form is that changes made later to the value of `sql_mode` will not affect the results from the view. However an additional consequence is that comments prior to `SELECT` are stripped from the definition by the server.

12.4.5.15. `SHOW DATABASES` Syntax

```
SHOW {DATABASES | SCHEMAS}
    [LIKE 'pattern' | WHERE expr]
```

`SHOW DATABASES` lists the databases on the MySQL server host. `SHOW SCHEMAS` is a synonym for `SHOW DATABASES`. The `LIKE` clause, if present, indicates which database names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

You see only those databases for which you have some kind of privilege, unless you have the global `SHOW DATABASES` privilege. You can also get this list using the `mysqlshow` command.

If the server was started with the `--skip-show-database` option, you cannot use this statement at all unless you have the `SHOW DATABASES` privilege.

MySQL implements databases as directories in the data directory, so this statement simply lists directories in that location. However, the output may include names of directories that do not correspond to actual databases.

12.4.5.16. `SHOW ENGINE` Syntax

```
SHOW ENGINE engine_name {STATUS | MUTEX}
```

`SHOW ENGINE` displays operational information about a storage engine. The following statements currently are supported:

```
SHOW ENGINE INNODB STATUS
SHOW ENGINE INNODB MUTEX
SHOW ENGINE PERFORMANCE_SCHEMA STATUS
```

`SHOW ENGINE INNODB STATUS` displays extensive information from the standard `InnoDB` Monitor about the state of the `InnoDB` storage engine. For information about the standard monitor and other `InnoDB` Monitors that provide information about `InnoDB` processing, see Section 13.3.14.2, “`SHOW ENGINE INNODB STATUS` and the `InnoDB` Monitors”.

`SHOW ENGINE INNODB MUTEX` displays `InnoDB` mutex statistics. The statement displays the following fields:

- `Type`

  Always `InnoDB`.

- `Name`

  The source file where the mutex is implemented, and the line number in the file where the mutex is created. The line number may change depending on your version of MySQL.

- `Status`

  The mutex status. This field displays several values if `UNIV_DEBUG` was defined at MySQL compilation time (for example, in `include/univ.h` in the `InnoDB` part of the MySQL source tree). If `UNIV_DEBUG` was not defined, the statement displays only the `os_waits` value. In the latter case (without UNIV_DEBUG), the information on which the output is based is insufficient to distinguish regular mutexes and mutexes that protect rw-locks (which permit multiple readers or a single writer). Consequently, the output may appear to contain multiple rows for the same mutex.

  - `count` indicates how many times the mutex was requested.
  - `spin_waits` indicates how many times the spinlock had to run.
  - `spin_rounds` indicates the number of spinlock rounds. (`spin_rounds` divided by `spin_waits` provides the average round count.)
  - `os_waits` indicates the number of operating system waits. This occurs when the spinlock did not work (the mutex was not locked during the spinlock and it was necessary to yield to the operating system and wait).
  - `os_yields` indicates the number of times a the thread trying to lock a mutex gave up its timeslice and yielded to the operating system (on the presumption that permitting other threads to run will free the mutex so that it can be locked).
  - `os_wait_times` indicates the amount of time (in ms) spent in operating system waits, if the `timed_mutexes` system variable is 1 (`ON`). If `timed_mutexes` is 0 (`OFF`), timing is disabled, so `os_wait_times` is 0. `timed_mutexes` is off by default.

Information from this statement can be used to diagnose system problems. For example, large values of `spin_waits` and `spin_rounds` may indicate scalability problems.

Use `SHOW ENGINE PERFORMANCE_SCHEMA STATUS` to inspect the internal operation of the Performance Schema code:

```
mysql> SHOW ENGINE PERFORMANCE_SCHEMA STATUS\G
...
*************************** 3. row ***************************
  Type: performance_schema
  Name: events_waits_history.row_size
Status: 76
*************************** 4. row ***************************
  Type: performance_schema
  Name: events_waits_history.row_count
Status: 10000
*************************** 5. row ***************************
  Type: performance_schema
  Name: events_waits_history.memory
Status: 760000
...
*************************** 57. row ***************************
  Type: performance_schema
  Name: performance_schema.memory
Status: 26459600
...
```

The intent of this statement is to help the DBA to understand the effects that different options have on memory requirements.

`Name` values consist of two parts, which name an internal buffer and an attribute of the buffer, respectively:

- Internal buffers that are exposed as a table in the `performance_schema` database are named after the table. Examples: `events_waits_history.row_size`, `mutex_instances.row_count`.
- Internal buffers that are not exposed as a table are named within parentheses. Examples: `(pfs_cond_class).row_size`, `(pfs_mutex_class).memory`.
- Values that apply to the Performance Schema as a whole begin with `performance_schema`. Example: `performance_schema.memory`.

Attributes have these meanings:

- `row_size` cannot be changed. It is the size of the internal record used by the implementation.
- `row_count` can be changed depending on the configuration options.
- For a table, `*tbl_name*.memory` is the product of `row_size` multiplied by `row_count`. For the Performance Schema as a whole, `performance_schema.memory` is the sum of all the memory used (the sum of all other `memory` values).

In some cases, there is a direct relationship between a configuration parameter and a `SHOW ENGINE` value. For example, `events_waits_history_long.row_count` corresponds to `performance_schema_events_waits_history_long_size`. In other cases, the relationship is more complex. For example, `events_waits_history.row_count` corresponds to `performance_schema_events_waits_history_size` (the number of rows per thread) multiplied by `performance_schema_max_thread_instances` (the number of threads).

12.4.5.17. `SHOW ENGINES` Syntax

```
SHOW [STORAGE] ENGINES
```

`SHOW ENGINES` displays status information about the server's storage engines. This is particularly useful for checking whether a storage engine is supported, or to see what the default engine is.

```
mysql> SHOW ENGINES\G
*************************** 1. row ***************************
      Engine: MEMORY
     Support: YES
     Comment: Hash based, stored in memory, useful for temporary tables
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 2. row ***************************
      Engine: MyISAM
     Support: DEFAULT
     Comment: Default engine as of MySQL 3.23 with great performance
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 3. row ***************************
      Engine: InnoDB
     Support: YES
     Comment: Supports transactions, row-level locking, and foreign keys
Transactions: YES
          XA: YES
  Savepoints: YES
*************************** 4. row ***************************
      Engine: EXAMPLE
     Support: YES
     Comment: Example storage engine
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 5. row ***************************
      Engine: ARCHIVE
     Support: YES
     Comment: Archive storage engine
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 6. row ***************************
      Engine: CSV
     Support: YES
     Comment: CSV storage engine
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 7. row ***************************
      Engine: BLACKHOLE
     Support: YES
     Comment: /dev/null storage engine (anything you write »
              to it disappears)
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 8. row ***************************
      Engine: FEDERATED
     Support: YES
     Comment: Federated MySQL storage engine
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 9. row ***************************
      Engine: MRG_MYISAM
     Support: YES
     Comment: Collection of identical MyISAM tables
Transactions: NO
          XA: NO
  Savepoints: NO
```

The output from `SHOW ENGINES` may vary according to the MySQL version used and other factors. The values shown in the `Support` column indicate the server's level of support for the storage engine, as shown in the following table.

Value	**Meaning**
`YES`	The engine is supported and is active
`DEFAULT`	Like `YES`, plus this is the default engine
`NO`	The engine is not supported
`DISABLED`	The engine is supported but has been disabled

A value of `NO` means that the server was compiled without support for the engine, so it cannot be enabled at runtime.

A value of `DISABLED` occurs either because the server was started with an option that disables the engine, or because not all options required to enable it were given. In the latter case, the error log file should contain a reason indicating why the option is disabled. See Section 5.2.2, “The Error Log”.

You might also see `DISABLED` for a storage engine if the server was compiled to support it, but was started with a `--skip-engine_name` option.

All MySQL servers support `MyISAM` tables, because `MyISAM` is the default storage engine. It is not possible to disable `MyISAM`.

The `Transactions`, `XA`, and `Savepoints` columns indicate whether the storage engine supports transactions, XA transactions, and savepoints, respectively.

12.4.5.18. `SHOW ERRORS` Syntax

```
SHOW ERRORS [LIMIT [offset,] row_count]
SHOW COUNT(*) ERRORS
```

This statement is similar to `SHOW WARNINGS`, except that instead of displaying errors, warnings, and notes, it displays only errors.

The `LIMIT` clause has the same syntax as for the `SELECT` statement. See Section 12.2.9, “`SELECT` Syntax”.

The `SHOW COUNT(*) ERRORS` statement displays the number of errors. You can also retrieve this number from the `error_count` variable:

```
SHOW COUNT(*) ERRORS;
SELECT @@error_count;
```

For more information, see Section 12.4.5.41, “`SHOW WARNINGS` Syntax”.

12.4.5.19. `SHOW EVENTS` Syntax

```
SHOW EVENTS [{FROM | IN} schema_name]
    [LIKE 'pattern' | WHERE expr]
```

In its simplest form, `SHOW EVENTS` lists all of the events in the current schema:

```
mysql> SELECT CURRENT_USER(), SCHEMA();
+----------------+----------+
| CURRENT_USER() | SCHEMA() |
+----------------+----------+
| jon@ghidora    | myschema |
+----------------+----------+
1 row in set (0.00 sec)

mysql> SHOW EVENTS\G
*************************** 1. row ***************************
                  Db: myschema
                Name: e_daily
             Definer: jon@ghidora
           Time zone: SYSTEM
                Type: RECURRING
          Execute at: NULL
      Interval value: 10
      Interval field: SECOND
              Starts: 2006-02-09 10:41:23
                Ends: NULL
              Status: ENABLED
          Originator: 0
character_set_client: latin1
collation_connection: latin1_swedish_ci
  Database Collation: latin1_swedish_ci
```

To see events for a specific schema, use the `FROM` clause. For example, to see events for the `test` schema, use the following statement:

```
SHOW EVENTS FROM test;
```

The `LIKE` clause, if present, indicates which event names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

`SHOW EVENTS` output has the following columns:

- `Db`: The schema (database) on which the event is defined.
- `Name`: The name of the event.
- `Time zone`: The event time zone, which is the time zone used for scheduling the event and that is in effect within the event as it executes. The default value is `SYSTEM`.
- `Definer`: The account of the user who created the event, in `'user_name'@'host_name'` format.
- `Type`: The event repetition type, either `ONE TIME` (transient) or `RECURRING` (repeating).
- `Execute At`: The date and time when a transient event is set to execute. Shown as a `DATETIME` value.

  For a recurring event, the value of this column is always `NULL`.
- `Interval Value`: For a recurring event, the number of intervals to wait between event executions.

  For a transient event, the value of this column is always `NULL`.
- `Interval Field`: The time units used for the interval which a recurring event waits before repeating.

For a transient event, the value of this column is always `NULL`.

- `Starts`: The start date and time for a recurring event. This is displayed as a `DATETIME` value, and is `NULL` if no start date and time are defined for the event.

  For a transient event, this column is always `NULL`.

- `Ends`: The end date and time for a recurring event. This is displayed as a `DATETIME` value, and defaults to `NULL` if no end date and time is defined for the event.

  For a transient event, this column is always `NULL`.

- `Status`: The event status. One of `ENABLED`, `DISABLED`, or `SLAVESIDE_DISABLED`.

  `SLAVESIDE_DISABLED` indicates that the creation of the event occurred on another MySQL server acting as a replication master and replicated to the current MySQL server which is acting as a slave, but the event is not presently being executed on the slave.

- `Originator`: The server ID of the MySQL server on which the event was created. Defaults to 0.

- `character_set_client` is the session value of the `character_set_client` system variable when the routine was created. `collation_connection` is the session value of the `collation_connection` system variable when the routine was created. `Database Collation` is the collation of the database with which the routine is associated.

For more information about `SLAVE_DISABLED` and the `Originator` column, see Section 15.4.1.8, “Replication of Invoked Features”.

The event action statement is not shown in the output of `SHOW EVENTS`. Use `SHOW CREATE EVENT` or the `INFORMATION_SCHEMA.EVENTS` table.

Times displayed by `SHOW EVENTS` are given in the event time zone, as discussed in Section 17.4.4, “Event Metadata”.

The columns in the output of `SHOW EVENTS` are similar to, but not identical to the columns in the `INFORMATION_SCHEMA.EVENTS` table. See Section 18.20, “The `INFORMATION_SCHEMA EVENTS` Table”.

12.4.5.20. `SHOW FUNCTION CODE` Syntax

```
SHOW FUNCTION CODE func_name
```

This statement is similar to `SHOW PROCEDURE CODE` but for stored functions. See Section 12.4.5.28, “`SHOW PROCEDURE CODE` Syntax”.

12.4.5.21. `SHOW FUNCTION STATUS` Syntax

```
SHOW FUNCTION STATUS
    [LIKE 'pattern' | WHERE expr]
```

This statement is similar to `SHOW PROCEDURE STATUS` but for stored functions. See Section 12.4.5.29, “`SHOW PROCEDURE STATUS` Syntax”.

12.4.5.22. `SHOW GRANTS` Syntax

```
SHOW GRANTS [FOR user]
```

This statement lists the `GRANT` statement or statements that must be issued to duplicate the privileges that are granted to a MySQL user account. The account is named using the same format as for the `GRANT` statement; for example, `'jeffrey'@'localhost'`. If you specify only the user name part of the account name, a host name part of `'%'` is used. For additional information about specifying account names, see Section 12.4.1.3, “`GRANT` Syntax”.

```
mysql> SHOW GRANTS FOR 'root'@'localhost';
+---------------------------------------------------------------------+
| Grants for root@localhost                                           |
+---------------------------------------------------------------------+
| GRANT ALL PRIVILEGES ON *.* TO 'root'@'localhost' WITH GRANT OPTION |
+---------------------------------------------------------------------+
```

To list the privileges granted to the account that you are using to connect to the server, you can use any of the following statements:

```
SHOW GRANTS;
SHOW GRANTS FOR CURRENT_USER;
SHOW GRANTS FOR CURRENT_USER();
```

If `SHOW GRANTS FOR CURRENT_USER` (or any of the equivalent syntaxes) is used in `DEFINER` context, such as within a stored procedure that is defined with `SQL SECURITY DEFINER`), the grants displayed are those of the definer and not the invoker.

`SHOW GRANTS` displays only the privileges granted explicitly to the named account. Other privileges might be available to the account, but they are not displayed. For example, if an anonymous account exists, the named account might be able to use its privileges, but `SHOW GRANTS` will not display them.

`SHOW GRANTS` requires the `SELECT` privilege for the `mysql` database.

12.4.5.23. `SHOW INDEX` Syntax

```
SHOW {INDEX | INDEXES | KEYS}
    {FROM | IN} tbl_name
    [{FROM | IN} db_name]
    [WHERE expr]
```

`SHOW INDEX` returns table index information. The format resembles that of the `SQLStatistics` call in ODBC. This statement requires some privilege for any column in the table.

`SHOW INDEX` returns the following fields:

- `Table`

  The name of the table.

- `Non_unique`

  0 if the index cannot contain duplicates, 1 if it can.

- `Key_name`

  The name of the index.

- `Seq_in_index`

  The column sequence number in the index, starting with 1.

- `Column_name`

  The column name.

- `Collation`

  How the column is sorted in the index. In MySQL, this can have values “`A`” (Ascending) or `NULL` (Not sorted).

- `Cardinality`

  An estimate of the number of unique values in the index. This is updated by running `ANALYZE TABLE` or `myisamchk -a`. `Cardinality` is counted based on statistics stored as integers, so the value is not necessarily exact even for small tables. The higher the cardinality, the greater the chance that MySQL uses the index when doing joins.

- `Sub_part`

  The number of indexed characters if the column is only partly indexed, `NULL` if the entire column is indexed.

- `Packed`

  Indicates how the key is packed. `NULL` if it is not.

- `Null`

  Contains `YES` if the column may contain `NULL`. If not, the column contains `NO`.

  Contains `YES` if the column may contain `NULL` values and `''` if not.

- `Index_type`

The index method used (`BTREE`, `FULLTEXT`, `HASH`, `RTREE`).

- `Comment`

  Information about the index not described in its own column, such as `disabled` if the index is disabled.

- `Index_comment`

  Any comment provided for the index with a `COMMENT` attribute when the index was created.

You can use *`db_name.tbl_name`* as an alternative to the *`tbl_name`* `FROM` *`db_name`* syntax. These two statements are equivalent:

```
SHOW INDEX FROM mytable FROM mydb;
SHOW INDEX FROM mydb.mytable;
```

The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

You can also list a table's indexes with the `mysqlshow -k` *`db_name tbl_name`* command.

12.4.5.24. `SHOW MASTER STATUS` Syntax

```
SHOW MASTER STATUS
```

This statement provides status information about the binary log files of the master. It requires either the `SUPER` or `REPLICATION CLIENT` privilege.

Example:

```
mysql> SHOW MASTER STATUS;
+---------------+----------+--------------+------------------+
| File          | Position | Binlog_Do_DB | Binlog_Ignore_DB |
+---------------+----------+--------------+------------------+
| mysql-bin.003 | 73       | test         | manual,mysql     |
+---------------+----------+--------------+------------------+
```

12.4.5.25. `SHOW OPEN TABLES` Syntax

```
SHOW OPEN TABLES [{FROM | IN} db_name]
    [LIKE 'pattern' | WHERE expr]
```

`SHOW OPEN TABLES` lists the non-`TEMPORARY` tables that are currently open in the table cache. See Section 7.4.3.1, “How MySQL Opens and Closes Tables”. The `FROM` clause, if present, restricts the tables shown to those present in the *`db_name`* database. The `LIKE` clause, if present, indicates which table names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

`SHOW OPEN TABLES` returns the following columns:

- `Database`

  The database containing the table.

- `Table`

  The table name.

- `In_use`

  The number of table locks or lock requests there are for the table. For example, if one client acquires a lock for a table using `LOCK TABLE t1 WRITE`, `In_use` will be 1. If another client issues `LOCK TABLE t1 WRITE` while the table remains locked, the client will block waiting for the lock, but the lock request causes `In_use` to be 2. If the count is zero, the table is open but not currently being used. `In_use` is also increased by the `HANDLER ... OPEN` statement and decreased by `HANDLER ... CLOSE`.

- `Name_locked`

  Whether the table name is locked. Name locking is used for operations such as dropping or renaming tables.

If you have no privileges for a table, it does not show up in the output from `SHOW OPEN TABLES`.

12.4.5.26. `SHOW PLUGINS` Syntax

```
SHOW PLUGINS
```

`SHOW PLUGINS` displays information about server plugins. Plugin information is also available in the `INFORMATION_SCHEMA.PLUGINS` table. See Section 18.17, "The `INFORMATION_SCHEMA PLUGINS` Table".

Example of `SHOW PLUGINS` output:

```
mysql> SHOW PLUGINS\G
*************************** 1. row ***************************
   Name: binlog
 Status: ACTIVE
   Type: STORAGE ENGINE
Library: NULL
License: GPL
*************************** 2. row ***************************
   Name: CSV
 Status: ACTIVE
   Type: STORAGE ENGINE
Library: NULL
License: GPL
*************************** 3. row ***************************
   Name: MEMORY
 Status: ACTIVE
   Type: STORAGE ENGINE
Library: NULL
License: GPL
*************************** 4. row ***************************
   Name: MyISAM
 Status: ACTIVE
   Type: STORAGE ENGINE
Library: NULL
License: GPL
...
```

`SHOW PLUGINS` returns the following columns:

- `Name`: The name used to refer to the plugin in statements such as `INSTALL PLUGIN` and `UNINSTALL PLUGIN`.
- `Status`: The plugin status, one of `ACTIVE`, `INACTIVE`, `DISABLED`, or `DELETED`.
- `Type`: The type of plugin, such as `STORAGE ENGINE`, `INFORMATION_SCHEMA`, or `AUTHENTICATION`.
- `Library`: The name of the plugin shared object file. This is the name used to refer to the plugin file in statements such as `INSTALL PLUGIN` and `UNINSTALL PLUGIN`. This file is located in the directory named by the `plugin_dir` system variable. If the library name is `NULL`, the plugin is compiled in and cannot be uninstalled with `UNINSTALL PLUGIN`.
- `License`: How the plugin is licensed; for example, `GPL`.

For plugins installed with `INSTALL PLUGIN`, the `Name` and `Library` values are also registered in the `mysql.plugin` table.

For information about plugin data structures that form the basis of the information displayed by `SHOW PLUGINS`, see Section 21.2, "The MySQL Plugin API".

12.4.5.27. `SHOW PRIVILEGES` Syntax

```
SHOW PRIVILEGES
```

`SHOW PRIVILEGES` shows the list of system privileges that the MySQL server supports. The exact list of privileges depends on the version of your server.

```
mysql> SHOW PRIVILEGES\G
*************************** 1. row ***************************
Privilege: Alter
Context: Tables
Comment: To alter the table
*************************** 2. row ***************************
Privilege: Alter routine
Context: Functions,Procedures
Comment: To alter or drop stored functions/procedures
*************************** 3. row ***************************
Privilege: Create
Context: Databases,Tables,Indexes
Comment: To create new databases and tables
*************************** 4. row ***************************
```

```
Privilege: Create routine
Context: Functions,Procedures
Comment: To use CREATE FUNCTION/PROCEDURE
*************************** 5. row ***************************
Privilege: Create temporary tables
Context: Databases
Comment: To use CREATE TEMPORARY TABLE
...
```

Privileges belonging to a specific user are displayed by the `SHOW GRANTS` statement. See Section 12.4.5.22, "`SHOW GRANTS` Syntax", for more information.

12.4.5.28. `SHOW PROCEDURE CODE` Syntax

```
SHOW PROCEDURE CODE proc_name
```

This statement is a MySQL extension that is available only for servers that have been built with debugging support. It displays a representation of the internal implementation of the named stored procedure. A similar statement, `SHOW FUNCTION CODE`, displays information about stored functions (see Section 12.4.5.20, "`SHOW FUNCTION CODE` Syntax").

Both statements require that you be the owner of the routine or have `SELECT` access to the `mysql.proc` table.

If the named routine is available, each statement produces a result set. Each row in the result set corresponds to one "instruction" in the routine. The first column is `Pos`, which is an ordinal number beginning with 0. The second column is `Instruction`, which contains an SQL statement (usually changed from the original source), or a directive which has meaning only to the stored-routine handler.

```
mysql> DELIMITER //
mysql> CREATE PROCEDURE p1 ()
    -> BEGIN
    ->   DECLARE fanta INT DEFAULT 55;
    ->   DROP TABLE t2;
    ->   LOOP
    ->     INSERT INTO t3 VALUES (fanta);
    ->     END LOOP;
    ->   END//
Query OK, 0 rows affected (0.00 sec)

mysql> SHOW PROCEDURE CODE p1//
+-----+-----------------------------------------+
| Pos | Instruction                             |
+-----+-----------------------------------------+
|   0 | set fanta@0 55                          |
|   1 | stmt 9 "DROP TABLE t2"                  |
|   2 | stmt 5 "INSERT INTO t3 VALUES (fanta)"  |
|   3 | jump 2                                  |
+-----+-----------------------------------------+
4 rows in set (0.00 sec)
```

In this example, the nonexecutable `BEGIN` and `END` statements have disappeared, and for the `DECLARE variable_name` statement, only the executable part appears (the part where the default is assigned). For each statement that is taken from source, there is a code word `stmt` followed by a type (9 means `DROP`, 5 means `INSERT`, and so on). The final row contains an instruction `jump 2`, meaning `GOTO instruction #2`.

12.4.5.29. `SHOW PROCEDURE STATUS` Syntax

```
SHOW PROCEDURE STATUS
    [LIKE 'pattern' | WHERE expr]
```

This statement is a MySQL extension. It returns characteristics of a stored procedure, such as the database, name, type, creator, creation and modification dates, and character set information. A similar statement, `SHOW FUNCTION STATUS`, displays information about stored functions (see Section 12.4.5.21, "`SHOW FUNCTION STATUS` Syntax").

The `LIKE` clause, if present, indicates which procedure or function names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, "Extensions to `SHOW` Statements".

```
mysql> SHOW PROCEDURE STATUS LIKE 'sp1'\G
*************************** 1. row ***************************
                  Db: test
                Name: sp1
                Type: PROCEDURE
             Definer: testuser@localhost
            Modified: 2004-08-03 15:29:37
             Created: 2004-08-03 15:29:37
       Security_type: DEFINER
             Comment:
character_set_client: latin1
collation_connection: latin1_swedish_ci
  Database Collation: latin1_swedish_ci
```

`character_set_client` is the session value of the `character_set_client` system variable when the routine was created. `collation_connection` is the session value of the `collation_connection` system variable when the routine was created. `Database Collation` is the collation of the database with which the routine is associated.

You can also get information about stored routines from the `ROUTINES` table in `INFORMATION_SCHEMA`. See Section 18.14, “The `INFORMATION_SCHEMA ROUTINES` Table”.

12.4.5.30. `SHOW PROCESSLIST` Syntax

```
SHOW [FULL] PROCESSLIST
```

`SHOW PROCESSLIST` shows you which threads are running. You can also get this information from the `INFORMATION_SCHEMA PROCESSLIST` table or the `mysqladmin processlist` command. If you have the `PROCESS` privilege, you can see all threads. Otherwise, you can see only your own threads (that is, threads associated with the MySQL account that you are using). If you do not use the `FULL` keyword, only the first 100 characters of each statement are shown in the `Info` field.

This statement is very useful if you get the “too many connections” error message and want to find out what is going on. MySQL reserves one extra connection to be used by accounts that have the `SUPER` privilege, to ensure that administrators should always be able to connect and check the system (assuming that you are not giving this privilege to all your users).

Threads can be killed with the `KILL` statement. See Section 12.4.6.4, “`KILL` Syntax”.

Here is an example of `SHOW PROCESSLIST` output:

```
mysql> SHOW FULL PROCESSLIST\G
*************************** 1. row ***************************
Id: 1
User: system user
Host:
db: NULL
Command: Connect
Time: 1030455
State: Waiting for master to send event
Info: NULL
*************************** 2. row ***************************
Id: 2
User: system user
Host:
db: NULL
Command: Connect
Time: 1004
State: Has read all relay log; waiting for the slave
       I/O thread to update it
Info: NULL
*************************** 3. row ***************************
Id: 3112
User: replikator
Host: artemis:2204
db: NULL
Command: Binlog Dump
Time: 2144
State: Has sent all binlog to slave; waiting for binlog to be updated
Info: NULL
*************************** 4. row ***************************
Id: 3113
User: replikator
Host: iconnect2:45781
db: NULL
Command: Binlog Dump
Time: 2086
State: Has sent all binlog to slave; waiting for binlog to be updated
Info: NULL
*************************** 5. row ***************************
Id: 3123
User: stefan
Host: localhost
db: apollon
Command: Query
Time: 0
State: NULL
Info: SHOW FULL PROCESSLIST
5 rows in set (0.00 sec)
```

The columns produced by `SHOW PROCESSLIST` have the following meanings:

- `Id`

  The connection identifier.

- `User`

The MySQL user who issued the statement. If this is `system user`, it refers to a nonclient thread spawned by the server to handle tasks internally. This could be the I/O or SQL thread used on replication slaves or a delayed-row handler. `unauthenticated user` refers to a thread that has become associated with a client connection but for which authentication of the client user has not yet been done. `event_scheduler` refers to the thread that monitors scheduled events. For `system user`, there is no host specified in the `Host` column.

- `Host`

  The host name of the client issuing the statement (except for `system user` where there is no host). `SHOW PROCESSLIST` reports the host name for TCP/IP connections in `host_name:client_port` format to make it easier to determine which client is doing what.

- `db`

  The default database, if one is selected, otherwise `NULL`.

- `Command`

  The type of command the thread is executing. For descriptions for thread commands, see Section 7.12.5, “Examining Thread Information”. The value of this column corresponds to the `COM_xxx` commands of the client/server protocol and `Com_xxx` status variables. See Section 5.1.5, “Server Status Variables”

- `Time`

  The time in seconds that the thread has been in its current state.

- `State`

  An action, event, or state that indicates what the thread is doing. Descriptions for `State` values can be found at Section 7.12.5, “Examining Thread Information”.

  Most states correspond to very quick operations. If a thread stays in a given state for many seconds, there might be a problem that needs to be investigated.

  For the `SHOW PROCESSLIST` statement, the value of `State` is `NULL`.

- `Info`

  The statement the thread is executing, or `NULL` if it is not executing any statement. The statement might be the one sent to the server, or an innermost statement if the statement executes other statements. For example, if a `CALL` statement executes a stored procedure that is executing a `SELECT` statement, the `Info` value shows the `SELECT` statement.

12.4.5.31. `SHOW PROFILE` Syntax

```
SHOW PROFILES
```

The `SHOW PROFILE` statement display profiling information that indicates resource usage for statements executed during the course of the current session. It is used together with `SHOW PROFILES`; see Section 12.4.5.32, “`SHOW PROFILES` Syntax”.

12.4.5.32. `SHOW PROFILES` Syntax

```
SHOW PROFILE [type [, type] ... ]
    [FOR QUERY n]
    [LIMIT row_count [OFFSET offset]]

type:
    ALL
  | BLOCK IO
  | CONTEXT SWITCHES
  | CPU
  | IPC
  | MEMORY
  | PAGE FAULTS
  | SOURCE
  | SWAPS
```

The `SHOW PROFILES` and `SHOW PROFILE` statements display profiling information that indicates resource usage for statements executed during the course of the current session.

Profiling is controlled by the `profiling` session variable, which has a default value of 0 (`OFF`). Profiling is enabled by setting `profiling` to 1 or `ON`:

```
mysql> SET profiling = 1;
```

`SHOW PROFILES` displays a list of the most recent statements sent to the master. The size of the list is controlled by the `profiling_history_size` session variable, which has a default value of 15. The maximum value is 100. Setting the value to 0 has the practical effect of disabling profiling.

All statements are profiled except `SHOW PROFILES` and `SHOW PROFILE`, so you will find neither of those statements in the profile list. Malformed statements are profiled. For example, `SHOW PROFILING` is an illegal statement, and a syntax error occurs if you try to execute it, but it will show up in the profiling list.

`SHOW PROFILE` displays detailed information about a single statement. Without the `FOR QUERY n` clause, the output pertains to the most recently executed statement. If `FOR QUERY n` is included, `SHOW PROFILE` displays information for statement *`n`*. The values of *`n`* correspond to the `Query_ID` values displayed by `SHOW PROFILES`.

The `LIMIT row_count` clause may be given to limit the output to *`row_count`* rows. If `LIMIT` is given, `OFFSET offset` may be added to begin the output *`offset`* rows into the full set of rows.

By default, `SHOW PROFILE` displays `Status` and `Duration` columns. The `Status` values are like the `State` values displayed by `SHOW PROCESSLIST`, although there might be some minor differences in interpretion for the two statements for some status values (see Section 7.12.5, "Examining Thread Information").

Optional *`type`* values may be specified to display specific additional types of information:

- `ALL` displays all information
- `BLOCK IO` displays counts for block input and output operations
- `CONTEXT SWITCHES` displays counts for voluntary and involuntary context switches
- `CPU` displays user and system CPU usage times
- `IPC` displays counts for messages sent and received
- `MEMORY` is not currently implemented
- `PAGE FAULTS` displays counts for major and minor page faults
- `SOURCE` displays the names of functions from the source code, together with the name and line number of the file in which the function occurs
- `SWAPS` displays swap counts

Profiling is enabled per session. When a session ends, its profiling information is lost.

```
mysql> SELECT @@profiling;
+-------------+
| @@profiling |
+-------------+
|           0 |
+-------------+
1 row in set (0.00 sec)

mysql> SET profiling = 1;
Query OK, 0 rows affected (0.00 sec)

mysql> DROP TABLE IF EXISTS t1;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> CREATE TABLE T1 (id INT);
Query OK, 0 rows affected (0.01 sec)

mysql> SHOW PROFILES;
+----------+----------+--------------------------+
| Query_ID | Duration | Query                    |
+----------+----------+--------------------------+
|        0 | 0.000088 | SET PROFILING = 1        |
|        1 | 0.000136 | DROP TABLE IF EXISTS t1  |
|        2 | 0.011947 | CREATE TABLE t1 (id INT) |
+----------+----------+--------------------------+
3 rows in set (0.00 sec)

mysql> SHOW PROFILE;
+----------------------+----------+
| Status               | Duration |
+----------------------+----------+
| checking permissions | 0.000040 |
| creating table       | 0.000056 |
| After create         | 0.011363 |
| query end             | 0.000375 |
| freeing items         | 0.000089 |
| logging slow query    | 0.000019 |
| cleaning up           | 0.000005 |
+-----------------------+----------+
7 rows in set (0.00 sec)

mysql> SHOW PROFILE FOR QUERY 1;
+--------------------+----------+
| Status             | Duration |
+--------------------+----------+
| query end          | 0.000107 |
| freeing items      | 0.000008 |
| logging slow query | 0.000015 |
| cleaning up        | 0.000006 |
+--------------------+----------+
4 rows in set (0.00 sec)

mysql> SHOW PROFILE CPU FOR QUERY 2;
+----------------------+----------+----------+------------+
| Status               | Duration | CPU_user | CPU_system |
+----------------------+----------+----------+------------+
| checking permissions | 0.000040 | 0.000038 |   0.000002 |
| creating table       | 0.000056 | 0.000028 |   0.000028 |
| After create         | 0.011363 | 0.000217 |   0.001571 |
| query end            | 0.000375 | 0.000013 |   0.000028 |
| freeing items        | 0.000089 | 0.000010 |   0.000014 |
| logging slow query   | 0.000019 | 0.000009 |   0.000010 |
| cleaning up          | 0.000005 | 0.000003 |   0.000002 |
+----------------------+----------+----------+------------+
7 rows in set (0.00 sec)
```

> **Note**
>
> Profiling is only partially functional on some architectures. For values that depend on the `getrusage()` system call, `NULL` is returned on systems such as Windows that do not support the call. In addition, profiling is per process and not per thread. This means that activity on threads within the server other than your own may affect the timing information that you see.

You can also get profiling information from the `PROFILING` table in `INFORMATION_SCHEMA`. See Section 18.28, “The `INFORMATION_SCHEMA PROFILING` Table”. For example, the following queries produce the same result:

```
SHOW PROFILE FOR QUERY 2;

SELECT STATE, FORMAT(DURATION, 6) AS DURATION
FROM INFORMATION_SCHEMA.PROFILING
WHERE QUERY_ID = 2 ORDER BY SEQ;
```

12.4.5.33. `SHOW RELAYLOG EVENTS` Syntax

```
SHOW RELAYLOG EVENTS
   [IN 'log_name'] [FROM pos] [LIMIT [offset,] row_count]
```

Shows the events in the relay log of a replication slave. If you do not specify `'log_name'`, the first relay log is displayed. This statement has no effect on the master.

The `LIMIT` clause has the same syntax as for the `SELECT` statement. See Section 12.2.9, “`SELECT` Syntax”.

> **Note**
>
> Issuing a `SHOW RELAYLOG EVENTS` with no `LIMIT` clause could start a very time- and resource-consuming process because the server returns to the client the complete contents of the relay log (including all statements modifying data that have been received by the slave).

> **Note**
>
> Some events relating to the setting of user and system variables are not included in the output from `SHOW RELAYLOG EVENTS`. To get complete coverage of events within a relay log, use `mysqlbinlog`.

12.4.5.34. `SHOW SLAVE HOSTS` Syntax

```
SHOW SLAVE HOSTS
```

Displays a list of replication slaves currently registered with the master. (Before MySQL 5.5.3, only slaves started with the `--report-host=host_name` option are visible in this list.)

The list is displayed on any server (not just the master server). The output looks like this:

```
mysql> SHOW SLAVE HOSTS;
```

```
+------------+-----------+------+-----------+
| Server_id  | Host      | Port | Master_id |
+------------+-----------+------+-----------+
|  192168010 | iconnect2 | 3306 | 192168011 |
| 1921680101 | athena    | 3306 | 192168011 |
+------------+-----------+------+-----------+
```

- `Server_id`: The unique server ID of the slave server, as configured in the server's option file, or on the command line with `--server-id=value`.
- `Host`: The host name of the slave server, as configured in the server's option file, or on the command line with `--report-host=host_name`. Note that this can differ from the machine name as configured in the operating system.
- `Port`: The port the slave server is listening on.
- `Master_id`: The unique server ID of the master server that the slave server is replicating from.

Some MySQL versions report another variable, `Rpl_recovery_rank`. This variable was never used, and was removed in MySQL 5.5.3. (Bug #13963)

12.4.5.35. `SHOW SLAVE STATUS` Syntax

```
SHOW SLAVE STATUS
```

This statement provides status information on essential parameters of the slave threads. It requires either the `SUPER` or `REPLICATION CLIENT` privilege.

If you issue this statement using the `mysql` client, you can use a `\G` statement terminator rather than a semicolon to obtain a more readable vertical layout:

```
mysql> SHOW SLAVE STATUS\G
*************************** 1. row ***************************
               Slave_IO_State: Waiting for master to send event
                  Master_Host: localhost
                  Master_User: root
                  Master_Port: 3306
                Connect_Retry: 3
              Master_Log_File: gbichot-bin.005
          Read_Master_Log_Pos: 79
               Relay_Log_File: gbichot-relay-bin.005
                Relay_Log_Pos: 548
        Relay_Master_Log_File: gbichot-bin.005
             Slave_IO_Running: Yes
            Slave_SQL_Running: Yes
              Replicate_Do_DB:
          Replicate_Ignore_DB:
           Replicate_Do_Table:
       Replicate_Ignore_Table:
      Replicate_Wild_Do_Table:
  Replicate_Wild_Ignore_Table:
                   Last_Errno: 0
                   Last_Error:
                 Skip_Counter: 0
          Exec_Master_Log_Pos: 79
              Relay_Log_Space: 552
              Until_Condition: None
               Until_Log_File:
                Until_Log_Pos: 0
           Master_SSL_Allowed: No
           Master_SSL_CA_File:
           Master_SSL_CA_Path:
              Master_SSL_Cert:
            Master_SSL_Cipher:
               Master_SSL_Key:
        Seconds_Behind_Master: 8
Master_SSL_Verify_Server_Cert: No
                Last_IO_Errno: 0
                Last_IO_Error:
               Last_SQL_Errno: 0
               Last_SQL_Error:
  Replicate_Ignore_Server_Ids: 0
             Master_Server_Id: 1
```

The following list describes the fields returned by `SHOW SLAVE STATUS`. For additional information about interpreting their meanings, see Section 15.1.4.1, “Checking Replication Status”.

- `Slave_IO_State`

  A copy of the `State` field of the `SHOW PROCESSLIST` output for the slave I/O thread. This tells you what the thread is doing: trying to connect to the master, waiting for events from the master, reconnecting to the master, and so on. Possible states are listed in Section 15.2.1, “Replication Implementation Details”.

- `Master_Host`

  The master host that the slave is connected to.

- `Master_User`

  The user name of the account used to connect to the master.

- `Master_Port`

  The port used to connect to the master.

- `Connect_Retry`

  The number of seconds between connect retries (default 60). This can be set with the `CHANGE MASTER TO` statement.

- `Master_Log_File`

  The name of the master binary log file from which the I/O thread is currently reading.

- `Read_Master_Log_Pos`

  The position in the current master binary log file up to which the I/O thread has read.

- `Relay_Log_File`

  The name of the relay log file from which the SQL thread is currently reading and executing.

- `Relay_Log_Pos`

  The position in the current relay log file up to which the SQL thread has read and executed.

- `Relay_Master_Log_File`

  The name of the master binary log file containing the most recent event executed by the SQL thread.

- `Slave_IO_Running`

  Whether the I/O thread is started and has connected successfully to the master. Internally, the state of this thread is represented by one of the following three values:

  - **`MYSQL_SLAVE_NOT_RUN`.** The slave I/O thread is not running. For this state, `Slave_IO_Running` is `No`.
  - **`MYSQL_SLAVE_RUN_NOT_CONNECT`.** The slave I/O thread is running, but is not connected to a replication master. For this state, `Slave_IO_Running` depends on the server version as shown in the following table.

MySQL Version	**`Slave_IO_Running`**
4.1 (4.1.13 and earlier); 5.0 (5.0.11 and earlier)	`Yes`
4.1 (4.1.14 and later); 5.0 (5.0.12 and later)	`No`
5.1 (5.1.45 and earlier); 5.4	`No`
5.1 (5.1.46 and later); 5.5	`Connecting`

  - **`MYSQL_SLAVE_RUN_CONNECT`.** The slave I/O thread is running, and is connected to a replication master. For this state, `Slave_IO_Running` is `Yes`.

  The value of the `Slave_running` system status variable corresponds with this value.

- `Slave_SQL_Running`

  Whether the SQL thread is started.

- `Replicate_Do_DB`, `Replicate_Ignore_DB`

  The lists of databases that were specified with the `--replicate-do-db` and `--replicate-ignore-db` options, if any.

- `Replicate_Do_Table`, `Replicate_Ignore_Table`, `Replicate_Wild_Do_Table`, `Replic-`

`ate_Wild_Ignore_Table`

The lists of tables that were specified with the `--replicate-do-table`, `--replicate-ignore-table`, `--replicate-wild-do-table`, and `--replicate-wild-ignore-table` options, if any.

- `Last_Errno`, `Last_Error`

  These columns are aliases for `Last_SQL_Errno` and `Last_SQL_Error`.

  Issuing `RESET MASTER` or `RESET SLAVE` resets the values shown in these columns.

  > **Note**
  >
  > When the slave SQL thread receives an error, it reports the error first, then stops the SQL thread. This means that there is a small window of time during which `SHOW SLAVE STATUS` shows a nonzero value for `Last_SQL_Errno` even though `Slave_SQL_Running` still displays `Yes`.

- `Skip_Counter`

  The current value of the `sql_slave_skip_counter` system variable. See Section 12.5.2.4, “`SET GLOBAL sql_slave_skip_counter` Syntax”.

- `Exec_Master_Log_Pos`

  The position in the current master binary file up to which the SQL thread has read and executed. The coordinates given by (`Relay_Master_Log_File`, `Exec_Master_Log_Pos`) in the master's binary log correspond to the coordinates given by (`Relay_Log_File`, `Relay_Log_Pos`) in the relay log.

- `Relay_Log_Space`

  The total combined size of all existing relay log files.

- `Until_Condition`, `Until_Log_File`, `Until_Log_Pos`

  The values specified in the `UNTIL` clause of the `START SLAVE` statement.

  `Until_Condition` has these values:

  - `None` if no `UNTIL` clause was specified
  - `Master` if the slave is reading until a given position in the master's binary log
  - `Relay` if the slave is reading until a given position in its relay log

  `Until_Log_File` and `Until_Log_Pos` indicate the log file name and position that define the coordinates at which the SQL thread stops executing.

- `Master_SSL_Allowed`, `Master_SSL_CA_File`, `Master_SSL_CA_Path`, `Master_SSL_Cert`, `Master_SSL_Cipher`, `Master_SSL_Key`, `Master_SSL_Verify_Server_Cert`

  These fields show the SSL parameters used by the slave to connect to the master, if any.

  `Master_SSL_Allowed` has these values:

  - `Yes` if an SSL connection to the master is permitted
  - `No` if an SSL connection to the master is not permitted
  - `Ignored` if an SSL connection is permitted but the slave server does not have SSL support enabled

  The values of the other SSL-related fields correspond to the values of the `MASTER_SSL_CA`, `MASTER_SSL_CAPATH`, `MASTER_SSL_CERT`, `MASTER_SSL_CIPHER`, `MASTER_SSL_KEY`, and `MASTER_SSL_VERIFY_SERVER_CERT` options to the `CHANGE MASTER TO` statement. See Section 12.5.2.1, “`CHANGE MASTER TO` Syntax”.

- `Seconds_Behind_Master`

  This field is an indication of how “late” the slave is:

  - When the slave SQL thread is actively processing updates, this field is the number of seconds that have elapsed since the timestamp of the most recent event on the master executed by that thread.
  - When the SQL thread has caught up to the slave I/O thread and is idle waiting for more events from the I/O thread, this field

is zero.

In essence, this field measures the time difference in seconds between the slave SQL thread and the slave I/O thread.

If the network connection between master and slave is fast, the slave I/O thread is very close to the master, so this field is a good approximation of how late the slave SQL thread is compared to the master. If the network is slow, this is *not* a good approximation; the slave SQL thread may quite often be caught up with the slow-reading slave I/O thread, so `Seconds_Behind_Master` often shows a value of 0, even if the I/O thread is late compared to the master. In other words, *this column is useful only for fast networks*.

This time difference computation works even though the master and slave do not have identical clocks (the clock difference is computed when the slave I/O thread starts, and assumed to remain constant from then on). `Seconds_Behind_Master` is `NULL` (“unknown”) if the slave SQL thread is not running, or if the slave I/O thread is not running or not connected to master. For example, if the slave I/O thread is running but is not connected to the master and is sleeping for the number of seconds set by the `MASTER_CONNECT_RETRY` option of the `CHANGE MASTER TO` statement (default 60) before attempting to reconnect, the value is `NULL`. This is because the slave cannot know what the master is doing, and so cannot say reliably how late it is.

The value of this field is based on the timestamps stored in events, which are preserved through replication. This means that if a master M1 is itself a slave of M0, any event from M1's binary log that originates from M0's binary log has M0's timestamp for that event. This enables MySQL to replicate `TIMESTAMP` successfully. However, the problem for `Seconds_Behind_Master` is that if M1 also receives direct updates from clients, the `Seconds_Behind_Master` value randomly fluctuates because sometimes the last event from M1 originates from M0 and sometimes is the result of a direct update on M1.

- `Last_IO_Errno`, `Last_IO_Error`

  The error number and error message of the last error that caused the I/O thread to stop. An error number of 0 and message of the empty string mean “no error.” If the `Last_IO_Error` value is not empty, the error values also appear in the slave's error log.

  Prior to MySQL 5.5, `Last_IO_Error` and `Last_IO_Errno` were not set in the event that replication failed due to exceeding `max_allowed_packet` (Bug #42914).

  Issuing `RESET MASTER` or `RESET SLAVE` resets the values shown in these columns.

- `Last_SQL_Errno`, `Last_SQL_Error`

  The error number and error message of the last error that caused the SQL thread to stop. An error number of 0 and message of the empty string mean “no error.” If the `Last_SQL_Error` value is not empty, the error values also appear in the slave's error log.

  Example:

  ```
  Last_SQL_Errno: 1051
  Last_SQL_Error: error 'Unknown table 'z'' on query 'drop table z'
  ```

  The message indicates that the table `z` existed on the master and was dropped there, but it did not exist on the slave, so `DROP TABLE` failed on the slave. (This might occur, for example, if you forget to copy the table to the slave when setting up replication.)

  Issuing `RESET MASTER` or `RESET SLAVE` resets the values shown in these columns.

- `Replicate_Ignore_Server_Ids`

  Beginning with MySQL 5.5, you can tell a slave to ignore events from 0 or more masters using the `IGNORE_SERVER_IDS` option in a `CHANGE MASTER TO` statement. This is normally of interest only when using a circular or other multi-master replication setup.

  The message shown for `Replicate_Ignore_Server_Ids` consists of a space-delimited list of one or more numbers, the first value indicating the number of servers to be ignored; if not 0 (the default), this server-count value is followed by the actual server IDs. For example, if a `CHANGE MASTER TO` statement containing the `IGNORE_SERVER_IDS = (2,6,9)` option has been issued to tell a slave to ignore masters having the server ID 2, 6, or 9, that information appears as shown here:

  ```
    Replicate_Ignore_Server_Ids: 3 2 6 9
  ```

- `Master_Server_Id`

  The `server_id` value from the master.

12.4.5.36. `SHOW STATUS` Syntax

```
SHOW [GLOBAL | SESSION] STATUS
    [LIKE 'pattern' | WHERE expr]
```

`SHOW STATUS` provides server status information. This information also can be obtained using the `mysqladmin extended-status` command. The `LIKE` clause, if present, indicates which variable names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”. This statement does not require any privilege. It requires only the ability to connect to the server.

Partial output is shown here. The list of names and values may be different for your server. The meaning of each variable is given in Section 5.1.5, “Server Status Variables”.

```
mysql> SHOW STATUS;
+--------------------------+------------+
| Variable_name            | Value      |
+--------------------------+------------+
| Aborted_clients          | 0          |
| Aborted_connects         | 0          |
| Bytes_received           | 155372598  |
| Bytes_sent               | 1176560426 |
| Connections              | 30023      |
| Created_tmp_disk_tables  | 0          |
| Created_tmp_tables       | 8340       |
| Created_tmp_files        | 60         |
...
| Open_tables              | 1          |
| Open_files               | 2          |
| Open_streams             | 0          |
| Opened_tables            | 44600      |
| Questions                | 2026873    |
...
| Table_locks_immediate    | 1920382    |
| Table_locks_waited       | 0          |
| Threads_cached           | 0          |
| Threads_created          | 30022      |
| Threads_connected        | 1          |
| Threads_running          | 1          |
| Uptime                   | 80380      |
+--------------------------+------------+
```

With a `LIKE` clause, the statement displays only rows for those variables with names that match the pattern:

```
mysql> SHOW STATUS LIKE 'Key%';
+--------------------+----------+
| Variable_name      | Value    |
+--------------------+----------+
| Key_blocks_used    | 14955    |
| Key_read_requests  | 96854827 |
| Key_reads          | 162040   |
| Key_write_requests | 7589728  |
| Key_writes         | 3813196  |
+--------------------+----------+
```

With the `GLOBAL` modifier, `SHOW STATUS` displays the status values for all connections to MySQL. With `SESSION`, it displays the status values for the current connection. If no modifier is present, the default is `SESSION`. `LOCAL` is a synonym for `SESSION`.

Some status variables have only a global value. For these, you get the same value for both `GLOBAL` and `SESSION`. The scope for each status variable is listed at Section 5.1.5, “Server Status Variables”.

Each invocation of the `SHOW STATUS` statement uses an internal temporary table and increments the global `Created_tmp_tables` value.

12.4.5.37. `SHOW TABLE STATUS` Syntax

```
SHOW TABLE STATUS [{FROM | IN} db_name]
    [LIKE 'pattern' | WHERE expr]
```

`SHOW TABLE STATUS` works likes `SHOW TABLES`, but provides a lot of information about each non-`TEMPORARY` table. You can also get this list using the `mysqlshow --status db_name` command. The `LIKE` clause, if present, indicates which table names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

This statement also displays information about views.

`SHOW TABLE STATUS` returns the following fields:

- `Name`

  The name of the table.

- `Engine`

  The storage engine for the table. See Chapter 13, *Storage Engines*.

- `Version`

  The version number of the table's `.frm` file.

- `Row_format`

  The row-storage format (`Fixed`, `Dynamic`, `Compressed`, `Redundant`, `Compact`). For `MyISAM` tables, (`Dynamic` corresponds to what `myisamchk -dvv` reports as `Packed`. The format of `InnoDB` tables is reported as `Redundant` or `Compact`. For the `Barracuda` file format of the `InnoDB Plugin`, the format may be `Compressed` or `Dynamic`.

- `Rows`

  The number of rows. Some storage engines, such as `MyISAM`, store the exact count. For other storage engines, such as `InnoDB`, this value is an approximation, and may vary from the actual value by as much as 40 to 50%. In such cases, use `SELECT COUNT(*)` to obtain an accurate count.

  The `Rows` value is `NULL` for tables in the `INFORMATION_SCHEMA` database.

- `Avg_row_length`

  The average row length.

- `Data_length`

  The length of the data file.

- `Max_data_length`

  The maximum length of the data file. This is the total number of bytes of data that can be stored in the table, given the data pointer size used.

- `Index_length`

  The length of the index file.

- `Data_free`

  The number of allocated but unused bytes.

  This information is also shown for `InnoDB` tables (previously, it was in the `Comment` value). `InnoDB` tables report the free space of the tablespace to which the table belongs. For a table located in the shared tablespace, this is the free space of the shared tablespace. If you are using multiple tablespaces and the table has its own tablespace, the free space is for only that table. Free space means the number of completely free 1MB extents minus a safety margin. Even if free space displays as 0, it may be possible to insert rows as long as new extents need not be allocated.

  For partitioned tables, this value is only an estimate and may not be absolutely correct. A more accurate method of obtaining this information in such cases is to query the `INFORMATION_SCHEMA.PARTITIONS` table, as shown in this example:

  ```
  SELECT    SUM(DATA_FREE)
      FROM  INFORMATION_SCHEMA.PARTITIONS
      WHERE TABLE_SCHEMA = 'mydb'
      AND   TABLE_NAME   = 'mytable';
  ```

  For more information, see Section 18.19, “The `INFORMATION_SCHEMA PARTITIONS` Table”.

- `Auto_increment`

  The next `AUTO_INCREMENT` value.

- `Create_time`

  When the table was created.

- `Update_time`

When the data file was last updated. For some storage engines, this value is `NULL`. For example, `InnoDB` stores multiple tables in its tablespace and the data file timestamp does not apply. For `MyISAM`, the data file timestamp is used; however, on Windows the timestamp is not updated by updates so the value is inaccurate.

- `Check_time`

  When the table was last checked. Not all storage engines update this time, in which case the value is always `NULL`.

- `Collation`

  The table's character set and collation.

- `Checksum`

  The live checksum value (if any).

- `Create_options`

  Extra options used with `CREATE TABLE`. The original options supplied when `CREATE TABLE` is called are retained and the options reported here may differ from the active table settings and options.

- `Comment`

  The comment used when creating the table (or information as to why MySQL could not access the table information).

For `MEMORY` tables, the `Data_length`, `Max_data_length`, and `Index_length` values approximate the actual amount of allocated memory. The allocation algorithm reserves memory in large amounts to reduce the number of allocation operations.

For views, all the fields displayed by `SHOW TABLE STATUS` are `NULL` except that `Name` indicates the view name and `Comment` says `view`.

12.4.5.38. `SHOW TABLES` Syntax

```
SHOW [FULL] TABLES [{FROM | IN} db_name]
    [LIKE 'pattern' | WHERE expr]
```

`SHOW TABLES` lists the non-`TEMPORARY` tables in a given database. You can also get this list using the `mysqlshow db_name` command. The `LIKE` clause, if present, indicates which table names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

This statement also lists any views in the database. The `FULL` modifier is supported such that `SHOW FULL TABLES` displays a second output column. Values for the second column are `BASE TABLE` for a table and `VIEW` for a view.

If you have no privileges for a base table or view, it does not show up in the output from `SHOW TABLES` or `mysqlshow db_name`.

12.4.5.39. `SHOW TRIGGERS` Syntax

```
SHOW TRIGGERS [{FROM | IN} db_name]
    [LIKE 'pattern' | WHERE expr]
```

`SHOW TRIGGERS` lists the triggers currently defined for tables in a database (the default database unless a `FROM` clause is given). This statement returns results only for databases and tables for which you have the `TRIGGER` privilege. The `LIKE` clause, if present, indicates which table names to match and causes the statement to display triggers for those tables. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”.

For the trigger `ins_sum` as defined in Section 17.3, “Using Triggers”, the output of this statement is as shown here:

```
mysql> SHOW TRIGGERS LIKE 'acc%'\G
*************************** 1. row ***************************
             Trigger: ins_sum
               Event: INSERT
               Table: account
           Statement: SET @sum = @sum + NEW.amount
              Timing: BEFORE
             Created: NULL
            sql_mode:
             Definer: myname@localhost
character_set_client: latin1
collation_connection: latin1_swedish_ci
  Database Collation: latin1_swedish_ci
```

`character_set_client` is the session value of the `character_set_client` system variable when the trigger was created. `collation_connection` is the session value of the `collation_connection` system variable when the trigger was created. `Database Collation` is the collation of the database with which the trigger is associated.

> **Note**
>
> When using a `LIKE` clause with `SHOW TRIGGERS`, the expression to be matched (*`expr`*) is compared with the name of the table on which the trigger is declared, and not with the name of the trigger:

```
mysql> SHOW TRIGGERS LIKE 'ins%';
Empty set (0.01 sec)
```

A brief explanation of the columns in the output of this statement is shown here:

- `Trigger`

  The name of the trigger.

- `Event`

  The event that causes trigger activation: one of `'INSERT'`, `'UPDATE'`, or `'DELETE'`.

- `Table`

  The table for which the trigger is defined.

- `Statement`

  The statement to be executed when the trigger is activated. This is the same as the text shown in the `ACTION_STATEMENT` column of `INFORMATION_SCHEMA.TRIGGERS`.

- `Timing`

  One of the two values `'BEFORE'` or `'AFTER'`.

- `Created`

  Currently, the value of this column is always `NULL`.

- `sql_mode`

  The SQL mode in effect when the trigger executes.

- `Definer`

  The account that created the trigger.

See also Section 18.16, “The `INFORMATION_SCHEMA TRIGGERS` Table”.

12.4.5.40. `SHOW VARIABLES` Syntax

```
SHOW [GLOBAL | SESSION] VARIABLES
    [LIKE 'pattern' | WHERE expr]
```

`SHOW VARIABLES` shows the values of MySQL system variables. This information also can be obtained using the `mysqladmin variables` command. The `LIKE` clause, if present, indicates which variable names to match. The `WHERE` clause can be given to select rows using more general conditions, as discussed in Section 18.31, “Extensions to `SHOW` Statements”. This statement does not require any privilege. It requires only the ability to connect to the server.

With the `GLOBAL` modifier, `SHOW VARIABLES` displays the values that are used for new connections to MySQL. As of MySQL 5.5.3, if a variable has no global value, no value is displayed. Before 5.5.3, the session value is displayed. With `SESSION`, `SHOW VARIABLES` displays the values that are in effect for the current connection. If no modifier is present, the default is `SESSION`. `LOCAL` is a synonym for `SESSION`.

`SHOW VARIABLES` is subject to a version-dependent display-width limit. For variables with very long values that are not completely displayed, use `SELECT` as a workaround. For example:

```
SELECT @@GLOBAL.innodb_data_file_path;
```

If the default system variable values are unsuitable, you can set them using command options when `mysqld` starts, and most can be changed at runtime with the `SET` statement. See Section 5.1.4, “Using System Variables”, and Section 12.4.4, “`SET` Syntax”.

Partial output is shown here. The list of names and values may be different for your server. Section 5.1.3, “Server System Variables”, describes the meaning of each variable, and Section 7.11.2, “Tuning Server Parameters”, provides information about tuning them.

```
mysql> SHOW VARIABLES;
+---------------------------------+---------------------------+
| Variable_name                   | Value                     |
+---------------------------------+---------------------------+
| auto_increment_increment        | 1                         |
| auto_increment_offset           | 1                         |
| automatic_sp_privileges         | ON                        |
| back_log                        | 50                        |
| basedir                         | /home/jon/bin/mysql-5.1/  |
| binlog_cache_size               | 32768                     |
| bulk_insert_buffer_size         | 8388608                   |
| character_set_client            | latin1                    |
| character_set_connection        | latin1                    |
...
| max_user_connections            | 0                         |
| max_write_lock_count            | 4294967295                |
| multi_range_count               | 256                       |
| myisam_data_pointer_size        | 6                         |
| myisam_max_sort_file_size       | 2147483647                |
| myisam_recover_options          | OFF                       |
| myisam_repair_threads           | 1                         |
| myisam_sort_buffer_size         | 8388608                   |
| ndb_autoincrement_prefetch_sz   | 32                        |
| ndb_cache_check_time            | 0                         |
| ndb_force_send                  | ON                        |
...
| time_zone                       | SYSTEM                    |
| timed_mutexes                   | OFF                       |
| tmp_table_size                  | 33554432                  |
| tmpdir                          |                           |
| transaction_alloc_block_size    | 8192                      |
| transaction_prealloc_size       | 4096                      |
| tx_isolation                    | REPEATABLE-READ           |
| updatable_views_with_limit      | YES                       |
| version                         | 5.1.6-alpha-log           |
| version_comment                 | Source distribution       |
| version_compile_machine         | i686                      |
| version_compile_os              | suse-linux                |
| wait_timeout                    | 28800                     |
+---------------------------------+---------------------------+
```

With a `LIKE` clause, the statement displays only rows for those variables with names that match the pattern. To obtain the row for a specific variable, use a `LIKE` clause as shown:

```
SHOW VARIABLES LIKE 'max_join_size';
SHOW SESSION VARIABLES LIKE 'max_join_size';
```

To get a list of variables whose name match a pattern, use the “`%`” wildcard character in a `LIKE` clause:

```
SHOW VARIABLES LIKE '%size%';
SHOW GLOBAL VARIABLES LIKE '%size%';
```

Wildcard characters can be used in any position within the pattern to be matched. Strictly speaking, because “`_`” is a wildcard that matches any single character, you should escape it as “`\_`” to match it literally. In practice, this is rarely necessary.

12.4.5.41. `SHOW WARNINGS` Syntax

```
SHOW WARNINGS [LIMIT [offset,] row_count]
SHOW COUNT(*) WARNINGS
```

`SHOW WARNINGS` shows the error, warning, and note messages that resulted from the last statement that generated messages in the current session. It shows nothing if the last statement used a table and generated no messages. (That is, a statement that uses a table but generates no messages clears the message list.) Statements that do not use tables and do not generate messages have no effect on the message list.

Warnings are generated for DML statements such as `INSERT`, `UPDATE`, and `LOAD DATA INFILE` as well as DDL statements such as `CREATE TABLE` and `ALTER TABLE`.

A related statement, `SHOW ERRORS`, shows only the errors. See Section 12.4.5.18, “`SHOW ERRORS` Syntax”.

The `SHOW COUNT(*) WARNINGS` statement displays the total number of errors, warnings, and notes. You can also retrieve this number from the `warning_count` variable:

```
SHOW COUNT(*) WARNINGS;
SELECT @@warning_count;
```

The value of `warning_count` might be greater than the number of messages displayed by `SHOW WARNINGS` if the `max_error_count` system variable is set so low that not all messages are stored. An example shown later in this section demonstrates how this can happen.

The `LIMIT` clause has the same syntax as for the `SELECT` statement. See Section 12.2.9, “`SELECT` Syntax”.

The MySQL server sends back the total number of errors, warnings, and notes resulting from the last statement. If you are using the C API, this value can be obtained by calling `mysql_warning_count()`. See Section 20.9.3.72, “`mysql_warning_count()`”.

The following `DROP TABLE` statement results in a note:

```
mysql> DROP TABLE IF EXISTS no_such_table;
mysql> SHOW WARNINGS;
+-------+------+-------------------------------+
| Level | Code | Message                       |
+-------+------+-------------------------------+
| Note  | 1051 | Unknown table 'no_such_table' |
+-------+------+-------------------------------+
```

Here is a simple example that shows a syntax warning for `CREATE TABLE` and conversion warnings for `INSERT`:

```
mysql> CREATE TABLE t1 (a TINYINT NOT NULL, b CHAR(4)) TYPE=MyISAM;
Query OK, 0 rows affected, 1 warning (0.00 sec)
mysql> SHOW WARNINGS\G
*************************** 1. row ***************************
  Level: Warning
   Code: 1287
Message: 'TYPE=storage_engine' is deprecated, use
         'ENGINE=storage_engine' instead
1 row in set (0.00 sec)

mysql> INSERT INTO t1 VALUES(10,'mysql'),(NULL,'test'),
    -> (300,'Open Source');
Query OK, 3 rows affected, 4 warnings (0.01 sec)
Records: 3  Duplicates: 0  Warnings: 4

mysql> SHOW WARNINGS\G
*************************** 1. row ***************************
  Level: Warning
   Code: 1265
Message: Data truncated for column 'b' at row 1
*************************** 2. row ***************************
  Level: Warning
   Code: 1263
Message: Data truncated, NULL supplied to NOT NULL column 'a' at row 2
*************************** 3. row ***************************
  Level: Warning
   Code: 1264
Message: Data truncated, out of range for column 'a' at row 3
*************************** 4. row ***************************
  Level: Warning
   Code: 1265
Message: Data truncated for column 'b' at row 3
4 rows in set (0.00 sec)
```

The maximum number of error, warning, and note messages to store is controlled by the `max_error_count` system variable. By default, its value is 64. To change the number of messages you want stored, change the value of `max_error_count`. In the following example, the `ALTER TABLE` statement produces three warning messages, but only one is stored because `max_error_count` has been set to 1:

```
mysql> SHOW VARIABLES LIKE 'max_error_count';
+-----------------+-------+
| Variable_name   | Value |
+-----------------+-------+
| max_error_count | 64    |
+-----------------+-------+
1 row in set (0.00 sec)

mysql> SET max_error_count=1;
Query OK, 0 rows affected (0.00 sec)

mysql> ALTER TABLE t1 MODIFY b CHAR;
Query OK, 3 rows affected, 3 warnings (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 3

mysql> SELECT @@warning_count;
+-----------------+
| @@warning_count |
+-----------------+
|               3 |
+-----------------+
1 row in set (0.01 sec)
```

```
mysql> SHOW WARNINGS;
+---------+------+--------------------------------------+
| Level   | Code | Message                              |
+---------+------+--------------------------------------+
| Warning | 1263 | Data truncated for column 'b' at row 1 |
+---------+------+--------------------------------------+
1 row in set (0.00 sec)
```

To disable warnings, set `max_error_count` to 0. In this case, `warning_count` still indicates how many warnings have occurred, but none of the messages are stored.

You can set the `sql_notes` session variable to 0 to cause `Note`-level warnings not to be recorded.

12.4.6. Other Administrative Statements

12.4.6.1. `BINLOG` Syntax

```
BINLOG 'str'
```

`BINLOG` is an internal-use statement. It is generated by the `mysqlbinlog` program as the printable representation of certain events in binary log files. (See Section 4.6.7, "`mysqlbinlog` — Utility for Processing Binary Log Files".) The `'str'` value is a base 64-encoded string the that server decodes to determine the data change indicated by the corresponding event. This statement requires the `SUPER` privilege.

12.4.6.2. `CACHE INDEX` Syntax

```
CACHE INDEX
  tbl_index_list [, tbl_index_list] ...
  [PARTITION (partition_list | ALL)]
  IN key_cache_name

tbl_index_list:
  tbl_name [[INDEX|KEY] (index_name[, index_name] ...)]

partition_list:
  partition_name[, partition_name][, ...]
```

The `CACHE INDEX` statement assigns table indexes to a specific key cache. It is used only for `MyISAM` tables. After the indexes have been assigned, they can be preloaded into the cache if desired with `LOAD INDEX INTO CACHE`.

The following statement assigns indexes from the tables `t1`, `t2`, and `t3` to the key cache named `hot_cache`:

```
mysql> CACHE INDEX t1, t2, t3 IN hot_cache;
+---------+--------------------+----------+----------+
| Table   | Op                 | Msg_type | Msg_text |
+---------+--------------------+----------+----------+
| test.t1 | assign_to_keycache | status   | OK       |
| test.t2 | assign_to_keycache | status   | OK       |
| test.t3 | assign_to_keycache | status   | OK       |
+---------+--------------------+----------+----------+
```

The syntax of `CACHE INDEX` enables you to specify that only particular indexes from a table should be assigned to the cache. The current implementation assigns all the table's indexes to the cache, so there is no reason to specify anything other than the table name.

The key cache referred to in a `CACHE INDEX` statement can be created by setting its size with a parameter setting statement or in the server parameter settings. For example:

```
mysql> SET GLOBAL keycache1.key_buffer_size=128*1024;
```

Key cache parameters can be accessed as members of a structured system variable. See Section 5.1.4.1, "Structured System Variables".

A key cache must exist before you can assign indexes to it:

```
mysql> CACHE INDEX t1 IN non_existent_cache;
ERROR 1284 (HY000): Unknown key cache 'non_existent_cache'
```

By default, table indexes are assigned to the main (default) key cache created at the server startup. When a key cache is destroyed, all indexes assigned to it become assigned to the default key cache again.

Index assignment affects the server globally: If one client assigns an index to a given cache, this cache is used for all queries involving the index, no matter which client issues the queries.

As of MySQL 5.5, this statement is also supported for partitioned `MyISAM` tables. You can assign one or more indexes for one, several, or all partitions to a given key cache. For example, you can do the following:

```
CREATE TABLE pt (c1 INT, c2 VARCHAR(50), INDEX i(c1))
    PARTITION BY HASH(c1)
    PARTITIONS 4;

SET GLOBAL kc_fast.key_buffer_size = 128 * 1024;
SET GLOBAL kc_slow.key_buffer_size = 128 * 1024;

CACHE INDEX pt PARTITION (p0) IN kc_fast;
CACHE INDEX pt PARTITION (p1, p3) IN kc_slow;
```

The previous set of statements performs the following actions:

- Creates a partitioned table with 4 partitions; these partitions are automatically named `p0`, ..., `p3`; this table has an index named `i` on column `c1`.
- Creates 2 key caches named `kc_fast` and `kc_slow`
- Assigns the index for partition `p0` to the `kc_fast` key cache and the index for partitions `p1` and `p3` to the `kc_slow` key cache; the index for the remaining partition (`p2`) uses the server's default key cache.

If you wish instead to assign the indexes for all partitions in table `pt` to a single key cache named `kc_all`, you can use either one of the following 2 statements:

```
CACHE INDEX pt PARTITION (ALL) IN kc_all;

CACHE INDEX pt IN kc_all;
```

The two statements just shown are equivalent, and issuing either one of them has exactly the same effect. In other words, if you wish to assign indexes for all partitions of a partitioned table to the same key cache, then the `PARTITION (ALL)` clause is optional.

When assigning indexes for multiple partitions to a key cache, the partitions do not have to be contiguous, and you are not required to list their names in any particular order. Indexes for any partitions that are not explicitly assigned to a key cache automatically use the server's default key cache.

As of MySQL 5.5, index preloading is also supported for partitioned `MyISAM` tables. For more information, see Section 12.4.6.5, “`LOAD INDEX INTO CACHE` Syntax”.

12.4.6.3. `FLUSH` Syntax

```
FLUSH [NO_WRITE_TO_BINLOG | LOCAL]
    flush_option [, flush_option] ...
```

The `FLUSH` statement clears or reloads various internal caches used by MySQL. Some variants acquire locks. To execute `FLUSH`, you must have the `RELOAD` privilege. Specific flush options might require additional privileges, as described later.

By default, `FLUSH` statements are written to the binary log so that they will be replicated to replication slaves. Logging can be suppressed with the optional `NO_WRITE_TO_BINLOG` keyword or its alias `LOCAL`.

> **Note**
>
> `FLUSH LOGS`, `FLUSH MASTER`, `FLUSH SLAVE`, and `FLUSH TABLES WITH READ LOCK` (with or without a table list) are not written to the binary log in any case because they would cause problems if replicated to a slave.

The `RESET` statement is similar to `FLUSH`. See Section 12.4.6.6, “`RESET` Syntax”, for information about using the `RESET` statement with replication.

`flush_option` can be any of the following items.

- `DES_KEY_FILE`

  Reloads the DES keys from the file that was specified with the `--des-key-file` option at server startup time.

- `HOSTS`

  Empties the host cache tables. You should flush the host tables if some of your hosts change IP address or if you get the error message `Host 'host_name' is blocked`. When more than `max_connect_errors` errors occur successively for a given host while connecting to the MySQL server, MySQL assumes that something is wrong and blocks the host from further connection requests. Flushing the host tables enables further connection attempts from the host. See Section C.5.2.6, "`Host 'host_name' is blocked`". You can start `mysqld` with `--max_connect_errors=999999999` to avoid this error message.

- `[log_type] LOGS`

  With no `log_type` option, `FLUSH LOGS` closes and reopens all log files. If binary logging is enabled, the sequence number of the binary log file is incremented by one relative to the previous file. On Unix, this is the same thing as sending a `SIGHUP` signal to the `mysqld` server (except on some Mac OS X 10.3 versions where `mysqld` ignores `SIGHUP` and `SIGQUIT`).

  Prior to MySQL 5.5.7, if you flush the logs using `FLUSH LOGS` and `mysqld` is writing the error log to a file (for example, if it was started with the `--log-error` option), log file renaming may occur, as described in Section 5.2.2, "The Error Log".

  With a `log_type` option, only the specified log type is flushed. These `log_type` options are permitted:

  - `BINARY` closes and reopens the binary log files.
  - `ENGINE` closes and reopens any flushable logs for installed storage engines. Currently, this causes `InnoDB` to flush its logs to disk and perform a checkpoint.
  - `ERROR` closes and reopens the error log file.
  - `GENERAL` closes and reopens the general query log file.
  - `RELAY` closes and reopens the relay log files.
  - `SLOW` closes and reopens the slow query log file.

  The `log_type` options were added in MySQL 5.5.3.

- `MASTER`

  Deletes all binary logs, resets the binary log index file and creates a new binary log. `FLUSH MASTER` is deprecated in favor of `RESET MASTER`. `FLUSH MASTER` is still accepted in MySQL 5.5 for backward compatibility, but is removed in MySQL 5.6. See Section 12.5.1.2, "`RESET MASTER` Syntax".

- `PRIVILEGES`

  Reloads the privileges from the grant tables in the `mysql` database. On Unix, this also occurs if the server receives a `SIGHUP` signal.

  The server caches information in memory as a result of `GRANT`, `CREATE USER`, `CREATE SERVER`, and `INSTALL PLUGIN` statements. This memory is not released by the corresponding `REVOKE`, `DROP USER`, `DROP SERVER`, and `UNINSTALL PLUGIN` statements, so for a server that executes many instances of the statements that cause caching, there will be an increase in memory use. This cached memory can be freed with `FLUSH PRIVILEGES`.

- `QUERY CACHE`

  Defragment the query cache to better utilize its memory. `FLUSH QUERY CACHE` does not remove any queries from the cache, unlike `FLUSH TABLES` or `RESET QUERY CACHE`.

- `SLAVE`

  Resets all replication slave parameters, including relay log files and replication position in the master's binary logs. `FLUSH SLAVE` is deprecated in favor of `RESET SLAVE`. `FLUSH SLAVE` is still accepted in MySQL 5.5 for backward compatibility, but is removed in MySQL 5.6. See Section 12.5.2.3, "`RESET SLAVE` Syntax".

- `STATUS`

  This option adds the current thread's session status variable values to the global values and resets the session values to zero. It also resets the counters for key caches (default and named) to zero and sets `Max_used_connections` to the current number of open connections. This is something you should use only when debugging a query. See Section 1.7, "How to Report Bugs or Problems".

- `TABLES`

  `FLUSH TABLES` has several variant forms. As of MySQL 5.5.3, if any variant of the `TABLES` option is used, it must be the only option used. `FLUSH TABLE` is a synonym for `FLUSH TABLES`, except that `TABLE` does not work with the `WITH`

`READ LOCK` variants prior to MySQL 5.5.3.

- `FLUSH TABLES`

  Closes all open tables, forces all tables in use to be closed, and flushes the query cache. `FLUSH TABLES` also removes all query results from the query cache, like the `RESET QUERY CACHE` statement.

  As of MySQL 5.5.3, `FLUSH TABLES` is not permitted when there is an active `LOCK TABLES ... READ`. To flush and lock tables, use `FLUSH TABLES tbl_list WITH READ LOCK` instead.

- `FLUSH TABLES tbl_name [, tbl_name] ...`

  With a list of one or more comma-separated table names, this is like `FLUSH TABLES` with no names except that the server flushes only the named tables. No error occurs if a named table does not exist.

- `FLUSH TABLES WITH READ LOCK`

  Closes all open tables and locks all tables for all databases with a global read lock until you explicitly release the lock by executing `UNLOCK TABLES`. This is a very convenient way to get backups if you have a file system such as Veritas or ZFS that can take snapshots in time.

  `FLUSH TABLES WITH READ LOCK` acquires a global read lock and not table locks, so it is not subject to the same behavior as `LOCK TABLES` and `UNLOCK TABLES` with respect to table locking and implicit commits:

  - `UNLOCK TABLES` implicitly commits any active transaction only if any tables currently have been locked with `LOCK TABLES`. The commit does not occur for `UNLOCK TABLES` following `FLUSH TABLES WITH READ LOCK` because the latter statement does not acquire table locks.

  - Beginning a transaction causes table locks acquired with `LOCK TABLES` to be released, as though you had executed `UNLOCK TABLES`. Beginning a transaction does not release a global read lock acquired with `FLUSH TABLES WITH READ LOCK`.

  `FLUSH TABLES WITH READ LOCK` does not prevent the server from inserting rows into the log tables (see Section 5.2.1, “Selecting General Query and Slow Query Log Output Destinations”).

- `FLUSH TABLES tbl_name [, tbl_name] ... WITH READ LOCK`

  With a list of one or more comma-separated table names, flushes and acquires read locks for each table. This statement first acquires exclusive metadata locks, flushes the tables from the table cache, reopens the tables, acquires table locks (like `LOCK TABLES ... READ`), and downgrades the metadata locks from exclusive to shared. Because this statement acquires table locks, you must have the `LOCK TABLES` privilege in addition to the `RELOAD` privilege that is required to use any `FLUSH` statement.

  This variant of `FLUSH` enables tables to be flushed and locked in a single operation. It provides a workaround for the restriction as of MySQL 5.5.3 that `FLUSH TABLES` is not permitted when there is an active `LOCK TABLES ... READ`.

  This statement applies only to existing base tables. If a name refers to a base table, that table is used. If it applies to a view, `ER_WRONG_OBJECT` is returned. If it refers to a `TEMPORARY` table, it is ignored. Otherwise, `ER_NO_SUCH_TABLE` is returned.

  This statement begins by acquiring exclusive metadata locks for the named tables, so it waits for transactions that have those tables open to complete. After the statement acquires locks and downgrades the metadata locks, other sessions can read but not modify the tables.

  If a flushed table was opened with `HANDLER`, the handler is implicitly flushed and loses its position.

  This statement does not perform an implicit `UNLOCK TABLES`, so an error results if you use the statement a second time without first releasing the locks acquired or while there is any active `LOCK TABLES`.

  Use `UNLOCK TABLES` to release the locks, or `LOCK TABLES` to release the locks and acquire other locks.

  This variant of `FLUSH` is available as of MySQL 5.5.3.

- `USER_RESOURCES`

  Resets all per-hour user resources to zero. This enables clients that have reached their hourly connection, query, or update limits to resume activity immediately. `FLUSH USER_RESOURCES` does not apply to the limit on maximum simultaneous connections. See Section 5.5.4, “Setting Account Resource Limits”.

The `mysqladmin` utility provides a command-line interface to some flush operations, using commands such as `flush-hosts`, `flush-logs`, `flush-privileges`, `flush-status`, and `flush-tables`.

> **Note**
>
> It is not possible in MySQL 5.5 to issue `FLUSH` statements within stored functions or triggers. However, you may use `FLUSH` in stored procedures, so long as these are not called from stored functions or triggers. See Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.

12.4.6.4. `KILL` Syntax

```
KILL [CONNECTION | QUERY] thread_id
```

Each connection to `mysqld` runs in a separate thread. You can see which threads are running with the `SHOW PROCESSLIST` statement and kill a thread with the `KILL thread_id` statement.

`KILL` permits an optional `CONNECTION` or `QUERY` modifier:

- `KILL CONNECTION` is the same as `KILL` with no modifier: It terminates the connection associated with the given *`thread_id`*.
- `KILL QUERY` terminates the statement that the connection is currently executing, but leaves the connection itself intact.

If you have the `PROCESS` privilege, you can see all threads. If you have the `SUPER` privilege, you can kill all threads and statements. Otherwise, you can see and kill only your own threads and statements.

You can also use the `mysqladmin processlist` and `mysqladmin kill` commands to examine and kill threads.

> **Note**
>
> You cannot use `KILL` with the Embedded MySQL Server library because the embedded server merely runs inside the threads of the host application. It does not create any connection threads of its own.

When you use `KILL`, a thread-specific kill flag is set for the thread. In most cases, it might take some time for the thread to die because the kill flag is checked only at specific intervals:

- In `SELECT`, `ORDER BY` and `GROUP BY` loops, the flag is checked after reading a block of rows. If the kill flag is set, the statement is aborted.
- During `ALTER TABLE`, the kill flag is checked before each block of rows are read from the original table. If the kill flag was set, the statement is aborted and the temporary table is deleted.
- During `UPDATE` or `DELETE` operations, the kill flag is checked after each block read and after each updated or deleted row. If the kill flag is set, the statement is aborted. Note that if you are not using transactions, the changes are not rolled back.
- `GET_LOCK()` aborts and returns `NULL`.
- An `INSERT DELAYED` thread quickly flushes (inserts) all rows it has in memory and then terminates.
- If the thread is in the table lock handler (state: `Locked`), the table lock is quickly aborted.
- If the thread is waiting for free disk space in a write call, the write is aborted with a “disk full” error message.
-
  > **Warning**
  >
  > Killing a `REPAIR TABLE` or `OPTIMIZE TABLE` operation on a `MyISAM` table results in a table that is corrupted and unusable. Any reads or writes to such a table fail until you optimize or repair it again (without interruption).

12.4.6.5. `LOAD INDEX INTO CACHE` Syntax

```
LOAD INDEX INTO CACHE
  tbl_index_list [, tbl_index_list] ...

tbl_index_list:
  tbl_name
    [PARTITION (partition_list | ALL)]
    [[INDEX|KEY] (index_name[, index_name] ...)]
    [IGNORE LEAVES]

partition_list:
    partition_name[, partition_name][, ...]
```

The `LOAD INDEX INTO CACHE` statement preloads a table index into the key cache to which it has been assigned by an explicit `CACHE INDEX` statement, or into the default key cache otherwise.

`LOAD INDEX INTO CACHE` is used only for `MyISAM` tables. In MySQL 5.5, it is also supported for partitioned `MyISAM` tables; in addition, indexes on partitioned tables can be preloaded for one, several, or all partitions.

The `IGNORE LEAVES` modifier causes only blocks for the nonleaf nodes of the index to be preloaded.

`IGNORE LEAVES` is also supported for partitioned `MyISAM` tables.

The following statement preloads nodes (index blocks) of indexes for the tables `t1` and `t2`:

```
mysql> LOAD INDEX INTO CACHE t1, t2 IGNORE LEAVES;
+---------+--------------+----------+----------+
| Table   | Op           | Msg_type | Msg_text |
+---------+--------------+----------+----------+
| test.t1 | preload_keys | status   | OK       |
| test.t2 | preload_keys | status   | OK       |
+---------+--------------+----------+----------+
```

This statement preloads all index blocks from `t1`. It preloads only blocks for the nonleaf nodes from `t2`.

The syntax of `LOAD INDEX INTO CACHE` enables you to specify that only particular indexes from a table should be preloaded. The current implementation preloads all the table's indexes into the cache, so there is no reason to specify anything other than the table name.

In MySQL 5.5, it is possible to preload indexes on specific partitions of partitioned `MyISAM` tables. For example, of the following 2 statements, the first preloads indexes for partition `p0` of a partitioned table `pt`, while the second preloads the indexes for partitions `p1` and `p3` of the same table:

```
LOAD INDEX INTO CACHE pt PARTITION (p0);
LOAD INDEX INTO CACHE pt PARTITION (p1, p3);
```

To preload the indexes for all partitions in table `pt`, you can use either one of the following 2 statements:

```
LOAD INDEX INTO CACHE pt PARTITION (ALL);

LOAD INDEX INTO CACHE pt;
```

The two statements just shown are equivalent, and issuing either one of them has exactly the same effect. In other words, if you wish to preload indexes for all partitions of a partitioned table, then the `PARTITION (ALL)` clause is optional.

When preloading indexes for multiple partitions, the partitions do not have to be contiguous, and you are not required to list their names in any particular order.

`LOAD INDEX INTO CACHE ... IGNORE LEAVES` fails unless all indexes in a table have the same block size. You can determine index block sizes for a table by using `myisamchk -dv` and checking the `Blocksize` column.

12.4.6.6. `RESET` Syntax

```
RESET reset_option [, reset_option] ...
```

The `RESET` statement is used to clear the state of various server operations. You must have the `RELOAD` privilege to execute `RESET`.

`RESET` acts as a stronger version of the `FLUSH` statement. See Section 12.4.6.3, “`FLUSH` Syntax”.

`reset_option` can be any of the following:

- `MASTER`

  Deletes all binary logs listed in the index file, resets the binary log index file to be empty, and creates a new binary log file.

- `QUERY CACHE`

  Removes all query results from the query cache.

- `SLAVE`

Makes the slave forget its replication position in the master binary logs. Also resets the relay log by deleting any existing relay log files and beginning a new one.

12.5. Replication Statements

Replication can be controlled through the SQL interface using the statements described in this section. One group of statements controls master servers, the other controls slave servers.

12.5.1. SQL Statements for Controlling Master Servers

This section discusses statements for managing master replication servers. Section 12.5.2, “SQL Statements for Controlling Slave Servers”, discusses statements for managing slave servers.

In addition to the statements described here, the following `SHOW` statements are used with master servers in replication. For information about these statements, see Section 12.4.5, “`SHOW` Syntax”.

- `SHOW BINARY LOGS`
- `SHOW BINLOG EVENTS`
- `SHOW MASTER STATUS`
- `SHOW SLAVE HOSTS`

12.5.1.1. `PURGE BINARY LOGS` Syntax

```
PURGE { BINARY | MASTER } LOGS
    { TO 'log_name' | BEFORE datetime_expr }
```

The binary log is a set of files that contain information about data modifications made by the MySQL server. The log consists of a set of binary log files, plus an index file (see Section 5.2.4, “The Binary Log”).

The `PURGE BINARY LOGS` statement deletes all the binary log files listed in the log index file prior to the specified log file name or date. `BINARY` and `MASTER` are synonyms. Deleted log files also are removed from the list recorded in the index file, so that the given log file becomes the first in the list.

This statement has no effect if the server was not started with the `--log-bin` option to enable binary logging.

Examples:

```
PURGE BINARY LOGS TO 'mysql-bin.010';
PURGE BINARY LOGS BEFORE '2008-04-02 22:46:26';
```

The `BEFORE` variant's *`datetime_expr`* argument should evaluate to a `DATETIME` value (a value in `'YYYY-MM-DD hh:mm:ss'` format).

This statement is safe to run while slaves are replicating. You need not stop them. If you have an active slave that currently is reading one of the log files you are trying to delete, this statement does nothing and fails with an error. However, if a slave is not connected and you happen to purge one of the log files it has yet to read, the slave will be unable to replicate after it reconnects.

To safely purge binary log files, follow this procedure:

1. On each slave server, use `SHOW SLAVE STATUS` to check which log file it is reading.
2. Obtain a listing of the binary log files on the master server with `SHOW BINARY LOGS`.
3. Determine the earliest log file among all the slaves. This is the target file. If all the slaves are up to date, this is the last log file on the list.
4. Make a backup of all the log files you are about to delete. (This step is optional, but always advisable.)
5. Purge all log files up to but not including the target file.

You can also set the `expire_logs_days` system variable to expire binary log files automatically after a given number of days (see Section 5.1.3, “Server System Variables”). If you are using replication, you should set the variable no lower than the maximum number of days your slaves might lag behind the master.

`PURGE BINARY LOGS TO` and `PURGE BINARY LOGS BEFORE` both fail with an error when binary log files listed in the `.index` file had been removed from the system by some other means (such as using `rm` on Linux). (Bug #18199, Bug #18453) To handle such errors, edit the `.index` file (which is a simple text file) manually to ensure that it lists only the binary log files that are actually present, then run again the `PURGE BINARY LOGS` statement that failed.

12.5.1.2. `RESET MASTER` Syntax

```
RESET MASTER
```

Deletes all binary log files listed in the index file, resets the binary log index file to be empty, and creates a new binary log file. This statement is intended to be used only when the master is started for the first time.

> **Important**
>
> The effects of `RESET MASTER` differ from those of `PURGE BINARY LOGS` in 2 key ways:
>
> 1. `RESET MASTER` removes *all* binary log files that are listed in the index file, leaving only a single, empty binary log file with a numeric suffix of `.000001`, whereas the numbering is not reset by `PURGE BINARY LOGS`.
> 2. `RESET MASTER` is *not* intended to be used while any replication slaves are running. The behavior of `RESET MASTER` when used while slaves are running is undefined (and thus unsupported), whereas `PURGE BINARY LOGS` may be safely used while replication slaves are running.
>
> See also Section 12.5.1.1, “`PURGE BINARY LOGS` Syntax”.

`RESET MASTER` can prove useful when you first set up the master and the slave, so that you can verify the setup as follows:

1. Start the master and slave, and start replication (see Section 15.1.1, “How to Set Up Replication”).
2. Execute a few test queries on the master.
3. Check that the queries were replicated to the slave.
4. When replication is running correctly, issue `STOP SLAVE` followed by `RESET SLAVE` on the slave, then verify that any unwanted data no longer exists on the slave.
5. Issue `RESET MASTER` on the master to clean up the test queries.

After verifying the setup and getting rid of any unwanted and log files generated by testing, you can start the slave and begin replicating.

12.5.1.3. `SET sql_log_bin` Syntax

```
SET sql_log_bin = {0|1}
```

Disables or enables binary logging for the current session (`sql_log_bin` is a session variable) if the client has the `SUPER` privilege. The statement fails with an error if the client does not have that privilege.

12.5.2. SQL Statements for Controlling Slave Servers

This section discusses statements for managing slave replication servers. Section 12.5.1, “SQL Statements for Controlling Master Servers”, discusses statements for managing master servers.

In addition to the statements described here, `SHOW SLAVE STATUS` is also used with replication slaves. For information about this statement, see Section 12.4.5.35, “`SHOW SLAVE STATUS` Syntax”.

12.5.2.1. `CHANGE MASTER TO` Syntax

```
CHANGE MASTER TO option [, option] ...

option:
    MASTER_HOST = 'host_name'
  | MASTER_USER = 'user_name'
  | MASTER_PASSWORD = 'password'
  | MASTER_PORT = port_num
  | MASTER_CONNECT_RETRY = interval
  | MASTER_HEARTBEAT_PERIOD = interval
  | MASTER_LOG_FILE = 'master_log_name'
  | MASTER_LOG_POS = master_log_pos
  | RELAY_LOG_FILE = 'relay_log_name'
  | RELAY_LOG_POS = relay_log_pos
  | MASTER_SSL = {0|1}
  | MASTER_SSL_CA = 'ca_file_name'
  | MASTER_SSL_CAPATH = 'ca_directory_name'
  | MASTER_SSL_CERT = 'cert_file_name'
  | MASTER_SSL_KEY = 'key_file_name'
  | MASTER_SSL_CIPHER = 'cipher_list'
  | MASTER_SSL_VERIFY_SERVER_CERT = {0|1}
  | IGNORE_SERVER_IDS = (server_id_list)

server_id_list:
    [server_id [, server_id] ... ]
```

`CHANGE MASTER TO` changes the parameters that the slave server uses for connecting to the master server, for reading the master binary log, and reading the slave relay log. It also updates the contents of the `master.info` and `relay-log.info` files. To use `CHANGE MASTER TO`, the slave replication threads must be stopped (use `STOP SLAVE` if necessary).

Options not specified retain their value, except as indicated in the following discussion. Thus, in most cases, there is no need to specify options that do not change. For example, if the password to connect to your MySQL master has changed, you just need to issue these statements to tell the slave about the new password:

```
STOP SLAVE; -- if replication was running
CHANGE MASTER TO MASTER_PASSWORD='new3cret';
START SLAVE; -- if you want to restart replication
```

`MASTER_HOST`, `MASTER_USER`, `MASTER_PASSWORD`, and `MASTER_PORT` provide information to the slave about how to connect to its master:

- `MASTER_HOST` and `MASTER_PORT` are the host name (or IP address) of the master host and its TCP/IP port.

  Note

  Replication cannot use Unix socket files. You must be able to connect to the master MySQL server using TCP/IP.

  If you specify the `MASTER_HOST` or `MASTER_PORT` option, the slave assumes that the master server is different from before (even if the option value is the same as its current value.) In this case, the old values for the master binary log file name and position are considered no longer applicable, so if you do not specify `MASTER_LOG_FILE` and `MASTER_LOG_POS` in the statement, `MASTER_LOG_FILE=''` and `MASTER_LOG_POS=4` are silently appended to it.

  Setting `MASTER_HOST=''` (that is, setting its value explicitly to an empty string) is *not* the same as not setting `MASTER_HOST` at all. Beginning with MySQL 5.5, trying to set `MASTER_HOST` to an empty string fails with an error. Previously, setting `MASTER_HOST` to an empty string caused `START SLAVE` subsequently to fail. (Bug #28796)

- `MASTER_USER` and `MASTER_PASSWORD` are the user name and password of the account to use for connecting to the master.

The `MASTER_SSL_xxx` options provide information about using SSL for the connection. They correspond to the `--ssl-xxx` options described in Section 5.5.8.3, “SSL Command Options”, and Section 15.3.7, “Setting Up Replication Using SSL”. These options can be changed even on slaves that are compiled without SSL support. They are saved to the `master.info` file, but are ignored if the slave does not have SSL support enabled.

`MASTER_CONNECT_RETRY` specifies how many seconds to wait between connect retries. The default is 60. The *number* of reconnection attempts is limited by the `--master-retry-count` server option; for more information, see Section 15.1.3, “Replication and Binary Logging Options and Variables”.

`MASTER_HEARTBEAT_PERIOD` sets the interval in seconds between replication heartbeats. Whenever the master's binary log is updated with an event, the waiting period for the next heartbeat is reset. `interval` is a decimal value having the range 0 to 4294967 seconds and a resolution in milliseconds; the smallest nonzero value is 0.001. Heartbeats are sent by the master only if there are no unsent events in the binary log file for a period longer than `interval`.

Setting `interval` to 0 disables heartbeats altogether. The default value for `interval` is equal to the value of `slave_net_timeout` divided by 2.

Setting `@@global.slave_net_timeout` to a value less than that of the current heartbeat interval results in a warning being issued. The effect of issuing `RESET SLAVE` on the heartbeat interval is to reset it to the default value.

`MASTER_LOG_FILE` and `MASTER_LOG_POS` are the coordinates at which the slave I/O thread should begin reading from the master the next time the thread starts. `RELAY_LOG_FILE` and `RELAY_LOG_POS` are the coordinates at which the slave SQL thread should begin reading from the relay log the next time the thread starts. If you specify either of `MASTER_LOG_FILE` or

`MASTER_LOG_POS`, you cannot specify `RELAY_LOG_FILE` or `RELAY_LOG_POS`. If neither of `MASTER_LOG_FILE` or `MASTER_LOG_POS` is specified, the slave uses the last coordinates of the *slave SQL thread* before `CHANGE MASTER TO` was issued. This ensures that there is no discontinuity in replication, even if the slave SQL thread was late compared to the slave I/O thread, when you merely want to change, say, the password to use.

`CHANGE MASTER TO` *deletes all relay log files* and starts a new one, unless you specify `RELAY_LOG_FILE` or `RELAY_LOG_POS`. In that case, relay log files are kept; the `relay_log_purge` global variable is set silently to 0.

Prior to MySQL 5.5, `RELAY_LOG_FILE` required an absolute path. In MySQL 5.5, the path can be relative, and uses the same basename as `MASTER_LOG_FILE`. (Bug #12190)

`IGNORE_SERVER_IDS` was added in MySQL 5.5. This option takes a comma-separated list of 0 or more server IDs. Events originating from the corresponding servers are ignored, with the exception of log rotation and deletion events, which are still recorded in the relay log.

In circular replication, the originating server normally acts as the terminator of its own events, so that they are not applied more than once. Thus, this option is useful in circular replication when one of the servers in the circle is removed. Suppose that you have a circular replication setup with 4 servers, having server IDs 1, 2, 3, and 4, and server 3 fails. When bridging the gap by starting replication from server 2 to server 4, you can include `IGNORE_SERVER_IDS = (3)` in the `CHANGE MASTER TO` statement that you issue on server 4 to tell it to use server 2 as its master instead of server 3. Doing so causes it to ignore and not to propagate any statements that originated with the server that is no longer in use.

If a `CHANGE MASTER TO` statement is issued without any `IGNORE_SERVER_IDS` option, any existing list is preserved; `RESET SLAVE` also has no effect on the server ID list. To clear the list of ignored servers, it is necessary to use the option with an empty list:

```
CHANGE MASTER TO IGNORE_SERVER_IDS = ();
```

If `IGNORE_SERVER_IDS` contains the server's own ID and the server was started with the `--replicate-same-server-id` option enabled, an error results.

Also beginning with MySQL 5.5, the `master.info` file and the output of `SHOW SLAVE STATUS` are extended to provide the list of servers that are currently ignored. For more information, see Section 15.2.2.2, “Slave Status Logs”, and Section 12.4.5.35, “`SHOW SLAVE STATUS` Syntax”.

Beginning with MySQL 5.5.5, invoking `CHANGE MASTER TO` causes the previous values for `MASTER_HOST`, `MASTER_PORT`, `MASTER_LOG_FILE`, and `MASTER_LOG_POS` to be written to the error log, along with other information about the slave's state prior to execution.

`CHANGE MASTER TO` is useful for setting up a slave when you have the snapshot of the master and have recorded the master binary log coordinates corresponding to the time of the snapshot. After loading the snapshot into the slave to synchronize it to the slave, you can run `CHANGE MASTER TO MASTER_LOG_FILE='`*`log_name`*`', MASTER_LOG_POS=`*`log_pos`* on the slave to specify the coordinates at which the slave should begin reading the master binary log.

The following example changes the master server the slave uses and establishes the master binary log coordinates from which the slave begins reading. This is used when you want to set up the slave to replicate the master:

```
CHANGE MASTER TO
  MASTER_HOST='master2.mycompany.com',
  MASTER_USER='replication',
  MASTER_PASSWORD='bigs3cret',
  MASTER_PORT=3306,
  MASTER_LOG_FILE='master2-bin.001',
  MASTER_LOG_POS=4,
  MASTER_CONNECT_RETRY=10;
```

The next example shows an operation that is less frequently employed. It is used when the slave has relay log files that you want it to execute again for some reason. To do this, the master need not be reachable. You need only use `CHANGE MASTER TO` and start the SQL thread (`START SLAVE SQL_THREAD`):

```
CHANGE MASTER TO
  RELAY_LOG_FILE='slave-relay-bin.006',
  RELAY_LOG_POS=4025;
```

You can even use the second operation in a nonreplication setup with a standalone, nonslave server for recovery following a crash. Suppose that your server has crashed and you have restored it from a backup. You want to replay the server's own binary log files (not relay log files, but regular binary log files), named (for example) `myhost-bin.*`. First, make a backup copy of these binary log files in some safe place, in case you don't exactly follow the procedure below and accidentally have the server purge the binary log. Use `SET GLOBAL relay_log_purge=0` for additional safety. Then start the server without the `--log-bin` option, Instead, use the `--replicate-same-server-id`, `--relay-log=myhost-bin` (to make the server believe that these regular binary log files are relay log files) and `--skip-slave-start` options. After the server starts, issue these statements:

```
CHANGE MASTER TO
```

```
  RELAY_LOG_FILE='myhost-bin.153',
  RELAY_LOG_POS=410,
  MASTER_HOST='some_dummy_string';
START SLAVE SQL_THREAD;
```

The server reads and executes its own binary log files, thus achieving crash recovery. Once the recovery is finished, run `STOP SLAVE`, shut down the server, delete the `master.info` and `relay-log.info` files, and restart the server with its original options.

Specifying the `MASTER_HOST` option (even with a dummy value) is required to make the server think it is a slave.

The following table shows the maximum permissible length for the string-valued options.

Option	**Maximum Length**
`MASTER_HOST`	60
`MASTER_USER`	16
`MASTER_PASSWORD`	32
`MASTER_LOG_FILE`	255
`RELAY_LOG_FILE`	255
`MASTER_SSL_CA`	255
`MASTER_SSL_CAPATH`	255
`MASTER_SSL_CERT`	255
`MASTER_SSL_KEY`	255
`MASTER_SSL_CIPHER`	511

12.5.2.2. `MASTER_POS_WAIT()` Syntax

```
SELECT MASTER_POS_WAIT('master_log_file', master_log_pos [, timeout])
```

This is actually a function, not a statement. It is used to ensure that the slave has read and executed events up to a given position in the master's binary log. See Section 11.15, “Miscellaneous Functions”, for a full description.

12.5.2.3. `RESET SLAVE` Syntax

```
RESET SLAVE [ALL]
```

`RESET SLAVE` makes the slave forget its replication position in the master's binary log. This statement is meant to be used for a clean start: It deletes the `master.info` and `relay-log.info` files, all the relay log files, and starts a new relay log file. To use `RESET SLAVE`, the slave replication threads must be stopped (use `STOP SLAVE` if necessary).

> **Note**
>
> All relay log files are deleted, even if they have not been completely executed by the slave SQL thread. (This is a condition likely to exist on a replication slave if you have issued a `STOP SLAVE` statement or if the slave is highly loaded.)

In MySQL 5.5 (unlike the case in MySQL 5.1 and earlier), `RESET SLAVE` does not change any replication connection parameters such as master host, master port, master user, or master password, which are retained in memory. This means that `START SLAVE` can be issued without requiring a `CHANGE MASTER TO` statement following `RESET SLAVE`.

In MySQL 5.5.16 and later, you can use `RESET SLAVE ALL` to reset these connection parameters (Bug#11809016). Connection parameters are also reset if the slave `mysqld` is shut down.

If the slave SQL thread was in the middle of replicating temporary tables when it was stopped, and `RESET SLAVE` is issued, these replicated temporary tables are deleted on the slave.

12.5.2.4. `SET GLOBAL sql_slave_skip_counter` Syntax

```
SET GLOBAL sql_slave_skip_counter = N
```

This statement skips the next *`N`* events from the master. This is useful for recovering from replication stops caused by a statement.

This statement is valid only when the slave threads are not running. Otherwise, it produces an error.

When using this statement, it is important to understand that the binary log is actually organized as a sequence of groups known as *event groups*. Each event group consists of a sequence of events.

- For transactional tables, an event group corresponds to a transaction.
- For nontransactional tables, an event group corresponds to a single SQL statement.

> **Note**
>
> A single transaction can contain changes to both transactional and nontransactional tables.

When you use `SET GLOBAL sql_slave_skip_counter` to skip events and the result is in the middle of a group, the slave continues to skip events until it reaches the end of the group. Execution then starts with the next event group.

Beginning with MySQL 5.5.5, issuing this statement causes the previous values of `RELAY_LOG_FILE`, `RELAY_LOG_POS`, and `sql_slave_skip_counter` to be written to the error log.

12.5.2.5. `START SLAVE` Syntax

```
START SLAVE [thread_type [, thread_type] ... ]
START SLAVE [SQL_THREAD] UNTIL
    MASTER_LOG_FILE = 'log_name', MASTER_LOG_POS = log_pos
START SLAVE [SQL_THREAD] UNTIL
    RELAY_LOG_FILE = 'log_name', RELAY_LOG_POS = log_pos

thread_type: IO_THREAD | SQL_THREAD
```

`START SLAVE` with no *`thread_type`* options starts both of the slave threads. The I/O thread reads events from the master server and stores them in the relay log. The SQL thread reads events from the relay log and executes them. `START SLAVE` requires the `SUPER` privilege.

If `START SLAVE` succeeds in starting the slave threads, it returns without any error. However, even in that case, it might be that the slave threads start and then later stop (for example, because they do not manage to connect to the master or read its binary log, or some other problem). `START SLAVE` does not warn you about this. You must check the slave's error log for error messages generated by the slave threads, or check that they are running satisfactorily with `SHOW SLAVE STATUS`.

`START SLAVE` sends an acknowledgment to the user after both the I/O thread and the SQL thread have started. However, the I/O thread may not yet have connected. For this reason, a successful `START SLAVE` causes `SHOW SLAVE STATUS` to show `Slave_SQL_Running=Yes`, but this does not guarantee that `Slave_IO_Running=Yes` (because `Slave_IO_Running=Yes` only if the I/O thread is running *and connected*). For more information, see Section 12.4.5.35, “`SHOW SLAVE STATUS` Syntax”, and Section 15.1.4.1, “Checking Replication Status”.

You can add `IO_THREAD` and `SQL_THREAD` options to the statement to name which of the threads to start.

An `UNTIL` clause may be added to specify that the slave should start and run until the SQL thread reaches a given point in the master binary log or in the slave relay log. When the SQL thread reaches that point, it stops. If the `SQL_THREAD` option is specified in the statement, it starts only the SQL thread. Otherwise, it starts both slave threads. If the SQL thread is running, the `UNTIL` clause is ignored and a warning is issued.

For an `UNTIL` clause, you must specify both a log file name and position. Do not mix master and relay log options.

Any `UNTIL` condition is reset by a subsequent `STOP SLAVE` statement, a `START SLAVE` statement that includes no `UNTIL` clause, or a server restart.

The `UNTIL` clause can be useful for debugging replication, or to cause replication to proceed until just before the point where you want to avoid having the slave replicate an event. For example, if an unwise `DROP TABLE` statement was executed on the master, you can use `UNTIL` to tell the slave to execute up to that point but no farther. To find what the event is, use `mysqlbinlog` with the master binary log or slave relay log, or by using a `SHOW BINLOG EVENTS` statement.

If you are using `UNTIL` to have the slave process replicated queries in sections, it is recommended that you start the slave with the `--skip-slave-start` option to prevent the SQL thread from running when the slave server starts. It is probably best to use this option in an option file rather than on the command line, so that an unexpected server restart does not cause it to be forgotten.

The `SHOW SLAVE STATUS` statement includes output fields that display the current values of the `UNTIL` condition.

In old versions of MySQL (before 4.0.5), this statement was called `SLAVE START`. This usage is still accepted in MySQL 5.5 for backward compatibility, but is deprecated and is removed in MySQL 5.6.

12.5.2.6. `STOP SLAVE` Syntax

```
STOP SLAVE [thread_type [, thread_type] ... ]

thread_type: IO_THREAD | SQL_THREAD
```

Stops the slave threads. `STOP SLAVE` requires the `SUPER` privilege.

Like `START SLAVE`, this statement may be used with the `IO_THREAD` and `SQL_THREAD` options to name the thread or threads to be stopped.

> **Note**
>
> In MySQL 5.5, `STOP SLAVE` waits until the current replication event group affecting one or more non-transactional tables has finished executing (if there is any such replication group), or until the user issues a `KILL QUERY` or `KILL CONNECTION` statement. (Bug #319, Bug #38205)

In old versions of MySQL (before 4.0.5), this statement was called `SLAVE STOP`. This usage is still accepted in MySQL 5.5 for backward compatibility, but is deprecated and is removed in MySQL 5.6.

12.6. SQL Syntax for Prepared Statements

MySQL 5.5 provides support for server-side prepared statements. This support takes advantage of the efficient client/server binary protocol implemented in MySQL 4.1, provided that you use an appropriate client programming interface. Candidate interfaces include the MySQL C API client library (for C programs), MySQL Connector/J (for Java programs), and MySQL Connector/Net. For example, the C API provides a set of function calls that make up its prepared statement API. See Section 20.9.4, “C API Prepared Statements”. Other language interfaces can provide support for prepared statements that use the binary protocol by linking in the C client library, one example being the `mysqli` extension, available in PHP 5.0 and later.

An alternative SQL interface to prepared statements is available. This interface is not as efficient as using the binary protocol through a prepared statement API, but requires no programming because it is available directly at the SQL level:

- You can use it when no programming interface is available to you.
- You can use it from any program that enables you to send SQL statements to the server to be executed, such as the `mysql` client program.
- You can use it even if the client is using an old version of the client library. The only requirement is that you be able to connect to a server that is recent enough to support SQL syntax for prepared statements.

SQL syntax for prepared statements is intended to be used for situations such as these:

- You want to test how prepared statements work in your application before coding it.
- An application has problems executing prepared statements and you want to determine interactively what the problem is.
- You want to create a test case that describes a problem you are having with prepared statements, so that you can file a bug report.
- You need to use prepared statements but do not have access to a programming API that supports them.

SQL syntax for prepared statements is based on three SQL statements:

- `PREPARE` prepares a statement for execution (see Section 12.6.1, “`PREPARE` Syntax”).
- `EXECUTE` executes a prepared statement (see Section 12.6.2, “`EXECUTE` Syntax”).
- `DEALLOCATE PREPARE` releases a prepared statement (see Section 12.6.3, “`DEALLOCATE PREPARE` Syntax”).

The following examples show two equivalent ways of preparing a statement that computes the hypotenuse of a triangle given the lengths of the two sides.

The first example shows how to create a prepared statement by using a string literal to supply the text of the statement:

```
mysql> PREPARE stmt1 FROM 'SELECT SQRT(POW(?,2) + POW(?,2)) AS hypotenuse';
mysql> SET @a = 3;
mysql> SET @b = 4;
mysql> EXECUTE stmt1 USING @a, @b;
```

```
+------------+
| hypotenuse |
+------------+
|          5 |
+------------+
mysql> DEALLOCATE PREPARE stmt1;
```

The second example is similar, but supplies the text of the statement as a user variable:

```
mysql> SET @s = 'SELECT SQRT(POW(?,2) + POW(?,2)) AS hypotenuse';
mysql> PREPARE stmt2 FROM @s;
mysql> SET @a = 6;
mysql> SET @b = 8;
mysql> EXECUTE stmt2 USING @a, @b;
+------------+
| hypotenuse |
+------------+
|         10 |
+------------+
mysql> DEALLOCATE PREPARE stmt2;
```

Here is an additional example that demonstrates how to choose the table on which to perform a query at runtime, by storing the name of the table as a user variable:

```
mysql> USE test;
mysql> CREATE TABLE t1 (a INT NOT NULL);
mysql> INSERT INTO t1 VALUES (4), (8), (11), (32), (80);

mysql> SET @table = 't1';
mysql> SET @s = CONCAT('SELECT * FROM ', @table);

mysql> PREPARE stmt3 FROM @s;
mysql> EXECUTE stmt3;
+----+
| a  |
+----+
|  4 |
|  8 |
| 11 |
| 32 |
| 80 |
+----+

mysql> DEALLOCATE PREPARE stmt3;
```

A prepared statement is specific to the session in which it was created. If you terminate a session without deallocating a previously prepared statement, the server deallocates it automatically.

A prepared statement is also global to the session. If you create a prepared statement within a stored routine, it is not deallocated when the stored routine ends.

To guard against too many prepared statements being created simultaneously, set the `max_prepared_stmt_count` system variable. To prevent the use of prepared statements, set the value to 0.

The following SQL statements can be used as prepared statements:

```
ALTER TABLE
ANALYZE TABLE
CACHE INDEX
CALL
CHANGE MASTER
CHECKSUM {TABLE | TABLES}
COMMIT
{CREATE | DROP} DATABASE
{CREATE | RENAME | DROP} USER
CREATE INDEX
CREATE TABLE
DELETE
DO
DROP INDEX
DROP TABLE
FLUSH {TABLE | TABLES | TABLES WITH READ LOCK | HOSTS | PRIVILEGES
  | LOGS | STATUS | MASTER | SLAVE | DES_KEY_FILE | USER_RESOURCES}
GRANT
INSERT
INSTALL PLUGIN
KILL
LOAD INDEX INTO CACHE
OPTIMIZE TABLE
RENAME TABLE
REPAIR TABLE
REPLACE
RESET {MASTER | SLAVE | QUERY CACHE}
REVOKE
SELECT
SET
SHOW BINLOG EVENTS
SHOW CREATE {PROCEDURE | FUNCTION | EVENT | TABLE | VIEW}
SHOW {AUTHORS | CONTRIBUTORS | WARNINGS | ERRORS}
SHOW {MASTER | BINARY} LOGS
SHOW {MASTER | SLAVE} STATUS
SLAVE {START | STOP}
UNINSTALL PLUGIN
UPDATE
```

Other statements are not yet supported.

Statements not permitted in SQL prepared statements are generally also not permitted in stored routines. Any exceptions to this rule are noted in Section 17.2, “Using Stored Routines (Procedures and Functions)”.

Placeholders can be used for the arguments of the `LIMIT` clause when using prepared statements. See Section 12.2.9, “`SELECT` Syntax”.

In prepared `CALL` statements used with `PREPARE` and `EXECUTE`, placeholder support for `OUT` and `INOUT` parameters is available beginning with MySQL 5.5. See Section 12.2.1, “`CALL` Syntax”, for an example and a workaround for earlier versions. Placeholders can be used for `IN` parameters regardless of version.

SQL syntax for prepared statements cannot be used in nested fashion. That is, a statement passed to `PREPARE` cannot itself be a `PREPARE`, `EXECUTE`, or `DEALLOCATE PREPARE` statement.

SQL syntax for prepared statements is distinct from using prepared statement API calls. For example, you cannot use the `mysql_stmt_prepare()` C API function to prepare a `PREPARE`, `EXECUTE`, or `DEALLOCATE PREPARE` statement.

SQL syntax for prepared statements can be used within stored procedures, but not in stored functions or triggers. However, a cursor cannot be used for a dynamic statement that is prepared and executed with `PREPARE` and `EXECUTE`. The statement for a cursor is checked at cursor creation time, so the statement cannot be dynamic.

SQL syntax for prepared statements does not support multi-statements (that is, multiple statements within a single string separated by “`;`” characters).

Prepared statements use the query cache under the conditions described in Section 7.9.3.1, “How the Query Cache Operates”.

To write C programs that use the `CALL` SQL statement to execute stored procedures that contain prepared statements, the `CLIENT_MULTI_RESULTS` flag must be enabled. This is because each `CALL` returns a result to indicate the call status, in addition to any result sets that might be returned by statements executed within the procedure.

`CLIENT_MULTI_RESULTS` can be enabled when you call `mysql_real_connect()`, either explicitly by passing the `CLIENT_MULTI_RESULTS` flag itself, or implicitly by passing `CLIENT_MULTI_STATEMENTS` (which also enables `CLIENT_MULTI_RESULTS`). For additional information, see Section 12.2.1, “`CALL` Syntax”.

12.6.1. `PREPARE` Syntax

```
PREPARE stmt_name FROM preparable_stmt
```

The `PREPARE` statement prepares a statement and assigns it a name, *`stmt_name`*, by which to refer to the statement later. Statement names are not case sensitive. *`preparable_stmt`* is either a string literal or a user variable that contains the text of the statement. The text must represent a single SQL statement, not multiple statements. Within the statement, “`?`” characters can be used as parameter markers to indicate where data values are to be bound to the query later when you execute it. The “`?`” characters should not be enclosed within quotation marks, even if you intend to bind them to string values. Parameter markers can be used only where data values should appear, not for SQL keywords, identifiers, and so forth.

If a prepared statement with the given name already exists, it is deallocated implicitly before the new statement is prepared. This means that if the new statement contains an error and cannot be prepared, an error is returned and no statement with the given name exists.

A prepared statement is executed with `EXECUTE` and released with `DEALLOCATE PREPARE`.

The scope of a prepared statement is the session within which it is created. Other sessions cannot see it.

For examples, see Section 12.6, “SQL Syntax for Prepared Statements”.

12.6.2. `EXECUTE` Syntax

```
EXECUTE stmt_name
    [USING @var_name [, @var_name] ...]
```

After preparing a statement with `PREPARE`, you execute it with an `EXECUTE` statement that refers to the prepared statement name. If the prepared statement contains any parameter markers, you must supply a `USING` clause that lists user variables containing the values to be bound to the parameters. Parameter values can be supplied only by user variables, and the `USING` clause must name exactly as many variables as the number of parameter markers in the statement.

You can execute a given prepared statement multiple times, passing different variables to it or setting the variables to different values before each execution.

For examples, see Section 12.6, “SQL Syntax for Prepared Statements”.

12.6.3. `DEALLOCATE PREPARE` Syntax

```
{DEALLOCATE | DROP} PREPARE stmt_name
```

To deallocate a prepared statement produced with `PREPARE`, use a `DEALLOCATE PREPARE` statement that refers to the prepared statement name. Attempting to execute a prepared statement after deallocating it results in an error.

For examples, see Section 12.6, “SQL Syntax for Prepared Statements”.

12.6.4. Automatic Prepared Statement Repreparation

Metadata changes to tables or views referred to by prepared statements are detected and cause automatic repreparation of the statement when it is next executed. This applies to prepared statements processed at the SQL level (using the `PREPARE` statement) and those processed using the binary client/server protocol (using the `mysql_stmt_prepare()` C API function).

Metadata changes occur for DDL statements such as those that create, drop, alter, rename, or truncate tables, or that analyze, optimize, or repair tables. Repreparation also occurs after referenced tables or views are flushed from the table definition cache, either implicitly to make room for new entries in the cache, or explicitly due to `FLUSH TABLES`.

Repreparation is automatic, but to the extent that it occurs, performance of prepared statements is diminished.

When a statement is reprepared, the default database and SQL mode that were in effect for the original preparation are used.

Table content changes (for example, with `INSERT` or `UPDATE`) do not cause repreparation, nor do `SELECT` statements.

An incompatibility with previous versions of MySQL is that a prepared statement may return a different set of columns or different column types from one execution to the next. For example, if the prepared statement is `SELECT * FROM t1`, altering `t1` to contain a different number of columns causes the next execution to return a number of columns different from the previous execution.

Older versions of the client library cannot handle this change in behavior. For applications that use prepared statements with a server that performs automatic repreparation, an upgrade to the new client library is strongly recommended.

The `Com_stmt_reprepare` status variable tracks the number of repreparations.

The server attempts repreparation up to three times. An error occurs if all attempts fail.

12.7. MySQL Compound-Statement Syntax

This section describes the syntax for the `BEGIN ... END` compound statement and other statements that can be used in the body of stored programs: Stored procedures and functions, triggers, and events. These objects are defined in terms of SQL code that is stored on the server for later invocation (see Chapter 17, *Stored Programs and Views*).

12.7.1. `BEGIN ... END` Compound Statement Syntax

```
[begin_label:] BEGIN
    [statement_list]
END [end_label]
```

`BEGIN ... END` syntax is used for writing compound statements, which can appear within stored programs. A compound statement can contain multiple statements, enclosed by the `BEGIN` and `END` keywords. *`statement_list`* represents a list of one or more statements, each terminated by a semicolon (`;`) statement delimiter. *`statement_list`* is optional, which means that the empty compound statement (`BEGIN END`) is legal.

Use of multiple statements requires that a client is able to send statement strings containing the `;` statement delimiter. This is handled in the `mysql` command-line client with the `delimiter` command. Changing the `;` end-of-statement delimiter (for example, to `//`) permit `;` to be used in a program body. For an example, see Section 17.1, “Defining Stored Programs”.

A `BEGIN ... END` block can be labeled. Labels follow these rules:

- *`end_label`* cannot be given unless *`begin_label`* is also present.

- If both `begin_label` and `end_label` are present, they must be the same.
- Labels can be up to 16 characters long.

Labels are also permitted for the `LOOP`, `REPEAT`, and `WHILE` statements.

The optional `[NOT] ATOMIC` clause is not supported. This means that no transactional savepoint is set at the start of the instruction block and the `BEGIN` clause used in this context has no effect on the current transaction.

> **Note**
>
> Within all stored programs (stored procedures and functions, triggers, and events), the parser treats `BEGIN [WORK]` as the beginning of a `BEGIN ... END` block. Begin a transaction in this context with `START TRANSACTION` instead.

12.7.2. `DECLARE` Syntax

The `DECLARE` statement is used to define various items local to a program:

- Local variables. See Section 12.7.3, “Variables in Stored Programs”.
- Conditions and handlers. See Section 12.7.4, “Conditions and Handlers”.
- Cursors. See Section 12.7.5, “Cursors”.

`DECLARE` is permitted only inside a `BEGIN ... END` compound statement and must be at its start, before any other statements.

Declarations must follow a certain order. Cursors must be declared before declaring handlers, and variables and conditions must be declared before declaring either cursors or handlers.

12.7.3. Variables in Stored Programs

You may declare and use variables within stored programs.

12.7.3.1. `DECLARE` for Local Variables

```
DECLARE var_name [, var_name] ... type [DEFAULT value]
```

This statement is used to declare local variables within stored programs. To provide a default value for the variable, include a `DEFAULT` clause. The value can be specified as an expression; it need not be a constant. If the `DEFAULT` clause is missing, the initial value is `NULL`.

Local variables are treated like stored routine parameters with respect to data type and overflow checking. See Section 12.1.12, “`CREATE PROCEDURE` and `CREATE FUNCTION` Syntax”.

Local variable names are not case sensitive. Permissible characters and quoting rules are the same as for other identifiers, as described in Section 8.2, “Schema Object Names”.

The scope of a local variable is within the `BEGIN ... END` block where it is declared. The variable can be referred to in blocks nested within the declaring block, except those blocks that declare a variable with the same name.

12.7.3.2. Variable `SET` Statement

```
SET var_name = expr [, var_name = expr] ...
```

The `SET` statement in stored programs is an extended version of the general `SET` statement (see Section 12.4.4, “`SET` Syntax”). Each `var_name` may refer to a local variable declared inside a stored program, a system variable, or a user-defined variable.

The `SET` statement in stored programs is implemented as part of the pre-existing `SET` syntax. This enables an extended syntax of `SET a=x, b=y, ...` where different variable types (locally declared variables, global and session system variables, user-defined variables) can be mixed. This also enables combinations of local variables and some options that make sense only for system variables; in that case, the options are recognized but ignored.

12.7.3.3. `SELECT ... INTO` Statement

```
SELECT col_name [, col_name] ...
```

```
    INTO var_name [, var_name] ...
    table_expr
```

`SELECT ... INTO` syntax enables selected columns to be stored directly into variables. The query should return a single row. If the query returns no rows, a warning with error code 1329 occurs (`No data`), and the variable values remain unchanged. If the query returns multiple rows, error 1172 occurs (`Result consisted of more than one row`). If it is possible that the statement may retrieve multiple rows, you can use `LIMIT 1` to limit the result set to a single row.

```
SELECT id,data INTO x,y FROM test.t1 LIMIT 1;
```

User variable names are not case sensitive. See Section 8.4, “User-Defined Variables”.

In the context of `SELECT ... INTO` statements that occur as part of events executed by the Event Scheduler, diagnostics messages (not only errors, but also warnings) are written to the error log, and, on Windows, to the application event log. For additional information, see Section 17.4.5, “Event Scheduler Status”.

12.7.3.4. Scope and Resolution of Local Variables

The scope of a local variable is within the `BEGIN ... END` block where it is declared. The variable can be referred to in blocks nested within the declaring block, except those blocks that declare a variable with the same name.

Local variables are within scope only during stored routine execution, so references to them are not permitted within prepared statements because those are global to the current session and the variables might have gone out of scope when the statement is executed. For example, `SELECT ... INTO local_var` cannot be used as a prepared statement.

Local variable names should not be the same as column names. If an SQL statement, such as a `SELECT ... INTO` statement, contains a reference to a column and a declared local variable with the same name, MySQL currently interprets the reference as the name of a variable. Consider the following procedure definition:

```
CREATE PROCEDURE sp1 (x VARCHAR(5))
BEGIN
  DECLARE xname VARCHAR(5) DEFAULT 'bob';
  DECLARE newname VARCHAR(5);
  DECLARE xid INT;

  SELECT xname, id INTO newname, xid
    FROM table1 WHERE xname = xname;
  SELECT newname;
END;
```

MySQL interprets `xname` in the `SELECT` statement as a reference to the `xname` *variable* rather than the `xname` *column*. Consequently, when the procedure `sp1()` is called, the `newname` variable returns the value `'bob'` regardless of the value of the `table1.xname` column.

Similarly, the cursor definition in the following procedure contains a `SELECT` statement that refers to `xname`. MySQL interprets this as a reference to the variable of that name rather than a column reference.

```
CREATE PROCEDURE sp2 (x VARCHAR(5))
BEGIN
  DECLARE xname VARCHAR(5) DEFAULT 'bob';
  DECLARE newname VARCHAR(5);
  DECLARE xid INT;
  DECLARE done TINYINT DEFAULT 0;
  DECLARE cur1 CURSOR FOR SELECT xname, id FROM table1;
  DECLARE CONTINUE HANDLER FOR NOT FOUND SET done = 1;

  OPEN cur1;
  read_loop: LOOP
    FETCH FROM cur1 INTO newname, xid;
    IF done THEN LEAVE read_loop; END IF;
    SELECT newname;
  END LOOP;
  CLOSE cur1;
END;
```

See also Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.

12.7.4. Conditions and Handlers

Certain conditions may require specific handling. These conditions can relate to errors or warnings, as well as to general flow control inside a stored program.

12.7.4.1. `DECLARE` for Conditions

```
DECLARE condition_name CONDITION FOR condition_value
```

```
condition_value:
    SQLSTATE [VALUE] sqlstate_value
  | mysql_error_code
```

The `DECLARE ... CONDITION` statement defines a named error condition. It specifies a condition that needs specific handling and associates a name with that condition. The name can be referred to in a subsequent `DECLARE ... HANDLER` statement. For an example, see Section 12.7.4.2, "`DECLARE` for Handlers".

A *`condition_value`* for `DECLARE ... CONDITION` can be an SQLSTATE value (a 5-character string literal) or a MySQL error code (a number). You should not use SQLSTATE value `'00000'` or MySQL error code 0, because those indicate success rather than an error condition. For a list of SQLSTATE values and MySQL error codes, see Section C.3, "Server Error Codes and Messages".

12.7.4.2. `DECLARE` for Handlers

```
DECLARE handler_type HANDLER
    FOR condition_value [, condition_value] ...
    statement

handler_type:
    CONTINUE
  | EXIT
  | UNDO

condition_value:
    SQLSTATE [VALUE] sqlstate_value
  | condition_name
  | SQLWARNING
  | NOT FOUND
  | SQLEXCEPTION
  | mysql_error_code
```

The `DECLARE ... HANDLER` statement specifies handlers that each may deal with one or more conditions. If one of these conditions occurs, the specified *`statement`* is executed. *`statement`* can be a simple statement (for example, `SET var_name = value`), or it can be a compound statement written using `BEGIN` and `END` (see Section 12.7.1, "`BEGIN ... END` Compound Statement Syntax").

For a `CONTINUE` handler, execution of the current program continues after execution of the handler statement. For an `EXIT` handler, execution terminates for the `BEGIN ... END` compound statement in which the handler is declared. (This is true even if the condition occurs in an inner block.) The `UNDO` handler type statement is not supported.

If a condition occurs for which no handler has been declared, the default action is `EXIT`.

A *`condition_value`* for `DECLARE ... HANDLER` can be any of the following values:

- An SQLSTATE value (a 5-character string literal) or a MySQL error code (a number). You should not use SQLSTATE value `'00000'` or MySQL error code 0, because those indicate success rather than an error condition. For a list of SQLSTATE values and MySQL error codes, see Section C.3, "Server Error Codes and Messages".
- A condition name previously specified with `DECLARE ... CONDITION`. See Section 12.7.4.1, "`DECLARE` for Conditions".
- `SQLWARNING` is shorthand for the class of SQLSTATE values that begin with `'01'`.
- `NOT FOUND` is shorthand for the class of SQLSTATE values that begin with `'02'`. This is relevant only within the context of cursors and is used to control what happens when a cursor reaches the end of a data set. If no more rows are available, a No Data condition occurs with SQLSTATE value 02000. To detect this condition, you can set up a handler for it (or for a `NOT FOUND` condition). An example is shown in Section 12.7.5, "Cursors". This condition also occurs for `SELECT ... INTO var_list` statements that retrieve no rows.
- `SQLEXCEPTION` is shorthand for the class of SQLSTATE values that do not begin with `'00'`, `'01'`, or `'02'`.

Example:

```
mysql> CREATE TABLE test.t (s1 INT, PRIMARY KEY (s1));
Query OK, 0 rows affected (0.00 sec)

mysql> delimiter //

mysql> CREATE PROCEDURE handlerdemo ()
    -> BEGIN
    ->   DECLARE CONTINUE HANDLER FOR SQLSTATE '23000' SET @x2 = 1;
    ->   SET @x = 1;
    ->   INSERT INTO test.t VALUES (1);
    ->   SET @x = 2;
    ->   INSERT INTO test.t VALUES (1);
    ->   SET @x = 3;
    -> END;
    -> //
Query OK, 0 rows affected (0.00 sec)

mysql> CALL handlerdemo()//
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @x//
    +------+
    | @x   |
    +------+
    | 3    |
    +------+
    1 row in set (0.00 sec)
```

The example associates a handler with SQLSTATE value `'23000'`, which occurs for a duplicate-key error. Notice that `@x` is `3` after the procedure executes, which shows that execution continued to the end of the procedure. If the `DECLARE ... HANDLER` statement had not been present, MySQL would have taken the default path (`EXIT`) after the second `INSERT` failed due to the `PRIMARY KEY` constraint, and `SELECT @x` would have returned `2`.

If you want to ignore a condition, you can declare a `CONTINUE` handler for it and associate it with an empty block. For example:

```
DECLARE CONTINUE HANDLER FOR SQLWARNING BEGIN END;
```

The statement associated with a handler cannot use `ITERATE` or `LEAVE` to refer to labels for blocks that enclose the handler declaration. That is, the scope of a block label does not include the code for handlers declared within the block. Consider the following example, where the `REPEAT` block has a label of `retry`:

```
CREATE PROCEDURE p ()
BEGIN
  DECLARE i INT DEFAULT 3;
  retry:
    REPEAT
      BEGIN
        DECLARE CONTINUE HANDLER FOR SQLWARNING
          BEGIN
            ITERATE retry;  # illegal
          END;
      END;
      IF i < 0 THEN
        LEAVE retry;        # legal
      END IF;
      SET i = i - 1;
    UNTIL FALSE END REPEAT;
END;
```

The label is in scope for the `IF` statement within the block. It is not in scope for the `CONTINUE` handler, so the reference there is invalid and results in an error:

```
ERROR 1308 (42000): LEAVE with no matching label: retry
```

To avoid using references to outer labels in handlers, you can use these strategies:

- To leave the block, use an `EXIT` handler:

  ```
  DECLARE EXIT HANDLER FOR SQLWARNING BEGIN END;
  ```

- To iterate, set a status variable in the handler that can be checked in the enclosing block to determine whether the handler was invoked. The following example uses the variable `done` for this purpose:

  ```
  CREATE PROCEDURE p ()
  BEGIN
    DECLARE i INT DEFAULT 3;
    DECLARE done INT DEFAULT FALSE;
    retry:
      REPEAT
        BEGIN
          DECLARE CONTINUE HANDLER FOR SQLWARNING
            BEGIN
              SET done = TRUE;
            END;
        END;
        IF NOT done AND i < 0 THEN
          LEAVE retry;
        END IF;
        SET i = i - 1;
      UNTIL FALSE END REPEAT;
  END;
  ```

12.7.5. Cursors

Cursors are supported inside stored routines, triggers, and events. The syntax is as in embedded SQL. Cursors in MySQL have these properties:

- Asensitive: The server may or may not make a copy of its result table
- Read only: Not updatable
- Nonscrollable: Can be traversed only in one direction and cannot skip rows

Cursors must be declared before declaring handlers. Variables and conditions must be declared before declaring either cursors or handlers. Variables should not have the same names as columns for reasons described in Section 12.7.3.4, “Scope and Resolution of Local Variables”.

Example:

```
CREATE PROCEDURE curdemo()
BEGIN
  DECLARE done INT DEFAULT 0;
  DECLARE a CHAR(16);
  DECLARE b,c INT;
  DECLARE cur1 CURSOR FOR SELECT id,data FROM test.t1;
  DECLARE cur2 CURSOR FOR SELECT i FROM test.t2;
  DECLARE CONTINUE HANDLER FOR NOT FOUND SET done = 1;

  OPEN cur1;
  OPEN cur2;

  read_loop: LOOP
    FETCH cur1 INTO a, b;
    FETCH cur2 INTO c;
    IF done THEN
      LEAVE read_loop;
    END IF;
    IF b < c THEN
      INSERT INTO test.t3 VALUES (a,b);
    ELSE
      INSERT INTO test.t3 VALUES (a,c);
    END IF;
  END LOOP;

  CLOSE cur1;
  CLOSE cur2;
END;
```

12.7.5.1. `DECLARE` for Cursors

```
DECLARE cursor_name CURSOR FOR select_statement
```

This statement declares a cursor. Multiple cursors may be declared in a stored program, but each cursor in a given block must have a unique name.

The `SELECT` statement cannot have an `INTO` clause.

Local variables should not be declared with the same name as columns referenced by the `SELECT` statement, for reasons described in Section 12.7.3.4, “Scope and Resolution of Local Variables”.

For information available through `SHOW` statements, it is possible in many cases to obtain equivalent information by using a cursor with an `INFORMATION_SCHEMA` table.

12.7.5.2. Cursor `OPEN` Statement

```
OPEN cursor_name
```

This statement opens a previously declared cursor.

12.7.5.3. Cursor `FETCH` Statement

```
FETCH cursor_name INTO var_name [, var_name] ...
```

This statement fetches the next row (if a row exists) using the specified open cursor, and advances the cursor pointer.

If no more rows are available, a No Data condition occurs with SQLSTATE value 02000. To detect this condition, you can set up a handler for it (or for a `NOT FOUND` condition). An example is shown in Section 12.7.5, “Cursors”.

12.7.5.4. Cursor `CLOSE` Statement

```
CLOSE cursor_name
```

This statement closes a previously opened cursor.

If not closed explicitly, a cursor is closed at the end of the compound statement in which it was declared.

12.7.6. Flow Control Constructs

MySQL supports the `IF`, `CASE`, `ITERATE`, `LEAVE LOOP`, `WHILE`, and `REPEAT` constructs for flow control within stored programs.

Many of these constructs contain other statements, as indicated by the grammar specifications in the following sections. Such constructs may be nested. For example, an `IF` statement might contain a `WHILE` loop, which itself contains a `CASE` statement.

`FOR` loops are not supported.

12.7.6.1. `IF` Statement

```
IF search_condition THEN statement_list
    [ELSEIF search_condition THEN statement_list] ...
    [ELSE statement_list]
END IF
```

`IF` implements a basic conditional construct. If the *`search_condition`* evaluates to true, the corresponding SQL statement list is executed. If no *`search_condition`* matches, the statement list in the `ELSE` clause is executed. Each *`statement_list`* consists of one or more statements.

> **Note**
>
> There is also an `IF()` *function*, which differs from the `IF` *statement* described here. See Section 11.4, “Control Flow Functions”.

An `IF ... END IF` block, like all other flow-control blocks used within stored programs, must be terminated with a semicolon, as shown in this example:

```
DELIMITER //

CREATE FUNCTION SimpleCompare(n INT, m INT)
  RETURNS VARCHAR(20)

  BEGIN
    DECLARE s VARCHAR(20);

    IF n > m THEN SET s = '>';
    ELSEIF n = m THEN SET s = '=';
    ELSE SET s = '<';
    END IF;

    SET s = CONCAT(n, ' ', s, ' ', m);

    RETURN s;
  END //

DELIMITER ;
```

As with other flow-control constructs, `IF ... END IF` blocks may be nested within other flow-control constructs, including other `IF` statements. Each `IF` must be terminated by its own `END IF` followed by a semicolon. You can use indentation to make nested flow-control blocks more easily readable by humans (although this is not required by MySQL), as shown here:

```
DELIMITER //

CREATE FUNCTION VerboseCompare (n INT, m INT)
  RETURNS VARCHAR(50)

  BEGIN
    DECLARE s VARCHAR(50);

    IF n = m THEN SET s = 'equals';
    ELSE
      IF n > m THEN SET s = 'greater';
      ELSE SET s = 'less';
      END IF;

      SET s = CONCAT('is ', s, ' than');
    END IF;

    SET s = CONCAT(n, ' ', s, ' ', m, '.');

    RETURN s;
  END //

DELIMITER ;
```

In this example, the inner `IF` is evaluated only if `n` is not equal to `m`.

12.7.6.2. `CASE` Statement

```
CASE case_value
    WHEN when_value THEN statement_list
    [WHEN when_value THEN statement_list] ...
    [ELSE statement_list]
END CASE
```

Or:

```
CASE
    WHEN search_condition THEN statement_list
    [WHEN search_condition THEN statement_list] ...
    [ELSE statement_list]
END CASE
```

The `CASE` statement for stored programs implements a complex conditional construct. If a *`search_condition`* evaluates to true, the corresponding SQL statement list is executed. If no search condition matches, the statement list in the `ELSE` clause is executed. Each *`statement_list`* consists of one or more statements.

If no *`when_value`* or *`search_condition`* matches the value tested and the `CASE` statement contains no `ELSE` clause, a `Case not found for CASE statement` error results.

Each *`statement_list`* consists of one or more statements; an empty *`statement_list`* is not permitted. To handle situations where no value is matched by any `WHEN` clause, use an `ELSE` containing an empty `BEGIN ... END` block, as shown in this example:

```
DELIMITER |

CREATE PROCEDURE p()
  BEGIN
    DECLARE v INT DEFAULT 1;

    CASE v
      WHEN 2 THEN SELECT v;
      WHEN 3 THEN SELECT 0;
      ELSE
        BEGIN
        END;
    END CASE;
  END;
  |
```

(The indentation used here in the `ELSE` clause is for purposes of clarity only, and is not otherwise significant.)

> **Note**
>
> The syntax of the `CASE` *statement* used inside stored programs differs slightly from that of the SQL `CASE` *expression* described in Section 11.4, “Control Flow Functions”. The `CASE` statement cannot have an `ELSE NULL` clause, and it is terminated with `END CASE` instead of `END`.

12.7.6.3. `LOOP` Statement

```
[begin_label:] LOOP
    statement_list
END LOOP [end_label]
```

`LOOP` implements a simple loop construct, enabling repeated execution of the statement list, which consists of one or more statements, each terminated by a semicolon (`;`) statement delimiter. The statements within the loop are repeated until the loop is exited; usually this is accomplished with a `LEAVE` statement.

A `LOOP` statement can be labeled. See Section 12.7.1, “`BEGIN ... END` Compound Statement Syntax” for the rules regarding label use.

12.7.6.4. `LEAVE` Statement

```
LEAVE label
```

This statement is used to exit the flow control construct that has the given label. It can be used within `BEGIN ... END` or loop constructs (`LOOP`, `REPEAT`, `WHILE`).

12.7.6.5. `ITERATE` Statement

```
ITERATE label
```

`ITERATE` can appear only within `LOOP`, `REPEAT`, and `WHILE` statements. `ITERATE` means “do the loop again.”

Example:

```
CREATE PROCEDURE doiterate(p1 INT)
BEGIN
  label1: LOOP
    SET p1 = p1 + 1;
    IF p1 < 10 THEN ITERATE label1; END IF;
    LEAVE label1;
  END LOOP label1;
  SET @x = p1;
END;
```

12.7.6.6. `REPEAT` Statement

```
[begin_label:] REPEAT
    statement_list
UNTIL search_condition
END REPEAT [end_label]
```

The statement list within a `REPEAT` statement is repeated until the *`search_condition`* is true. Thus, a `REPEAT` always enters the loop at least once. *`statement_list`* consists of one or more statements, each terminated by a semicolon (`;`) statement delimiter.

A `REPEAT` statement can be labeled. See Section 12.7.1, “`BEGIN ... END` Compound Statement Syntax” for the rules regarding label use.

Example:

```
mysql> delimiter //

mysql> CREATE PROCEDURE dorepeat(p1 INT)
    -> BEGIN
    ->   SET @x = 0;
    ->   REPEAT SET @x = @x + 1; UNTIL @x > p1 END REPEAT;
    -> END
    -> //
Query OK, 0 rows affected (0.00 sec)

mysql> CALL dorepeat(1000)//
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @x//
+------+
| @x   |
+------+
| 1001 |
+------+
1 row in set (0.00 sec)
```

12.7.6.7. `WHILE` Statement

```
[begin_label:] WHILE search_condition DO
    statement_list
END WHILE [end_label]
```

The statement list within a `WHILE` statement is repeated as long as the *`search_condition`* is true. *`statement_list`* consists of one or more statements.

A `WHILE` statement can be labeled. See Section 12.7.1, “`BEGIN ... END` Compound Statement Syntax” for the rules regarding label use.

Example:

```
CREATE PROCEDURE dowhile()
BEGIN
  DECLARE v1 INT DEFAULT 5;
  WHILE v1 > 0 DO
    ...
    SET v1 = v1 - 1;
  END WHILE;
END;
```

12.7.7. RETURN Syntax

```
RETURN expr
```

The `RETURN` statement terminates execution of a stored function and returns the value *`expr`* to the function caller. There must be at least one `RETURN` statement in a stored function. There may be more than one if the function has multiple exit points.

This statement is not used in stored procedures, triggers, or events.

12.7.8. SIGNAL and RESIGNAL

This section documents the `SIGNAL` and `RESIGNAL` statements. See also Section E.2, “Restrictions on Signals”.

12.7.8.1. SIGNAL Syntax

```
SIGNAL condition_value
    [SET signal_information [, signal_information] ...]

condition_value:
    SQLSTATE [VALUE] sqlstate_value
  | condition_name

signal_information:
    condition_information_item = simple_value_specification

condition_information_item:
{
    CLASS_ORIGIN
  | SUBCLASS_ORIGIN
  | CONSTRAINT_CATALOG
  | CONSTRAINT_SCHEMA
  | CONSTRAINT_NAME
  | CATALOG_NAME
  | SCHEMA_NAME
  | TABLE_NAME
  | COLUMN_NAME
  | CURSOR_NAME
  | MESSAGE_TEXT
  | MYSQL_ERRNO
}

simple_value_specification: (see following discussion)
```

`SIGNAL` is the way to “return” an error. `SIGNAL` provides error information to a handler, to an outer portion of the application, or to the client. Also, it provides control over the error's characteristics (error number, `SQLSTATE` value, message). Without `SIGNAL`, it is necessary to resort to workarounds such as deliberately referring to a nonexistent table to cause a routine to return an error.

No special privileges are required to execute the `SIGNAL` statement.

The *`condition_value`* in a `SIGNAL` statement indicates the error value to be returned. It can be an `SQLSTATE` value (a 5-character string literal) or a *`condition_name`* that refers to a named condition previously defined with `DECLARE ... CONDITION` (see Section 12.7.4.1, “`DECLARE` for Conditions”).

An `SQLSTATE` value can indicate errors, warnings, or “not found.” The first two characters of the value indicate its error class, as discussed in Section 12.7.8.1.1, “Signal Condition Information Items”. Some signal values cause statement termination; see Section 12.7.8.1.2, “Effect of Signals on Handlers, Cursors, and Statements”.

The `SQLSTATE` value for a `SIGNAL` statement should not start with `'00'` because such values indicate success and are not valid for signaling an error. This is true whether the `SQLSTATE` value is specified directly in the `SIGNAL` statement or in a named condition referred to in the statement. If the value is invalid, a `Bad SQLSTATE` error occurs.

To signal a generic `SQLSTATE` value, use `'45000'`, which means “unhandled user-defined exception.”

The `SIGNAL` statement optionally includes a `SET` clause that contains multiple signal items, in a comma-separated list of *`condition_information_item`* = *`simple_value_specification`* assignments.

All *`condition_information_item`* values are standard SQL except `MYSQL_ERRNO`, which is a MySQL extension. Section 12.7.8.1.1, “Signal Condition Information Items”, discusses permissible *`condition_information_item`* values.

Each *`condition_information_item`* may be specified only once in the `SET` clause. Otherwise, a `Duplicate condition information item` error occurs.

For MySQL, valid *`simple_value_specification`* terms include local variables declared with `DECLARE`, user-defined variables, system variables, parameters (that is, input parameters of procedures or functions), and literals, but not `NULL` values. A character literal may include a *`_charset`* introducer.

The following procedure signals an error or warning depending on the value of `pval`, its input parameter:

```
CREATE PROCEDURE p (pval INT)
BEGIN
  DECLARE specialty CONDITION FOR SQLSTATE '45000';
  IF pval = 0 THEN
    SIGNAL SQLSTATE '01000';
  ELSEIF pval = 1 THEN
    SIGNAL SQLSTATE '45000'
      SET MESSAGE_TEXT = 'An error occurred';
  ELSEIF pval = 2 THEN
    SIGNAL specialty
      SET MESSAGE_TEXT = 'An error occurred';
  ELSE
    SIGNAL SQLSTATE '01000'
      SET MESSAGE_TEXT = 'A warning occurred', MYSQL_ERRNO = 1000;
    SIGNAL SQLSTATE '45000'
      SET MESSAGE_TEXT = 'An error occurred', MYSQL_ERRNO = 1001;
  END IF;
END;
```

If `pval` is 0, `p()` signals a warning because `SQLSTATE` values that begin with `'01'` are signals in the warning class. The warning does not terminate the procedure, and can be seen with `SHOW WARNINGS` after the procedure returns.

If `pval` is 1, `p()` signals an error and sets the `MESSAGE_TEXT` condition information item. The error terminates the procedure, and the text is returned with the error information.

If `pval` is 2, the same error is signaled, although the `SQLSTATE` value is specified using a named condition in this case.

If `pval` is anything else, `p()` first signals a warning and sets the message text and error number condition information items. This warning does not terminate the procedure, so execution continues and `p()` then signals an error. The error does terminate the procedure. The message text and error number set by the warning are replaced by the values set by the error, which are returned with the error information.

`SIGNAL` is typically used within compound statements, but it is a MySQL extension that `SIGNAL` is permitted outside compound statements, For example, if you invoke the `mysql` program, you can enter any of these statements at the prompt:

```
mysql> SIGNAL SQLSTATE '77777';
mysql> CREATE TRIGGER t_bi BEFORE INSERT ON t
    -> FOR EACH ROW SIGNAL SQLSTATE '77777';
mysql> CREATE EVENT e ON SCHEDULE EVERY 1 SECOND
    -> DO SIGNAL SQLSTATE '77777';
```

`SIGNAL` executes according to the following rules:

If the `SIGNAL` statement indicates a particular `SQLSTATE` value, that value is used to signal the condition specified. Example:

```
CREATE PROCEDURE p (divisor INT)
BEGIN
  IF divisor = 0 THEN
    SIGNAL SQLSTATE '22012';
  END IF;
END;
```

If the `SIGNAL` statement uses a named condition, the condition must satisfy the following requirements:

- The condition must be declared in some scope that applies to the `SIGNAL` statement.
- The condition must be defined with `SQLSTATE`, not with a MySQL error number.

Example:

```
CREATE PROCEDURE p (divisor INT)
BEGIN
  DECLARE divide_by_zero CONDITION FOR SQLSTATE '22012';
  IF divisor = 0 THEN
    SIGNAL divide_by_zero;
  END IF;
END;
```

If the named condition does not exist in the scope of the `SIGNAL` statement, an `Undefined CONDITION` error occurs.

If `SIGNAL` refers to a named condition that is not defined with `SQLSTATE`, a `SIGNAL/RESIGNAL can only use a CONDITION defined with SQLSTATE` error occurs. The following statements cause that error because the condition is associated with a MySQL error number:

```
DECLARE x CONDITION FOR 1234;
SIGNAL x;
```

If a named condition is declared multiple times, the declaration with the most local scope applies. Consider the following procedure:

```
CREATE PROCEDURE p (divisor INT)
BEGIN
  DECLARE my_error CONDITION FOR SQLSTATE '45000';
  IF divisor = 0 THEN
    BEGIN
      DECLARE my_error CONDITION FOR SQLSTATE '22012';
      SIGNAL my_error;
    END;
  END IF;
  SIGNAL my_error;
END;
```

If `divisor` is 0, the first `SIGNAL` statement executes. The innermost `my_error` condition declaration applies, raising `SQLSTATE` value `'22012'`.

If `divisor` is not 0, the second `SIGNAL` statement executes. The outermost `my_error` condition declaration applies, raising `SQLSTATE` value `'45000'`.

Signals can be raised within exception handlers:

```
CREATE PROCEDURE p ()
BEGIN
  DECLARE EXIT HANDLER FOR SQLEXCEPTION
  BEGIN
    SIGNAL SQLSTATE VALUE '99999'
      SET MESSAGE_TEXT = 'An error occurred';
  END;
  DROP TABLE no_such_table;
END;
```

`CALL p()` reaches the `DROP TABLE` statement. There is no table named `no_such_table`, so the error handler comes into play. The error handler destroys the original error (“no such table”) and makes a new error with `SQLSTATE` value `'99999'` and message `An error occurred`.

12.7.8.1.1. Signal Condition Information Items

The following table lists the condition information items that can be set in a `SIGNAL` statement. All items are standard SQL except `MYSQL_ERRNO`, which is a MySQL extension.

```
Item Name             Definition
---------             ----------
CLASS_ORIGIN          VARCHAR(64)
SUBCLASS_ORIGIN       VARCHAR(64)
CONSTRAINT_CATALOG    VARCHAR(64)
CONSTRAINT_SCHEMA     VARCHAR(64)
CONSTRAINT_NAME       VARCHAR(64)
CATALOG_NAME          VARCHAR(64)
SCHEMA_NAME           VARCHAR(64)
TABLE_NAME            VARCHAR(64)
COLUMN_NAME           VARCHAR(64)
CURSOR_NAME           VARCHAR(64)
MESSAGE_TEXT          VARCHAR(128)
MYSQL_ERRNO           SMALLINT UNSIGNED
```

All character items are UTF-8.

It is illegal to assign `NULL` to a condition information item in a `SIGNAL` statement.

A `SIGNAL` statement always specifies an `SQLSTATE` value, either directly, or indirectly by referring to a named condition defined with an `SQLSTATE` value. The first two letters of an `SQLSTATE` value are its class, and the class determines the default value for the condition information items:

- Class = `'00'` (success)

  Illegal. This cannot happen because `SQLSTATE` values that begin with `'00'` indicate success and are not valid for `SIGNAL`.

- Class = `'01'` (warning)

  ```
  MESSAGE_TEXT = 'Unhandled user-defined warning';
  MYSQL_ERRNO = ER_SIGNAL_WARN
  ```

- Class = `'02'` (not found)

  ```
  MESSAGE_TEXT = 'Unhandled user-defined not found';
  MYSQL_ERRNO = ER_SIGNAL_NOT_FOUND
  ```

- Class > `'02'` (exception)

  ```
  MESSAGE_TEXT = 'Unhandled user-defined exception';
  MYSQL_ERRNO = ER_SIGNAL_EXCEPTION
  ```

For legal classes, the other condition information items are set as follows:

```
CLASS_ORIGIN = SUBCLASS_ORIGIN = '';
CONSTRAINT_CATALOG = CONSTRAINT_SCHEMA = CONSTRAINT_NAME = '';
CATALOG_NAME = SCHEMA_NAME = TABLE_NAME = COLUMN_NAME = '';
CURSOR_NAME = '';
```

The error values that are accessible after `SIGNAL` executes are the `SQLSTATE` value raised by the `SIGNAL` statement and the `MESSAGE_TEXT` and `MYSQL_ERRNO` items. These values are available from the C API:

- `SQLSTATE` value: Call `mysql_sqlstate()`
- `MYSQL_ERRNO` value: Call `mysql_errno()`
- `MESSAGE_TEXT` value: Call `mysql_error()`

From SQL, the output from `SHOW WARNINGS` and `SHOW ERRORS` indicates the `MYSQL_ERRNO` and `MESSAGE_TEXT` values in the `Code` and `Message` columns.

Other condition information items can be set, but currently have no effect, in the sense that they are not accessible from error returns. For example, you can set `CLASS_ORIGIN` in a `SIGNAL` statement, but cannot see it after `SIGNAL` executes.

12.7.8.1.2. Effect of Signals on Handlers, Cursors, and Statements

Signals have different effects on statement execution depending on the signal class. The class determines how severe an error is. MySQL ignores the `sql_mode` value; in particular, strict SQL mode does not matter. MySQL also ignores `IGNORE`: The intent of `SIGNAL` is to raise a user-generated error explicitly, so a signal is never ignored.

In the following descriptions, “unhandled” means that no handler for the signaled `SQLSTATE` value has been defined with `DECLARE ... HANDLER`.

- Class = `'00'` (success)

  Illegal. This cannot happen because `SQLSTATE` values that begin with `'00'` indicate success and are not valid for `SIGNAL`.

- Class = `'01'` (warning)

  The value of the `warning_count` system variable goes up. `SHOW WARNINGS` shows the signal. `SQLWARNING` handlers catch the signal. If the signal is unhandled in a function, statements do not end.

- Class = `'02'` (not found)

  `NOT FOUND` handlers catch the signal. There is no effect on cursors. If the signal is unhandled in a function, statements end.

- Class > `'02'` (exception)

  `SQLEXCEPTION` handlers catch the signal. If the signal is unhandled in a function, statements end.

- Class = `'40'`

  Treated as an ordinary exception.

Example:

```
mysql> delimiter //
mysql> CREATE FUNCTION f () RETURNS INT
    -> BEGIN
    ->   SIGNAL SQLSTATE '01234';  -- signal a warning
    ->   RETURN 5;
    -> END//
mysql> delimiter ;
mysql> CREATE TABLE t (s1 INT);
mysql> INSERT INTO t VALUES (f());
```

The result is that a row containing 5 is inserted into table `t`. The warning that is signaled can be viewed with `SHOW WARNINGS`.

12.7.8.2. `RESIGNAL` Syntax

```
RESIGNAL [condition_value]
    [SET signal_information [, signal_information] ...];

condition_value:
    SQLSTATE [VALUE] sqlstate_value
  | condition_name

signal_information:
    condition_information_item = simple_value_specification

condition_information_item:
{
    CLASS_ORIGIN
  | SUBCLASS_ORIGIN
  | CONSTRAINT_CATALOG
  | CONSTRAINT_SCHEMA
  | CONSTRAINT_NAME
  | CATALOG_NAME
  | SCHEMA_NAME
  | TABLE_NAME
  | COLUMN_NAME
  | CURSOR_NAME
  | MESSAGE_TEXT
  | MYSQL_ERRNO
}

simple_value_specification: (see following discussion)
```

`RESIGNAL` passes on the error condition information that is available during execution of a condition handler within a compound statement inside a stored procedure or function, trigger, or event. `RESIGNAL` may change some or all information before passing it on.

`RESIGNAL` makes it possible to both handle an error and return the error information. Otherwise, by executing an SQL statement within the handler, information that caused the handler's activation is destroyed. `RESIGNAL` also can make some procedures shorter if a given handler could handle part of a situation, then pass the condition “up the line” to another handler.

No special privileges are required to execute the `RESIGNAL` statement.

Unless otherwise indicated, the definitions and rules for *`condition_value`* and *`signal_information`* are the same for the `RESIGNAL` statement as for `SIGNAL` (see Section 12.7.8.1, “`SIGNAL` Syntax”).

The `RESIGNAL` statement takes *`condition_value`* and `SET` clauses, both of which are optional. This leads to several possible uses:

- `RESIGNAL` alone:

  ```
  RESIGNAL;
  ```

- `RESIGNAL` with new signal information:

  ```
  RESIGNAL SET signal_information [, signal_information] ...;
  ```

- `RESIGNAL` with a condition value and possibly new signal information:

  ```
  RESIGNAL condition_value
      [SET signal_information [, signal_information] ...];
  ```

These use cases all cause changes to the diagnostics and condition areas:

- A diagnostics area contains one or more condition areas.
- A condition area contains condition information items, such as the `SQLSTATE` value, `MYSQL_ERRNO`, or `MESSAGE_TEXT`.

There is a stack of diagnostics areas. When a handler takes control, it pushes the top of the stack, so there are two diagnostics areas during handler execution:

- The current diagnostics area, which starts as a copy of the last diagnostics area, but will be overwritten by the first procedure statement in the handler.
- The last diagnostics area, which has the condition areas that were set up before the handler took control.

The maximum number of condition areas in a diagnostics area is determined by the value of the `max_error_count` system variable.

12.7.8.2.1. `RESIGNAL` Alone

A simple `RESIGNAL` alone means “pass on the error with no change.” It restores the last diagnostics area and makes it the current diagnostics area. That is, it “pops” the diagnostics area stack.

Within a condition handler that catches a condition, one use for `RESIGNAL` alone is to perform some other actions, and then pass on without change the original condition information (the information that existed before entry into the handler).

Example:

```
DROP TABLE IF EXISTS xx;
delimiter //
CREATE PROCEDURE p ()
BEGIN
  DECLARE EXIT HANDLER FOR SQLEXCEPTION
  BEGIN
    SET @error_count = @error_count + 1;
    IF @a = 0 THEN RESIGNAL; END IF;
  END;
  DROP TABLE xx;
END//
delimiter ;
SET @error_count = 0;
SET @a = 0;
CALL p();
```

The `DROP TABLE xx` statement fails. The diagnostics area stack looks like this:

```
1. ERROR 1051 (42S02): Unknown table 'xx'
```

Then execution enters the `EXIT` handler. It starts by pushing the top of the diagnostics area stack, which now looks like this:

```
1. ERROR 1051 (42S02): Unknown table 'xx'
2. ERROR 1051 (42S02): Unknown table 'xx'
```

Usually a procedure statement clears the first diagnostics area (also called the “current” diagnostics area). `BEGIN` is an exception, it does not clear, it does nothing. `SET` is not an exception, it clears, performs the operation, and then produces a result of “success.” The diagnostics area stack now looks like this:

```
1. ERROR 0000 (00000): Successful operation
2. ERROR 1051 (42S02): Unknown table 'xx'
```

At this point, if `@a = 0`, `RESIGNAL` pops the diagnostics area stack, which now looks like this:

```
1. ERROR 1051 (42S02): Unknown table 'xx'
```

And that is what the caller sees.

If `@a` is not 0, the handler simply ends, which means that there is no more use for the last diagnostics area (it has been “handled”), so it can be thrown away. The diagnostics area stack looks like this:

```
1. ERROR 0000 (00000): Successful operation
```

The details make it look complex, but the end result is quite useful: Handlers can execute without destroying information about the condition that caused activation of the handler.

12.7.8.2.2. `RESIGNAL` with New Signal Information

`RESIGNAL` with a `SET` clause provides new signal information, so the statement means “pass on the error with changes”:

```
RESIGNAL SET signal_information [, signal_information] ...;
```

As with `RESIGNAL` alone, the idea is to pop the diagnostics area stack so that the original information will go out. Unlike `RESIGNAL` alone, anything specified in the `SET` clause changes.

Example:

```
DROP TABLE IF EXISTS xx;
delimiter //
CREATE PROCEDURE p ()
BEGIN
  DECLARE EXIT HANDLER FOR SQLEXCEPTION
  BEGIN
    SET @error_count = @error_count + 1;
    IF @a = 0 THEN RESIGNAL SET MYSQL_ERRNO = 5; END IF;
  END;
  DROP TABLE xx;
END//
delimiter ;
SET @error_count = 0;
SET @a = 0;
CALL p();
```

Remember from the previous discussion that `RESIGNAL` alone results in a diagnostics area stack like this:

```
1. ERROR 1051 (42S02): Unknown table 'xx'
```

The `RESIGNAL SET MYSQL_ERRNO = 5` statement results in this stack instead:

```
1. ERROR 5 (42S02): Unknown table 'xx'
```

In other words, it changes the error number, and nothing else.

The `RESIGNAL` statement can change any or all of the signal information items, making the first condition area of the diagnostics area look quite different.

12.7.8.2.3. `RESIGNAL` with a Condition Value and Optional New Signal Information

`RESIGNAL` with a condition value means “push a condition into the current diagnostics stack area.” If the `SET` clause is present, it also changes the error information.

```
RESIGNAL condition_value
    [SET signal_information [, signal_information] ...];
```

This form of `RESIGNAL` restores the last diagnostics area and makes it the current diagnostics area. That is, it “pops” the diagnostics area stack, which is the same as what a simple `RESIGNAL` alone would do. However, it also changes the diagnostics area depending on the condition value or signal information.

Example:

```
DROP TABLE IF EXISTS xx;
delimiter //
CREATE PROCEDURE p ()
BEGIN
  DECLARE EXIT HANDLER FOR SQLEXCEPTION
  BEGIN
    SET @error_count = @error_count + 1;
    IF @a = 0 THEN RESIGNAL SQLSTATE '45000' SET MYSQL_ERRNO=5; END IF;
  END;
  DROP TABLE xx;
END//
delimiter ;
SET @error_count = 0;
SET @a = 0;
SET @@max_error_count = 2;
CALL p();
SHOW ERRORS;
```

This is similar to the previous example, and the effects are the same, except that if `RESIGNAL` happens the current condition area looks different at the end. (The reason the condition is added rather than replaced is the use of a condition value.)

The `RESIGNAL` statement includes a condition value (`SQLSTATE '45000'`), so it “pushes” a new condition area, resulting in a diagnostics area stack that looks like this:

```
1. (condition 1) ERROR 5 (45000) Unknown table 'xx'
   (condition 2) ERROR 1051 (42S02): Unknown table 'xx'
```

The result of `CALL p()` and `SHOW ERRORS` for this example is:

```
mysql> CALL p();
ERROR 5 (45000): Unknown table 'xx'
mysql> SHOW ERRORS;
+-------+------+----------------------------------+
| Level | Code | Message                          |
+-------+------+----------------------------------+
| Error |    5 | Unknown table 'xx'               |
| Error | 1051 | Unknown table 'xx'               |
+-------+------+----------------------------------+
```

12.7.8.2.4. `RESIGNAL` Requires an Active Handler

All forms of `RESIGNAL` require that a handler be active when it executes. If no handler is active, `RESIGNAL` is illegal and a `resignal when handler not active` error occurs. For example:

```
mysql> CREATE PROCEDURE p () RESIGNAL;
Query OK, 0 rows affected (0.00 sec)

mysql> CALL p();
ERROR 1739 (0K000): RESIGNAL when handler not active
```

Here is a more difficult example:

```
delimiter //
CREATE FUNCTION f () RETURNS INT
BEGIN
  RESIGNAL;
  RETURN 5;
END//
CREATE PROCEDURE p ()
BEGIN
  DECLARE EXIT HANDLER FOR SQLEXCEPTION SET @a=f();
  SIGNAL SQLSTATE '55555';
END//
delimiter ;
CALL p();
```

At the time the `RESIGNAL` executes, there is a handler, even though the `RESIGNAL` is not defined inside the handler.

A statement such as the one following may appear bizarre because `RESIGNAL` apparently is not in a handler:

```
CREATE TRIGGER t_bi BEFORE INSERT ON t FOR EACH ROW RESIGNAL;
```

But it does not matter. `RESIGNAL` does not have to be technically “in” (that is, contained in), a handler declaration. The requirement is that a handler must be active.

12.8. MySQL Utility Statements

12.8.1. `DESCRIBE` Syntax

```
{DESCRIBE | DESC} tbl_name [col_name | wild]
```

`DESCRIBE` provides information about the columns in a table. It is a shortcut for `SHOW COLUMNS FROM`. These statements also display information for views. (See Section 12.4.5.6, “`SHOW COLUMNS` Syntax”.)

`col_name` can be a column name, or a string containing the SQL “`%`” and “`_`” wildcard characters to obtain output only for the columns with names matching the string. There is no need to enclose the string within quotation marks unless it contains spaces or other special characters.

```
mysql> DESCRIBE City;
+------------+----------+------+-----+---------+----------------+
| Field      | Type     | Null | Key | Default | Extra          |
+------------+----------+------+-----+---------+----------------+
| Id         | int(11)  | NO   | PRI | NULL    | auto_increment |
| Name       | char(35) | NO   |     |         |                |
| Country    | char(3)  | NO   | UNI |         |                |
| District   | char(20) | YES  | MUL |         |                |
| Population | int(11)  | NO   |     | 0       |                |
+------------+----------+------+-----+---------+----------------+
5 rows in set (0.00 sec)
```

The description for `SHOW COLUMNS` provides more information about the output columns (see Section 12.4.5.6, “`SHOW COLUMNS` Syntax”).

If the data types differ from what you expect them to be based on a `CREATE TABLE` statement, note that MySQL sometimes changes data types when you create or alter a table. The conditions under which this occurs are described in Section 12.1.14.2, “Silent Column Specification Changes”.

The `DESCRIBE` statement is provided for compatibility with Oracle.

The `SHOW CREATE TABLE`, `SHOW TABLE STATUS`, and `SHOW INDEX` statements also provide information about tables. See Section 12.4.5, “`SHOW` Syntax”.

12.8.2. `EXPLAIN` Syntax

```
EXPLAIN [EXTENDED | PARTITIONS] SELECT select_options
```

Or:

```
EXPLAIN tbl_name
```

The `EXPLAIN` statement can be used either as a way to obtain information about how MySQL executes a `SELECT` statement or as a synonym for `DESCRIBE`:

- When you precede a `SELECT` statement with the keyword `EXPLAIN`, MySQL displays information from the optimizer about the query execution plan. That is, MySQL explains how it would process the `SELECT`, including information about how tables are joined and in which order. `EXPLAIN EXTENDED` can be used to provide additional information.

  For information on how to use `EXPLAIN` and `EXPLAIN EXTENDED` to obtain query execution plan information, see Section 7.8.1, “Optimizing Queries with `EXPLAIN`”.

- `EXPLAIN PARTITIONS` is useful only when examining queries involving partitioned tables. For details, see Section 16.3.4, “Obtaining Information About Partitions”.

- `EXPLAIN tbl_name` is synonymous with `DESCRIBE tbl_name` or `SHOW COLUMNS FROM tbl_name`.

  For a description of the `DESCRIBE` and `SHOW COLUMNS` statements, see Section 12.8.1, “`DESCRIBE` Syntax”, and Section 12.4.5.6, “`SHOW COLUMNS` Syntax”.

12.8.3. `HELP` Syntax

```
HELP 'search_string'
```

The `HELP` statement returns online information from the MySQL Reference manual. Its proper operation requires that the help tables in the `mysql` database be initialized with help topic information (see Section 5.1.8, “Server-Side Help”).

The `HELP` statement searches the help tables for the given search string and displays the result of the search. The search string is not case sensitive.

The HELP statement understands several types of search strings:

- At the most general level, use `contents` to retrieve a list of the top-level help categories:

  ```
  HELP 'contents'
  ```

- For a list of topics in a given help category, such as `Data Types`, use the category name:

  ```
  HELP 'data types'
  ```

- For help on a specific help topic, such as the `ASCII()` function or the `CREATE TABLE` statement, use the associated keyword or keywords:

  ```
  HELP 'ascii'
  HELP 'create table'
  ```

In other words, the search string matches a category, many topics, or a single topic. You cannot necessarily tell in advance whether a given search string will return a list of items or the help information for a single help topic. However, you can tell what kind of response `HELP` returned by examining the number of rows and columns in the result set.

The following descriptions indicate the forms that the result set can take. Output for the example statements is shown using the familiar "tabular" or "vertical" format that you see when using the `mysql` client, but note that `mysql` itself reformats `HELP` result sets in a different way.

- Empty result set

  No match could be found for the search string.

- Result set containing a single row with three columns

  This means that the search string yielded a hit for the help topic. The result has three columns:

  - `name`: The topic name.
  - `description`: Descriptive help text for the topic.
  - `example`: Usage example or examples. This column might be blank.

  Example: `HELP 'replace'`

  Yields:

```
name: REPLACE
description: Syntax:
REPLACE(str,from_str,to_str)

Returns the string str with all occurrences of the string from_str
replaced by the string to_str. REPLACE() performs a case-sensitive
match when searching for from_str.
example: mysql> SELECT REPLACE('www.mysql.com', 'w', 'Ww');
        -> 'WwWwWw.mysql.com'
```

- Result set containing multiple rows with two columns

  This means that the search string matched many help topics. The result set indicates the help topic names:

  - `name`: The help topic name.
  - `is_it_category`: `Y` if the name represents a help category, `N` if it does not. If it does not, the `name` value when specified as the argument to the `HELP` statement should yield a single-row result set containing a description for the named item.

  Example: `HELP 'status'`

  Yields:

```
+-----------------------+----------------+
| name                  | is_it_category |
+-----------------------+----------------+
| SHOW                  | N              |
| SHOW ENGINE           | N              |
| SHOW MASTER STATUS    | N              |
| SHOW PROCEDURE STATUS | N              |
| SHOW SLAVE STATUS     | N              |
| SHOW STATUS           | N              |
| SHOW TABLE STATUS     | N              |
+-----------------------+----------------+
```

- Result set containing multiple rows with three columns

  This means the search string matches a category. The result set contains category entries:

  - `source_category_name`: The help category name.
  - `name`: The category or topic name
  - `is_it_category`: `Y` if the name represents a help category, `N` if it does not. If it does not, the `name` value when specified as the argument to the `HELP` statement should yield a single-row result set containing a description for the named item.

Example: `HELP 'functions'`

Yields:

```
+----------------------+-------------------------+----------------+
| source_category_name | name                    | is_it_category |
+----------------------+-------------------------+----------------+
| Functions            | CREATE FUNCTION         | N              |
| Functions            | DROP FUNCTION           | N              |
| Functions            | Bit Functions           | Y              |
| Functions            | Comparison operators    | Y              |
| Functions            | Control flow functions  | Y              |
| Functions            | Date and Time Functions | Y              |
| Functions            | Encryption Functions    | Y              |
| Functions            | Information Functions   | Y              |
| Functions            | Logical operators       | Y              |
| Functions            | Miscellaneous Functions | Y              |
| Functions            | Numeric Functions       | Y              |
| Functions            | String Functions        | Y              |
+----------------------+-------------------------+----------------+
```

12.8.4. USE Syntax

```
USE db_name
```

The `USE` *`db_name`* statement tells MySQL to use the *`db_name`* database as the default (current) database for subsequent statements. The database remains the default until the end of the session or another `USE` statement is issued:

```
USE db1;
SELECT COUNT(*) FROM mytable;   # selects from db1.mytable
USE db2;
SELECT COUNT(*) FROM mytable;   # selects from db2.mytable
```

Making a particular database the default by means of the `USE` statement does not preclude you from accessing tables in other databases. The following example accesses the `author` table from the `db1` database and the `editor` table from the `db2` database:

```
USE db1;
SELECT author_name,editor_name FROM author,db2.editor
  WHERE author.editor_id = db2.editor.editor_id;
```

The `USE` statement is provided for compatibility with Sybase.

Chapter 13. Storage Engines

MySQL supports several storage engines that act as handlers for different table types. MySQL storage engines include both those that handle transaction-safe tables and those that handle nontransaction-safe tables.

MySQL Server uses a pluggable storage engine architecture that enables storage engines to be loaded into and unloaded from a running MySQL server.

To determine which storage engines your server supports by using the `SHOW ENGINES` statement. The value in the `Support` column indicates whether an engine can be used. A value of `YES`, `NO`, or `DEFAULT` indicates that an engine is available, not available, or available and currently set as the default storage engine.

```
mysql> SHOW ENGINES\G
*************************** 1. row ***************************
      Engine: FEDERATED
     Support: NO
     Comment: Federated MySQL storage engine
Transactions: NULL
          XA: NULL
  Savepoints: NULL
*************************** 2. row ***************************
      Engine: MRG_MYISAM
     Support: YES
     Comment: Collection of identical MyISAM tables
Transactions: NO
          XA: NO
  Savepoints: NO
*************************** 3. row ***************************
      Engine: MyISAM
     Support: DEFAULT
     Comment: Default engine as of MySQL 3.23 with great performance
Transactions: NO
          XA: NO
  Savepoints: NO
...
```

This chapter describes each of the MySQL storage engines except for `NDBCLUSTER`, which is covered in MySQL Cluster NDB 6.X/7.X. It also contains a description of the pluggable storage engine architecture (see Section 13.2, “Overview of MySQL Storage Engine Architecture”).

For information about storage engine support offered in commercial MySQL Server binaries, see *MySQL Enterprise Server 5.1*, on the MySQL Web site. The storage engines available might depend on which edition of Enterprise Server you are using.

For answers to some commonly asked questions about MySQL storage engines, see Section B.2, “MySQL 5.5 FAQ: Storage Engines”.

MySQL 5.5 supported storage engines

- `InnoDB`: A transaction-safe (ACID compliant) storage engine for MySQL that has commit, rollback, and crash-recovery capabilities to protect user data. `InnoDB` row-level locking (without escalation to coarser granularity locks) and Oracle-style consistent nonlocking reads increase multi-user concurrency and performance. `InnoDB` stores user data in clustered indexes to reduce I/O for common queries based on primary keys. To maintain data integrity, `InnoDB` also supports `FOREIGN KEY` referential-integrity constraints. `InnoDB` is the default storage engine as of MySQL 5.5.5.

- `MyISAM`: The MySQL storage engine that is used the most in Web, data warehousing, and other application environments. `MyISAM` is supported in all MySQL configurations, and is the default storage engine prior to MySQL 5.5.5.

- `Memory`: Stores all data in RAM for extremely fast access in environments that require quick lookups of reference and other like data. This engine was formerly known as the `HEAP` engine.

- `Merge`: Enables a MySQL DBA or developer to logically group a series of identical `MyISAM` tables and reference them as one object. Good for VLDB environments such as data warehousing.

- `Archive`: Provides the perfect solution for storing and retrieving large amounts of seldom-referenced historical, archived, or security audit information.

- `Federated`: Offers the ability to link separate MySQL servers to create one logical database from many physical servers. Very good for distributed or data mart environments.

- `CSV`: The CSV storage engine stores data in text files using comma-separated values format. You can use the CSV engine to easily exchange data between other software and applications that can import and export in CSV format.

- `Blackhole`: The Blackhole storage engine accepts but does not store data and retrievals always return an empty set. The functionality can be used in distributed database design where data is automatically replicated, but not stored locally.

- `Example`: The Example storage engine is "stub" engine that does nothing. You can create tables with this engine, but no data can be stored in them or retrieved from them. The purpose of this engine is to serve as an example in the MySQL source code that illustrates how to begin writing new storage engines. As such, it is primarily of interest to developers.

It is important to remember that you are not restricted to using the same storage engine for an entire server or schema: you can use a different storage engine for each table in your schema.

Choosing a Storage Engine

The various storage engines provided with MySQL are designed with different use cases in mind. To use the pluggable storage architecture effectively, it is good to have an idea of the advantages and disadvantages of the various storage engines. The following table provides an overview of some storage engines provided with MySQL:

Table 13.1. Storage Engines Feature Summary

Feature	MyISAM	Memory	InnoDB	Archive	NDB
Storage limits	256TB	RAM	64TB	None	384EB
Transactions	No	No	Yes	No	Yes
Locking granularity	Table	Table	Row	Row	Row
MVCC	No	No	Yes	No	No
Geospatial data type support	Yes	No	Yes	Yes	Yes
Geospatial indexing support	Yes	No	No	No	No
B-tree indexes	Yes	Yes	Yes	No	Yes
Hash indexes	No	Yes	No[a]	No	Yes
Full-text search indexes	Yes	No	No	No	No
Clustered indexes	No	No	Yes	No	No
Data caches	No	N/A	Yes	No	Yes
Index caches	Yes	N/A	Yes	No	Yes
Compressed data	Yes[b]	No	Yes[c]	Yes	No
Encrypted data[d]	Yes	Yes	Yes	Yes	Yes
Cluster database support	No	No	No	No	Yes
Replication support[e]	Yes	Yes	Yes	Yes	Yes
Foreign key support	No	No	Yes	No	No
Backup / point-in-time recovery[f]	Yes	Yes	Yes	Yes	Yes
Query cache support	Yes	Yes	Yes	Yes	Yes
Update statistics for data dictionary	Yes	Yes	Yes	Yes	Yes

[a] InnoDB utilizes hash indexes internally for its Adaptive Hash Index feature.
[b] Compressed MyISAM tables are supported only when using the compressed row format. Tables using the compressed row format with MyISAM are read only.
[c] Compressed InnoDB tables require the InnoDB Barracuda file format.

[d] Implemented in the server (via encryption functions), rather than in the storage engine.
[e] Implemented in the server, rather than in the storage product.
[f] Implemented in the server, rather than in the storage product.

13.1. Setting the Storage Engine

When you create a new table, you can specify which storage engine to use by adding an `ENGINE` table option to the `CREATE TABLE` statement:

```
CREATE TABLE t (i INT) ENGINE = INNODB;
```

If you omit the `ENGINE` option, the default storage engine is used. The default engine is `InnoDB` as of MySQL 5.5.5 (`MyISAM` before 5.5.5). You can specify the default engine by using the `--default-storage-engine` server startup option, or by setting the `default-storage-engine` option in the `my.cnf` configuration file.

You can set the default storage engine to be used during the current session by setting the `default_storage_engine` variable:

```
SET default_storage_engine=MYISAM;
```

When MySQL is installed on Windows using the MySQL Configuration Wizard, the `InnoDB` or `MyISAM` storage engine can be selected as the default. See Section 2.3.4.5, “The Database Usage Dialog”.

To convert a table from one storage engine to another, use an `ALTER TABLE` statement that indicates the new engine:

```
ALTER TABLE t ENGINE = MYISAM;
```

See Section 12.1.14, “`CREATE TABLE` Syntax”, and Section 12.1.6, “`ALTER TABLE` Syntax”.

If you try to use a storage engine that is not compiled in or that is compiled in but deactivated, MySQL instead creates a table using the default storage engine. This behavior is convenient when you want to copy tables between MySQL servers that support different storage engines. (For example, in a replication setup, perhaps your master server supports transactional storage engines for increased safety, but the slave servers use only nontransactional storage engines for greater speed.)

This automatic substitution of the default storage engine for unavailable engines can be confusing for new MySQL users. A warning is generated whenever a storage engine is automatically changed. To prevent this from happening if the desired engine is unavailable, enable the `NO_ENGINE_SUBSTITUTION` SQL mode. In this case, an error occurs instead of a warning and the table is not created or altered if the desired engine is unavailable. See Section 5.1.6, “Server SQL Modes”.

For new tables, MySQL always creates an `.frm` file to hold the table and column definitions. The table's index and data may be stored in one or more other files, depending on the storage engine. The server creates the `.frm` file above the storage engine level. Individual storage engines create any additional files required for the tables that they manage. If a table name contains special characters, the names for the table files contain encoded versions of those characters as described in Section 8.2.3, “Mapping of Identifiers to File Names”.

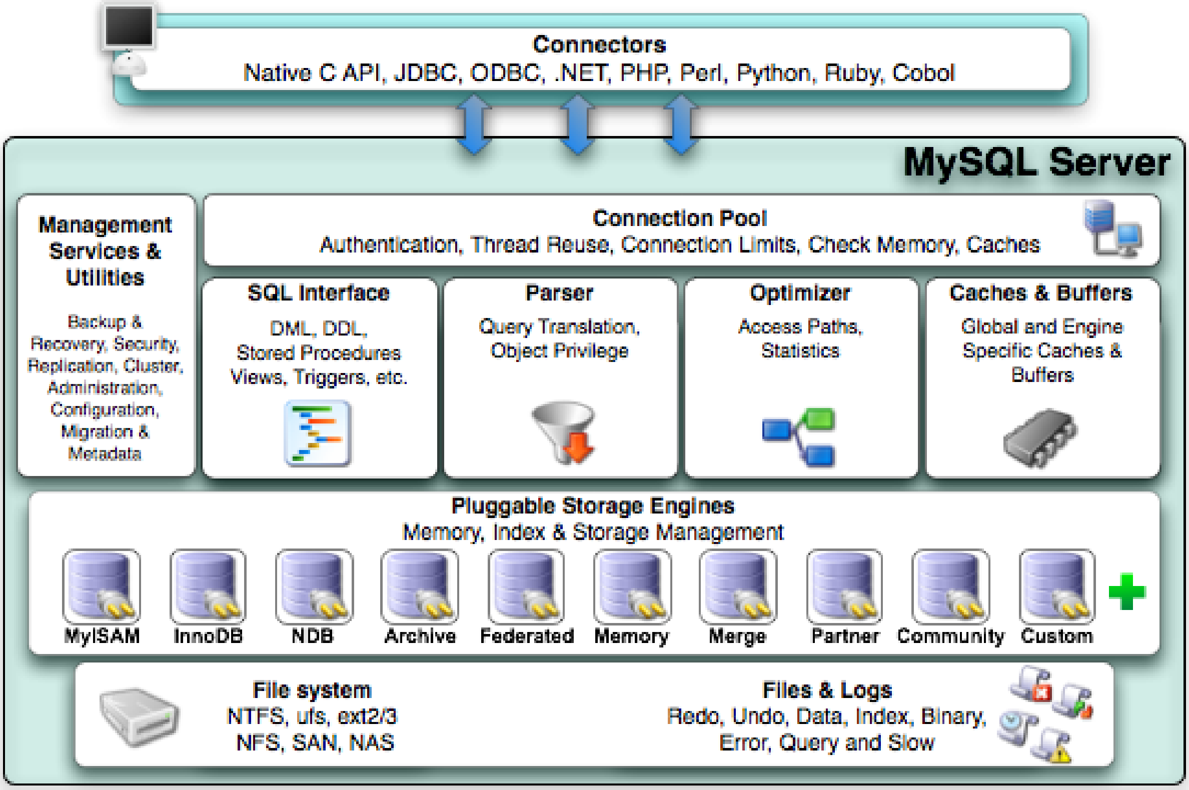
A database may contain tables of different types. That is, tables need not all be created with the same storage engine.

13.2. Overview of MySQL Storage Engine Architecture

The MySQL pluggable storage engine architecture enables a database professional to select a specialized storage engine for a particular application need while being completely shielded from the need to manage any specific application coding requirements. The MySQL server architecture isolates the application programmer and DBA from all of the low-level implementation details at the storage level, providing a consistent and easy application model and API. Thus, although there are different capabilities across different storage engines, the application is shielded from these differences.

The MySQL pluggable storage engine architecture is shown in Figure 13.1, “MySQL Architecture with Pluggable Storage Engines”.

Figure 13.1. MySQL Architecture with Pluggable Storage Engines


Connectors
Native C API, JDBC, ODBC, .NET, PHP, Perl, Python, Ruby, Cobol
MySQL Server
Management Services & Utilities
Backup & Recovery, Security, Replication, Cluster, Administration, Configuration, Migration & Metadata
Connection Pool
Authentication, Thread Reuse, Connection Limits, Check Memory, Caches
SQL Interface
DML, DDL, Stored Procedures Views, Triggers, etc.
Parser
Query Translation, Object Privilege
Optimizer
Access Paths, Statistics
Caches & Buffers
Global and Engine Specific Caches & Buffers
Pluggable Storage Engines
Memory, Index & Storage Management
MyISAM
InnoDB
NDB
Archive
Federated
Memory
Merge
Partner
Community
Custom
File system
NTFS, ufs, ext2/3
NFS, SAN, NAS
Files & Logs
Redo, Undo, Data, Index, Binary, Error, Query and Slow

The pluggable storage engine architecture provides a standard set of management and support services that are common among all underlying storage engines. The storage engines themselves are the components of the database server that actually perform actions on the underlying data that is maintained at the physical server level.

This efficient and modular architecture provides huge benefits for those wishing to specifically target a particular application need—such as data warehousing, transaction processing, or high availability situations—while enjoying the advantage of utilizing a set of interfaces and services that are independent of any one storage engine.

The application programmer and DBA interact with the MySQL database through Connector APIs and service layers that are above the storage engines. If application changes bring about requirements that demand the underlying storage engine change, or that one or more storage engines be added to support new needs, no significant coding or process changes are required to make things work. The MySQL server architecture shields the application from the underlying complexity of the storage engine by presenting a consistent and easy-to-use API that applies across storage engines.

13.2.1. Pluggable Storage Engine Architecture

MySQL Server uses a pluggable storage engine architecture that enables storage engines to be loaded into and unloaded from a running MySQL server.

Plugging in a Storage Engine

Before a storage engine can be used, the storage engine plugin shared library must be loaded into MySQL using the `INSTALL PLUGIN` statement. For example, if the `EXAMPLE` engine plugin is named `example` and the shared library is named `ha_example.so`, you load it with the following statement:

```
mysql> INSTALL PLUGIN example SONAME 'ha_example.so';
```

To install a pluggable storage engine, the plugin file must be located in the MySQL plugin directory, and the user issuing the `INSTALL PLUGIN` statement must have `INSERT` privilege for the `mysql.plugin` table.

The shared library must be located in the MySQL server plugin directory, the location of which is given by the `plugin_dir` system variable.

Unplugging a Storage Engine

To unplug a storage engine, use the `UNINSTALL PLUGIN` statement:

```
mysql> UNINSTALL PLUGIN example;
```

If you unplug a storage engine that is needed by existing tables, those tables become inaccessible, but will still be present on disk (where applicable). Ensure that there are no tables using a storage engine before you unplug the storage engine.

13.2.2. The Common Database Server Layer

A MySQL pluggable storage engine is the component in the MySQL database server that is responsible for performing the actual data I/O operations for a database as well as enabling and enforcing certain feature sets that target a specific application need. A major benefit of using specific storage engines is that you are only delivered the features needed for a particular application, and therefore you have less system overhead in the database, with the end result being more efficient and higher database performance. This is one of the reasons that MySQL has always been known to have such high performance, matching or beating proprietary monolithic databases in industry standard benchmarks.

From a technical perspective, what are some of the unique supporting infrastructure components that are in a storage engine? Some of the key feature differentiations include:

- *Concurrency*: Some applications have more granular lock requirements (such as row-level locks) than others. Choosing the right locking strategy can reduce overhead and therefore improve overall performance. This area also includes support for capabilities such as multi-version concurrency control or “snapshot” read.
- *Transaction Support*: Not every application needs transactions, but for those that do, there are very well defined requirements such as ACID compliance and more.
- *Referential Integrity*: The need to have the server enforce relational database referential integrity through DDL defined foreign keys.
- *Physical Storage*: This involves everything from the overall page size for tables and indexes as well as the format used for storing data to physical disk.
- *Index Support*: Different application scenarios tend to benefit from different index strategies. Each storage engine generally has its own indexing methods, although some (such as B-tree indexes) are common to nearly all engines.
- *Memory Caches*: Different applications respond better to some memory caching strategies than others, so although some memory caches are common to all storage engines (such as those used for user connections or MySQL's high-speed Query Cache), others are uniquely defined only when a particular storage engine is put in play.
- *Performance Aids*: This includes multiple I/O threads for parallel operations, thread concurrency, database checkpointing, bulk insert handling, and more.
- *Miscellaneous Target Features*: This may include support for geospatial operations, security restrictions for certain data manipulation operations, and other similar features.

Each set of the pluggable storage engine infrastructure components are designed to offer a selective set of benefits for a particular application. Conversely, avoiding a set of component features helps reduce unnecessary overhead. It stands to reason that understanding a particular application's set of requirements and selecting the proper MySQL storage engine can have a dramatic impact on overall system efficiency and performance.

13.3. The `InnoDB` Storage Engine

`InnoDB` is a high-reliability and high-performance storage engine for MySQL. Starting with MySQL 5.5, it is the default MySQL storage engine. Key advantages of InnoDB include:

- Its design follows the ACID model, with transactions featuring commit, rollback, and crash-recovery capabilities to protect user data.
- Row-level locking and Oracle-style consistent reads increase multi-user concurrency and performance.
- `InnoDB` tables arrange your data on disk to optimize common queries based on primary keys. Each `InnoDB` table has a primary key index called the clustered index that organizes the data to minimize I/O for primary key lookups.
- To maintain data integrity, `InnoDB` also supports `FOREIGN KEY` referential-integrity constraints.
- You can freely mix `InnoDB` tables with tables from other MySQL storage engines, even within the same statement. For ex-

ample, you can use a join operation to combine data from `InnoDB` and `MEMORY` tables in a single query.

To determine whether your server supports `InnoDB` use the `SHOW ENGINES` statement. See Section 12.4.5.17, “`SHOW ENGINES` Syntax”.

Table 13.2. `InnoDB` Storage Engine Features

Storage limits	64TB	**Transactions**	Yes	**Locking granularity**	Row
MVCC	Yes	**Geospatial data type support**	Yes	**Geospatial indexing support**	No
B-tree indexes	Yes	**Hash indexes**	No[a]	**Full-text search indexes**	No
Clustered indexes	Yes	**Data caches**	Yes	**Index caches**	Yes
Compressed data	Yes[b]	**Encrypted data**[c]	Yes	**Cluster database support**	No
Replication support[d]	Yes	**Foreign key support**	Yes	**Backup / point-in-time recovery**[e]	Yes
Query cache support	Yes	**Update statistics for data dictionary**	Yes		

[a] InnoDB utilizes hash indexes internally for its Adaptive Hash Index feature.
[b] Compressed InnoDB tables require the InnoDB Barracuda file format.
[c] Implemented in the server (via encryption functions), rather than in the storage engine.
[d] Implemented in the server, rather than in the storage product.
[e] Implemented in the server, rather than in the storage product.

`InnoDB` has been designed for maximum performance when processing large data volumes. Its CPU efficiency is probably not matched by any other disk-based relational database engine.

The `InnoDB` storage engine maintains its own buffer pool for caching data and indexes in main memory. `InnoDB` stores its tables and indexes in a tablespace, which may consist of several files (or raw disk partitions). This is different from, for example, `MyISAM` tables where each table is stored using separate files. `InnoDB` tables can be very large even on operating systems where file size is limited to 2GB.

`InnoDB` is published under the same GNU GPL License Version 2 (of June 1991) as MySQL. For more information on MySQL licensing, see http://www.mysql.com/company/legal/licensing/.

Additional Resources

- A forum dedicated to the `InnoDB` storage engine is available at http://forums.mysql.com/list.php?22.
- The InnoDB storage engine in MySQL 5.5 releases includes a number performance improvements that in MySQL 5.1 were only available by installing the InnoDB Plugin. This latest InnoDB (now known as InnoDB 1.1) offers new features, improved performance and scalability, enhanced reliability and new capabilities for flexibility and ease of use. Among the top features are Fast Index Creation, table and index compression, file format management, new `INFORMATION_SCHEMA` tables, capacity tuning, multiple background I/O threads, multiple buffer pools, and group commit.

  For information about these features, see Section 13.4, “New Features of InnoDB 1.1”.
- The MySQL Enterprise Backup product lets you back up a running MySQL database, including `InnoDB` and `MyISAM` tables, with minimal disruption to operations while producing a consistent snapshot of the database. When MySQL Enterprise Backup is copying `InnoDB` tables, reads and writes to both `InnoDB` and `MyISAM` tables can continue. During the copying of `MyISAM` and other non-InnoDB tables, reads (but not writes) to those tables are permitted. In addition, MySQL Enterprise Backup can create compressed backup files, and back up subsets of `InnoDB` tables. In conjunction with the MySQL binary log, you can perform point-in-time recovery. MySQL Enterprise Backup is included as part of the MySQL Enterprise subscription.

  For a more complete description of MySQL Enterprise Backup, see MySQL Enterprise Backup User's Guide (Version 3.5.4).

13.3.1. InnoDB as the Default MySQL Storage Engine

MySQL has a well-earned reputation for being easy-to-use and delivering performance and scalability. In previous versions of MySQL, MyISAM was the default storage engine. In our experience, most users never changed the default settings. With MySQL 5.5, InnoDB becomes the default storage engine. Again, we expect most users will not change the default settings. But, because of InnoDB, the default settings deliver the benefits users expect from their RDBMS: ACID Transactions, Referential Integrity, and Crash Recovery. Let's explore how using InnoDB tables improves your life as a MySQL user, DBA, or developer.

Trends in Storage Engine Usage

In the first years of MySQL growth, early web-based applications didn't push the limits of concurrency and availability. In 2010, hard drive and memory capacity and the performance/price ratio have all gone through the roof. Users pushing the performance boundaries of MySQL care a lot about reliability and crash recovery. MySQL databases are big, busy, robust, distributed, and important.

InnoDB hits the sweet spot of these top user priorities. The trend of storage engine usage has shifted in favor of the more efficient InnoDB. With MySQL 5.5, the time is right to make InnoDB the default storage engine.

Consequences of InnoDB as Default MySQL Storage Engine

Starting from MySQL 5.5.5, the default storage engine for new tables is InnoDB. This change applies to newly created tables that don't specify a storage engine with a clause such as `ENGINE=MyISAM`. (Given this change of default behavior, MySQL 5.5 might be a logical point to evaluate whether your tables that do use MyISAM could benefit from switching to InnoDB.)

The `mysql` and `information_schema` databases, that implement some of the MySQL internals, still use MyISAM. In particular, you cannot switch the grant tables to use InnoDB.

Benefits of InnoDB Tables

If you use MyISAM tables but aren't tied to them for technical reasons, you'll find many things more convenient when you use InnoDB tables in MySQL 5.5:

- If your server crashes because of a hardware or software issue, regardless of what was happening in the database at the time, you don't need to do anything special after restarting the database. InnoDB automatically finalizes any changes that were committed before the time of the crash, and undoes any changes that were in process but not committed. Just restart and continue where you left off.
- The InnoDB buffer pool caches table and index data as the data is accessed. Frequently used data is processed directly from memory. This cache applies to so many types of information, and speeds up processing so much, that dedicated database servers assign up to 80% of their physical memory to the InnoDB buffer pool.
- If you split up related data into different tables, you can set up foreign keys that enforce referential integrity. Update or delete data, and the related data in other tables is updated or deleted automatically. Try to insert data into a secondary table without corresponding data in the primary table, and it gets kicked out automatically.
- If data becomes corrupted on disk or in memory, a checksum mechanism alerts you to the bogus data before you use it.
- When you design your database with appropriate primary key columns for each table, operations involving those columns are automatically optimized. It is very fast to reference the primary key columns in `WHERE` clauses, `ORDER BY` clauses, `GROUP BY` clauses, and join operations.
- Inserts, updates, deletes are optimized by an automatic mechanism called change buffering. InnoDB not only allows concurrent read and write access to the same table, it caches changed data to streamline disk I/O.
- Performance benefits are not limited to giant tables with long-running queries. When the same rows are accessed over and over from a table, a feature called the Adaptive Hash Index takes over to make these lookups even faster, as if they came out of a hash table.

Best Practices for InnoDB Tables

If you have been using InnoDB for a long time, you already know about features like transactions and foreign keys. If not, read about them throughout this chapter. To make a long story short:

- Specify a primary key for every table using the most frequently queried column or columns, or an auto-increment value if there isn't an obvious primary key.
- Embrace the idea of joins, where data is pulled from multiple tables based on identical ID values from those tables. For fast join performance, define foreign keys on the join columns, and declare those columns with the same datatype in each table. The foreign keys also propagate deletes or updates to all affected tables, and prevent insertion of data in a child table if the corresponding IDs are not present in the parent table.
- Turn off autocommit. Committing hundreds of times a second puts a cap on performance (limited by the write speed of your storage device).
- Bracket sets of related changes, logical units of work, with `START TRANSACTION` and `COMMIT` statements. While you don't want to commit too often, you also don't want to issue huge batches of `INSERT`, `UPDATE`, or `DELETE` statements that run for

hours without committing.

- Stop using `LOCK TABLE` statements. InnoDB can handle multiple sessions all reading and writing to the same table at once, without sacrificing reliability or high performance. To get exclusive write access to a set of rows, use the `SELECT ... FOR UPDATE` syntax to lock just the rows you intend to update.
- Enable the `innodb_file_per_table` option to put the data and indexes for individual tables into separate files, instead of in a single giant system tablespace. (This setting is required to use some of the other features, such as table compression and fast truncation.)
- Evaluate whether your data and access patterns benefit from the new InnoDB table compression feature (`ROW_FORMAT=COMPRESSED` on the `CREATE TABLE` statement. You can compress InnoDB tables without sacrificing read/write capability.
- Run your server with the option `--sql_mode=NO_ENGINE_SUBSTITUTION` to prevent tables being created with a different storage engine if there is an issue with the one specified in the `ENGINE=` clause of `CREATE TABLE`.

Recent Improvements for InnoDB Tables (from the Plugin Era)

If you have experience with InnoDB, but not the recent incarnation known as the InnoDB Plugin, read about the latest enhancements in Section 13.4, “New Features of InnoDB 1.1”. To make a long story short:

- You can compress tables and associated indexes.
- You can create and drop indexes with much less performance or availability impact than before.
- Truncating a table is very fast, and can free up disk space for the operating system to reuse, rather than freeing up space within the system tablespace that only InnoDB could reuse.
- The storage layout for table data is more efficient for BLOBs and long text fields.
- You can monitor the internal workings of the storage engine by querying `INFORMATION_SCHEMA` tables.
- You can monitor the performance details of the storage engine by querying `performance_schema` tables.
- There are many many performance improvements. In particular, crash recovery, the automatic process that makes all data consistent when the database is restarted, is fast and reliable. (Now much much faster than long-time InnoDB users are used to.) The bigger the database, the more dramatic the speedup.

  Most new performance features are automatic, or at most require setting a value for a configuration option. For details, see Section 13.4.7, “InnoDB Performance and Scalability Enhancements”. For InnoDB-specific tuning techniques you can apply in your application code, see Section 7.5, “Optimizing for `InnoDB` Tables”. Advanced users can review Section 13.3.4, “`InnoDB` Startup Options and System Variables”.

Testing and Benchmarking with InnoDB as Default Storage Engine

Even before completing your upgrade to MySQL 5.5, you can preview whether your database server or application works correctly with InnoDB as the default storage engine. To set up InnoDB as the default storage engine with an earlier MySQL release, either specify on the command line `--default-storage-engine=InnoDB`, or add to your `my.cnf` file `default-storage-engine=innodb` in the `[mysqld]` section, then restart the server.

Since changing the default storage engine only affects new tables as they are created, run all your application installation and setup steps to confirm that everything installs properly. Then exercise all the application features to make sure all the data loading, editing, and querying features work. If a table relies on some MyISAM-specific feature, you'll receive an error; add the `ENGINE=MyISAM` clause to the `CREATE TABLE` statement to avoid the error. (For example, tables that rely on full-text search must be MyISAM tables rather than InnoDB ones.)

If you didn't make a deliberate decision about the storage engine, and you just want to preview how certain tables work when they're created under InnoDB, issue the command `ALTER TABLE table_name ENGINE=InnoDB;` for each table. Or, to run test queries and other statements without disturbing the original table, make a copy like so:

```
CREATE TABLE InnoDB_Table (...) ENGINE=InnoDB AS SELECT * FROM MyISAM_Table;
```

Since there are so many performance enhancements in the InnoDB that is part of MySQL 5.5, to get a true idea of the performance with a full application under a realistic workload, install the real MySQL 5.5 and run benchmarks.

Test the full application lifecycle, from installation, through heavy usage, and server restart. Kill the server process while the database is busy to simulate a power failure, and verify that the data is recovered successfully when you restart the server.

Test any replication configurations, especially if you use different MySQL versions and options on the master and the slaves.

Verifying that InnoDB is the Default Storage Engine

To know what the status of InnoDB is, whether you're doing what-if testing with an older MySQL or comprehensive testing with MySQL 5.5:

- Issue the command `SHOW VARIABLES LIKE 'have_innodb';` to confirm that InnoDB is available at all. If the result is `NO`, you have a mysqld binary that was compiled without InnoDB support and you need to get a different one. If the result is `DISABLED`, go back through your startup options and configuration file and get rid of any `skip-innodb` option.
- Issue the command `SHOW ENGINES;` to see all the different MySQL storage engines. Look for `DEFAULT` in the InnoDB line.

13.3.2. Configuring `InnoDB`

The first decisions to make about InnoDB configuration involve how to lay out InnoDB data files, and how much memory to allocate for the InnoDB storage engine. You record these choices either by recording them in a configuration file that MySQL reads at startup, or by specifying them as command-line options in a startup script.

Overview of InnoDB Tablespace and Log Files

Two important disk-based resources managed by the `InnoDB` storage engine are its tablespace data files and its log files. If you specify no `InnoDB` configuration options, MySQL creates an auto-extending 10MB data file named `ibdata1` and two 5MB log files named `ib_logfile0` and `ib_logfile1` in the MySQL data directory. To get good performance, explicitly provide `InnoDB` parameters as discussed in the following examples. Naturally, edit the settings to suit your hardware and requirements.

The examples shown here are representative. See Section 13.3.4, “`InnoDB` Startup Options and System Variables” for additional information about `InnoDB`-related configuration parameters.

Considerations for Storage Devices

In some cases, database performance improves if the data is not all placed on the same physical disk. Putting log files on a different disk from data is very often beneficial for performance. The example illustrates how to do this. It places the two data files on different disks and places the log files on the third disk. `InnoDB` fills the tablespace beginning with the first data file. You can also use raw disk partitions (raw devices) as `InnoDB` data files, which may speed up I/O. See Section 13.3.3.1, “Using Raw Devices for the Shared Tablespace”.

> **Caution**
>
> `InnoDB` is a transaction-safe (ACID compliant) storage engine for MySQL that has commit, rollback, and crash-recovery capabilities to protect user data. **However, it cannot do so** if the underlying operating system or hardware does not work as advertised. Many operating systems or disk subsystems may delay or reorder write operations to improve performance. On some operating systems, the very `fsync()` system call that should wait until all unwritten data for a file has been flushed might actually return before the data has been flushed to stable storage. Because of this, an operating system crash or a power outage may destroy recently committed data, or in the worst case, even corrupt the database because of write operations having been reordered. If data integrity is important to you, perform some “pull-the-plug” tests before using anything in production. On Mac OS X 10.3 and up, `InnoDB` uses a special `fcntl()` file flush method. Under Linux, it is advisable to **disable the write-back cache**.
>
> On ATA/SATA disk drives, a command such `hdparm -W0 /dev/hda` may work to disable the write-back cache. **Beware that some drives or disk controllers may be unable to disable the write-back cache.**

> **Caution**
>
> If reliability is a consideration for your data, do not configure `InnoDB` to use data files or log files on NFS volumes. Potential problems vary according to OS and version of NFS, and include such issues as lack of protection from conflicting writes, and limitations on maximum file sizes.

Specifying the Location and Size for InnoDB Tablespace Files

To set up the `InnoDB` tablespace files, use the `innodb_data_file_path` option in the `[mysqld]` section of the `my.cnf` option file. On Windows, you can use `my.ini` instead. The value of `innodb_data_file_path` should be a list of one or more data file specifications. If you name more than one data file, separate them by semicolon (“`;`”) characters:

```
innodb_data_file_path=datafile_spec1[;datafile_spec2]...
```

For example, the following setting explicitly creates a tablespace having the same characteristics as the default:

```
[mysqld]
innodb_data_file_path=ibdata1:10M:autoextend
```

This setting configures a single 10MB data file named `ibdata1` that is auto-extending. No location for the file is given, so by default, `InnoDB` creates it in the MySQL data directory.

Sizes are specified using `K`, `M`, or `G` suffix letters to indicate units of KB, MB, or GB.

A tablespace containing a fixed-size 50MB data file named `ibdata1` and a 50MB auto-extending file named `ibdata2` in the data directory can be configured like this:

```
[mysqld]
innodb_data_file_path=ibdata1:50M;ibdata2:50M:autoextend
```

The full syntax for a data file specification includes the file name, its size, and several optional attributes:

```
file_name:file_size[:autoextend[:max:max_file_size]]
```

The `autoextend` and `max` attributes can be used only for the last data file in the `innodb_data_file_path` line.

If you specify the `autoextend` option for the last data file, `InnoDB` extends the data file if it runs out of free space in the tablespace. The increment is 8MB at a time by default. To modify the increment, change the `innodb_autoextend_increment` system variable.

If the disk becomes full, you might want to add another data file on another disk. For tablespace reconfiguration instructions, see Section 13.3.6, “Adding, Removing, or Resizing `InnoDB` Data and Log Files”.

`InnoDB` is not aware of the file system maximum file size, so be cautious on file systems where the maximum file size is a small value such as 2GB. To specify a maximum size for an auto-extending data file, use the `max` attribute following the `autoextend` attribute. Use the `max` attribute only in cases where constraining disk usage is of critical importance, because exceeding the maximum size causes a fatal error, possibly including a crash. The following configuration permits `ibdata1` to grow up to a limit of 500MB:

```
[mysqld]
innodb_data_file_path=ibdata1:10M:autoextend:max:500M
```

`InnoDB` creates tablespace files in the MySQL data directory by default. To specify a location explicitly, use the `innodb_data_home_dir` option. For example, to use two files named `ibdata1` and `ibdata2` but create them in the `/ibdata` directory, configure `InnoDB` like this:

```
[mysqld]
innodb_data_home_dir = /ibdata
innodb_data_file_path=ibdata1:50M;ibdata2:50M:autoextend
```

> **Note**
>
> `InnoDB` does not create directories, so make sure that the `/ibdata` directory exists before you start the server. This is also true of any log file directories that you configure. Use the Unix or DOS `mkdir` command to create any necessary directories.
>
> Make sure that the MySQL server has the proper access rights to create files in the data directory. More generally, the server must have access rights in any directory where it needs to create data files or log files.

`InnoDB` forms the directory path for each data file by textually concatenating the value of `innodb_data_home_dir` to the data file name, adding a path name separator (slash or backslash) between values if necessary. If the `innodb_data_home_dir` option is not mentioned in `my.cnf` at all, the default value is the “dot” directory `./`, which means the MySQL data directory. (The MySQL server changes its current working directory to its data directory when it begins executing.)

If you specify `innodb_data_home_dir` as an empty string, you can specify absolute paths for the data files listed in the `innodb_data_file_path` value. The following example is equivalent to the preceding one:

```
[mysqld]
innodb_data_home_dir =
innodb_data_file_path=/ibdata/ibdata1:50M;/ibdata/ibdata2:50M:autoextend
```

Specifying InnoDB Configuration Options

Sample `my.cnf` file for small systems. Suppose that you have a computer with 512MB RAM and one hard disk. The following example shows possible configuration parameters in `my.cnf` or `my.ini` for `InnoDB`, including the `autoextend` attribute. The example suits most users, both on Unix and Windows, who do not want to distribute `InnoDB` data files and log files onto several disks. It creates an auto-extending data file `ibdata1` and two `InnoDB` log files `ib_logfile0` and `ib_logfile1` in the MySQL data directory.

```
[mysqld]
# You can write your other MySQL server options here
# ...
# Data files must be able to hold your data and indexes.
# Make sure that you have enough free disk space.
innodb_data_file_path = ibdata1:10M:autoextend
#
# Set buffer pool size to 50-80% of your computer's memory
innodb_buffer_pool_size=256M
innodb_additional_mem_pool_size=20M
#
# Set the log file size to about 25% of the buffer pool size
innodb_log_file_size=64M
innodb_log_buffer_size=8M
#
innodb_flush_log_at_trx_commit=1
```

Note that data files must be less than 2GB in some file systems. The combined size of the log files must be less than 4GB. The combined size of data files must be at least 10MB.

Setting Up the InnoDB System Tablespace

When you create an `InnoDB` system tablespace for the first time, it is best that you start the MySQL server from the command prompt. `InnoDB` then prints the information about the database creation to the screen, so you can see what is happening. For example, on Windows, if `mysqld` is located in `C:\Program Files\MySQL\MySQL Server 5.5\bin`, you can start it like this:

```
C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld" --console
```

If you do not send server output to the screen, check the server's error log to see what `InnoDB` prints during the startup process.

For an example of what the information displayed by `InnoDB` should look like, see Section 13.3.3.2, “Creating the `InnoDB` Tablespace”.

Editing the MySQL Configuration File

You can place `InnoDB` options in the `[mysqld]` group of any option file that your server reads when it starts. The locations for option files are described in Section 4.2.3.3, “Using Option Files”.

If you installed MySQL on Windows using the installation and configuration wizards, the option file will be the `my.ini` file located in your MySQL installation directory. See The Location of the my.ini File.

If your PC uses a boot loader where the `C:` drive is not the boot drive, your only option is to use the `my.ini` file in your Windows directory (typically `C:\WINDOWS`). You can use the `SET` command at the command prompt in a console window to print the value of `WINDIR`:

```
C:\> SET WINDIR
windir=C:\WINDOWS
```

To make sure that `mysqld` reads options only from a specific file, use the `--defaults-file` option as the first option on the command line when starting the server:

```
mysqld --defaults-file=your_path_to_my_cnf
```

Sample `my.cnf` file for large systems. Suppose that you have a Linux computer with 2GB RAM and three 60GB hard disks at directory paths `/`, `/dr2` and `/dr3`. The following example shows possible configuration parameters in `my.cnf` for `InnoDB`.

```
[mysqld]
# You can write your other MySQL server options here
# ...
innodb_data_home_dir =
#
# Data files must be able to hold your data and indexes
innodb_data_file_path = /db/ibdata1:2000M;/dr2/db/ibdata2:2000M:autoextend
#
# Set buffer pool size to 50-80% of your computer's memory,
# but make sure on Linux x86 total memory usage is < 2GB
innodb_buffer_pool_size=1G
innodb_additional_mem_pool_size=20M
innodb_log_group_home_dir = /dr3/iblogs
```

```
#
# Set the log file size to about 25% of the buffer pool size
innodb_log_file_size=250M
innodb_log_buffer_size=8M
#
innodb_flush_log_at_trx_commit=1
innodb_lock_wait_timeout=50
#
# Uncomment the next line if you want to use it
#innodb_thread_concurrency=5
```

Determining the Maximum Memory Allocation for InnoDB

> **Warning**
>
> On 32-bit GNU/Linux x86, be careful not to set memory usage too high. `glibc` may permit the process heap to grow over thread stacks, which crashes your server. It is a risk if the value of the following expression is close to or exceeds 2GB:
>
> ```
> innodb_buffer_pool_size
> + key_buffer_size
> + max_connections*(sort_buffer_size+read_buffer_size+binlog_cache_size)
> + max_connections*2MB
> ```
>
> Each thread uses a stack (often 2MB, but only 256KB in MySQL binaries provided by Oracle Corporation.) and in the worst case also uses `sort_buffer_size + read_buffer_size` additional memory.

Tuning other `mysqld` server parameters. The following values are typical and suit most users:

```
[mysqld]
skip-external-locking
max_connections=200
read_buffer_size=1M
sort_buffer_size=1M
#
# Set key_buffer to 5 - 50% of your RAM depending on how much
# you use MyISAM tables, but keep key_buffer_size + InnoDB
# buffer pool size < 80% of your RAM
key_buffer_size=value
```

On Linux, if the kernel is enabled for large page support, `InnoDB` can use large pages to allocate memory for its buffer pool and additional memory pool. See Section 7.11.4.2, "Enabling Large Page Support".

Turning Off InnoDB

Oracle recommends InnoDB as the preferred storage engine for typical database applications, from single-user wikis and blogs running on a local system, to high-end applications pushing the limits of performance. In MySQL 5.5, InnoDB is is the default storage engine for new tables.

If you do not want to use `InnoDB` tables, start the server with the `--innodb=OFF` or `--skip-innodb` option to disable the `InnoDB` storage engine. In this case, because the default storage engine is `InnoDB`, the server will not start unless you also use `--default-storage-engine` to set the default to some other engine.

13.3.3. Using Per-Table Tablespaces

By default, all InnoDB tables and indexes are stored in the system tablespace. As an alternative, you can store each `InnoDB` table and its indexes in its own file. This feature is called "multiple tablespaces" because each table that is created when this setting is in effect has its own tablespace.

Using multiple tablespaces is useful in a number of situations:

- Storing specific tables on separate physical disks, for I/O optimization or backup purposes.
- Restoring backups of single tables quickly without interrupting the use of other `InnoDB` tables.
- Using compressed row format to compress table data.
- Reclaiming disk space when truncating a table.

Enabling and Disabling Multiple Tablespaces

To enable multiple tablespaces, start the server with the `--innodb_file_per_table` option. For example, add a line to the `[mysqld]` section of `my.cnf`:

```
[mysqld]
innodb_file_per_table
```

With multiple tablespaces enabled, `InnoDB` stores each newly created table in its own `tbl_name.ibd` file in the appropriate database directory. Unlike the `MyISAM` storage engine, with its separate `tbl_name.MYD` and `tbl_name.MYI` files for indexes and data, `InnoDB` stores the data and the indexes together in a single `.ibd` file. The `tbl_name.frm` file is still created as usual.

If you remove the `innodb_file_per_table` line from `my.cnf` and restart the server, `InnoDB` creates any new tables inside the shared tablespace files.

You can always access both tables in the system tablespace and tables in their own tablespaces, regardless of the file-per-table setting. To move a table from the system tablespace to its own tablespace, or vice versa, you can change the `innodb_file_per_table` setting and issue the command:

ALTER TABLE *table_name* ENGINE=InnoDB;

> **Note**
>
> `InnoDB` always needs the shared tablespace because it puts its internal data dictionary and undo logs there. The `.ibd` files are not sufficient for `InnoDB` to operate.

Portability Considerations for .ibd Files

You cannot freely move `.ibd` files between database directories as you can with `MyISAM` table files. The table definition stored in the `InnoDB` shared tablespace includes the database name. The transaction IDs and log sequence numbers stored in the tablespace files also differ between databases.

To move an `.ibd` file and the associated table from one database to another, use a `RENAME TABLE` statement:

```
RENAME TABLE db1.tbl_name TO db2.tbl_name;
```

If you have a “clean” backup of an `.ibd` file, you can restore it to the MySQL installation from which it originated as follows:

1. Issue this `ALTER TABLE` statement to delete the current `.ibd` file:

   ```
   ALTER TABLE tbl_name DISCARD TABLESPACE;
   ```

2. Copy the backup `.ibd` file to the proper database directory.
3. Issue this `ALTER TABLE` statement to tell `InnoDB` to use the new `.ibd` file for the table:

   ```
   ALTER TABLE tbl_name IMPORT TABLESPACE;
   ```

In this context, a “clean” `.ibd` file backup is one for which the following requirements are satisfied:

- There are no uncommitted modifications by transactions in the `.ibd` file.
- There are no unmerged insert buffer entries in the `.ibd` file.
- Purge has removed all delete-marked index records from the `.ibd` file.
- `mysqld` has flushed all modified pages of the `.ibd` file from the buffer pool to the file.

You can make a clean backup `.ibd` file using the following method:

1. Stop all activity from the `mysqld` server and commit all transactions.
2. Wait until `SHOW ENGINE INNODB STATUS` shows that there are no active transactions in the database, and the main thread status of `InnoDB` is `Waiting for server activity`. Then you can make a copy of the `.ibd` file.

Another method for making a clean copy of an `.ibd` file is to use the MySQL Enterprise Backup product:

1. Use MySQL Enterprise Backup to back up the `InnoDB` installation.
2. Start a second `mysqld` server on the backup and let it clean up the `.ibd` files in the backup.

13.3.3.1. Using Raw Devices for the Shared Tablespace

You can use raw disk partitions as data files in the system tablespace. Using a raw disk, you can perform nonbuffered I/O on Windows and on some Unix systems without file system overhead. Perform tests with and without raw partitions to verify whether this change actually improves performance on your system.

When you create a new data file, put the keyword `newraw` immediately after the data file size in `innodb_data_file_path`. The partition must be at least as large as the size that you specify. Note that 1MB in `InnoDB` is 1024 × 1024 bytes, whereas 1MB in disk specifications usually means 1,000,000 bytes.

```
[mysqld]
innodb_data_home_dir=
innodb_data_file_path=/dev/hdd1:3Gnewraw;/dev/hdd2:2Gnewraw
```

The next time you start the server, `InnoDB` notices the `newraw` keyword and initializes the new partition. However, do not create or change any `InnoDB` tables yet. Otherwise, when you next restart the server, `InnoDB` reinitializes the partition and your changes are lost. (As a safety measure `InnoDB` prevents users from modifying data when any partition with `newraw` is specified.)

After `InnoDB` has initialized the new partition, stop the server, change `newraw` in the data file specification to `raw`:

```
[mysqld]
innodb_data_home_dir=
innodb_data_file_path=/dev/hdd1:3Graw;/dev/hdd2:2Graw
```

Then restart the server and `InnoDB` permits changes to be made.

On Windows, you can allocate a disk partition as a data file like this:

```
[mysqld]
innodb_data_home_dir=
innodb_data_file_path=//./D::10Gnewraw
```

The `//./` corresponds to the Windows syntax of `\\.\` for accessing physical drives.

When you use a raw disk partition, be sure that it has permissions that enable read and write access by the account used for running the MySQL server. For example, if you run the server as the `mysql` user, the partition must permit read and write access to `mysql`. If you run the server with the `--memlock` option, the server must be run as `root`, so the partition must permit access to `root`.

13.3.3.2. Creating the `InnoDB` Tablespace

Suppose that you have installed MySQL and have edited your option file so that it contains the necessary `InnoDB` configuration parameters. Before starting MySQL, verify that the directories you have specified for `InnoDB` data files and log files exist and that the MySQL server has access rights to those directories. `InnoDB` does not create directories, only files. Check also that you have enough disk space for the data and log files.

It is best to run the MySQL server `mysqld` from the command prompt when you first start the server with `InnoDB` enabled, not from `mysqld_safe` or as a Windows service. When you run from a command prompt you see what `mysqld` prints and what is happening. On Unix, just invoke `mysqld`. On Windows, start `mysqld` with the `--console` option to direct the output to the console window.

When you start the MySQL server after initially configuring `InnoDB` in your option file, `InnoDB` creates your data files and log files, and prints something like this:

```
InnoDB: The first specified datafile /home/heikki/data/ibdata1
did not exist:
InnoDB: a new database to be created!
InnoDB: Setting file /home/heikki/data/ibdata1 size to 134217728
InnoDB: Database physically writes the file full: wait...
InnoDB: datafile /home/heikki/data/ibdata2 did not exist:
new to be created
InnoDB: Setting file /home/heikki/data/ibdata2 size to 262144000
InnoDB: Database physically writes the file full: wait...
InnoDB: Log file /home/heikki/data/logs/ib_logfile0 did not exist:
new to be created
InnoDB: Setting log file /home/heikki/data/logs/ib_logfile0 size
to 5242880
InnoDB: Log file /home/heikki/data/logs/ib_logfile1 did not exist:
new to be created
InnoDB: Setting log file /home/heikki/data/logs/ib_logfile1 size
```

```
to 5242880
InnoDB: Doublewrite buffer not found: creating new
InnoDB: Doublewrite buffer created
InnoDB: Creating foreign key constraint system tables
InnoDB: Foreign key constraint system tables created
InnoDB: Started
mysqld: ready for connections
```

At this point `InnoDB` has initialized its tablespace and log files. You can connect to the MySQL server with the usual MySQL client programs like `mysql`. When you shut down the MySQL server with `mysqladmin shutdown`, the output is like this:

```
010321 18:33:34  mysqld: Normal shutdown
010321 18:33:34  mysqld: Shutdown Complete
InnoDB: Starting shutdown...
InnoDB: Shutdown completed
```

You can look at the data file and log directories and you see the files created there. When MySQL is started again, the data files and log files have been created already, so the output is much briefer:

```
InnoDB: Started
mysqld: ready for connections
```

If you add the `innodb_file_per_table` option to `my.cnf`, `InnoDB` stores each table in its own `.ibd` file in the same MySQL database directory where the `.frm` file is created. See Section 13.3.3, "Using Per-Table Tablespaces".

13.3.3.3. Troubleshooting `InnoDB` I/O Problems

The troubleshooting steps for `InnoDB` I/O problems depend on when the problem occurs: during startup of the MySQL server, or during normal operations when a DML or DDL statement fails due to problems at the file system level.

Initialization Problems

If something goes wrong when `InnoDB` attempts to initialize its tablespace or its log files, delete all files created by `InnoDB`: all `ibdata` files and all `ib_logfile` files. If you already created some `InnoDB` tables, also delete the corresponding `.frm` files for these tables, and any `.ibd` files if you are using multiple tablespaces, from the MySQL database directories. Then try the `InnoDB` database creation again. For easiest troubleshooting, start the MySQL server from a command prompt so that you see what is happening.

Runtime Problems

If `InnoDB` prints an operating system error during a file operation, usually the problem has one of the following solutions:

- Make sure the `InnoDB` data file directory and the `InnoDB` log directory exist.
- Make sure `mysqld` has access rights to create files in those directories.
- Make sure `mysqld` can read the proper `my.cnf` or `my.ini` option file, so that it starts with the options that you specified.
- Make sure the disk is not full and you are not exceeding any disk quota.
- Make sure that the names you specify for subdirectories and data files do not clash.
- Doublecheck the syntax of the `innodb_data_home_dir` and `innodb_data_file_path` values. In particular, any `MAX` value in the `innodb_data_file_path` option is a hard limit, and exceeding that limit causes a fatal error.

13.3.4. `InnoDB` Startup Options and System Variables

This section describes the `InnoDB`-related command options and system variables. System variables that are true or false can be enabled at server startup by naming them, or disabled by using a `--skip-` prefix. For example, to enable or disable `InnoDB` checksums, you can use `--innodb_checksums` or `--skip-innodb_checksums` on the command line, or `innodb_checksums` or `skip-innodb_checksums` in an option file. System variables that take a numeric value can be specified as `--var_name=value` on the command line or as `var_name=value` in option files. For more information on specifying options and system variables, see Section 4.2.3, "Specifying Program Options". Many of the system variables can be changed at runtime (see Section 5.1.4.2, "Dynamic System Variables").

Certain options control the locations and layout of the `InnoDB` data files. Section 13.3.2, "Configuring `InnoDB`" explains how to use these options. Many other options, that you might not use initially, help to tune `InnoDB` performance characteristics based on machine capacity and your database workload. The performance-related options are explained in Section 13.3.14, "`InnoDB` Performance Tuning and Troubleshooting" and Section 13.4.7, "InnoDB Performance and Scalability Enhancements".

Table 13.3. `InnoDB` Option/Variable Reference

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
foreign_key_checks			Yes		Both	Yes
have_innodb			Yes		Global	No
ignore-builtin-innodb	Yes	Yes			Global	No
- *Variable*: ignore_builtin_innodb			Yes		Global	No
innodb	Yes	Yes				
innodb_adaptive_flushing	Yes	Yes	Yes		Global	Yes
innodb_adaptive_hash_index	Yes	Yes	Yes		Global	Yes
innodb_additional_mem_pool_size	Yes	Yes	Yes		Global	No
innodb_autoextend_increment	Yes	Yes	Yes		Global	Yes
innodb_autoinc_lock_mode	Yes	Yes	Yes		Global	No
innodb_buffer_pool_instances	Yes	Yes	Yes		Global	No
Innodb_buffer_pool_pages_data				Yes	Global	No
Innodb_buffer_pool_pages_dirty				Yes	Global	No
Innodb_buffer_pool_pages_flushed				Yes	Global	No
Innodb_buffer_pool_pages_free				Yes	Global	No
Innodb_buffer_pool_pages_latched				Yes	Global	No
Innodb_buffer_pool_pages_misc				Yes	Global	No
Innodb_buffer_pool_pages_total				Yes	Global	No
Innodb_buffer_pool_read_ahead				Yes	Global	No
Innodb_buffer_pool_read_ahead_evicted				Yes	Global	No
Innodb_buffer_pool_read_requests				Yes	Global	No
Innodb_buffer_pool_rea				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
ds						
innodb_buffer_pool_size	Yes	Yes	Yes		Global	No
Innodb_buffer_pool_wait_free				Yes	Global	No
Innodb_buffer_pool_write_requests				Yes	Global	No
innodb_change_buffering	Yes	Yes	Yes		Global	Yes
innodb_checksums	Yes	Yes	Yes		Global	No
innodb_commit_concurrency	Yes	Yes	Yes		Global	Yes
innodb_concurrency_tickets	Yes	Yes	Yes		Global	Yes
innodb_data_file_path	Yes	Yes	Yes		Global	No
Innodb_data_fsyncs				Yes	Global	No
innodb_data_home_dir	Yes	Yes	Yes		Global	No
Innodb_data_pending_fsyncs				Yes	Global	No
Innodb_data_pending_reads				Yes	Global	No
Innodb_data_pending_writes				Yes	Global	No
Innodb_data_read				Yes	Global	No
Innodb_data_reads				Yes	Global	No
Innodb_data_writes				Yes	Global	No
Innodb_data_written				Yes	Global	No
Innodb_dblwr_pages_written				Yes	Global	No
Innodb_dblwr_writes				Yes	Global	No
innodb_doublewrite	Yes	Yes	Yes		Global	No
innodb_fast_shutdown	Yes	Yes	Yes		Global	Yes
innodb_file_format	Yes	Yes	Yes		Global	Yes
innodb_file_format_check	Yes	Yes	Yes		Global	No
innodb_file_format_max	Yes	Yes	Yes		Global	Yes
innodb_file_per_table	Yes	Yes	Yes		Global	Yes
innodb_flush_log_at_trx_commit	Yes	Yes	Yes		Global	Yes
innodb_flush_method	Yes	Yes	Yes		Global	No
in-	Yes	Yes	Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
nodb_force_recovery						
Innodb_have_atomic_builtins				Yes	Global	No
innodb_io_capacity	Yes	Yes	Yes		Global	Yes
innodb_large_prefix	Yes	Yes	Yes		Global	Yes
innodb_lock_wait_timeout	Yes	Yes	Yes		Both	Yes
innodb_locks_unsafe_for_binlog	Yes	Yes	Yes		Global	No
innodb_log_buffer_size	Yes	Yes	Yes		Global	No
innodb_log_file_size	Yes	Yes	Yes		Global	No
innodb_log_files_in_group	Yes	Yes	Yes		Global	No
innodb_log_group_home_dir	Yes	Yes	Yes		Global	No
Innodb_log_waits				Yes	Global	No
Innodb_log_write_requests				Yes	Global	No
Innodb_log_writes				Yes	Global	No
innodb_max_dirty_pages_pct	Yes	Yes	Yes		Global	Yes
innodb_max_purge_lag	Yes	Yes	Yes		Global	Yes
innodb_mirrored_log_groups	Yes	Yes	Yes		Global	No
innodb_old_blocks_pct	Yes	Yes	Yes		Global	Yes
innodb_old_blocks_time	Yes	Yes	Yes		Global	Yes
innodb_open_files	Yes	Yes	Yes		Global	No
Innodb_os_log_fsyncs				Yes	Global	No
Innodb_os_log_pending_fsyncs				Yes	Global	No
Innodb_os_log_pending_writes				Yes	Global	No
Innodb_os_log_written				Yes	Global	No
Innodb_page_size				Yes	Global	No
Innodb_pages_created				Yes	Global	No
Innodb_pages_read				Yes	Global	No
Innodb_pages_written				Yes	Global	No
innodb_purge_batch_size	Yes	Yes	Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
innodb_purge_threads	Yes	Yes	Yes		Global	No
innodb_read_ahead_threshold	Yes	Yes	Yes		Global	Yes
innodb_read_io_threads	Yes	Yes	Yes		Global	No
innodb_replication_delay	Yes	Yes	Yes		Global	Yes
innodb_rollback_on_timeout	Yes	Yes	Yes		Global	No
innodb_rollback_segments	Yes	Yes	Yes		Global	Yes
Innodb_row_lock_current_waits				Yes	Global	No
Innodb_row_lock_time				Yes	Global	No
Innodb_row_lock_time_avg				Yes	Global	No
Innodb_row_lock_time_max				Yes	Global	No
Innodb_row_lock_waits				Yes	Global	No
Innodb_rows_deleted				Yes	Global	No
Innodb_rows_inserted				Yes	Global	No
Innodb_rows_read				Yes	Global	No
Innodb_rows_updated				Yes	Global	No
innodb_spin_wait_delay	Yes	Yes	Yes		Global	Yes
innodb_stats_method	Yes	Yes	Yes		Both	Yes
innodb_stats_on_metadata	Yes	Yes	Yes		Global	Yes
innodb_stats_sample_pages	Yes	Yes	Yes		Global	Yes
innodb-status-file	Yes	Yes				
innodb_strict_mode	Yes	Yes	Yes		Both	Yes
innodb_support_xa	Yes	Yes	Yes		Both	Yes
innodb_sync_spin_loops	Yes	Yes	Yes		Global	Yes
innodb_table_locks	Yes	Yes	Yes		Both	Yes
innodb_thread_concurrency	Yes	Yes	Yes		Global	Yes
innodb_thread_sleep_delay	Yes	Yes	Yes		Global	Yes
Innodb_truncated_status_writes				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
innodb_use_native_aio	Yes	Yes	Yes		Global	No
innodb_use_sys_malloc	Yes	Yes	Yes		Global	No
innodb_version			Yes		Global	No
innodb_write_io_threads	Yes	Yes	Yes		Global	No
timed_mutexes	Yes	Yes	Yes		Global	Yes
unique_checks			Yes		Both	Yes

`InnoDB` Command Options

- `--ignore-builtin-innodb`

Command-Line Format	`--ignore-builtin-innodb`	
Option-File Format	`ignore-builtin-innodb`	
Option Sets Variable	Yes, `ignore_builtin_innodb`	
Variable Name	`ignore-builtin-innodb`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`

  This option causes the server to behave as if the built-in `InnoDB` is not present. It has these effects:

  - Other `InnoDB` options (including `--innodb` and `--skip-innodb`) will not be recognized and should not be used.
  - The server will not start if the default storage engine is set to `InnoDB`. Use `--default-storage-engine` to set the default to some other engine if necessary.
  - `InnoDB` will not appear in the output of `SHOW ENGINES`.

- `--innodb[=value]`

  Controls loading of the `InnoDB` storage engine, if the server was compiled with `InnoDB` support. This option has a tristate format, with possible values of `OFF`, `ON`, or `FORCE`. See Section 5.1.7.1, “Installing and Uninstalling Plugins”.

  To disable `InnoDB`, use `--innodb=OFF` or `--skip-innodb`. In this case, because the default storage engine is `InnoDB`, the server will not start unless you also use `--default-storage-engine` to set the default to some other engine.

- `--innodb-status-file`

  Controls whether `InnoDB` creates a file named `innodb_status.<pid>` in the MySQL data directory. If enabled, `InnoDB` periodically writes the output of `SHOW ENGINE INNODB STATUS` to this file.

  By default, the file is not created. To create it, start `mysqld` with the `--innodb-status-file=1` option. The file is deleted during normal shutdown.

- `--skip-innodb`

  Disable the `InnoDB` storage engine. See the description of `--innodb`.

`InnoDB` System Variables

- `ignore_builtin_innodb`

  Whether the server was started with the `--ignore-builtin-innodb` option, which causes the server to behave as if the built-in `InnoDB` is not present. For more information, see the description of `--ignore-builtin-innodb` under “In-

`noDB` Command Options” earlier in this section.

- `innodb_adaptive_flushing`

Command-Line Format	`--innodb_adaptive_flushing=#`	
Option-File Format	`innodb_adaptive_flushing`	
Option Sets Variable	Yes, `innodb_adaptive_flushing`	
Variable Name	`innodb_adaptive_flushing`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

`InnoDB Plugin` 1.0.4 and up uses a heuristic to determine when to flush dirty pages in the buffer cache. This heuristic is designed to avoid bursts of I/O activity and is used when `innodb_adaptive_flushing` is enabled (which is the default).

- `innodb_adaptive_hash_index`

Command-Line Format	`--innodb_adaptive_hash_index=#`	
Option-File Format	`innodb_adaptive_hash_index`	
Option Sets Variable	Yes, `innodb_adaptive_hash_index`	
Variable Name	`innodb_adaptive_hash_index`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

Whether InnoDB adaptive hash indexes are enabled or disabled (see Section 13.3.11.4, “Adaptive Hash Indexes”). This variable is enabled by default. Use `--skip-innodb_adaptive_hash_index` at server startup to disable it.

- `innodb_additional_mem_pool_size`

Command-Line Format	`--innodb_additional_mem_pool_size=#`	
Option-File Format	`innodb_additional_mem_pool_size`	
Option Sets Variable	Yes, `innodb_additional_mem_pool_size`	
Variable Name	`innodb_additional_mem_pool_size`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`8388608`
	Range	`2097152-4294967295`

The size in bytes of a memory pool `InnoDB` uses to store data dictionary information and other internal data structures. The more tables you have in your application, the more memory you need to allocate here. If `InnoDB` runs out of memory in this pool, it starts to allocate memory from the operating system and writes warning messages to the MySQL error log. The default value is 8MB.

- `innodb_autoextend_increment`

Command-Line Format	`--innodb_autoextend_increment=#`
Option-File Format	`innodb_autoextend_increment`

Option Sets Variable	Yes, `innodb_autoextend_increment`	
Variable Name	`innodb_autoextend_increment`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`8`
	Range	`1-1000`

The increment size (in MB) for extending the size of an auto-extending shared tablespace file when it becomes full. The default value is 8. This variable does not affect the per-table tablespace files that are created if you use `innodb_file_per_table=1`. Those files are auto-extending regardless of the value of `innodb_autoextend_increment`. The initial extensions are by small amounts, after which extensions occur in increments of 4MB.

- `innodb_autoinc_lock_mode`

Command-Line Format	`--innodb_autoinc_lock_mode=#`	
Option-File Format	`innodb_autoinc_lock_mode`	
Option Sets Variable	Yes, `innodb_autoinc_lock_mode`	
Variable Name	`innodb_autoinc_lock_mode`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`1`

	Valid Values	`0`
		`1`
		`2`

The locking mode to use for generating auto-increment values. The permissible values are 0, 1, or 2, for “traditional”, “consecutive”, or “interleaved” lock mode, respectively. Section 13.3.5.3, “`AUTO_INCREMENT` Handling in `InnoDB`”, describes the characteristics of these modes.

This variable has a default of 1 (“consecutive” lock mode).

- `innodb_buffer_pool_instances`

Version Introduced	5.5.4	
Command-Line Format	`--innodb_buffer_pool_instances=#`	
Option-File Format	`innodb_buffer_pool_instances`	
Option Sets Variable	Yes, `innodb_buffer_pool_instances`	
Variable Name	`innodb_buffer_pool_instances`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`1`
	Range	`1-64`

The number of regions that the `InnoDB` buffer pool is divided into. For systems with buffer pools in the multi-gigabyte range, dividing the buffer pool into separate instances can improve concurrency, by reducing contention as different threads read and write to cached pages. Each page that is stored in or read from the buffer pool is assigned to one of the buffer pool instances randomly, using a hashing function. Each buffer pool manages its own free lists, flush lists, LRUs, and all other data structures connected to a buffer pool, and is protected by its own buffer pool mutex.

This option only takes effect when you set the `innodb_buffer_pool_size` to a size of 1 gigabyte or more. The total size you specify is divided up among all the buffer pools. We recommend specifying a combination of `innodb_buffer_pool_instances` and `innodb_buffer_pool_size` so that each buffer pool instance is at least 1 gigabyte.

- `innodb_buffer_pool_size`

Command-Line Format	`--innodb_buffer_pool_size=#`	
Option-File Format	`innodb_buffer_pool_size`	
Option Sets Variable	Yes, `innodb_buffer_pool_size`	
Variable Name	`innodb_buffer_pool_size`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`134217728`
	Range	`1048576-2**32-1`

The size in bytes of the memory buffer `InnoDB` uses to cache data and indexes of its tables. The default value is 128MB, increased from a historical default of 8MB. The maximum value depends on the CPU architecture, 32-bit or 64-bit. For 32-bit systems, the CPU architecture and operating system sometimes impose a lower practical maximum size.

The larger you set this value, the less disk I/O is needed to access data in tables. On a dedicated database server, you may set this to up to 80% of the machine physical memory size. Be prepared to scale back this value if these other issues occur:

- Competition for physical memory might cause paging in the operating system.
- InnoDB reserves additional memory for buffers and control structures, so that the total allocated space is approximately 10% greater than the specified size.
- The address space must be contiguous, which can be an issue on Windows systems with DLLs that load at specific addresses.
- The time to initialize the buffer pool is roughly proportional to its size. On large installations, this initialization time may be significant. For example, on a modern Linux x86_64 server, initialization of a 10GB buffer pool takes approximately 6 seconds. See Section 7.9.1, “The `InnoDB` Buffer Pool”.

- `innodb_change_buffering`

Command-Line Format	`--innodb_change_buffering=#`	
Option-File Format	`innodb_change_buffering`	
Option Sets Variable	Yes, `innodb_change_buffering`	
Variable Name	`innodb_change_buffering`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values (<= 5.5.3)	
	Type	`enumeration`
	Default	`inserts`
	Valid Values	`inserts` `none`

	Permitted Values (>= 5.5.4)	
	Type	`enumeration`
	Default	`all`

	Valid Values	`inserts`
		`deletes`
		`purges`
		`changes`
		`all`
		`none`

Whether `InnoDB` performs change buffering, an optimization that delays write operations to secondary indexes so that the I/O operations can be performed sequentially. The permitted values are `inserts` (buffer insert operations), `deletes` (buffer delete operations; strictly speaking, the writes that mark index records for later deletion during a purge operation), `changes` (buffer insert and delete-marking operations), `purges` (buffer purge operations, the writes when deleted index entries are finally garbage-collected), `all` (buffer insert, delete-marking, and purge operations) and `none` (do not buffer any operations). The default is `all`. For details, see Section 13.4.7.4, “Controlling InnoDB Change Buffering”.

- `innodb_checksums`

Command-Line Format	`--innodb_checksums`	
Option-File Format	`innodb_checksums`	
Option Sets Variable	Yes, `innodb_checksums`	
Variable Name	`innodb_checksums`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

`InnoDB` can use checksum validation on all pages read from the disk to ensure extra fault tolerance against broken hardware or data files. This validation is enabled by default. However, under some rare circumstances (such as when running benchmarks) this extra safety feature is unneeded and can be disabled with `--skip-innodb-checksums`.

- `innodb_commit_concurrency`

Command-Line Format	`--innodb_commit_concurrency=#`	
Option-File Format	`innodb_commit_concurrency`	
Option Sets Variable	Yes, `innodb_commit_concurrency`	
Variable Name	`innodb_commit_concurrency`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-1000`

The number of threads that can commit at the same time. A value of 0 (the default) permits any number of transactions to commit simultaneously.

The value of `innodb_commit_concurrency` cannot be changed at runtime from zero to nonzero or vice versa. The value can be changed from one nonzero value to another.

- `innodb_concurrency_tickets`

Command-Line Format	`--innodb_concurrency_tickets=#`	
Option-File Format	`innodb_concurrency_tickets`	
Option Sets Variable	Yes, `innodb_concurrency_tickets`	
Variable Name	`innodb_concurrency_tickets`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`500`
	Range	`1-4294967295`

The number of threads that can enter `InnoDB` concurrently is determined by the `innodb_thread_concurrency` variable. A thread is placed in a queue when it tries to enter `InnoDB` if the number of threads has already reached the concurrency limit. When a thread is permitted to enter `InnoDB`, it is given a number of “free tickets” equal to the value of `innodb_concurrency_tickets`, and the thread can enter and leave `InnoDB` freely until it has used up its tickets. After that point, the thread again becomes subject to the concurrency check (and possible queuing) the next time it tries to enter `InnoDB`. The default value is 500.

- `innodb_data_file_path`

Command-Line Format	`--innodb_data_file_path=name`	
Option-File Format	`innodb_data_file_path`	
Variable Name	`innodb_data_file_path`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The paths to individual data files and their sizes. The full directory path to each data file is formed by concatenating `innodb_data_home_dir` to each path specified here. The file sizes are specified in KB, MB, or GB (1024MB) by appending `K`, `M`, or `G` to the size value. The sum of the sizes of the files must be at least 10MB. If you do not specify `innodb_data_file_path`, the default behavior is to create a single 10MB auto-extending data file named `ibdata1`. The size limit of individual files is determined by your operating system. You can set the file size to more than 4GB on those operating systems that support big files. You can also use raw disk partitions as data files. For detailed information on configuring `InnoDB` tablespace files, see Section 13.3.2, “Configuring `InnoDB`”.

- `innodb_data_home_dir`

Command-Line Format	`--innodb_data_home_dir=path`	
Option-File Format	`innodb_data_home_dir`	
Option Sets Variable	Yes, `innodb_data_home_dir`	
Variable Name	`innodb_data_home_dir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The common part of the directory path for all `InnoDB` data files in the shared tablespace. This setting does not affect the location of per-file tablespaces when `innodb_file_per_table` is enabled. The default value is the MySQL data directory. If you specify the value as an empty string, you can use absolute file paths in `innodb_data_file_path`.

- `innodb_doublewrite`

Command-Line Format	`--innodb-doublewrite`

Option-File Format	`innodb_doublewrite`	
Option Sets Variable	Yes, `innodb_doublewrite`	
Variable Name	`innodb_doublewrite`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`

If this variable is enabled (the default), `InnoDB` stores all data twice, first to the doublewrite buffer, and then to the actual data files. This variable can be turned off with `--skip-innodb_doublewrite` for benchmarks or cases when top performance is needed rather than concern for data integrity or possible failures.

- `innodb_fast_shutdown`

Command-Line Format	`--innodb_fast_shutdown[=#]`	
Option-File Format	`innodb_fast_shutdown`	
Option Sets Variable	Yes, `innodb_fast_shutdown`	
Variable Name	`innodb_fast_shutdown`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1`

	Valid Values	`0`
		`1`
		`2`

The `InnoDB` shutdown mode. If the value is 0, `InnoDB` does a slow shutdown, a full purge and an insert buffer merge before shutting down. If the value is 1 (the default), `InnoDB` skips these operations at shutdown, a process known as a fast shutdown. If the value is 2, `InnoDB` flushes its logs and shuts down cold, as if MySQL had crashed; no committed transactions are lost, but the crash recovery operation makes the next startup take longer.

The slow shutdown can take minutes, or even hours in extreme cases where substantial amounts of data are still buffered. Use the slow shutdown technique before upgrading or downgrading between MySQL major releases, so that all data files are fully prepared in case the upgrade process updates the file format.

Use `innodb_fast_shutdown=2` in emergency or troubleshooting situations, to get the absolute fastest shutdown if data is at risk of corruption.

- `innodb_file_format`

Command-Line Format	`--innodb_file_format=#`
Option-File Format	`innodb_file_format`
Option Sets Variable	Yes, `innodb_file_format`
Variable Name	`innodb_file_format`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values (>= 5.5.0, <= 5.5.6)	
	Type	`string`
	Default	`Barracuda`
	Valid Values	`Antelope` `Barracuda`
	Permitted Values (>= 5.5.7)	
	Type	`string`
	Default	`Antelope`
	Valid Values	`Antelope` `Barracuda`

The file format to use for new `InnoDB` tables. Currently, `Antelope` and `Barracuda` are supported. This applies only for tables that have their own tablespace, so for it to have an effect, `innodb_file_per_table` must be enabled. The Barracuda file format is required for certain InnoDB features such as table compression.

- `innodb_file_format_check`

Command-Line Format	`--innodb_file_format_check=#`	
Option-File Format	`innodb_file_format_check`	
Option Sets Variable	Yes, `innodb_file_format_check`	
Variable Name	`innodb_file_format_check`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values (<= 5.5.0)	
	Type	`string`
	Default	`Antelope`
	Permitted Values (>= 5.5.4)	
	Type	`string`
	Default	`Barracuda`
	Permitted Values (>= 5.5.5)	
	Type	`boolean`
	Default	`ON`

As of MySQL 5.5.5, this variable can be set to 1 or 0 at server startup to enable or disable whether `InnoDB` checks the file format tag in the shared tablespace (for example, `Antelope` or `Barracuda`). If the tag is checked and is higher than that supported by the current version of `InnoDB`, an error occurs and `InnoDB` does not start. If the tag is not higher, `InnoDB` sets the value of `innodb_file_format_max` to the file format tag.

Before MySQL 5.5.5, this variable can be set to 1 or 0 at server startup to enable or disable whether `InnoDB` checks the file format tag in the shared tablespace. If the tag is checked and is higher than that supported by the current version of `InnoDB`, an error occurs and `InnoDB` does not start. If the tag is not higher, `InnoDB` sets the value of `innodb_file_format_check` to the file format tag, which is the value seen at runtime.

- `innodb_file_format_max`

Version Introduced	5.5.5
Command-Line Format	`--innodb_file_format_max=#`
Option-File Format	`innodb_file_format_max`
Option Sets Variable	Yes, `innodb_file_format_max`
Variable Name	`innodb_file_format_max`
Variable Scope	Global

Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`
	Default	`Antelope`
	Valid Values	`Antelope` `Barracuda`

At server startup, `InnoDB` sets the value of `innodb_file_format_max` to the file format tag in the shared tablespace (for example, `Antelope` or `Barracuda`). If the server creates or opens a table with a “higher” file format, it sets the value of `innodb_file_format_max` to that format.

This variable was added in MySQL 5.5.5.

- `innodb_file_per_table`

Command-Line Format	`--innodb_file_per_table`	
Option-File Format	`innodb_file_per_table`	
Variable Name	`innodb_file_per_table`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values (>= 5.5.0, <= 5.5.6)	
	Type	`boolean`
	Default	`ON`
	Permitted Values (>= 5.5.7)	
	Type	`boolean`
	Default	`OFF`

If `innodb_file_per_table` is disabled (the default), `InnoDB` creates tables in the system tablespace. If `innodb_file_per_table` is enabled, `InnoDB` creates each new table using its own `.ibd` file for storing data and indexes, rather than in the system tablespace. See Section 13.3.3, “Using Per-Table Tablespaces” for information about the features, such as `InnoDB` table compression, that only work for tables stored in separate tablespaces.

- `innodb_flush_log_at_trx_commit`

Command-Line Format	`--innodb_flush_log_at_trx_commit[=#]`	
Option-File Format	`innodb_flush_log_at_trx_commit`	
Option Sets Variable	Yes, `innodb_flush_log_at_trx_commit`	
Variable Name	`innodb_flush_log_at_trx_commit`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1`

	Valid Values	`0`
		`1`
		`2`

If the value of `innodb_flush_log_at_trx_commit` is 0, the log buffer is written out to the log file once per second and the flush to disk operation is performed on the log file, but nothing is done at a transaction commit. When the value is 1 (the default), the log buffer is written out to the log file at each transaction commit and the flush to disk operation is performed on the log file. When the value is 2, the log buffer is written out to the file at each commit, but the flush to disk operation is not performed on it. However, the flushing on the log file takes place once per second also when the value is 2. Note that the once-per-second flushing is not 100% guaranteed to happen every second, due to process scheduling issues.

The default value of 1 is required for full ACID compliance. You can achieve better performance by setting the value different from 1, but then you can lose up to one second worth of transactions in a crash. With a value of 0, any `mysqld` process crash can erase the last second of transactions. With a value of 2, only an operating system crash or a power outage can erase the last second of transactions. `InnoDB`'s crash recovery works regardless of the value.

For the greatest possible durability and consistency in a replication setup using `InnoDB` with transactions, use `innodb_flush_log_at_trx_commit=1` and `sync_binlog=1` in your master server `my.cnf` file.

> ### Caution
>
> Many operating systems and some disk hardware fool the flush-to-disk operation. They may tell `mysqld` that the flush has taken place, even though it has not. Then the durability of transactions is not guaranteed even with the setting 1, and in the worst case a power outage can even corrupt the `InnoDB` database. Using a battery-backed disk cache in the SCSI disk controller or in the disk itself speeds up file flushes, and makes the operation safer. You can also try using the Unix command `hdparm` to disable the caching of disk writes in hardware caches, or use some other command specific to the hardware vendor.

- `innodb_flush_method`

<table>
<tr><td>Command-Line Format</td><td colspan="2"><code>--innodb_flush_method=name</code></td></tr>
<tr><td>Option-File Format</td><td colspan="2"><code>innodb_flush_method</code></td></tr>
<tr><td>Option Sets Variable</td><td colspan="2">Yes, <code>innodb_flush_method</code></td></tr>
<tr><td>Variable Name</td><td colspan="2"><code>innodb_flush_method</code></td></tr>
<tr><td>Variable Scope</td><td colspan="2">Global</td></tr>
<tr><td>Dynamic Variable</td><td colspan="2">No</td></tr>
<tr><td rowspan="4"></td><td colspan="2">Permitted Values</td></tr>
<tr><td>Type (solaris)</td><td><code>enumeration</code></td></tr>
<tr><td>Default</td><td><code>fdatasync</code></td></tr>
<tr><td>Valid Values</td><td><code>O_DSYNC</code>
<code>O_DIRECT</code></td></tr>
</table>

By default, `InnoDB` uses the `fsync()` system call to flush both the data and log files. If `innodb_flush_method` option is set to `O_DSYNC`, `InnoDB` uses `O_SYNC` to open and flush the log files, and `fsync()` to flush the data files. If `O_DIRECT` is specified (available on some GNU/Linux versions, FreeBSD, and Solaris), `InnoDB` uses `O_DIRECT` (or `directio()` on Solaris) to open the data files, and uses `fsync()` to flush both the data and log files. Note that `InnoDB` uses `fsync()` instead of `fdatasync()`, and it does not use `O_DSYNC` by default because there have been problems with it on many varieties of Unix. This variable is relevant only for Unix. On Windows, the flush method is always `async_unbuffered` and cannot be changed.

Different values of this variable can have a marked effect on `InnoDB` performance. For example, on some systems where `InnoDB` data and log files are located on a SAN, it has been found that setting `innodb_flush_method` to `O_DIRECT` can degrade performance of simple `SELECT` statements by a factor of three.

Formerly, a value of `fdatasync` also specified the default behavior. This value was removed, due to confusion that a value of `fdatasync` caused `fsync()` system calls rather than `fdatasync()` for flushing. To obtain the default value now, do not set any value for `innodb_flush_method` at startup.

- `innodb_force_recovery`

Command-Line Format	`--innodb_force_recovery=#`
Option-File Format	`innodb_force_recovery`
Option Sets Variable	Yes, `innodb_force_recovery`
Variable Name	`innodb_force_recovery`
Variable Scope	Global
Dynamic Variable	No

	Permitted Values	
	Type	`enumeration`
	Default	`0`

	Valid Values	`0`
		`1`
		`2`
		`3`
		`4`
		`5`
		`6`

The crash recovery mode. Possible values are from 0 to 6. The meanings of these values are described in Section 13.3.7.2, “Forcing `InnoDB` Recovery”.

> **Warning**
>
> Only set this variable greater than 0 in an emergency situation, to dump your tables from a corrupt database. As a safety measure, `InnoDB` prevents any changes to its data when this variable is greater than 0. This restriction also prohibits some queries that use `WHERE` or `ORDER BY` clauses, because high values can prevent queries from using indexes.

- `innodb_io_capacity`

Command-Line Format	`--innodb_io_capacity=#`	
Option-File Format	`innodb_io_capacity`	
Option Sets Variable	Yes, `innodb_io_capacity`	
Variable Name	`innodb_io_capacity`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`200`
	Range	`100-2**32-1`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`200`
	Range	`100-2**64-1`

An upper limit on the I/O activity performed by the `InnoDB` background tasks, such as flushing pages from the buffer pool and merging data from the insert buffer. The default value is 200. For busy systems capable of higher I/O rates, you can set a higher value at server startup, to help the server handle the background maintenance work associated with a high rate of row changes. For systems with individual 5400 RPM or 7200 RPM drives, you might lower the value to the former default of `100`.

This parameter should be set to approximately the number of I/O operations that the system can perform per second. The Ideally, keep this setting as low as practical, but not so low that these background activities fall behind. If the value is too high, data is removed from the buffer pool and insert buffer too quickly to provide significant benefit from the caching.

The value represents an estimated proportion of the I/O operations per second (IOPS) available to older-generation disk drives that could perform about 100 IOPS. The current default of 200 reflects that modern storage devices are capable of much higher I/O rates.

In general, you can increase the value as a function of the number of drives used for `InnoDB` I/O, particularly fast drives capable of high numbers of IOPS. For example, systems that use multiple disks or solid-state disks for `InnoDB` are likely to benefit from the ability to control this parameter.

Although you can specify a very high number, in practice such large values cease to have any benefit; for example, a value of one million would be considered very high.

You can set the `innodb_io_capacity` value to any number 100 or greater, and the default value is `200`. You can set the value of this parameter in the MySQL option file (`my.cnf` or `my.ini`) or change it dynamically with the `SET GLOBAL` command, which requires the `SUPER` privilege.

See Section 13.4.7.11, “Controlling the Master Thread I/O Rate” for more guidelines about this option. For general information about InnoDB I/O performance, see Section 7.5.7, “Optimizing `InnoDB` Disk I/O”.

- `innodb_large_prefix`

Version Introduced	5.5.14	
Command-Line Format	`--innodb_large_prefix`	
Option-File Format	`innodb_large_prefix`	
Option Sets Variable	Yes, `innodb_large_prefix`	
Variable Name	`innodb_large_prefix`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Enable this option to allow index key prefixes longer than 767 bytes (up to 3072 bytes), for `InnoDB` tables that use the `DYNAMIC` and `COMPRESSED` row formats. (Creating such tables also requires the option values `innodb_file_format=barracuda` and `innodb_file_per_table=true`.) See Section 13.3.15, “Limits on `InnoDB` Tables” for the relevant maximums associated with index key prefixes under various settings.

For tables using the `REDUNDANT` and `COMPACT` row formats, this option does not affect the allowed key prefix length. It does introduce a new error possibility. When this setting is enabled, attempting to create an index prefix with a key length greater than 3072 for a `REDUNDANT` or `COMPACT` table causes an error `ER_INDEX_COLUMN_TOO_LONG` (1727).

- `innodb_lock_wait_timeout`

Command-Line Format	`--innodb_lock_wait_timeout=#`	
Option-File Format	`innodb_lock_wait_timeout`	
Option Sets Variable	Yes, `innodb_lock_wait_timeout`	
Variable Name	`innodb_lock_wait_timeout`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`50`
	Range	`1-1073741824`

The timeout in seconds an `InnoDB` transaction waits for a row lock before giving up. The default value is 50 seconds. A transaction that tries to access a row that is locked by another `InnoDB` transaction waits at most this many seconds for write access to the row before issuing the following error:

```
ERROR 1205 (HY000): Lock wait timeout exceeded; try restarting transaction
```

When a lock wait timeout occurs, the current statement is rolled back (not the entire transaction). To have the entire transaction roll back, start the server with the `--innodb_rollback_on_timeout` option. See also Section 13.3.13, “`InnoDB` Error Handling”.

You might decrease this value for highly interactive applications or OLTP systems, to display user feedback quickly or put the update into a queue for processing later. You might increase this value for long-running back-end operations, such as a transform step in a data warehouse that waits for other large insert or update operations to finish.

`innodb_lock_wait_timeout` applies to `InnoDB` row locks only. A MySQL table lock does not happen inside `InnoDB` and this timeout does not apply to waits for table locks.

The lock wait timeout value does not apply to deadlocks, because `InnoDB` detects them immediately and rolls back one of the deadlocked transactions.

- `innodb_locks_unsafe_for_binlog`

Command-Line Format	`--innodb_locks_unsafe_for_binlog`	
Option-File Format	`innodb_locks_unsafe_for_binlog`	
Option Sets Variable	Yes, `innodb_locks_unsafe_for_binlog`	
Variable Name	`innodb_locks_unsafe_for_binlog`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

This variable affects how `InnoDB` uses gap locking for searches and index scans. Normally, `InnoDB` uses an algorithm called *next-key locking* that combines index-row locking with gap locking. `InnoDB` performs row-level locking in such a way that when it searches or scans a table index, it sets shared or exclusive locks on the index records it encounters. Thus, the row-level locks are actually index-record locks. In addition, a next-key lock on an index record also affects the “gap” before that index record. That is, a next-key lock is an index-record lock plus a gap lock on the gap preceding the index record. If one session has a shared or exclusive lock on record `R` in an index, another session cannot insert a new index record in the gap immediately before `R` in the index order. See Section 13.3.9.4, “`InnoDB` Record, Gap, and Next-Key Locks”.

By default, the value of `innodb_locks_unsafe_for_binlog` is 0 (disabled), which means that gap locking is enabled: `InnoDB` uses next-key locks for searches and index scans. To enable the variable, set it to 1. This causes gap locking to be disabled: `InnoDB` uses only index-record locks for searches and index scans.

Enabling `innodb_locks_unsafe_for_binlog` does not disable the use of gap locking for foreign-key constraint checking or duplicate-key checking.

The effect of enabling `innodb_locks_unsafe_for_binlog` is similar to but not identical to setting the transaction isolation level to `READ COMMITTED`:

- Enabling `innodb_locks_unsafe_for_binlog` is a global setting and affects all sessions, whereas the isolation level can be set globally for all sessions, or individually per session.
- `innodb_locks_unsafe_for_binlog` can be set only at server startup, whereas the isolation level can be set at startup or changed at runtime.

`READ COMMITTED` therefore offers finer and more flexible control than `innodb_locks_unsafe_for_binlog`. For additional details about the effect of isolation level on gap locking, see Section 12.3.6, “`SET TRANSACTION` Syntax”.

Enabling `innodb_locks_unsafe_for_binlog` may cause phantom problems because other sessions can insert new rows into the gaps when gap locking is disabled. Suppose that there is an index on the `id` column of the `child` table and that you want to read and lock all rows from the table having an identifier value larger than 100, with the intention of updating some column in the selected rows later:

```
SELECT * FROM child WHERE id > 100 FOR UPDATE;
```

The query scans the index starting from the first record where `id` is greater than 100. If the locks set on the index records in that range do not lock out inserts made in the gaps, another session can insert a new row into the table. Consequently, if you were to execute the same `SELECT` again within the same transaction, you would see a new row in the result set returned by the query. This also means that if new items are added to the database, `InnoDB` does not guarantee serializability. Therefore, if `innodb_locks_unsafe_for_binlog` is enabled, `InnoDB` guarantees at most an isolation level of `READ COMMITTED`. (Conflict serializability is still guaranteed.) For additional information about phantoms, see Section 13.3.9.5, "Avoiding the Phantom Problem Using Next-Key Locking".

Enabling `innodb_locks_unsafe_for_binlog` has additional effects:

- For `UPDATE` or `DELETE` statements, `InnoDB` holds locks only for rows that it updates or deletes. Record locks for nonmatching rows are released after MySQL has evaluated the `WHERE` condition. This greatly reduces the probability of deadlocks, but they can still happen.
- For `UPDATE` statements, if a row is already locked, `InnoDB` performs a "semi-consistent" read, returning the latest committed version to MySQL so that MySQL can determine whether the row matches the `WHERE` condition of the `UPDATE`. If the row matches (must be updated), MySQL reads the row again and this time `InnoDB` either locks it or waits for a lock on it.

Consider the following example, beginning with this table:

```
CREATE TABLE t (a INT NOT NULL, b INT) ENGINE = InnoDB;
INSERT INTO t VALUES (1,2),(2,3),(3,2),(4,3),(5,2);
COMMIT;
```

In this case, table has no indexes, so searches and index scans use the hidden clustered index for record locking (see Section 13.3.11.1, "Clustered and Secondary Indexes").

Suppose that one client performs an `UPDATE` using these statements:

```
SET autocommit = 0;
UPDATE t SET b = 5 WHERE b = 3;
```

Suppose also that a second client performs an `UPDATE` by executing these statements following those of the first client:

```
SET autocommit = 0;
UPDATE t SET b = 4 WHERE b = 2;
```

As `InnoDB` executes each `UPDATE`, it first acquires an exclusive lock for each row, and then determines whether to modify it. If `InnoDB` does not modify the row and `innodb_locks_unsafe_for_binlog` is enabled, it releases the lock. Otherwise, `InnoDB` retains the lock until the end of the transaction. This affects transaction processing as follows.

If `innodb_locks_unsafe_for_binlog` is disabled, the first `UPDATE` acquires x-locks and does not release any of them:

```
x-lock(1,2); retain x-lock
x-lock(2,3); update(2,3) to (2,5); retain x-lock
x-lock(3,2); retain x-lock
x-lock(4,3); update(4,3) to (4,5); retain x-lock
x-lock(5,2); retain x-lock
```

The second `UPDATE` blocks as soon as it tries to acquire any locks (because first update has retained locks on all rows), and does not proceed until the first `UPDATE` commits or rolls back:

```
x-lock(1,2); block and wait for first UPDATE to commit or roll back
```

If `innodb_locks_unsafe_for_binlog` is enabled, the first `UPDATE` acquires x-locks and releases those for rows that it does not modify:

```
x-lock(1,2); unlock(1,2)
x-lock(2,3); update(2,3) to (2,5); retain x-lock
x-lock(3,2); unlock(3,2)
x-lock(4,3); update(4,3) to (4,5); retain x-lock
x-lock(5,2); unlock(5,2)
```

For the second `UPDATE`, `InnoDB` does a "semi-consistent" read, returning the latest committed version of each row to MySQL so that MySQL can determine whether the row matches the `WHERE` condition of the `UPDATE`:

```
x-lock(1,2); update(1,2) to (1,4); retain x-lock
x-lock(2,3); unlock(2,3)
x-lock(3,2); update(3,2) to (3,4); retain x-lock
x-lock(4,3); unlock(4,3)
x-lock(5,2); update(5,2) to (5,4); retain x-lock
```

- `innodb_log_buffer_size`

Command-Line Format	`--innodb_log_buffer_size=#`

Option-File Format	`innodb_log_buffer_size`	
Option Sets Variable	Yes, `innodb_log_buffer_size`	
Variable Name	`innodb_log_buffer_size`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`8388608`
	Range	`262144-4294967295`

The size in bytes of the buffer that `InnoDB` uses to write to the log files on disk. The default value is 8MB. A large log buffer enables large transactions to run without a need to write the log to disk before the transactions commit. Thus, if you have big transactions, making the log buffer larger saves disk I/O.

- `innodb_log_file_size`

Command-Line Format	`--innodb_log_file_size=#`	
Option-File Format	`innodb_log_file_size`	
Option Sets Variable	Yes, `innodb_log_file_size`	
Variable Name	`innodb_log_file_size`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`5242880`
	Range	`108576-4294967295`

The size in bytes of each log file in a log group. The combined size of log files must be less than 4GB. The default value is 5MB. Sensible values range from 1MB to 1/`N`-th of the size of the buffer pool, where `N` is the number of log files in the group. The larger the value, the less checkpoint flush activity is needed in the buffer pool, saving disk I/O. But larger log files also mean that recovery is slower in case of a crash.

- `innodb_log_files_in_group`

Command-Line Format	`--innodb_log_files_in_group=#`	
Option-File Format	`innodb_log_files_in_group`	
Option Sets Variable	Yes, `innodb_log_files_in_group`	
Variable Name	`innodb_log_files_in_group`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`2`
	Range	`2-100`

The number of log files in the log group. `InnoDB` writes to the files in a circular fashion. The default (and recommended) value is 2.

- `innodb_log_group_home_dir`

Command-Line Format	`--innodb_log_group_home_dir=path`
Option-File Format	`innodb_log_group_home_dir`
Option Sets Variable	Yes, `innodb_log_group_home_dir`

Variable Name	`innodb_log_group_home_dir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

The directory path to the `InnoDB` redo log files. If you do not specify any `InnoDB` log variables, the default is to create two 5MB files named `ib_logfile0` and `ib_logfile1` in the MySQL data directory.

- `innodb_max_dirty_pages_pct`

Command-Line Format	`--innodb_max_dirty_pages_pct=#`	
Option-File Format	`innodb_max_dirty_pages_pct`	
Option Sets Variable	Yes, `innodb_max_dirty_pages_pct`	
Variable Name	`innodb_max_dirty_pages_pct`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`75`
	Range	`0-99`

This is an integer in the range from 0 to 99. The default value is 75. The main thread in `InnoDB` tries to write pages from the buffer pool so that the percentage of dirty (not yet written) pages will not exceed this value.

- `innodb_max_purge_lag`

Command-Line Format	`--innodb_max_purge_lag=#`	
Option-File Format	`innodb_max_purge_lag`	
Option Sets Variable	Yes, `innodb_max_purge_lag`	
Variable Name	`innodb_max_purge_lag`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`

This variable controls how to delay `INSERT`, `UPDATE`, and `DELETE` operations when purge operations are lagging (see Section 13.3.10, "`InnoDB` Multi-Versioning"). The default value 0 (no delays).

The `InnoDB` transaction system maintains a list of transactions that have index records delete-marked by `UPDATE` or `DELETE` operations. Let the length of this list be *`purge_lag`*. When *`purge_lag`* exceeds `innodb_max_purge_lag`, each `INSERT`, `UPDATE`, and `DELETE` operation is delayed by ((*`purge_lag`*/`innodb_max_purge_lag`)×10)–5 milliseconds. The delay is computed in the beginning of a purge batch, every ten seconds. The operations are not delayed if purge cannot run because of an old consistent read view that could see the rows to be purged.

A typical setting for a problematic workload might be 1 million, assuming that transactions are small, only 100 bytes in size, and it is permissible to have 100MB of unpurged `InnoDB` table rows.

The lag value is displayed as the history list length in the `TRANSACTIONS` section of InnoDB Monitor output. For example, if the output includes the following lines, the lag value is 20:

```
------------
TRANSACTIONS
------------
Trx id counter 0 290328385
```

```
Purge done for trx's n:o < 0 290315608 undo n:o < 0 17
History list length 20
```

- `innodb_mirrored_log_groups`

  The number of identical copies of log groups to keep for the database. This should be set to 1.

- `innodb_old_blocks_pct`

Command-Line Format	`--innodb_old_blocks_pct=#`	
Option-File Format	`innodb_old_blocks_pct`	
Variable Name	`innodb_old_blocks_pct`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`37`
	Range	`5-95`

  Specifies the approximate percentage of the `InnoDB` buffer pool used for the old block sublist. The range of values is 5 to 95. The default value is 37 (that is, 3/8 of the pool). See Section 7.9.1, “The `InnoDB` Buffer Pool”

- `innodb_old_blocks_time`

Command-Line Format	`--innodb_old_blocks_time=#`	
Option-File Format	`innodb_old_blocks_time`	
Variable Name	`innodb_old_blocks_time`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-2**32-1`

  Specifies how long in milliseconds (ms) a block inserted into the old sublist must stay there after its first access before it can be moved to the new sublist. The default value is 0: A block inserted into the old sublist moves immediately to the new sublist the first time it is accessed, no matter how soon after insertion the access occurs. If the value is greater than 0, blocks remain in the old sublist until an access occurs at least that many ms after the first access. For example, a value of 1000 causes blocks to stay in the old sublist for 1 second after the first access before they become eligible to move to the new sublist. See Section 7.9.1, “The `InnoDB` Buffer Pool”

- `innodb_open_files`

Command-Line Format	`--innodb_open_files=#`	
Option-File Format	`innodb_open_files`	
Variable Name	`innodb_open_files`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`300`
	Range	`10-4294967295`

  This variable is relevant only if you use multiple tablespaces in `InnoDB`. It specifies the maximum number of `.ibd` files that

`InnoDB` can keep open at one time. The minimum value is 10. The default value is 300.

The file descriptors used for `.ibd` files are for `InnoDB` only. They are independent of those specified by the `--open-files-limit` server option, and do not affect the operation of the table cache.

- `innodb_purge_batch_size`

Version Introduced	5.5.4	
Command-Line Format	`--innodb_purge_batch_size=#`	
Option-File Format	`innodb_purge_batch_size`	
Variable Name	`innodb_purge_batch_size`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values (>= 5.5.4)	
	Type	`numeric`
	Default	`20`
	Range	`1-5000`

The granularity of changes, expressed in units of redo log records, that trigger a purge operation, flushing the changed buffer pool blocks to disk. The default value is 20, and the range is 1-5000. This option is intended for tuning performance in combination with the setting `innodb_purge_threads=1`, and typical users do not need to modify it.

- `innodb_purge_threads`

Version Introduced	5.5.4	
Command-Line Format	`--innodb_purge_threads=#`	
Option-File Format	`innodb_purge_threads`	
Variable Name	`innodb_purge_threads`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values (>= 5.5.4)	
	Type	`numeric`
	Default	`0`
	Range	`0-1`

The number of background threads devoted to the InnoDB purge operation. Currently, can only be 0 (the default) or 1. The default value of 0 signifies that the purge operation is performed as part of the master thread. Running the purge operation in its own thread can reduce internal contention within InnoDB, improving scalability. Currently, the performance gain might be minimal because the background thread might encounter different kinds of contention than before. This feature primarily lays the groundwork for future performance work.

- `innodb_read_ahead_threshold`

Command-Line Format	`--innodb_read_ahead_threshold=#`	
Option-File Format	`innodb_read_ahead_threshold`	
Option Sets Variable	Yes, `innodb_read_ahead_threshold`	
Variable Name	`innodb_read_ahead_threshold`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`56`
	Range	`0-64`

Controls the sensitivity of linear read-ahead that `InnoDB` uses to prefetch pages into the buffer cache. If `InnoDB` reads at least `innodb_read_ahead_threshold` pages sequentially from an extent (64 pages), it initiates an asynchronous read for the entire following extent. The permissible range of values is 0 to 64. The default is 56: `InnoDB` must read at least 56 pages sequentially from an extent to initiate an asynchronous read for the following extent.

- `innodb_read_io_threads`

Command-Line Format	`--innodb_read_io_threads=#`	
Option-File Format	`innodb_read_io_threads`	
Option Sets Variable	Yes, `innodb_read_io_threads`	
Variable Name	`innodb_read_io_threads`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`4`
	Range	`1-64`

The number of I/O threads for read operations in `InnoDB`. The default value is 4.

- `innodb_replication_delay`

Command-Line Format	`--innodb_replication_delay=#`	
Option-File Format	`innodb_replication_delay`	
Option Sets Variable	Yes, `innodb_replication_delay`	
Variable Name	`innodb_replication_delay`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`

The replication thread delay (in ms) on a slave server if `innodb_thread_concurrency` is reached.

- `innodb_rollback_on_timeout`

Command-Line Format	`--innodb_rollback_on_timeout`	
Option-File Format	`innodb_rollback_on_timeout`	
Option Sets Variable	Yes, `innodb_rollback_on_timeout`	
Variable Name	`innodb_rollback_on_timeout`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

In MySQL 5.5, `InnoDB` rolls back only the last statement on a transaction timeout by default. If `--innodb_rollback_on_timeout` is specified, a transaction timeout causes `InnoDB` to abort and roll back the entire transaction (the same behavior as in MySQL 4.1).

- `innodb_rollback_segments`

Version Introduced	5.5.11

Command-Line Format	`--innodb_rollback_segments=#`	
Option-File Format	`innodb_rollback_segments`	
Option Sets Variable	Yes, `innodb_rollback_segments`	
Variable Name	`innodb_rollback_segments`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`128`
	Range	`1-128`

Defines how many of the rollback segments in the system tablespace that InnoDB uses within a transaction. You might reduce this value from its default of 128 if a smaller number of rollback segments performs better for your workload.

- `innodb_spin_wait_delay`

Command-Line Format	`--innodb_spin_wait_delay=#`	
Option-File Format	`innodb_spin_wait_delay`	
Option Sets Variable	Yes, `innodb_spin_wait_delay`	
Variable Name	`innodb_spin_wait_delay`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`6`
	Range	`0-4294967295`

The maximum delay between polls for a spin lock. The default value is 6.

- `innodb_stats_method`

Version Introduced	5.5.10	
Command-Line Format	`--innodb_stats_method=name`	
Option-File Format	`innodb_stats_method`	
Option Sets Variable	Yes, `innodb_stats_method`	
Variable Name	`innodb_stats_method`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`nulls_unequal`

How the server treats `NULL` values when collecting statistics about the distribution of index values for `InnoDB` tables. This variable has three possible values, `nulls_equal`, `nulls_unequal`, and `nulls_ignored`. For `nulls_equal`, all `NULL` index values are considered equal and form a single value group that has a size equal to the number of `NULL` values. For `nulls_unequal`, `NULL` values are considered unequal, and each `NULL` forms a distinct value group of size 1. For `nulls_ignored`, `NULL` values are ignored.

The method that is used for generating table statistics influences how the optimizer chooses indexes for query execution, as described in Section 7.3.7, “`InnoDB` and `MyISAM` Index Statistics Collection”.

- `innodb_stats_on_metadata`

Version Introduced	5.5.4	
Command-Line Format	`--innodb_stats_on_metadata`	
Option-File Format	`innodb_stats_on_metadata`	
Option Sets Variable	Yes, `innodb_stats_on_metadata`	
Variable Name	`innodb_stats_on_metadata`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

When this variable is enabled (which is the default, as before the variable was created), `InnoDB` updates statistics during metadata statements such as `SHOW TABLE STATUS` or `SHOW INDEX`, or when accessing the `INFORMATION_SCHEMA` tables `TABLES` or `STATISTICS`. (These updates are similar to what happens for `ANALYZE TABLE`.) When disabled, `InnoDB` does not update statistics during these operations. Disabling this variable can improve access speed for schemas that have a large number of tables or indexes. It can also improve the stability of execution plans for queries that involve `InnoDB` tables.

- `innodb_stats_sample_pages`

Command-Line Format	`--innodb_stats_sample_pages=#`	
Option-File Format	`innodb_stats_sample_pages`	
Option Sets Variable	Yes, `innodb_stats_sample_pages`	
Variable Name	`innodb_stats_sample_pages`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`8`
	Range	`1-2**64-1`

The number of index pages to sample for index distribution statistics such as are calculated by `ANALYZE TABLE`. The default value is 8. For more information, see Section 13.4.8, “Changes for Flexibility, Ease of Use and Reliability”.

- `innodb_strict_mode`

Command-Line Format	`--innodb_strict_mode=#`	
Option-File Format	`innodb_strict_mode`	
Option Sets Variable	Yes, `innodb_strict_mode`	
Variable Name	`innodb_strict_mode`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Whether `InnoDB` returns errors rather than warnings for certain conditions. This is analogous to strict SQL mode. The default value is `OFF`. See Section 13.4.8.4, “InnoDB Strict Mode” for a list of the conditions that are affected.

- `innodb_support_xa`

Command-Line Format	`--innodb_support_xa`
Option-File Format	`innodb_support_xa`
Option Sets Variable	Yes, `innodb_support_xa`

Variable Name	`innodb_support_xa`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`TRUE`

Enables `InnoDB` support for two-phase commit in XA transactions, causing an extra disk flush for transaction preparation. This setting is the default. The XA mechanism is used internally and is essential for any server that has its binary log turned on and is accepting changes to its data from more than one thread. If you turn it off, transactions can be written to the binary log in a different order from the one in which the live database is committing them. This can produce different data when the binary log is replayed in disaster recovery or on a replication slave. Do not turn it off on a replication master server unless you have an unusual setup where only one thread is able to change data.

For a server that is accepting data changes from only one thread, it is safe and recommended to turn off this option to improve performance for `InnoDB` tables. For example, you can turn it off on replication slaves where only the replication SQL thread is changing data.

You can also turn off this option if you do not need it for safe binary logging or replication, and you also do not use an external XA transaction manager.

- `innodb_sync_spin_loops`

Command-Line Format	`--innodb_sync_spin_loops=#`	
Option-File Format	`innodb_sync_spin_loops`	
Option Sets Variable	Yes, `innodb_sync_spin_loops`	
Variable Name	`innodb_sync_spin_loops`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`30`
	Range	`0-4294967295`

The number of times a thread waits for an `InnoDB` mutex to be freed before the thread is suspended. The default value is 30.

- `innodb_table_locks`

Command-Line Format	`--innodb_table_locks`	
Option-File Format	`innodb_table_locks`	
Option Sets Variable	Yes, `innodb_table_locks`	
Variable Name	`innodb_table_locks`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`TRUE`

If `autocommit = 0`, `InnoDB` honors `LOCK TABLES`; MySQL does not return from `LOCK TABLES ... WRITE` until all other threads have released all their locks to the table. The default value of `innodb_table_locks` is 1, which means that `LOCK TABLES` causes InnoDB to lock a table internally if `autocommit = 0`.

- `innodb_thread_concurrency`

Command-Line Format	`--innodb_thread_concurrency=#`

Option-File Format	`innodb_thread_concurrency`	
Option Sets Variable	Yes, `innodb_thread_concurrency`	
Variable Name	`innodb_thread_concurrency`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-1000`

`InnoDB` tries to keep the number of operating system threads concurrently inside `InnoDB` less than or equal to the limit given by this variable. Once the number of threads reaches this limit, additional threads are placed into a wait state within a FIFO queue for execution. Threads waiting for locks are not counted in the number of concurrently executing threads.

The correct value for this variable is dependent on environment and workload. Try a range of different values to determine what value works for your applications. A recommended value is 2 times the number of CPUs plus the number of disks.

The range of this variable is 0 to 1000. A value of 0 (the default) is interpreted as infinite concurrency (no concurrency checking). Disabling thread concurrency checking enables InnoDB to create as many threads as it needs.

- `innodb_thread_sleep_delay`

Command-Line Format	`--innodb_thread_sleep_delay=#`	
Option-File Format	`innodb_thread_sleep_delay`	
Option Sets Variable	Yes, `innodb_thread_sleep_delay`	
Variable Name	`innodb_thread_sleep_delay`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`10000`

How long `InnoDB` threads sleep before joining the `InnoDB` queue, in microseconds. The default value is 10,000. A value of 0 disables sleep.

- `innodb_use_native_aio`

Version Introduced	5.5.4	
Command-Line Format	`--innodb_use_native_aio=#`	
Option-File Format	`innodb_use_native_aio`	
Option Sets Variable	Yes, `innodb_use_native_aio`	
Variable Name	`innodb_use_native_aio`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

If a problem with the asynchronous I/O subsystem in the OS prevents `InnoDB` from starting, start the server with this variable disabled (use `innodb_use_native_aio=0` in the option file). This variable applies to Linux systems only, and cannot be changed while the server is running.

This variable was added in MySQL 5.5.4.

- `innodb_use_sys_malloc`

Command-Line Format	`--innodb_use_sys_malloc=#`	
Option-File Format	`innodb_use_sys_malloc`	
Option Sets Variable	Yes, `innodb_use_sys_malloc`	
Variable Name	`innodb_use_sys_malloc`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`
	Default	`ON`

Whether `InnoDB` uses the operating system memory allocator (`ON`) or its own (`OFF`). The default value is `ON`.

- `innodb_version`

The `InnoDB` version number.

- `innodb_write_io_threads`

Command-Line Format	`--innodb_write_io_threads=#`	
Option-File Format	`innodb_write_io_threads`	
Option Sets Variable	Yes, `innodb_write_io_threads`	
Variable Name	`innodb_write_io_threads`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`4`
	Range	`1-64`

The number of I/O threads for write operations in `InnoDB`. The default value is 4.

- `sync_binlog`

Command-Line Format	`--sync-binlog=#`	
Option-File Format	`sync_binlog`	
Option Sets Variable	Yes, `sync_binlog`	
Variable Name	`sync_binlog`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

If the value of this variable is greater than 0, the MySQL server synchronizes its binary log to disk (using `fdatasync()`) after every `sync_binlog` writes to the binary log. There is one write to the binary log per statement if autocommit is enabled, and one write per transaction otherwise. The default value of `sync_binlog` is 0, which does no synchronizing to disk. A value of 1 is the safest choice, because in the event of a crash you lose at most one statement or transaction from the binary log. However, it is also the slowest choice (unless the disk has a battery-backed cache, which makes synchronization very fast).

13.3.5. Creating and Using `InnoDB` Tables

To create an `InnoDB` table, specify an `ENGINE=InnoDB` option in the `CREATE TABLE` statement:

```
CREATE TABLE customers (a INT, b CHAR (20), INDEX (a)) ENGINE=InnoDB;
```

The statement creates a table and an index on column `a` in the `InnoDB` tablespace that consists of the data files that you specified in `my.cnf`. In addition, MySQL creates a file `customers.frm` in the `test` directory under the MySQL database directory. Internally, `InnoDB` adds an entry for the table to its own data dictionary. The entry includes the database name. For example, if `test` is the database in which the `customers` table is created, the entry is for `'test/customers'`. This means you can create a table of the same name `customers` in some other database, and the table names do not collide inside `InnoDB`.

You can query the amount of free space in the `InnoDB` tablespace by issuing a `SHOW TABLE STATUS` statement for any `InnoDB` table. The amount of free space in the tablespace appears in the `Data_free` section in the output of `SHOW TABLE STATUS`. For example:

```
SHOW TABLE STATUS FROM test LIKE 'customers'
```

The statistics `SHOW` displays for `InnoDB` tables are only approximate. They are used in SQL optimization. Table and index reserved sizes in bytes are accurate, though.

13.3.5.1. Using `InnoDB` Transactions

Transactions in SQL

By default, each client that connects to the MySQL server begins with autocommit mode enabled, which automatically commits every SQL statement as you execute it. To use multiple-statement transactions, you can switch autocommit off with the SQL statement `SET autocommit = 0` and end each transaction with either `COMMIT` or `ROLLBACK`. If you want to leave autocommit on, you can begin your transactions within `START TRANSACTION` and end them with `COMMIT` or `ROLLBACK`. The following example shows two transactions. The first is committed; the second is rolled back.

```
shell> mysql test

mysql> CREATE TABLE customer (a INT, b CHAR (20), INDEX (a))
    -> ENGINE=InnoDB;
Query OK, 0 rows affected (0.00 sec)
mysql> START TRANSACTION;
Query OK, 0 rows affected (0.00 sec)
mysql> INSERT INTO customer VALUES (10, 'Heikki');
Query OK, 1 row affected (0.00 sec)
mysql> COMMIT;
Query OK, 0 rows affected (0.00 sec)
mysql> SET autocommit=0;
Query OK, 0 rows affected (0.00 sec)
mysql> INSERT INTO customer VALUES (15, 'John');
Query OK, 1 row affected (0.00 sec)
mysql> ROLLBACK;
Query OK, 0 rows affected (0.00 sec)
mysql> SELECT * FROM customer;
+------+--------+
| a    | b      |
+------+--------+
|   10 | Heikki |
+------+--------+
1 row in set (0.00 sec)
mysql>
```

Transactions in Client-Side Languages

In APIs such as PHP, Perl DBI, JDBC, ODBC, or the standard C call interface of MySQL, you can send transaction control statements such as `COMMIT` to the MySQL server as strings just like any other SQL statements such as `SELECT` or `INSERT`. Some APIs also offer separate special transaction commit and rollback functions or methods.

13.3.5.2. Converting Tables from Other Storage Engines to `InnoDB`

To convert a non-`InnoDB` table to use `InnoDB` use `ALTER TABLE`:

```
ALTER TABLE table_name ENGINE=InnoDB;
```

> **Important**
>
> Do not convert MySQL system tables in the `mysql` database (such as `user` or `host`) to the `InnoDB` type. This is an unsupported operation. The system tables must always be of the `MyISAM` type.

To make an InnoDB table that is a clone of a MyISAM table:

- Create an empty `InnoDB` table with identical definitions.
- Create the appropriate indexes.
- Insert the rows with `INSERT INTO innodb_table SELECT * FROM myisam_table`.

You can also create the indexes after inserting the data. Historically, creating new secondary indexes was a slow operation for InnoDB, but this is no longer the case.

If you have `UNIQUE` constraints on secondary keys, you can speed up a table import by turning off the uniqueness checks temporarily during the import operation:

```
SET unique_checks=0;
... import operation ...
SET unique_checks=1;
```

For big tables, this saves disk I/O because `InnoDB` can use its insert buffer to write secondary index records as a batch. Be certain that the data contains no duplicate keys. `unique_checks` permits but does not require storage engines to ignore duplicate keys.

To get better control over the insertion process, you might insert big tables in pieces:

```
INSERT INTO newtable SELECT * FROM oldtable
   WHERE yourkey > something AND yourkey <= somethingelse;
```

After all records have been inserted, you can rename the tables.

During the conversion of big tables, increase the size of the `InnoDB` buffer pool to reduce disk I/O, to a maximum of 80% of physical memory. You can also increase the sizes of the `InnoDB` log files.

Make sure that you do not fill up the tablespace: `InnoDB` tables require a lot more disk space than `MyISAM` tables. If an `ALTER TABLE` operation runs out of space, it starts a rollback, and that can take hours if it is disk-bound. For inserts, `InnoDB` uses the insert buffer to merge secondary index records to indexes in batches. That saves a lot of disk I/O. For rollback, no such mechanism is used, and the rollback can take 30 times longer than the insertion.

In the case of a runaway rollback, if you do not have valuable data in your database, it may be advisable to kill the database process rather than wait for millions of disk I/O operations to complete. For the complete procedure, see Section 13.3.7.2, “Forcing `InnoDB` Recovery”.

If you want all new user-created tables to use the `InnoDB` storage engine, add the line `default-storage-engine=innodb` to the `[mysqld]` section of your server option file.

13.3.5.3. `AUTO_INCREMENT` Handling in `InnoDB`

`InnoDB` provides an optimization that significantly improves scalability and performance of SQL statements that insert rows into tables with `AUTO_INCREMENT` columns. This section provides background information on the original (“traditional”) implementation of auto-increment locking in `InnoDB`, explains the configurable locking mechanism, documents the parameter for configuring the mechanism, and describes its behavior and interaction with replication.

13.3.5.3.1. “Traditional” `InnoDB` Auto-Increment Locking

The original implementation of auto-increment handling in `InnoDB` uses the following strategy to prevent problems when using the binary log for statement-based replication or for certain recovery scenarios.

If you specify an `AUTO_INCREMENT` column for an `InnoDB` table, the table handle in the `InnoDB` data dictionary contains a special counter called the auto-increment counter that is used in assigning new values for the column. This counter is stored only in main memory, not on disk.

`InnoDB` uses the following algorithm to initialize the auto-increment counter for a table `t` that contains an `AUTO_INCREMENT` column named `ai_col`: After a server startup, for the first insert into a table `t`, `InnoDB` executes the equivalent of this statement:

```
SELECT MAX(ai_col) FROM t FOR UPDATE;
```

`InnoDB` increments the value retrieved by the statement and assigns it to the column and to the auto-increment counter for the table. By default, the value is incremented by one. This default can be overridden by the `auto_increment_increment` configuration setting.

If the table is empty, `InnoDB` uses the value `1`. This default can be overridden by the `auto_increment_offset` configuration setting.

If a `SHOW TABLE STATUS` statement examines the table `t` before the auto-increment counter is initialized, `InnoDB` initializes but does not increment the value and stores it for use by later inserts. This initialization uses a normal exclusive-locking read on the table and the lock lasts to the end of the transaction.

`InnoDB` follows the same procedure for initializing the auto-increment counter for a freshly created table.

After the auto-increment counter has been initialized, if a you do not explicitly specify a value for an `AUTO_INCREMENT` column, `InnoDB` increments the counter and assigns the new value to the column. If you insert a row that explicitly specifies the column value, and the value is bigger than the current counter value, the counter is set to the specified column value.

When accessing the auto-increment counter, `InnoDB` uses a special table-level `AUTO-INC` lock that it keeps to the end of the current SQL statement, not to the end of the transaction. The special lock release strategy was introduced to improve concurrency for inserts into a table containing an `AUTO_INCREMENT` column. Nevertheless, two transactions cannot have the `AUTO-INC` lock on the same table simultaneously, which can have a performance impact if the `AUTO-INC` lock is held for a long time. That might be the case for a statement such as `INSERT INTO t1 ... SELECT ... FROM t2` that inserts all rows from one table into another.

`InnoDB` uses the in-memory auto-increment counter as long as the server runs. When the server is stopped and restarted, `InnoDB` reinitializes the counter for each table for the first `INSERT` to the table, as described earlier.

You may see gaps in the sequence of values assigned to the `AUTO_INCREMENT` column if you roll back transactions that have generated numbers using the counter.

If a user specifies `NULL` or `0` for the `AUTO_INCREMENT` column in an `INSERT`, `InnoDB` treats the row as if the value was not specified and generates a new value for it.

The behavior of the auto-increment mechanism is not defined if you assign a negative value to the column, or if the value becomes bigger than the maximum integer that can be stored in the specified integer type.

An `AUTO_INCREMENT` column must appear as the first column in an index on an `InnoDB` table.

`InnoDB` supports the `AUTO_INCREMENT = N` table option in `CREATE TABLE` and `ALTER TABLE` statements, to set the initial counter value or alter the current counter value. The effect of this option is canceled by a server restart, for reasons discussed earlier in this section.

13.3.5.3.2. Configurable `InnoDB` Auto-Increment Locking

As described in the previous section, `InnoDB` uses a special lock called the table-level `AUTO-INC` lock for inserts into tables with `AUTO_INCREMENT` columns. This lock is normally held to the end of the statement (not to the end of the transaction), to ensure that auto-increment numbers are assigned in a predictable and repeatable order for a given sequence of `INSERT` statements.

In the case of statement-based replication, this means that when an SQL statement is replicated on a slave server, the same values are used for the auto-increment column as on the master server. The result of execution of multiple `INSERT` statements is deterministic, and the slave reproduces the same data as on the master. If auto-increment values generated by multiple `INSERT` statements were interleaved, the result of two concurrent `INSERT` statements would be nondeterministic, and could not reliably be propagated to a slave server using statement-based replication.

To make this clear, consider an example that uses this table:

```
CREATE TABLE t1 (
  c1 INT(11) NOT NULL AUTO_INCREMENT,
  c2 VARCHAR(10) DEFAULT NULL,
  PRIMARY KEY (c1)
) ENGINE=InnoDB;
```

Suppose that there are two transactions running, each inserting rows into a table with an `AUTO_INCREMENT` column. One transaction is using an `INSERT ... SELECT` statement that inserts 1000 rows, and another is using a simple `INSERT` statement that inserts one row:

```
Tx1: INSERT INTO t1 (c2) SELECT 1000 rows from another table ...
Tx2: INSERT INTO t1 (c2) VALUES ('xxx');
```

`InnoDB` cannot tell in advance how many rows will be retrieved from the `SELECT` in the `INSERT` statement in Tx1, and it assigns the auto-increment values one at a time as the statement proceeds. With a table-level lock, held to the end of the statement, only one `INSERT` statement referring to table `t1` can execute at a time, and the generation of auto-increment numbers by different statements is not interleaved. The auto-increment value generated by the Tx1 `INSERT ... SELECT` statement will be consecutive, and the (single) auto-increment value used by the `INSERT` statement in Tx2 will either be smaller or larger than all those used for Tx1, depending on which statement executes first.

As long as the SQL statements execute in the same order when replayed from the binary log (when using statement-based replication, or in recovery scenarios), the results will be the same as they were when Tx1 and Tx2 first ran. Thus, table-level locks held until the end of a statement make `INSERT` statements using auto-increment safe for use with statement-based replication. However, those locks limit concurrency and scalability when multiple transactions are executing insert statements at the same time.

In the preceding example, if there were no table-level lock, the value of the auto-increment column used for the `INSERT` in Tx2 depends on precisely when the statement executes. If the `INSERT` of Tx2 executes while the `INSERT` of Tx1 is running (rather than before it starts or after it completes), the specific auto-increment values assigned by the two `INSERT` statements are non-deterministic, and may vary from run to run.

`InnoDB` can avoid using the table-level `AUTO-INC` lock for a class of `INSERT` statements where the number of rows is known in advance, and still preserve deterministic execution and safety for statement-based replication. Further, if you are not using the binary log to replay SQL statements as part of recovery or replication, you can entirely eliminate use of the table-level `AUTO-INC` lock for even greater concurrency and performance—at the cost of permitting gaps in auto-increment numbers assigned by a statement and potentially having the numbers assigned by concurrently executing statements interleaved.

For `INSERT` statements where the number of rows to be inserted is known at the beginning of processing the statement, `InnoDB` quickly allocates the required number of auto-increment values without taking any lock, but only if there is no concurrent session already holding the table-level `AUTO-INC` lock (because that other statement will be allocating auto-increment values one-by-one as it proceeds). More precisely, such an `INSERT` statement obtains auto-increment values under the control of a mutex (a light-weight lock) that is *not* held until the statement completes, but only for the duration of the allocation process.

This new locking scheme enables much greater scalability, but it does introduce some subtle differences in how auto-increment values are assigned compared to the original mechanism. To describe the way auto-increment works in `InnoDB`, the following discussion defines some terms, and explains how `InnoDB` behaves using different settings of the new `innodb_autoinc_lock_mode` configuration parameter. Additional considerations are described following the explanation of auto-increment locking behavior.

First, some definitions:

- “`INSERT`-like” statements

  All statements that generate new rows in a table, including `INSERT`, `INSERT ... SELECT`, `REPLACE`, `REPLACE ... SELECT`, and `LOAD DATA`.

- “Simple inserts”

  Statements for which the number of rows to be inserted can be determined in advance (when the statement is initially processed). This includes single-row and multiple-row `INSERT` and `REPLACE` statements that do not have a nested subquery, but not `INSERT ... ON DUPLICATE KEY UPDATE`.

- “Bulk inserts”

  Statements for which the number of rows to be inserted (and the number of required auto-increment values) is not known in advance. This includes `INSERT ... SELECT`, `REPLACE ... SELECT`, and `LOAD DATA` statements, but not plain `INSERT`. `InnoDB` will assign new values for the `AUTO_INCREMENT` column one at a time as each row is processed.

- “Mixed-mode inserts”

  These are “simple insert” statements that specify the auto-increment value for some (but not all) of the new rows. An example follows, where `c1` is an `AUTO_INCREMENT` column of table `t1`:

  ```
  INSERT INTO t1 (c1,c2) VALUES (1,'a'), (NULL,'b'), (5,'c'), (NULL,'d');
  ```

  Another type of “mixed-mode insert” is `INSERT ... ON DUPLICATE KEY UPDATE`, which in the worst case is in effect an `INSERT` followed by a `UPDATE`, where the allocated value for the `AUTO_INCREMENT` column may or may not be used during the update phase.

In MySQL 5.5, there is a configuration parameter that controls how `InnoDB` uses locking when generating values for `AUTO_INCREMENT` columns. This parameter can be set using the `--innodb-autoinc-lock-mode` option at `mysqld` startup.

In general, if you encounter problems with the way auto-increment works (which will most likely involve replication), you can force use of the original behavior by setting the lock mode to 0.

There are three possible settings for the `innodb_autoinc_lock_mode` parameter:

- `innodb_autoinc_lock_mode = 0` (“traditional” lock mode)

  This lock mode provides the same behavior as before `innodb_autoinc_lock_mode` existed. For all “`INSERT`-like” statements, a special table-level `AUTO-INC` lock is obtained and held to the end of the statement. This assures that the auto-increment values assigned by any given statement are consecutive (although “gaps” can exist within a table if a transaction that generated auto-increment values is rolled back, as discussed later).

  This lock mode is provided only for backward compatibility and performance testing. There is little reason to use this lock mode unless you use “mixed-mode inserts” and care about the important difference in semantics described later.

- `innodb_autoinc_lock_mode = 1` (“consecutive” lock mode)

  This is the default lock mode. In this mode, “bulk inserts” use the special `AUTO-INC` table-level lock and hold it until the end of the statement. This applies to all `INSERT ... SELECT`, `REPLACE ... SELECT`, and `LOAD DATA` statements. Only one statement holding the `AUTO-INC` lock can execute at a time.

  With this lock mode, “simple inserts” (only) use a new locking model where a light-weight mutex is used during the allocation of auto-increment values, and no table-level `AUTO-INC` lock is used, unless an `AUTO-INC` lock is held by another transaction. If another transaction does hold an `AUTO-INC` lock, a “simple insert” waits for the `AUTO-INC` lock, as if it too were a “bulk insert.”

  This lock mode ensures that, in the presence of `INSERT` statements where the number of rows is not known in advance (and where auto-increment numbers are assigned as the statement progresses), all auto-increment values assigned by any “`INSERT`-like” statement are consecutive, and operations are safe for statement-based replication.

  Simply put, the important impact of this lock mode is significantly better scalability. This mode is safe for use with statement-based replication. Further, as with “traditional” lock mode, auto-increment numbers assigned by any given statement are *consecutive*. In this mode, there is *no change* in semantics compared to “traditional” mode for any statement that uses auto-increment, with one important exception.

  The exception is for “mixed-mode inserts”, where the user provides explicit values for an `AUTO_INCREMENT` column for some, but not all, rows in a multiple-row “simple insert.” For such inserts, `InnoDB` will allocate more auto-increment values than the number of rows to be inserted. However, all values automatically assigned are consecutively generated (and thus higher than) the auto-increment value generated by the most recently executed previous statement. “Excess” numbers are lost.

  A similar situation exists if you use `INSERT ... ON DUPLICATE KEY UPDATE`. This statement is also classified as a “mixed-mode insert” since an auto-increment value is not necessarily generated for each row. Because `InnoDB` allocates the auto-increment value before the insert is actually attempted, it cannot know whether an inserted value will be a duplicate of an existing value and thus cannot know whether the auto-increment value it generates will be used for a new row. Therefore, if you are using statement-based replication, either avoid `INSERT ... ON DUPLICATE KEY UPDATE` or use `innodb_autoinc_lock_mode = 0` (“traditional” lock mode).

- `innodb_autoinc_lock_mode = 2` (“interleaved” lock mode)

  In this lock mode, no “`INSERT`-like” statements use the table-level `AUTO-INC` lock, and multiple statements can execute at the same time. This is the fastest and most scalable lock mode, but it is *not safe* when using statement-based replication or recovery scenarios when SQL statements are replayed from the binary log.

  In this lock mode, auto-increment values are guaranteed to be unique and monotonically increasing across all concurrently executing “`INSERT`-like” statements. However, because multiple statements can be generating numbers at the same time (that is, allocation of numbers is *interleaved* across statements), the values generated for the rows inserted by any given statement may not be consecutive.

  If the only statements executing are “simple inserts” where the number of rows to be inserted is known ahead of time, there will be no gaps in the numbers generated for a single statement, except for “mixed-mode inserts.” However, when “bulk inserts” are executed, there may be gaps in the auto-increment values assigned by any given statement.

The auto-increment locking modes provided by `innodb_autoinc_lock_mode` have several usage implications:

- Using auto-increment with replication

  If you are using statement-based replication, set `innodb_autoinc_lock_mode` to 0 or 1 and use the same value on the master and its slaves. Auto-increment values are not ensured to be the same on the slaves as on the master if you use `in-`

`nodb_autoinc_lock_mode` = 2 (“interleaved”) or configurations where the master and slaves do not use the same lock mode.

If you are using row-based replication, all of the auto-increment lock modes are safe. Row-based replication is not sensitive to the order of execution of the SQL statements.

- “Lost” auto-increment values and sequence gaps

  In all lock modes (0, 1, and 2), if a transaction that generated auto-increment values rolls back, those auto-increment values are “lost.” Once a value is generated for an auto-increment column, it cannot be rolled back, whether or not the “`INSERT`-like” statement is completed, and whether or not the containing transaction is rolled back. Such lost values are not reused. Thus, there may be gaps in the values stored in an `AUTO_INCREMENT` column of a table.

- Gaps in auto-increment values for “bulk inserts”

  With `innodb_autoinc_lock_mode` set to 0 (“traditional”) or 1 (“consecutive”), the auto-increment values generated by any given statement will be consecutive, without gaps, because the table-level `AUTO-INC` lock is held until the end of the statement, and only one such statement can execute at a time.

  With `innodb_autoinc_lock_mode` set to 2 (“interleaved”), there may be gaps in the auto-increment values generated by “bulk inserts,” but only if there are concurrently executing “`INSERT`-like” statements.

  For lock modes 1 or 2, gaps may occur between successive statements because for bulk inserts the exact number of auto-increment values required by each statement may not be known and overestimation is possible.

- Auto-increment values assigned by “mixed-mode inserts”

  Consider a “mixed-mode insert,” where a “simple insert” specifies the auto-increment value for some (but not all) resulting rows. Such a statement will behave differently in lock modes 0, 1, and 2. For example, assume `c1` is an `AUTO_INCREMENT` column of table `t1`, and that the most recent automatically generated sequence number is 100. Consider the following “mixed-mode insert” statement:

  ```
  INSERT INTO t1 (c1,c2) VALUES (1,'a'), (NULL,'b'), (5,'c'), (NULL,'d');
  ```

  With `innodb_autoinc_lock_mode` set to 0 (“traditional”), the four new rows will be:

  ```
  +-----+------+
  | c1  | c2   |
  +-----+------+
  |   1 | a    |
  | 101 | b    |
  |   5 | c    |
  | 102 | d    |
  +-----+------+
  ```

  The next available auto-increment value will be 103 because the auto-increment values are allocated one at a time, not all at once at the beginning of statement execution. This result is true whether or not there are concurrently executing “`INSERT`-like” statements (of any type).

  With `innodb_autoinc_lock_mode` set to 1 (“consecutive”), the four new rows will also be:

  ```
  +-----+------+
  | c1  | c2   |
  +-----+------+
  |   1 | a    |
  | 101 | b    |
  |   5 | c    |
  | 102 | d    |
  +-----+------+
  ```

  However, in this case, the next available auto-increment value will be 105, not 103 because four auto-increment values are allocated at the time the statement is processed, but only two are used. This result is true whether or not there are concurrently executing “`INSERT`-like” statements (of any type).

  With `innodb_autoinc_lock_mode` set to mode 2 (“interleaved”), the four new rows will be:

  ```
  +-----+------+
  | c1  | c2   |
  +-----+------+
  |   1 | a    |
  |   x | b    |
  |   5 | c    |
  |   y | d    |
  +-----+------+
  ```

The values of `x` and `y` will be unique and larger than any previously generated rows. However, the specific values of `x` and `y` will depend on the number of auto-increment values generated by concurrently executing statements.

Finally, consider the following statement, issued when the most-recently generated sequence number was the value 4:

```
INSERT INTO t1 (c1,c2) VALUES (1,'a'), (NULL,'b'), (5,'c'), (NULL,'d');
```

With any `innodb_autoinc_lock_mode` setting, this statement will generate a duplicate-key error 23000 (`Can't write; duplicate key in table`) because 5 will be allocated for the row `(NULL, 'b')` and insertion of the row `(5, 'c')` will fail.

13.3.5.4. `FOREIGN KEY` Constraints

`InnoDB` supports foreign key constraints. The syntax for a foreign key constraint definition in `InnoDB` looks like this:

```
[CONSTRAINT [symbol]] FOREIGN KEY
    [index_name] (index_col_name, ...)
    REFERENCES tbl_name (index_col_name,...)
    [ON DELETE reference_option]
    [ON UPDATE reference_option]

reference_option:
    RESTRICT | CASCADE | SET NULL | NO ACTION
```

`index_name` represents a foreign key ID. If given, this is ignored if an index for the foreign key is defined explicitly. Otherwise, if `InnoDB` creates an index for the foreign key, it uses `index_name` for the index name.

Foreign keys definitions are subject to the following conditions:

- Both tables must be `InnoDB` tables and they must not be `TEMPORARY` tables.
- Corresponding columns in the foreign key and the referenced key must have similar internal data types inside `InnoDB` so that they can be compared without a type conversion. *The size and sign of integer types must be the same*. The length of string types need not be the same. For nonbinary (character) string columns, the character set and collation must be the same.
- `InnoDB` requires indexes on foreign keys and referenced keys so that foreign key checks can be fast and not require a table scan. In the referencing table, there must be an index where the foreign key columns are listed as the *first* columns in the same order. Such an index is created on the referencing table automatically if it does not exist. This index might be silently dropped later, if you create another index that can be used to enforce the foreign key constraint. `index_name`, if given, is used as described previously.
- `InnoDB` permits a foreign key to reference any index column or group of columns. However, in the referenced table, there must be an index where the referenced columns are listed as the *first* columns in the same order.
- Index prefixes on foreign key columns are not supported. One consequence of this is that `BLOB` and `TEXT` columns cannot be included in a foreign key because indexes on those columns must always include a prefix length.
- If the `CONSTRAINT symbol` clause is given, the `symbol` value must be unique in the database. If the clause is not given, `InnoDB` creates the name automatically.

`InnoDB` rejects any `INSERT` or `UPDATE` operation that attempts to create a foreign key value in a child table if there is no a matching candidate key value in the parent table. When an `UPDATE` or `DELETE` operation affects a key value in the parent table that has matching rows in the child table, the result depends on the *referential action* specified using `ON UPDATE` and `ON DELETE` subclauses of the `FOREIGN KEY` clause. `InnoDB` supports five options regarding the action to be taken. If `ON DELETE` or `ON UPDATE` are not specified, the default action is `RESTRICT`.

- `CASCADE`: Delete or update the row from the parent table, and automatically delete or update the matching rows in the child table. Both `ON DELETE CASCADE` and `ON UPDATE CASCADE` are supported. Between two tables, do not define several `ON UPDATE CASCADE` clauses that act on the same column in the parent table or in the child table.

  > **Note**
  >
  > Currently, cascaded foreign key actions do not activate triggers.

- `SET NULL`: Delete or update the row from the parent table, and set the foreign key column or columns in the child table to `NULL`. Both `ON DELETE SET NULL` and `ON UPDATE SET NULL` clauses are supported.

If you specify a `SET NULL` action, *make sure that you have not declared the columns in the child table as `NOT NULL`*.

- `RESTRICT`: Rejects the delete or update operation for the parent table. Specifying `RESTRICT` (or `NO ACTION`) is the same as omitting the `ON DELETE` or `ON UPDATE` clause.
- `NO ACTION`: A keyword from standard SQL. In MySQL, equivalent to `RESTRICT`. `InnoDB` rejects the delete or update operation for the parent table if there is a related foreign key value in the referenced table. Some database systems have deferred checks, and `NO ACTION` is a deferred check. In MySQL, foreign key constraints are checked immediately, so `NO ACTION` is the same as `RESTRICT`.
- `SET DEFAULT`: This action is recognized by the parser, but `InnoDB` rejects table definitions containing `ON DELETE SET DEFAULT` or `ON UPDATE SET DEFAULT` clauses.

`InnoDB` supports foreign key references within a table. In these cases, “child table records” really refers to dependent records within the same table.

Examples of Foreign Key Clauses

Here is a simple example that relates `parent` and `child` tables through a single-column foreign key:

```
CREATE TABLE parent (id INT NOT NULL,
                     PRIMARY KEY (id)
) ENGINE=INNODB;
CREATE TABLE child (id INT, parent_id INT,
                    INDEX par_ind (parent_id),
                    FOREIGN KEY (parent_id) REFERENCES parent(id)
                      ON DELETE CASCADE
) ENGINE=INNODB;
```

A more complex example in which a `product_order` table has foreign keys for two other tables. One foreign key references a two-column index in the `product` table. The other references a single-column index in the `customer` table:

```
CREATE TABLE product (category INT NOT NULL, id INT NOT NULL,
                      price DECIMAL,
                      PRIMARY KEY(category, id)) ENGINE=INNODB;
CREATE TABLE customer (id INT NOT NULL,
                       PRIMARY KEY (id)) ENGINE=INNODB;
CREATE TABLE product_order (no INT NOT NULL AUTO_INCREMENT,
                            product_category INT NOT NULL,
                            product_id INT NOT NULL,
                            customer_id INT NOT NULL,
                            PRIMARY KEY(no),
                            INDEX (product_category, product_id),
                            FOREIGN KEY (product_category, product_id)
                              REFERENCES product(category, id)
                              ON UPDATE CASCADE ON DELETE RESTRICT,
                            INDEX (customer_id),
                            FOREIGN KEY (customer_id)
                              REFERENCES customer(id)) ENGINE=INNODB;
```

`InnoDB` enables you to add a new foreign key constraint to a table by using `ALTER TABLE`:

```
ALTER TABLE tbl_name
    ADD [CONSTRAINT [symbol]] FOREIGN KEY
    [index_name] (index_col_name, ...)
    REFERENCES tbl_name (index_col_name,...)
    [ON DELETE reference_option]
    [ON UPDATE reference_option]
```

The foreign key can be self referential (referring to the same table). When you add a foreign key constraint to a table using `ALTER TABLE`, *remember to create the required indexes first.*

Foreign Keys and ALTER TABLE

`InnoDB` supports the use of `ALTER TABLE` to drop foreign keys:

```
ALTER TABLE tbl_name DROP FOREIGN KEY fk_symbol;
```

If the `FOREIGN KEY` clause included a `CONSTRAINT` name when you created the foreign key, you can refer to that name to drop the foreign key. Otherwise, the *`fk_symbol`* value is internally generated by `InnoDB` when the foreign key is created. To find out the symbol value when you want to drop a foreign key, use the `SHOW CREATE TABLE` statement. For example:

```
mysql> SHOW CREATE TABLE ibtest11c\G
*************************** 1. row ***************************
       Table: ibtest11c
Create Table: CREATE TABLE `ibtest11c` (
  `A` int(11) NOT NULL auto_increment,
  `D` int(11) NOT NULL default '0',
  `B` varchar(200) NOT NULL default '',
  `C` varchar(175) default NULL,
  PRIMARY KEY  (`A`,`D`,`B`),
  KEY `B` (`B`,`C`),
  KEY `C` (`C`),
  CONSTRAINT `0_38775` FOREIGN KEY (`A`, `D`)
REFERENCES `ibtest11a` (`A`, `D`)
ON DELETE CASCADE ON UPDATE CASCADE,
  CONSTRAINT `0_38776` FOREIGN KEY (`B`, `C`)
REFERENCES `ibtest11a` (`B`, `C`)
ON DELETE CASCADE ON UPDATE CASCADE
) ENGINE=INNODB CHARSET=latin1
1 row in set (0.01 sec)

mysql> ALTER TABLE ibtest11c DROP FOREIGN KEY `0_38775`;
```

You cannot add a foreign key and drop a foreign key in separate clauses of a single `ALTER TABLE` statement. Separate statements are required.

If `ALTER TABLE` for an `InnoDB` table results in changes to column values (for example, because a column is truncated), `InnoDB`'s `FOREIGN KEY` constraint checks do not notice possible violations caused by changing the values.

How Foreign Keys Work with Other MySQL Command

The `InnoDB` parser permits table and column identifiers in a `FOREIGN KEY ... REFERENCES ...` clause to be quoted within backticks. (Alternatively, double quotation marks can be used if the `ANSI_QUOTES` SQL mode is enabled.) The `InnoDB` parser also takes into account the setting of the `lower_case_table_names` system variable.

`InnoDB` returns a table's foreign key definitions as part of the output of the `SHOW CREATE TABLE` statement:

```
SHOW CREATE TABLE tbl_name;
```

`mysqldump` also produces correct definitions of tables in the dump file, and does not forget about the foreign keys.

To make it easier to reload dump files for tables that have foreign key relationships, `mysqldump` automatically includes a statement in the dump output to set `foreign_key_checks` to 0. This avoids problems with tables having to be reloaded in a particular order when the dump is reloaded. It is also possible to set this variable manually:

```
mysql> SET foreign_key_checks = 0;
mysql> SOURCE dump_file_name;
mysql> SET foreign_key_checks = 1;
```

This enables you to import the tables in any order if the dump file contains tables that are not correctly ordered for foreign keys. It also speeds up the import operation. Setting `foreign_key_checks` to 0 can also be useful for ignoring foreign key constraints during `LOAD DATA` and `ALTER TABLE` operations. However, even if `foreign_key_checks = 0`, InnoDB does not permit the creation of a foreign key constraint where a column references a nonmatching column type. Also, if an `InnoDB` table has foreign key constraints, `ALTER TABLE` cannot be used to change the table to use another storage engine. To alter the storage engine, drop any foreign key constraints first.

`InnoDB` does not permit you to drop a table that is referenced by a `FOREIGN KEY` constraint, unless you do `SET foreign_key_checks = 0`. When you drop a table, the constraints that were defined in its create statement are also dropped.

If you re-create a table that was dropped, it must have a definition that conforms to the foreign key constraints referencing it. It must have the right column names and types, and it must have indexes on the referenced keys, as stated earlier. If these are not satisfied, MySQL returns error number 1005 and refers to error 150 in the error message.

If MySQL reports an error number 1005 from a `CREATE TABLE` statement, and the error message refers to error 150, table creation failed because a foreign key constraint was not correctly formed. Similarly, if an `ALTER TABLE` fails and it refers to error 150, that means a foreign key definition would be incorrectly formed for the altered table. You can use `SHOW ENGINE INNODB STATUS` to display a detailed explanation of the most recent `InnoDB` foreign key error in the server.

> ### Important
>
> For users familiar with the ANSI/ISO SQL Standard, please note that no storage engine, including `InnoDB`, recognizes or enforces the `MATCH` clause used in referential-integrity constraint definitions. Use of an explicit `MATCH` clause will not have the specified effect, and also causes `ON DELETE` and `ON UPDATE` clauses to be ignored. For these reasons, specifying `MATCH` should be avoided.
>
> The `MATCH` clause in the SQL standard controls how `NULL` values in a composite (multiple-column) foreign key are handled when comparing to a primary key. `InnoDB` essentially implements the semantics defined by `MATCH SIMPLE`, which permit a foreign key to be all or partially `NULL`. In that case, the (child table) row containing such a foreign key is permitted to be inserted, and does not match any row in the referenced (parent) table. It is possible to

> implement other semantics using triggers.
>
> Additionally, MySQL and `InnoDB` require that the referenced columns be indexed for performance. However, the system does not enforce a requirement that the referenced columns be `UNIQUE` or be declared `NOT NULL`. The handling of foreign key references to nonunique keys or keys that contain `NULL` values is not well defined for operations such as `UPDATE` or `DELETE CASCADE`. You are advised to use foreign keys that reference only `UNIQUE` and `NOT NULL` keys.
>
> Furthermore, `InnoDB` does not recognize or support “inline `REFERENCES` specifications” (as defined in the SQL standard) where the references are defined as part of the column specification. `InnoDB` accepts `REFERENCES` clauses only when specified as part of a separate `FOREIGN KEY` specification. For other storage engines, MySQL Server parses and ignores foreign key specifications.

Deviation from SQL standards: If there are several rows in the parent table that have the same referenced key value, `InnoDB` acts in foreign key checks as if the other parent rows with the same key value do not exist. For example, if you have defined a `RESTRICT` type constraint, and there is a child row with several parent rows, `InnoDB` does not permit the deletion of any of those parent rows.

`InnoDB` performs cascading operations through a depth-first algorithm, based on records in the indexes corresponding to the foreign key constraints.

Deviation from SQL standards: A `FOREIGN KEY` constraint that references a non-`UNIQUE` key is not standard SQL. It is an `InnoDB` extension to standard SQL.

Deviation from SQL standards: If `ON UPDATE CASCADE` or `ON UPDATE SET NULL` recurses to update the *same table* it has previously updated during the cascade, it acts like `RESTRICT`. This means that you cannot use self-referential `ON UPDATE CASCADE` or `ON UPDATE SET NULL` operations. This is to prevent infinite loops resulting from cascaded updates. A self-referential `ON DELETE SET NULL`, on the other hand, is possible, as is a self-referential `ON DELETE CASCADE`. Cascading operations may not be nested more than 15 levels deep.

Deviation from SQL standards: Like MySQL in general, in an SQL statement that inserts, deletes, or updates many rows, `InnoDB` checks `UNIQUE` and `FOREIGN KEY` constraints row-by-row. When performing foreign key checks, `InnoDB` sets shared row-level locks on child or parent records it has to look at. `InnoDB` checks foreign key constraints immediately; the check is not deferred to transaction commit. According to the SQL standard, the default behavior should be deferred checking. That is, constraints are only checked after the *entire SQL statement* has been processed. Until `InnoDB` implements deferred constraint checking, some things will be impossible, such as deleting a record that refers to itself using a foreign key.

13.3.5.5. `InnoDB` and MySQL Replication

MySQL replication works for `InnoDB` tables as it does for `MyISAM` tables. It is also possible to use replication in a way where the storage engine on the slave is not the same as the original storage engine on the master. For example, you can replicate modifications to an `InnoDB` table on the master to a `MyISAM` table on the slave.

To set up a new slave for a master, you have to make a copy of the `InnoDB` tablespace and the log files, as well as the `.frm` files of the `InnoDB` tables, and move the copies to the slave. If the `innodb_file_per_table` variable is enabled, copy the `.ibd` files as well. For the proper procedure to do this, see Section 13.3.7, “Backing Up and Recovering an `InnoDB` Database”.

If you can shut down the master or an existing slave, you can take a cold backup of the `InnoDB` tablespace and log files and use that to set up a slave. To make a new slave without taking down any server you can also use the MySQL Enterprise Backup product.

Transactions that fail on the master do not affect replication at all. MySQL replication is based on the binary log where MySQL writes SQL statements that modify data. A transaction that fails (for example, because of a foreign key violation, or because it is rolled back) is not written to the binary log, so it is not sent to slaves. See Section 12.3.1, “`START TRANSACTION`, `COMMIT`, and `ROLLBACK` Syntax”.

Replication and `CASCADE`. Cascading actions for `InnoDB` tables on the master are replicated on the slave *only* if the tables sharing the foreign key relation use `InnoDB` on both the master and slave. This is true whether you are using statement-based or row-based replication. Suppose that you have started replication, and then create two tables on the master using the following `CREATE TABLE` statements:

```
CREATE TABLE fc1 (
    i INT PRIMARY KEY,
    j INT
) ENGINE = InnoDB;

CREATE TABLE fc2 (
    m INT PRIMARY KEY,
    n INT,
    FOREIGN KEY ni (n) REFERENCES fc1 (i)
        ON DELETE CASCADE
) ENGINE = InnoDB;
```

Suppose that the slave does not have `InnoDB` support enabled. If this is the case, then the tables on the slave are created, but they use the `MyISAM` storage engine, and the `FOREIGN KEY` option is ignored. Now we insert some rows into the tables on the master:

```
master> INSERT INTO fc1 VALUES (1, 1), (2, 2);
Query OK, 2 rows affected (0.09 sec)
Records: 2  Duplicates: 0  Warnings: 0

master> INSERT INTO fc2 VALUES (1, 1), (2, 2), (3, 1);
Query OK, 3 rows affected (0.19 sec)
Records: 3  Duplicates: 0  Warnings: 0
```

At this point, on both the master and the slave, table `fc1` contains 2 rows, and table `fc2` contains 3 rows, as shown here:

```
master> SELECT * FROM fc1;
+---+------+
| i | j    |
+---+------+
| 1 |    1 |
| 2 |    2 |
+---+------+
2 rows in set (0.00 sec)

master> SELECT * FROM fc2;
+---+------+
| m | n    |
+---+------+
| 1 |    1 |
| 2 |    2 |
| 3 |    1 |
+---+------+
3 rows in set (0.00 sec)

slave> SELECT * FROM fc1;
+---+------+
| i | j    |
+---+------+
| 1 |    1 |
| 2 |    2 |
+---+------+
2 rows in set (0.00 sec)

slave> SELECT * FROM fc2;
+---+------+
| m | n    |
+---+------+
| 1 |    1 |
| 2 |    2 |
| 3 |    1 |
+---+------+
3 rows in set (0.00 sec)
```

Now suppose that you perform the following `DELETE` statement on the master:

```
master> DELETE FROM fc1 WHERE i=1;
Query OK, 1 row affected (0.09 sec)
```

Due to the cascade, table `fc2` on the master now contains only 1 row:

```
master> SELECT * FROM fc2;
+---+---+
| m | n |
+---+---+
| 2 | 2 |
+---+---+
1 row in set (0.00 sec)
```

However, the cascade does not propagate on the slave because on the slave the `DELETE` for `fc1` deletes no rows from `fc2`. The slave's copy of `fc2` still contains all of the rows that were originally inserted:

```
slave> SELECT * FROM fc2;
+---+---+
| m | n |
+---+---+
| 1 | 1 |
| 3 | 1 |
| 2 | 2 |
+---+---+
3 rows in set (0.00 sec)
```

This difference is due to the fact that the cascading deletes are handled internally by the `InnoDB` storage engine, which means that none of the changes are logged.

13.3.6. Adding, Removing, or Resizing `InnoDB` Data and Log Files

This section describes what you can do when your `InnoDB` tablespace runs out of room or when you want to change the size of the log files.

The easiest way to increase the size of the `InnoDB` tablespace is to configure it from the beginning to be auto-extending. Specify the `autoextend` attribute for the last data file in the tablespace definition. Then `InnoDB` increases the size of that file automatically in 8MB increments when it runs out of space. The increment size can be changed by setting the value of the `innodb_autoextend_increment` system variable, which is measured in MB.

Alternatively, you can increase the size of your tablespace by adding another data file. To do this, you have to shut down the MySQL server, change the tablespace configuration to add a new data file to the end of `innodb_data_file_path`, and start the server again.

If your last data file was defined with the keyword `autoextend`, the procedure for reconfiguring the tablespace must take into account the size to which the last data file has grown. Obtain the size of the data file, round it down to the closest multiple of 1024 × 1024 bytes (= 1MB), and specify the rounded size explicitly in `innodb_data_file_path`. Then you can add another data file. Remember that only the last data file in the `innodb_data_file_path` can be specified as auto-extending.

As an example, assume that the tablespace has just one auto-extending data file `ibdata1`:

```
innodb_data_home_dir =
innodb_data_file_path = /ibdata/ibdata1:10M:autoextend
```

Suppose that this data file, over time, has grown to 988MB. Here is the configuration line after modifying the original data file to not be auto-extending and adding another auto-extending data file:

```
innodb_data_home_dir =
innodb_data_file_path = /ibdata/ibdata1:988M;/disk2/ibdata2:50M:autoextend
```

When you add a new file to the tablespace configuration, make sure that it does not exist. `InnoDB` will create and initialize the file when you restart the server.

Currently, you cannot remove a data file from the tablespace. To decrease the size of your tablespace, use this procedure:

1. Use `mysqldump` to dump all your `InnoDB` tables.
2. Stop the server.
3. Remove all the existing tablespace files, including the `ibdata` and `ib_log` files. If you want to keep a backup copy of the information, then copy all the `ib*` files to another location before the removing the files in your MySQL installation.
4. Remove any `.frm` files for `InnoDB` tables.
5. Configure a new tablespace.
6. Restart the server.
7. Import the dump files.

If you want to change the number or the size of your `InnoDB` log files, use the following instructions. The procedure to use depends on the value of `innodb_fast_shutdown`:

- If `innodb_fast_shutdown` is not set to 2: Stop the MySQL server and make sure that it shuts down without errors (to ensure that there is no information for outstanding transactions in the log). Copy the old log files into a safe place in case something went wrong during the shutdown and you need them to recover the tablespace. Delete the old log files from the log file directory, edit `my.cnf` to change the log file configuration, and start the MySQL server again. `mysqld` sees that no `InnoDB` log files exist at startup and creates new ones.
- If `innodb_fast_shutdown` is set to 2: Set `innodb_fast_shutdown` to 1:

  ```
  mysql> SET GLOBAL innodb_fast_shutdown = 1;
  ```

  Then follow the instructions in the previous item.

13.3.7. Backing Up and Recovering an InnoDB Database

The key to safe database management is making regular backups.

Hot Backups

`MySQL Enterprise Backup` enables you to back up a running MySQL database, including `InnoDB` and `MyISAM` tables, with minimal disruption to operations while producing a consistent snapshot of the database. When `MySQL Enterprise Backup` is copying `InnoDB` tables, reads and writes to both `InnoDB` and `MyISAM` tables can continue. During the copying of `MyISAM` tables, reads (but not writes) to those tables are permitted. In addition, `MySQL Enterprise Backup` supports creating compressed backup files, and performing backups of subsets of `InnoDB` tables. In conjunction with MySQL's binary log, users can perform point-in-time recovery. `MySQL Enterprise Backup` is part of the MySQL Enterprise subscription. For a more complete description of `MySQL Enterprise Backup`, see http://www.innodb.com/products/hot-backup/features/ or download the documentation from http://www.innodb.com/doc/hot_backup/manual.html.

Cold Backups

If you can shut down your MySQL server, you can make a binary backup that consists of all files used by `InnoDB` to manage its tables. Use the following procedure:

1. Shut down the MySQL server and make sure that it stops without errors.
2. Copy all `InnoDB` data files (`ibdata` files and `.ibd` files) into a safe place.
3. Copy all the `.frm` files for `InnoDB` tables to a safe place.
4. Copy all `InnoDB` log files (`ib_logfile` files) to a safe place.
5. Copy your `my.cnf` configuration file or files to a safe place.

Alternative Backup Types

In addition to making binary backups as just described, regularly make dumps of your tables with `mysqldump`. A binary file might be corrupted without you noticing it. Dumped tables are stored into text files that are human-readable, so spotting table corruption becomes easier. Also, because the format is simpler, the chance for serious data corruption is smaller. `mysqldump` also has a `--single-transaction` option for making a consistent snapshot without locking out other clients. See Section 6.3.1, “Establishing a Backup Policy”.

Replication works with `InnoDB` tables, so you can use MySQL replication capabilities to keep a copy of your database at database sites requiring high availability.

Performing Recovery

To be able to recover your `InnoDB` database to the present from the time at which the binary backup was made, you must run your MySQL server with binary logging turned on. To achieve point-in-time recovery after restoring a backup, you can apply changes from the binary log that occurred after the backup was made. See Section 6.5, “Point-in-Time (Incremental) Recovery Using the Binary Log”.

To recover from a crash of your MySQL server, the only requirement is to restart it. `InnoDB` automatically checks the logs and performs a roll-forward of the database to the present. `InnoDB` automatically rolls back uncommitted transactions that were present at the time of the crash. During recovery, `mysqld` displays output something like this:

```
InnoDB: Database was not shut down normally.
InnoDB: Starting recovery from log files...
InnoDB: Starting log scan based on checkpoint at
InnoDB: log sequence number 0 13674004
InnoDB: Doing recovery: scanned up to log sequence number 0 13739520
InnoDB: Doing recovery: scanned up to log sequence number 0 13805056
InnoDB: Doing recovery: scanned up to log sequence number 0 13870592
InnoDB: Doing recovery: scanned up to log sequence number 0 13936128
...
InnoDB: Doing recovery: scanned up to log sequence number 0 20555264
InnoDB: Doing recovery: scanned up to log sequence number 0 20620800
InnoDB: Doing recovery: scanned up to log sequence number 0 20664692
InnoDB: 1 uncommitted transaction(s) which must be rolled back
InnoDB: Starting rollback of uncommitted transactions
InnoDB: Rolling back trx no 16745
InnoDB: Rolling back of trx no 16745 completed
InnoDB: Rollback of uncommitted transactions completed
InnoDB: Starting an apply batch of log records to the database...
InnoDB: Apply batch completed
InnoDB: Started
mysqld: ready for connections
```

If your database becomes corrupted or disk failure occurs, you must perform the recovery using a backup. In the case of corruption, first find a backup that is not corrupted. After restoring the base backup, do a point-in-time recovery from the binary log files using `mysqlbinlog` and `mysql` to restore the changes that occurred after the backup was made.

In some cases of database corruption it is enough just to dump, drop, and re-create one or a few corrupt tables. You can use the `CHECK TABLE` SQL statement to check whether a table is corrupt, although `CHECK TABLE` naturally cannot detect every possible kind of corruption. You can use the Tablespace Monitor to check the integrity of the file space management inside the tablespace files.

In some cases, apparent database page corruption is actually due to the operating system corrupting its own file cache, and the data on disk may be okay. It is best first to try restarting your computer. Doing so may eliminate errors that appeared to be database page corruption.

13.3.7.1. The `InnoDB` Recovery Process

`InnoDB` crash recovery consists of several steps. The first step, redo log application, is performed during the initialization, before accepting any connections. If all changes were flushed from the buffer pool to the tablespaces (`ibdata*` and `*.ibd` files) at the time of the shutdown or crash, the redo log application can be skipped. If the redo log files are missing at startup, `InnoDB` skips the redo log application.

The remaining steps after redo log application do not depend on the redo log (other than for logging the writes) and are performed in parallel with normal processing. These include:

- Rolling back incomplete transactions: Any transactions that were active at the time of crash or fast shutdown.
- Insert buffer merge: Applying changes from the insert buffer tree (from the shared tablespace) to leaf pages of secondary indexes as the index pages are read to the buffer pool.
- Purge: Deleting delete-marked records that are no longer visible for any active transaction.

Of these, only rollback of incomplete transactions is special to crash recovery. The insert buffer merge and the purge are performed during normal processing.

13.3.7.2. Forcing `InnoDB` Recovery

If there is database page corruption, you may want to dump your tables from the database with `SELECT INTO ... OUTFILE`. Usually, most of the data obtained in this way is intact. However, it is possible that the corruption might cause `SELECT * FROM tbl_name` statements or `InnoDB` background operations to crash or assert, or even cause `InnoDB` roll-forward recovery to crash. In such cases, you can use the `innodb_force_recovery` option to force the `InnoDB` storage engine to start up while preventing background operations from running, so that you can dump your tables. For example, you can add the following line to the `[mysqld]` section of your option file before restarting the server:

```
[mysqld]
innodb_force_recovery = 4
```

`innodb_force_recovery` is 0 by default (normal startup without forced recovery). The permissible nonzero values for `innodb_force_recovery` follow. A larger number includes all precautions of smaller numbers. If you can dump your tables with an option value of at most 4, then you are relatively safe that only some data on corrupt individual pages is lost. A value of 6 is more drastic because database pages are left in an obsolete state, which in turn may introduce more corruption into B-trees and other database structures.

- `1` (`SRV_FORCE_IGNORE_CORRUPT`)

  Let the server run even if it detects a corrupt page. Try to make `SELECT * FROM tbl_name` jump over corrupt index records and pages, which helps in dumping tables.

- `2` (`SRV_FORCE_NO_BACKGROUND`)

  Prevent the main thread from running. If a crash would occur during the purge operation, this recovery value prevents it.

- `3` (`SRV_FORCE_NO_TRX_UNDO`)

  Do not run transaction rollbacks after recovery.

- `4` (`SRV_FORCE_NO_IBUF_MERGE`)

  Prevent insert buffer merge operations. If they would cause a crash, do not do them. Do not calculate table statistics.

- `5` (`SRV_FORCE_NO_UNDO_LOG_SCAN`)

  Do not look at undo logs when starting the database: `InnoDB` treats even incomplete transactions as committed.

- `6` (`SRV_FORCE_NO_LOG_REDO`)

  Do not do the log roll-forward in connection with recovery.

  With this value, you might not be able to do queries other than a basic `SELECT * FROM t`, with no `WHERE`, `ORDER BY`, or other clauses. More complex queries could encounter corrupted data structures and fail.

  If corruption within the table data prevents you from dumping the entire table contents, a query with an `ORDER BY primary_key DESC` clause might be able to dump the portion of the table after the corrupted part.

The database must not otherwise be used with any nonzero value of `innodb_force_recovery`. As a safety measure, `InnoDB` prevents users from performing `INSERT`, `UPDATE`, or `DELETE` operations when `innodb_force_recovery` is greater than 0.

You can `SELECT` from tables to dump them, or `DROP` or `CREATE` tables even if forced recovery is used. If you know that a given table is causing a crash on rollback, you can drop it. You can also use this to stop a runaway rollback caused by a failing mass import or `ALTER TABLE`. You can kill the `mysqld` process and set `innodb_force_recovery` to `3` to bring the database up without the rollback, then `DROP` the table that is causing the runaway rollback.

13.3.7.3. `InnoDB` Checkpoints

Making your log files very large may reduce disk I/O during checkpointing. It often makes sense to set the total size of the log files as large as the buffer pool or even larger. Although in the past large log files could make crash recovery take excessive time, starting with MySQL 5.5, performance enhancements to crash recovery make it possible to use large log files with fast startup after a crash. (Strictly speaking, this performance improvement is available for MySQL 5.1 with the InnoDB Plugin 1.0.7 and higher. It is with MySQL 5.5 and InnoDB 1.1 that this improvement is available in the default InnoDB storage engine.)

How Checkpoint Processing Works

`InnoDB` implements a checkpoint mechanism known as “fuzzy” checkpointing. `InnoDB` flushes modified database pages from the buffer pool in small batches. There is no need to flush the buffer pool in one single batch, which would in practice stop processing of user SQL statements during the checkpointing process.

During crash recovery, `InnoDB` looks for a checkpoint label written to the log files. It knows that all modifications to the database before the label are present in the disk image of the database. Then `InnoDB` scans the log files forward from the checkpoint, applying the logged modifications to the database.

`InnoDB` writes to its log files on a rotating basis. It also writes checkpoint information to the first log file at each checkpoint. All committed modifications that make the database pages in the buffer pool different from the images on disk must be available in the log files in case `InnoDB` has to do a recovery. This means that when `InnoDB` starts to reuse a log file, it has to make sure that the database page images on disk contain the modifications logged in the log file that `InnoDB` is going to reuse. In other words, `InnoDB` must create a checkpoint and this often involves flushing of modified database pages to disk.

13.3.8. Moving an `InnoDB` Database to Another Machine

On Windows, `InnoDB` always stores database and table names internally in lowercase. To move databases in a binary format from Unix to Windows or from Windows to Unix, create all databases and tables using lowercase names. A convenient way to accomplish this is to add the following line to the `[mysqld]` section of your `my.cnf` or `my.ini` file before creating any databases or tables:

```
[mysqld]
lower_case_table_names=1
```

Like `MyISAM` data files, `InnoDB` data and log files are binary-compatible on all platforms having the same floating-point number format. You can move an `InnoDB` database simply by copying all the relevant files listed in Section 13.3.7, “Backing Up and Recovering an `InnoDB` Database”. If the floating-point formats differ but you have not used `FLOAT` or `DOUBLE` data types in your tables, then the procedure is the same: simply copy the relevant files. If you use `mysqldump` to dump your tables on one machine and then import the dump files on the other machine, it does not matter whether the formats differ or your tables contain floating-point data.

One way to increase performance is to switch off autocommit mode when importing data, assuming that the tablespace has enough space for the big rollback segment that the import transactions generate. Do the commit only after importing a whole table or a segment of a table.

13.3.9. The `InnoDB` Transaction Model and Locking

To implement a large-scale, busy, or highly reliable database application, to port substantial code from a different database system, or to push MySQL performance to the limits of the laws of physics, you must understand the notions of transactions and locking as they relate to the InnoDB storage engine.

In the `InnoDB` transaction model, the goal is to combine the best properties of a multi-versioning database with traditional two-phase locking. `InnoDB` does locking on the row level and runs queries as nonlocking consistent reads by default, in the style of Oracle. The lock information in `InnoDB` is stored so space-efficiently that lock escalation is not needed: Typically, several users are permitted to lock every row in `InnoDB` tables, or any random subset of the rows, without causing `InnoDB` memory exhaustion.

In `InnoDB`, all user activity occurs inside a transaction. If autocommit mode is enabled, each SQL statement forms a single transaction on its own. By default, MySQL starts the session for each new connection with autocommit enabled, so MySQL does a commit after each SQL statement if that statement did not return an error. If a statement returns an error, the commit or rollback behavior depends on the error. See Section 13.3.13, “`InnoDB` Error Handling”.

A session that has autocommit enabled can perform a multiple-statement transaction by starting it with an explicit `START TRANSACTION` or `BEGIN` statement and ending it with a `COMMIT` or `ROLLBACK` statement. See Section 12.3.1, “`START TRANSACTION`, `COMMIT`, and `ROLLBACK` Syntax”.

If autocommit mode is disabled within a session with `SET autocommit = 0`, the session always has a transaction open. A `COMMIT` or `ROLLBACK` statement ends the current transaction and a new one starts.

A `COMMIT` means that the changes made in the current transaction are made permanent and become visible to other sessions. A `ROLLBACK` statement, on the other hand, cancels all modifications made by the current transaction. Both `COMMIT` and `ROLLBACK` release all `InnoDB` locks that were set during the current transaction.

In terms of the SQL:1992 transaction isolation levels, the default `InnoDB` level is `REPEATABLE READ`. `InnoDB` offers all four transaction isolation levels described by the SQL standard: `READ UNCOMMITTED`, `READ COMMITTED`, `REPEATABLE READ`, and `SERIALIZABLE`.

A user can change the isolation level for a single session or for all subsequent connections with the `SET TRANSACTION` statement. To set the server's default isolation level for all connections, use the `--transaction-isolation` option on the command line or in an option file. For detailed information about isolation levels and level-setting syntax, see Section 12.3.6, “`SET TRANSACTION` Syntax”.

In row-level locking, `InnoDB` normally uses next-key locking. That means that besides index records, `InnoDB` can also lock the “gap” preceding an index record to block insertions by other sessions in the gap immediately before the index record. A next-key lock refers to a lock that locks an index record and the gap before it. A gap lock refers to a lock that locks only the gap before some index record.

For more information about row-level locking, and the circumstances under which gap locking is disabled, see Section 13.3.9.4, “`InnoDB` Record, Gap, and Next-Key Locks”.

13.3.9.1. `InnoDB` Lock Modes

`InnoDB` implements standard row-level locking where there are two types of locks:

- A shared (*`S`*) lock permits a transaction to read a row.
- An exclusive (*`X`*) lock permits a transaction to update or delete a row.

If transaction `T1` holds a shared (*`S`*) lock on row `r`, then requests from some distinct transaction `T2` for a lock on row `r` are handled as follows:

- A request by `T2` for an *`S`* lock can be granted immediately. As a result, both `T1` and `T2` hold an *`S`* lock on `r`.
- A request by `T2` for an *`X`* lock cannot be granted immediately.

If a transaction `T1` holds an exclusive (*`X`*) lock on row `r`, a request from some distinct transaction `T2` for a lock of either type on `r` cannot be granted immediately. Instead, transaction `T2` has to wait for transaction `T1` to release its lock on row `r`.

Additionally, `InnoDB` supports *multiple granularity locking* which permits coexistence of record locks and locks on entire tables. To make locking at multiple granularity levels practical, additional types of locks called *intention locks* are used. Intention locks are table locks in `InnoDB`. The idea behind intention locks is for a transaction to indicate which type of lock (shared or exclusive) it will require later for a row in that table. There are two types of intention locks used in `InnoDB` (assume that transaction `T` has requested a lock of the indicated type on table `t`):

- Intention shared (*`IS`*): Transaction `T` intends to set *`S`* locks on individual rows in table `t`.
- Intention exclusive (*`IX`*): Transaction `T` intends to set *`X`* locks on those rows.

For example, `SELECT ... LOCK IN SHARE MODE` sets an *`IS`* lock and `SELECT ... FOR UPDATE` sets an *`IX`* lock.

The intention locking protocol is as follows:

- Before a transaction can acquire an *`S`* lock on a row in table `t`, it must first acquire an *`IS`* or stronger lock on `t`.
- Before a transaction can acquire an *`X`* lock on a row, it must first acquire an *`IX`* lock on `t`.

These rules can be conveniently summarized by means of the following *lock type compatibility matrix*.

	`X`	***`IX`***	***`S`***	***`IS`***
`X`	Conflict	Conflict	Conflict	Conflict
`IX`	Conflict	Compatible	Conflict	Compatible
`S`	Conflict	Conflict	Compatible	Compatible
`IS`	Conflict	Compatible	Compatible	Compatible

A lock is granted to a requesting transaction if it is compatible with existing locks, but not if it conflicts with existing locks. A transaction waits until the conflicting existing lock is released. If a lock request conflicts with an existing lock and cannot be granted because it would cause deadlock, an error occurs.

Thus, intention locks do not block anything except full table requests (for example, `LOCK TABLES ... WRITE`). The main purpose of *`IX`* and *`IS`* locks is to show that someone is locking a row, or going to lock a row in the table.

The following example illustrates how an error can occur when a lock request would cause a deadlock. The example involves two clients, A and B.

First, client A creates a table containing one row, and then begins a transaction. Within the transaction, A obtains an *`S`* lock on the row by selecting it in share mode:

```
mysql> CREATE TABLE t (i INT) ENGINE = InnoDB;
Query OK, 0 rows affected (1.07 sec)

mysql> INSERT INTO t (i) VALUES(1);
Query OK, 1 row affected (0.09 sec)

mysql> START TRANSACTION;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT * FROM t WHERE i = 1 LOCK IN SHARE MODE;
+------+
| i    |
+------+
|    1 |
+------+
1 row in set (0.10 sec)
```

Next, client B begins a transaction and attempts to delete the row from the table:

```
mysql> START TRANSACTION;
Query OK, 0 rows affected (0.00 sec)

mysql> DELETE FROM t WHERE i = 1;
```

The delete operation requires an *`X`* lock. The lock cannot be granted because it is incompatible with the *`S`* lock that client A holds, so the request goes on the queue of lock requests for the row and client B blocks.

Finally, client A also attempts to delete the row from the table:

```
mysql> DELETE FROM t WHERE i = 1;
ERROR 1213 (40001): Deadlock found when trying to get lock;
try restarting transaction
```

Deadlock occurs here because client A needs an *`X`* lock to delete the row. However, that lock request cannot be granted because client B already has a request for an *`X`* lock and is waiting for client A to release its *`S`* lock. Nor can the *`S`* lock held by A be upgraded to an *`X`* lock because of the prior request by B for an *`X`* lock. As a result, `InnoDB` generates an error for client A and releases its locks. At that point, the lock request for client B can be granted and B deletes the row from the table.

13.3.9.2. Consistent Nonlocking Reads

A consistent read means that `InnoDB` uses multi-versioning to present to a query a snapshot of the database at a point in time. The query sees the changes made by transactions that committed before that point of time, and no changes made by later or uncommitted transactions. The exception to this rule is that the query sees the changes made by earlier statements within the same transaction. This exception causes the following anomaly: If you update some rows in a table, a `SELECT` sees the latest version of the updated rows, but it might also see older versions of any rows. If other sessions simultaneously update the same table, the anomaly means that you might see the table in a state that never existed in the database.

If the transaction isolation level is `REPEATABLE READ` (the default level), all consistent reads within the same transaction read the snapshot established by the first such read in that transaction. You can get a fresher snapshot for your queries by committing the current transaction and after that issuing new queries.

With `READ COMMITTED` isolation level, each consistent read within a transaction sets and reads its own fresh snapshot.

Consistent read is the default mode in which `InnoDB` processes `SELECT` statements in `READ COMMITTED` and `REPEATABLE READ` isolation levels. A consistent read does not set any locks on the tables it accesses, and therefore other sessions are free to modify those tables at the same time a consistent read is being performed on the table.

Suppose that you are running in the default `REPEATABLE READ` isolation level. When you issue a consistent read (that is, an ordinary `SELECT` statement), `InnoDB` gives your transaction a timepoint according to which your query sees the database. If another transaction deletes a row and commits after your timepoint was assigned, you do not see the row as having been deleted. Inserts and updates are treated similarly.

You can advance your timepoint by committing your transaction and then doing another `SELECT`.

This is called *multi-versioned concurrency control*.

In the following example, session A sees the row inserted by B only when B has committed the insert and A has committed as well, so that the timepoint is advanced past the commit of B.

```
             Session A              Session B

           SET autocommit=0;      SET autocommit=0;
time
|          SELECT * FROM t;
|          empty set
|                                 INSERT INTO t VALUES (1, 2);
|
v          SELECT * FROM t;
           empty set
                                  COMMIT;

           SELECT * FROM t;
           empty set

           COMMIT;

           SELECT * FROM t;
           ---------------------
           |    1    |    2    |
           ---------------------
           1 row in set
```

If you want to see the “freshest” state of the database, use either the `READ COMMITTED` isolation level or a locking read:

```
SELECT * FROM t LOCK IN SHARE MODE;
```

With `READ COMMITTED` isolation level, each consistent read within a transaction sets and reads its own fresh snapshot. With `LOCK IN SHARE MODE`, a locking read occurs instead: A `SELECT` blocks until the transaction containing the freshest rows ends (see Section 13.3.9.3, “`SELECT ... FOR UPDATE` and `SELECT ... LOCK IN SHARE MODE` Locking Reads”).

Consistent read does not work over certain DDL statements:

- Consistent read does not work over `DROP TABLE`, because MySQL cannot use a table that has been dropped and `InnoDB` destroys the table.
- Consistent read does not work over `ALTER TABLE`, because that statement makes a temporary copy of the original table and deletes the original table when the temporary copy is built. When you reissue a consistent read within a transaction, rows in the new table are not visible because those rows did not exist when the transaction's snapshot was taken.

`InnoDB` uses a consistent read for select in clauses like `INSERT INTO ... SELECT`, `UPDATE ... (SELECT)`, and `CREATE TABLE ... SELECT` that do not specify `FOR UPDATE` or `LOCK IN SHARE MODE` if the `innodb_locks_unsafe_for_binlog` option is set and the isolation level of the transaction is not set to `SERIALIZABLE`. Thus, no locks are set on rows read from the selected table. Otherwise, `InnoDB` uses stronger locks and the `SELECT` part acts like `READ COMMITTED`, where each consistent read, even within the same transaction, sets and reads its own fresh snapshot.

13.3.9.3. `SELECT ... FOR UPDATE` and `SELECT ... LOCK IN SHARE MODE` Locking Reads

If you query data and then insert or update related data within the same transaction, the regular `SELECT` statement does not give enough protection. Other transactions can update or delete the same rows you just queried. `InnoDB` supports two types of locking reads that offer extra safety:

- `SELECT ... LOCK IN SHARE MODE` sets a shared mode lock on any rows that are read. Other sessions can read the rows, but cannot modify them until your transaction commits. If any of these rows were changed by another transaction that has not yet committed, your query waits until that transaction ends and then uses the latest values.
- `SELECT ... FOR UPDATE` locks the rows and any associated index entries, the same as if you issued an `UPDATE` statement for those rows. Other transactions are blocked from updating those rows, from doing `SELECT ... LOCK IN SHARE MODE`, or from reading the data in certain transaction isolation levels. Consistent reads ignore any locks set on the records that exist in the read view. (Old versions of a record cannot be locked; they are reconstructed by applying undo logs on an in-memory copy of the record.)

These clauses are primarily useful when dealing with tree-structured or graph-structured data, either in a single table or split across multiple tables.

All locks set by `LOCK IN SHARE MODE` and `FOR UPDATE` queries are released when the transaction is committed or rolled back.

> **Note**
>
> Locking of rows for update using `SELECT FOR UPDATE` only applies when autocommit is disabled (either by beginning transaction with `START TRANSACTION` or by setting `autocommit` to 0. If autocommit is enabled, the rows matching the specification are not locked.

Usage Examples

Suppose that you want to insert a new row into a table `child`, and make sure that the child row has a parent row in table `parent`. Your application code can ensure referential integrity throughout this sequence of operations.

First, use a consistent read to query the table `PARENT` and verify that the parent row exists. Can you safely insert the child row to table `CHILD`? No, because some other session could delete the parent row in the moment between your `SELECT` and your `INSERT`, without you being aware of it.

To avoid this potential issue, perform the `SELECT` using `LOCK IN SHARE MODE`:

```
SELECT * FROM parent WHERE NAME = 'Jones' LOCK IN SHARE MODE;
```

After the `LOCK IN SHARE MODE` query returns the parent `'Jones'`, you can safely add the child record to the `CHILD` table and commit the transaction. Any transaction that tries to read or write to the applicable row in the `PARENT` table waits until you are finished, that is, the data in all tables is in a consistent state.

For another example, consider an integer counter field in a table `CHILD_CODES`, used to assign a unique identifier to each child added to table `CHILD`. Do not use either consistent read or a shared mode read to read the present value of the counter, because two users of the database could see the same value for the counter, and a duplicate-key error occurs if two transactions attempt to add rows with the same identifier to the `CHILD` table.

Here, `LOCK IN SHARE MODE` is not a good solution because if two users read the counter at the same time, at least one of them ends up in deadlock when it attempts to update the counter.

Here are two ways to implement reading and incrementing the counter without interference from another transaction:

- First update the counter by incrementing it by 1, then read it and use the new value in the `CHILD` table. Any other transaction that tries to read the counter waits until your transaction commits. If another transaction is in the middle of this same sequence, your transaction waits until the other one commits.
- First perform a locking read of the counter using `FOR UPDATE`, and then increment the counter:

  ```
  SELECT counter_field FROM child_codes FOR UPDATE;
  UPDATE child_codes SET counter_field = counter_field + 1;
  ```

A `SELECT ... FOR UPDATE` reads the latest available data, setting exclusive locks on each row it reads. Thus, it sets the same locks a searched SQL `UPDATE` would set on the rows.

The preceding description is merely an example of how `SELECT ... FOR UPDATE` works. In MySQL, the specific task of generating a unique identifier actually can be accomplished using only a single access to the table:

```
UPDATE child_codes SET counter_field = LAST_INSERT_ID(counter_field + 1);
SELECT LAST_INSERT_ID();
```

The `SELECT` statement merely retrieves the identifier information (specific to the current connection). It does not access any table.

13.3.9.4. InnoDB Record, Gap, and Next-Key Locks

`InnoDB` has several types of record-level locks:

- Record lock: This is a lock on an index record.
- Gap lock: This is a lock on a gap between index records, or a lock on the gap before the first or after the last index record.
- Next-key lock: This is a combination of a record lock on the index record and a gap lock on the gap before the index record.

Record locks always lock index records, even if a table is defined with no indexes. For such cases, `InnoDB` creates a hidden clustered index and uses this index for record locking. See Section 13.3.11.1, “Clustered and Secondary Indexes”.

By default, `InnoDB` operates in `REPEATABLE READ` transaction isolation level and with the `innodb_locks_unsafe_for_binlog` system variable disabled. In this case, `InnoDB` uses next-key locks for searches and index scans, which prevents phantom rows (see Section 13.3.9.5, “Avoiding the Phantom Problem Using Next-Key Locking”).

Next-key locking combines index-row locking with gap locking. `InnoDB` performs row-level locking in such a way that when it searches or scans a table index, it sets shared or exclusive locks on the index records it encounters. Thus, the row-level locks are actually index-record locks. In addition, a next-key lock on an index record also affects the “gap” before that index record. That is, a next-key lock is an index-record lock plus a gap lock on the gap preceding the index record. If one session has a shared or exclusive lock on record `R` in an index, another session cannot insert a new index record in the gap immediately before `R` in the index order.

Suppose that an index contains the values 10, 11, 13, and 20. The possible next-key locks for this index cover the following intervals, where `(` or `)` denote exclusion of the interval endpoint and `[` or `]` denote inclusion of the endpoint:

```
(negative infinity, 10]
(10, 11]
(11, 13]
(13, 20]
(20, positive infinity)
```

For the last interval, the next-key lock locks the gap above the largest value in the index and the “supremum” pseudo-record having a value higher than any value actually in the index. The supremum is not a real index record, so, in effect, this next-key lock locks only the gap following the largest index value.

The preceding example shows that a gap might span a single index value, multiple index values, or even be empty.

Gap locking is not needed for statements that lock rows using a unique index to search for a unique row. (This does not include the case that the search condition includes only some columns of a multiple-column unique index; in that case, gap locking does occur.) For example, if the `id` column has a unique index, the following statement uses only an index-record lock for the row having `id` value 100 and it does not matter whether other sessions insert rows in the preceding gap:

```
SELECT * FROM child WHERE id = 100;
```

If `id` is not indexed or has a nonunique index, the statement does lock the preceding gap.

A type of gap lock called an insertion intention gap lock is set by `INSERT` operations prior to row insertion. This lock signals the intent to insert in such a way that multiple transactions inserting into the same index gap need not wait for each other if they are not inserting at the same position within the gap. Suppose that there are index records with values of 4 and 7. Separate transactions that attempt to insert values of 5 and 6 each lock the gap between 4 and 7 with insert intention locks prior to obtaining the exclusive lock on the inserted row, but do not block each other because the rows are nonconflicting.

Gap locking can be disabled explicitly. This occurs if you change the transaction isolation level to `READ COMMITTED` or enable the `innodb_locks_unsafe_for_binlog` system variable. Under these circumstances, gap locking is disabled for searches and index scans and is used only for foreign-key constraint checking and duplicate-key checking.

There are also other effects of using the `READ COMMITTED` isolation level or enabling `in-`

`nodb_locks_unsafe_for_binlog`: Record locks for nonmatching rows are released after MySQL has evaluated the `WHERE` condition. For `UPDATE` statements, `InnoDB` does a “semi-consistent” read, such that it returns the latest committed version to MySQL so that MySQL can determine whether the row matches the `WHERE` condition of the `UPDATE`.

13.3.9.5. Avoiding the Phantom Problem Using Next-Key Locking

The so-called *phantom* problem occurs within a transaction when the same query produces different sets of rows at different times. For example, if a `SELECT` is executed twice, but returns a row the second time that was not returned the first time, the row is a “phantom” row.

Suppose that there is an index on the `id` column of the `child` table and that you want to read and lock all rows from the table having an identifier value larger than 100, with the intention of updating some column in the selected rows later:

```
SELECT * FROM child WHERE id > 100 FOR UPDATE;
```

The query scans the index starting from the first record where `id` is bigger than 100. Let the table contain rows having `id` values of 90 and 102. If the locks set on the index records in the scanned range do not lock out inserts made in the gaps (in this case, the gap between 90 and 102), another session can insert a new row into the table with an `id` of 101. If you were to execute the same `SELECT` within the same transaction, you would see a new row with an `id` of 101 (a “phantom”) in the result set returned by the query. If we regard a set of rows as a data item, the new phantom child would violate the isolation principle of transactions that a transaction should be able to run so that the data it has read does not change during the transaction.

To prevent phantoms, `InnoDB` uses an algorithm called *next-key locking* that combines index-row locking with gap locking. `InnoDB` performs row-level locking in such a way that when it searches or scans a table index, it sets shared or exclusive locks on the index records it encounters. Thus, the row-level locks are actually index-record locks. In addition, a next-key lock on an index record also affects the “gap” before that index record. That is, a next-key lock is an index-record lock plus a gap lock on the gap preceding the index record. If one session has a shared or exclusive lock on record `R` in an index, another session cannot insert a new index record in the gap immediately before `R` in the index order.

When `InnoDB` scans an index, it can also lock the gap after the last record in the index. Just that happens in the preceding example: To prevent any insert into the table where `id` would be bigger than 100, the locks set by `InnoDB` include a lock on the gap following `id` value 102.

You can use next-key locking to implement a uniqueness check in your application: If you read your data in share mode and do not see a duplicate for a row you are going to insert, then you can safely insert your row and know that the next-key lock set on the successor of your row during the read prevents anyone meanwhile inserting a duplicate for your row. Thus, the next-key locking enables you to “lock” the nonexistence of something in your table.

Gap locking can be disabled as discussed in Section 13.3.9.4, “`InnoDB` Record, Gap, and Next-Key Locks”. This may cause phantom problems because other sessions can insert new rows into the gaps when gap locking is disabled.

13.3.9.6. Locks Set by Different SQL Statements in `InnoDB`

A locking read, an `UPDATE`, or a `DELETE` generally set record locks on every index record that is scanned in the processing of the SQL statement. It does not matter whether there are `WHERE` conditions in the statement that would exclude the row. `InnoDB` does not remember the exact `WHERE` condition, but only knows which index ranges were scanned. The locks are normally next-key locks that also block inserts into the “gap” immediately before the record. However, gap locking can be disabled explicitly, which causes next-key locking not to be used. For more information, see Section 13.3.9.4, “`InnoDB` Record, Gap, and Next-Key Locks”. The transaction isolation level also can affect which locks are set; see Section 12.3.6, “`SET TRANSACTION` Syntax”.

If a secondary index is used in a search and index record locks to be set are exclusive, `InnoDB` also retrieves the corresponding clustered index records and sets locks on them.

Differences between shared and exclusive locks are described in Section 13.3.9.1, “`InnoDB` Lock Modes”.

If you have no indexes suitable for your statement and MySQL must scan the entire table to process the statement, every row of the table becomes locked, which in turn blocks all inserts by other users to the table. It is important to create good indexes so that your queries do not unnecessarily scan many rows.

For `SELECT ... FOR UPDATE` or `SELECT ... LOCK IN SHARE MODE`, locks are acquired for scanned rows, and expected to be released for rows that do not qualify for inclusion in the result set (for example, if they do not meet the criteria given in the `WHERE` clause). However, in some cases, rows might not be unlocked immediately because the relationship between a result row and its original source is lost during query execution. For example, in a `UNION`, scanned (and locked) rows from a table might be inserted into a temporary table before evaluation whether they qualify for the result set. In this circumstance, the relationship of the rows in the temporary table to the rows in the original table is lost and the latter rows are not unlocked until the end of query execution.

`InnoDB` sets specific types of locks as follows.

- `SELECT ... FROM` is a consistent read, reading a snapshot of the database and setting no locks unless the transaction isolation level is set to `SERIALIZABLE`. For `SERIALIZABLE` level, the search sets shared next-key locks on the index records it encounters.
- `SELECT ... FROM ... LOCK IN SHARE MODE` sets shared next-key locks on all index records the search encounters.
- For index records the search encounters, `SELECT ... FROM ... FOR UPDATE` blocks other sessions from doing `SELECT ... FROM ... LOCK IN SHARE MODE` or from reading in certain transaction isolation levels. Consistent reads will ignore any locks set on the records that exist in the read view.
- `UPDATE ... WHERE ...` sets an exclusive next-key lock on every record the search encounters.
- `DELETE FROM ... WHERE ...` sets an exclusive next-key lock on every record the search encounters.
- `INSERT` sets an exclusive lock on the inserted row. This lock is an index-record lock, not a next-key lock (that is, there is no gap lock) and does not prevent other sessions from inserting into the gap before the inserted row.

  Prior to inserting the row, a type of gap lock called an insertion intention gap lock is set. This lock signals the intent to insert in such a way that multiple transactions inserting into the same index gap need not wait for each other if they are not inserting at the same position within the gap. Suppose that there are index records with values of 4 and 7. Separate transactions that attempt to insert values of 5 and 6 each lock the gap between 4 and 7 with insert intention locks prior to obtaining the exclusive lock on the inserted row, but do not block each other because the rows are nonconflicting.

  If a duplicate-key error occurs, a shared lock on the duplicate index record is set. This use of a shared lock can result in deadlock should there be multiple sessions trying to insert the same row if another session already has an exclusive lock. This can occur if another session deletes the row. Suppose that an `InnoDB` table `t1` has the following structure:

  ```
  CREATE TABLE t1 (i INT, PRIMARY KEY (i)) ENGINE = InnoDB;
  ```

  Now suppose that three sessions perform the following operations in order:

  Session 1:

  ```
  START TRANSACTION;
  INSERT INTO t1 VALUES(1);
  ```

  Session 2:

  ```
  START TRANSACTION;
  INSERT INTO t1 VALUES(1);
  ```

  Session 3:

  ```
  START TRANSACTION;
  INSERT INTO t1 VALUES(1);
  ```

  Session 1:

  ```
  ROLLBACK;
  ```

  The first operation by session 1 acquires an exclusive lock for the row. The operations by sessions 2 and 3 both result in a duplicate-key error and they both request a shared lock for the row. When session 1 rolls back, it releases its exclusive lock on the row and the queued shared lock requests for sessions 2 and 3 are granted. At this point, sessions 2 and 3 deadlock: Neither can acquire an exclusive lock for the row because of the shared lock held by the other.

  A similar situation occurs if the table already contains a row with key value 1 and three sessions perform the following operations in order:

  Session 1:

  ```
  START TRANSACTION;
  DELETE FROM t1 WHERE i = 1;
  ```

  Session 2:

  ```
  START TRANSACTION;
  INSERT INTO t1 VALUES(1);
  ```

  Session 3:

```
START TRANSACTION;
INSERT INTO t1 VALUES(1);
```

Session 1:

```
COMMIT;
```

The first operation by session 1 acquires an exclusive lock for the row. The operations by sessions 2 and 3 both result in a duplicate-key error and they both request a shared lock for the row. When session 1 commits, it releases its exclusive lock on the row and the queued shared lock requests for sessions 2 and 3 are granted. At this point, sessions 2 and 3 deadlock: Neither can acquire an exclusive lock for the row because of the shared lock held by the other.

- `INSERT ... ON DUPLICATE KEY UPDATE` differs from a simple `INSERT` in that an exclusive next-key lock rather than a shared lock is placed on the row to be updated when a duplicate-key error occurs.

- `REPLACE` is done like an `INSERT` if there is no collision on a unique key. Otherwise, an exclusive next-key lock is placed on the row to be replaced.

- `INSERT INTO T SELECT ... FROM S WHERE ...` sets an exclusive index record without a gap lock on each row inserted into `T`. If the transaction isolation level is `READ COMMITTED` or `innodb_locks_unsafe_for_binlog` is enabled, and the transaction isolation level is not `SERIALIZABLE`, `InnoDB` does the search on `S` as a consistent read (no locks). Otherwise, `InnoDB` sets shared next-key locks on rows from `S`. `InnoDB` has to set locks in the latter case: In roll-forward recovery from a backup, every SQL statement must be executed in exactly the same way it was done originally.

  `CREATE TABLE ... SELECT ...` performs the `SELECT` with shared next-key locks or as a consistent read, as for `INSERT ... SELECT`.

  For `REPLACE INTO T SELECT ... FROM S WHERE ...`, `InnoDB` sets shared next-key locks on rows from `S`.

- While initializing a previously specified `AUTO_INCREMENT` column on a table, `InnoDB` sets an exclusive lock on the end of the index associated with the `AUTO_INCREMENT` column. In accessing the auto-increment counter, `InnoDB` uses a specific `AUTO-INC` table lock mode where the lock lasts only to the end of the current SQL statement, not to the end of the entire transaction. Other sessions cannot insert into the table while the `AUTO-INC` table lock is held; see Section 13.3.9, “The `InnoDB` Transaction Model and Locking”.

  `InnoDB` fetches the value of a previously initialized `AUTO_INCREMENT` column without setting any locks.

- If a `FOREIGN KEY` constraint is defined on a table, any insert, update, or delete that requires the constraint condition to be checked sets shared record-level locks on the records that it looks at to check the constraint. `InnoDB` also sets these locks in the case where the constraint fails.

- `LOCK TABLES` sets table locks, but it is the higher MySQL layer above the `InnoDB` layer that sets these locks. `InnoDB` is aware of table locks if `innodb_table_locks = 1` (the default) and `autocommit = 0`, and the MySQL layer above `InnoDB` knows about row-level locks.

  Otherwise, `InnoDB`'s automatic deadlock detection cannot detect deadlocks where such table locks are involved. Also, because in this case the higher MySQL layer does not know about row-level locks, it is possible to get a table lock on a table where another session currently has row-level locks. However, this does not endanger transaction integrity, as discussed in Section 13.3.9.8, “Deadlock Detection and Rollback”. See also Section 13.3.15, “Limits on `InnoDB` Tables”.

13.3.9.7. Implicit Transaction Commit and Rollback

By default, MySQL starts the session for each new connection with autocommit mode enabled, so MySQL does a commit after each SQL statement if that statement did not return an error. If a statement returns an error, the commit or rollback behavior depends on the error. See Section 13.3.13, “`InnoDB` Error Handling”.

If a session that has autocommit disabled ends without explicitly committing the final transaction, MySQL rolls back that transaction.

Some statements implicitly end a transaction, as if you had done a `COMMIT` before executing the statement. For details, see Section 12.3.3, “Statements That Cause an Implicit Commit”.

13.3.9.8. Deadlock Detection and Rollback

`InnoDB` automatically detects transaction deadlocks and rolls back a transaction or transactions to break the deadlock. `InnoDB` tries to pick small transactions to roll back, where the size of a transaction is determined by the number of rows inserted, updated, or deleted.

`InnoDB` is aware of table locks if `innodb_table_locks = 1` (the default) and `autocommit = 0`, and the MySQL layer above it knows about row-level locks. Otherwise, `InnoDB` cannot detect deadlocks where a table lock set by a MySQL `LOCK TABLES` statement or a lock set by a storage engine other than `InnoDB` is involved. Resolve these situations by setting the value of the `innodb_lock_wait_timeout` system variable.

When `InnoDB` performs a complete rollback of a transaction, all locks set by the transaction are released. However, if just a single SQL statement is rolled back as a result of an error, some of the locks set by the statement may be preserved. This happens because `InnoDB` stores row locks in a format such that it cannot know afterward which lock was set by which statement.

If a `SELECT` calls a stored function in a transaction, and a statement within the function fails, that statement rolls back. Furthermore, if `ROLLBACK` is executed after that, the entire transaction rolls back.

13.3.9.9. How to Cope with Deadlocks

Deadlocks are a classic problem in transactional databases, but they are not dangerous unless they are so frequent that you cannot run certain transactions at all. Normally, you must write your applications so that they are always prepared to re-issue a transaction if it gets rolled back because of a deadlock.

`InnoDB` uses automatic row-level locking. You can get deadlocks even in the case of transactions that just insert or delete a single row. That is because these operations are not really “atomic”; they automatically set locks on the (possibly several) index records of the row inserted or deleted.

You can cope with deadlocks and reduce the likelihood of their occurrence with the following techniques:

- Use `SHOW ENGINE INNODB STATUS` to determine the cause of the latest deadlock. That can help you to tune your application to avoid deadlocks.

- Always be prepared to re-issue a transaction if it fails due to deadlock. Deadlocks are not dangerous. Just try again.

- Commit your transactions often. Small transactions are less prone to collision.

- If you are using locking reads (`SELECT ... FOR UPDATE` or `SELECT ... LOCK IN SHARE MODE`), try using a lower isolation level such as `READ COMMITTED`.

- Access your tables and rows in a fixed order. Then transactions form well-defined queues and do not deadlock.

- Add well-chosen indexes to your tables. Then your queries need to scan fewer index records and consequently set fewer locks. Use `EXPLAIN SELECT` to determine which indexes the MySQL server regards as the most appropriate for your queries.

- Use less locking. If you can afford to permit a `SELECT` to return data from an old snapshot, do not add the clause `FOR UPDATE` or `LOCK IN SHARE MODE` to it. Using the `READ COMMITTED` isolation level is good here, because each consistent read within the same transaction reads from its own fresh snapshot.

- If nothing else helps, serialize your transactions with table-level locks. The correct way to use `LOCK TABLES` with transactional tables, such as `InnoDB` tables, is to begin a transaction with `SET autocommit = 0` (not `START TRANSACTION`) followed by `LOCK TABLES`, and to not call `UNLOCK TABLES` until you commit the transaction explicitly. For example, if you need to write to table `t1` and read from table `t2`, you can do this:

  ```
  SET autocommit=0;
  LOCK TABLES t1 WRITE, t2 READ, ...;
  ... do something with tables t1 and t2 here ...
  COMMIT;
  UNLOCK TABLES;
  ```

  Table-level locks make your transactions queue nicely and avoid deadlocks.

- Another way to serialize transactions is to create an auxiliary “semaphore” table that contains just a single row. Have each transaction update that row before accessing other tables. In that way, all transactions happen in a serial fashion. Note that the `InnoDB` instant deadlock detection algorithm also works in this case, because the serializing lock is a row-level lock. With MySQL table-level locks, the timeout method must be used to resolve deadlocks.

13.3.10. `InnoDB` Multi-Versioning

`InnoDB` is a multi-versioned storage engine: it keeps information about old versions of changed rows, to support transactional features such as concurrency and rollback. This information is stored in the tablespace in a data structure called a rollback segment (after an analogous data structure in Oracle). `InnoDB` uses the information in the rollback segment to perform the undo operations needed in a transaction rollback. It also uses the information to build earlier versions of a row for a consistent read.

Internal Details of Multi-Versioning

Internally, `InnoDB` adds three fields to each row stored in the database. A 6-byte `DB_TRX_ID` field indicates the transaction identifier for the last transaction that inserted or updated the row. Also, a deletion is treated internally as an update where a special bit in the row is set to mark it as deleted. Each row also contains a 7-byte `DB_ROLL_PTR` field called the roll pointer. The roll pointer points to an undo log record written to the rollback segment. If the row was updated, the undo log record contains the information necessary to rebuild the content of the row before it was updated. A 6-byte `DB_ROW_ID` field contains a row ID that increases monotonically as new rows are inserted. If `InnoDB` generates a clustered index automatically, the index contains row ID values. Otherwise, the `DB_ROW_ID` column does not appear in any index.

Undo logs in the rollback segment are divided into insert and update undo logs. Insert undo logs are needed only in transaction rollback and can be discarded as soon as the transaction commits. Update undo logs are used also in consistent reads, but they can be discarded only after there is no transaction present for which `InnoDB` has assigned a snapshot that in a consistent read could need the information in the update undo log to build an earlier version of a database row.

Guidelines for Managing Rollback Segments

Commit your transactions regularly, including those transactions that issue only consistent reads. Otherwise, `InnoDB` cannot discard data from the update undo logs, and the rollback segment may grow too big, filling up your tablespace.

The physical size of an undo log record in the rollback segment is typically smaller than the corresponding inserted or updated row. You can use this information to calculate the space needed for your rollback segment.

In the `InnoDB` multi-versioning scheme, a row is not physically removed from the database immediately when you delete it with an SQL statement. `InnoDB` only physically removes the corresponding row and its index records when it discards the update undo log record written for the deletion. This removal operation is called a purge, and it is quite fast, usually taking the same order of time as the SQL statement that did the deletion.

If you insert and delete rows in smallish batches at about the same rate in the table, the purge thread can start to lag behind and the table can grow bigger and bigger because of all the “dead” rows, making everything disk-bound and very slow In such a case, throttle new row operations, and allocate more resources to the purge thread by tuning the `innodb_max_purge_lag` system variable. See Section 13.3.4, “`InnoDB` Startup Options and System Variables” for more information.

13.3.11. `InnoDB` Table and Index Structures

Role of the .frm File

MySQL stores its data dictionary information for tables in `.frm` files in database directories. This is true for all MySQL storage engines, but every `InnoDB` table also has its own entry in the `InnoDB` internal data dictionary inside the tablespace. When MySQL drops a table or a database, it has to delete one or more `.frm` files as well as the corresponding entries inside the `InnoDB` data dictionary. Consequently, you cannot move `InnoDB` tables between databases simply by moving the `.frm` files.

13.3.11.1. Clustered and Secondary Indexes

Every `InnoDB` table has a special index called the clustered index where the data for the rows is stored. Typically, the clustered index is synonymous with the primary key. To get the best performance from queries, inserts, and other database operations, you must understand how InnoDB uses the clustered index to optimize the most common lookup and DML operations for each table.

- If you define a `PRIMARY KEY` on your table, `InnoDB` uses it as the clustered index. Define a primary key for each table that you create. If there is no logical unique and non-null column or set of columns, add a new auto-increment column, whose values are filled in automatically.

- If you do not define a `PRIMARY KEY` for your table, MySQL locates the first `UNIQUE` index where all the key columns are `NOT NULL` and `InnoDB` uses it as the clustered index.

- If the table has no `PRIMARY KEY` or suitable `UNIQUE` index, `InnoDB` internally generates a hidden clustered index on a synthetic column containing row ID values. The rows are ordered by the ID that `InnoDB` assigns to the rows in such a table. The row ID is a 6-byte field that increases monotonically as new rows are inserted. Thus, the rows ordered by the row ID are physically in insertion order.

How the Clustered Index Speeds Up Queries

Accessing a row through the clustered index is fast because the row data is on the same page where the index search leads. If a table is large, the clustered index architecture often saves a disk I/O operation when compared to storage organizations that store row data using a different page from the index record. (For example, `MyISAM` uses one file for data rows and another for index records.)

How Secondary Indexes Relate to the Clustered Index

All indexes other than the clustered index are known as secondary indexes. In `InnoDB`, each record in a secondary index contains the primary key columns for the row, as well as the columns specified for the secondary index. `InnoDB` uses this primary key value to search for the row in the clustered index.

If the primary key is long, the secondary indexes use more space, so it is advantageous to have a short primary key.

13.3.11.2. Physical Structure of an InnoDB Index

All `InnoDB` indexes are B-trees where the index records are stored in the leaf pages of the tree. The default size of an index page is 16KB. When new records are inserted, `InnoDB` tries to leave 1/16 of the page free for future insertions and updates of the index records.

If index records are inserted in a sequential order (ascending or descending), the resulting index pages are about 15/16 full. If records are inserted in a random order, the pages are from 1/2 to 15/16 full. If the fill factor of an index page drops below 1/2, `InnoDB` tries to contract the index tree to free the page.

> **Note**
>
> Changing the page size is not a supported operation and there is no guarantee that `InnoDB` will function normally with a page size other than 16KB. Problems compiling or running InnoDB may occur. In particular, `ROW_FORMAT=COMPRESSED` in the Barracuda file format assumes that the page size is at most 16KB and uses 14-bit pointers.
>
> A version of `InnoDB` built for one page size cannot use data files or log files from a version built for a different page size.

13.3.11.3. Insert Buffering

Database applications often insert new rows in the ascending order of the primary key. In this case, due to the layout of the clustered index in the same order as the primary key, insertions into an InnoDB table do not require random reads from a disk.

On the other hand, secondary indexes are usually nonunique, and insertions into secondary indexes happen in a relatively random order. In the same way, deletes and updates can affect data pages that are not adjacent in secondary indexes. This would cause a lot of random disk I/O operations without a special mechanism used in `InnoDB`.

When an index record is inserted, marked for deletion, or deleted from a nonunique secondary index, `InnoDB` checks whether the secondary index page is in the buffer pool. If that is the case, `InnoDB` applies the change directly to the index page. If the index page is not found in the buffer pool, `InnoDB` records the change in a special structure known as the insert buffer. The insert buffer is kept small so that it fits entirely in the buffer pool, and changes can be applied very quickly. This process is known as change buffering. (Formerly, it applied only to inserts and was called insert buffering. The data structure is still called the insert buffer.)

Disk I/O for Flushing the Insert Buffer

Periodically, the insert buffer is merged into the secondary index trees in the database. Often, it is possible to merge several changes into the same page of the index tree, saving disk I/O operations. It has been measured that the insert buffer can speed up insertions into a table up to 15 times.

The insert buffer merging may continue to happen *after* the transaction has been committed. In fact, it may continue to happen after a server shutdown and restart (see Section 13.3.7.2, “Forcing `InnoDB` Recovery”).

Insert buffer merging may take many hours when many secondary indexes must be updated and many rows have been inserted. During this time, disk I/O will be increased, which can cause significant slowdown on disk-bound queries. Another significant background I/O operation is the purge thread (see Section 13.3.10, “`InnoDB` Multi-Versioning”).

13.3.11.4. Adaptive Hash Indexes

The feature known as the adaptive hash index lets `InnoDB` perform more like an in-memory database on systems with appropriate combinations of workload and ample memory for the buffer pool, without sacrificing any transactional features or reliability.

If a table fits almost entirely in main memory, a hash index can speed up queries by enabling direct lookup of any element, turning the index value into a sort of pointer. `InnoDB` has a mechanism that monitors index searches. If `InnoDB` notices that queries could benefit from building a hash index, it does so automatically.

The hash index is always built based on an existing B-tree index on the table. `InnoDB` can build a hash index on a prefix of any length of the key defined for the B-tree, depending on the pattern of searches that `InnoDB` observes for the B-tree index. A hash index can be partial, covering only those pages of the index that are often accessed.

13.3.11.5. Physical Row Structure

The physical row structure for an `InnoDB` table depends on the row format specified when the table was created. `InnoDB` uses the `COMPACT` format by default, but the `REDUNDANT` format is available to retain compatibility with older versions of MySQL. To check the row format of an `InnoDB` table, use `SHOW TABLE STATUS`.

The compact row format decreases row storage space by about 20% at the cost of increasing CPU use for some operations. If your workload is a typical one that is limited by cache hit rates and disk speed, compact format is likely to be faster. If the workload is a rare case that is limited by CPU speed, compact format might be slower.

Rows in `InnoDB` tables that use `REDUNDANT` row format have the following characteristics:

- Each index record contains a six-byte header. The header is used to link together consecutive records, and also in row-level locking.
- Records in the clustered index contain fields for all user-defined columns. In addition, there is a six-byte transaction ID field and a seven-byte roll pointer field.
- If no primary key was defined for a table, each clustered index record also contains a six-byte row ID field.
- Each secondary index record also contains all the primary key fields defined for the clustered index key that are not in the secondary index.
- A record contains a pointer to each field of the record. If the total length of the fields in a record is less than 128 bytes, the pointer is one byte; otherwise, two bytes. The array of these pointers is called the record directory. The area where these pointers point is called the data part of the record.
- Internally, `InnoDB` stores fixed-length character columns such as `CHAR(10)` in a fixed-length format. `InnoDB` does not truncate trailing spaces from `VARCHAR` columns.
- An SQL `NULL` value reserves one or two bytes in the record directory. Besides that, an SQL `NULL` value reserves zero bytes in the data part of the record if stored in a variable length column. In a fixed-length column, it reserves the fixed length of the column in the data part of the record. Reserving the fixed space for `NULL` values enables an update of the column from `NULL` to a non-`NULL` value to be done in place without causing fragmentation of the index page.

Rows in `InnoDB` tables that use `COMPACT` row format have the following characteristics:

- Each index record contains a five-byte header that may be preceded by a variable-length header. The header is used to link together consecutive records, and also in row-level locking.
- The variable-length part of the record header contains a bit vector for indicating `NULL` columns. If the number of columns in the index that can be `NULL` is *`N`*, the bit vector occupies `CEILING(`*`N`*`/8)` bytes. (For example, if there are anywhere from 9 to 15 columns that can be `NULL`, the bit vector uses two bytes.) Columns that are `NULL` do not occupy space other than the bit in this vector. The variable-length part of the header also contains the lengths of variable-length columns. Each length takes one or two bytes, depending on the maximum length of the column. If all columns in the index are `NOT NULL` and have a fixed length, the record header has no variable-length part.
- For each non-`NULL` variable-length field, the record header contains the length of the column in one or two bytes. Two bytes will only be needed if part of the column is stored externally in overflow pages or the maximum length exceeds 255 bytes and the actual length exceeds 127 bytes. For an externally stored column, the two-byte length indicates the length of the internally stored part plus the 20-byte pointer to the externally stored part. The internal part is 768 bytes, so the length is 768+20. The 20-byte pointer stores the true length of the column.
- The record header is followed by the data contents of the non-`NULL` columns.
- Records in the clustered index contain fields for all user-defined columns. In addition, there is a six-byte transaction ID field and a seven-byte roll pointer field.
- If no primary key was defined for a table, each clustered index record also contains a six-byte row ID field.
- Each secondary index record also contains all the primary key fields defined for the clustered index key that are not in the secondary index. If any of these primary key fields are variable length, the record header for each secondary index will have a variable-length part to record their lengths, even if the secondary index is defined on fixed-length columns.
- Internally, `InnoDB` stores fixed-length, fixed-width character columns such as `CHAR(10)` in a fixed-length format. `InnoDB` does not truncate trailing spaces from `VARCHAR` columns.
- Internally, `InnoDB` attempts to store UTF-8 `CHAR(`*`N`*`)` columns in *`N`* bytes by trimming trailing spaces. (With `REDUNDANT` row format, such columns occupy 3 × *`N`* bytes.) Reserving the minimum space *`N`* in many cases enables column updates to be done in place without causing fragmentation of the index page.

13.3.12. `InnoDB` Disk I/O and File Space Management

The laws of physics dictate that it takes time and effort to read and write data. The ACID design model requires a certain amount of I/O that might seem redundant, but helps to ensure data reliability. Within these constraints, InnoDB tries to optimize the database work and the organization of disk files to minimize the amount of disk I/O. Sometimes, I/O is postponed until the database is not busy, or until everything needs to be brought to a consistent state, such as during a database restart after a crash.

13.3.12.1. `InnoDB` Disk I/O

`InnoDB` uses asynchronous disk I/O where possible, by creating a number of threads to handle I/O operations, while permitting other database operations to proceed while the I/O is still in progress. On Linux and Windows platforms, InnoDB uses the available OS and library functions to perform “native” asynchronous I/O. On other platforms, InnoDB still uses I/O threads, but the threads may actually wait for I/O requests to complete; this technique is known as “simulated” asynchronous I/O.

Read-Ahead

If InnoDB can determine there is a high probability that data might be needed soon, it performs read-ahead operations to bring that data into the buffer pool so that it is available in memory. Making a few large read requests for contiguous data can be more efficient than making several small, spread-out requests. There are two read-ahead heuristics in InnoDB:

- In sequential read-ahead, if `InnoDB` notices that the access pattern to a segment in the tablespace is sequential, it posts in advance a batch of reads of database pages to the I/O system.
- In random read-ahead, if `InnoDB` notices that some area in a tablespace seems to be in the process of being fully read into the buffer pool, it posts the remaining reads to the I/O system.

Doublewrite Buffer

`InnoDB` uses a novel file flush technique involving a structure called the doublewrite buffer. It adds safety to recovery following an operating system crash or a power outage, and improves performance on most varieties of Unix by reducing the need for `fsync()` operations.

Before writing pages to a data file, `InnoDB` first writes them to a contiguous tablespace area called the doublewrite buffer. Only after the write and the flush to the doublewrite buffer has completed does `InnoDB` write the pages to their proper positions in the data file. If the operating system crashes in the middle of a page write, `InnoDB` can later find a good copy of the page from the doublewrite buffer during recovery.

13.3.12.2. File Space Management

The data files that you define in the configuration file form the `InnoDB` system tablespace. The files are logically concatenated to form the tablespace. There is no striping in use. Currently, you cannot define where within the tablespace your tables are allocated. However, in a newly created tablespace, `InnoDB` allocates space starting from the first data file.

To avoid the issues that come with storing all tables and indexes inside the system tablespace, you can turn on the `innodb_file_per_table` configuration option, which stores each newly created table in a separate tablespace file (with extension `.ibd`). For tables stored this way, there is less fragmentation within the disk file, and when the table is truncated, the space is returned to the operating system rather than still being reserved by InnoDB within the system tablespace.

Pages, Extents, Segments, and Tablespaces

Each tablespace consists of database pages with a default size of 16KB. The pages are grouped into extents of size 1MB (64 consecutive pages). The “files” inside a tablespace are called *segments* in `InnoDB`. (These segments are different from the “rollback segment”, which actually contains many tablespace segments.)

When a segment grows inside the tablespace, `InnoDB` allocates the first 32 pages to it individually. After that, `InnoDB` starts to allocate whole extents to the segment. `InnoDB` can add up to 4 extents at a time to a large segment to ensure good sequentiality of data.

Two segments are allocated for each index in `InnoDB`. One is for nonleaf nodes of the B-tree, the other is for the leaf nodes. Keeping the leaf nodes contiguous on disk enables better sequential I/O operations, because these leaf nodes contain the actual table data.

Some pages in the tablespace contain bitmaps of other pages, and therefore a few extents in an `InnoDB` tablespace cannot be allocated to segments as a whole, but only as individual pages.

When you ask for available free space in the tablespace by issuing a `SHOW TABLE STATUS` statement, `InnoDB` reports the extents that are definitely free in the tablespace. `InnoDB` always reserves some extents for cleanup and other internal purposes; these reserved extents are not included in the free space.

When you delete data from a table, `InnoDB` contracts the corresponding B-tree indexes. Whether the freed space becomes available for other users depends on whether the pattern of deletes frees individual pages or extents to the tablespace. Dropping a table or deleting all rows from it is guaranteed to release the space to other users, but remember that deleted rows are physically removed only in an (automatic) purge operation after they are no longer needed for transaction rollbacks or consistent reads. (See Section 13.3.10, “`InnoDB` Multi-Versioning”.)

To see information about the tablespace, use the Tablespace Monitor. See Section 13.3.14.2, “`SHOW ENGINE INNODB STATUS` and the `InnoDB` Monitors”.

How Pages Relate to Table Rows

The maximum row length, except for variable-length columns (`VARBINARY`, `VARCHAR`, `BLOB` and `TEXT`), is slightly less than half of a database page. That is, the maximum row length is about 8000 bytes. `LONGBLOB` and `LONGTEXT` columns must be less than 4GB, and the total row length, including `BLOB` and `TEXT` columns, must be less than 4GB.

If a row is less than half a page long, all of it is stored locally within the page. If it exceeds half a page, variable-length columns are chosen for external off-page storage until the row fits within half a page. For a column chosen for off-page storage, `InnoDB` stores the first 768 bytes locally in the row, and the rest externally into overflow pages. Each such column has its own list of overflow pages. The 768-byte prefix is accompanied by a 20-byte value that stores the true length of the column and points into the overflow list where the rest of the value is stored.

13.3.12.3. Defragmenting a Table

Random insertions into or deletions from a secondary index may cause the index to become fragmented. Fragmentation means that the physical ordering of the index pages on the disk is not close to the index ordering of the records on the pages, or that there are many unused pages in the 64-page blocks that were allocated to the index.

One symptom of fragmentation is that a table takes more space than it “should” take. How much that is exactly, is difficult to determine. All `InnoDB` data and indexes are stored in B-trees, and their fill factor may vary from 50% to 100%. Another symptom of fragmentation is that a table scan such as this takes more time than it “should” take:

```
SELECT COUNT(*) FROM t WHERE a_non_indexed_column <> 12345;
```

The preceding query requires MySQL to scan the clustered index rather than a secondary index. Most disks can read 10MB/s to 50MB/s, which can be used to estimate how fast a table scan should be.

To speed up index scans, you can periodically perform a “null” `ALTER TABLE` operation, which causes MySQL to rebuild the table:

```
ALTER TABLE tbl_name ENGINE=INNODB
```

Another way to perform a defragmentation operation is to use `mysqldump` to dump the table to a text file, drop the table, and reload it from the dump file.

If the insertions into an index are always ascending and records are deleted only from the end, the `InnoDB` filespace management algorithm guarantees that fragmentation in the index does not occur.

13.3.13. `InnoDB` Error Handling

Error handling in `InnoDB` is not always the same as specified in the SQL standard. According to the standard, any error during an SQL statement should cause rollback of that statement. `InnoDB` sometimes rolls back only part of the statement, or the whole transaction. The following items describe how `InnoDB` performs error handling:

- If you run out of file space in the tablespace, a MySQL `Table is full` error occurs and `InnoDB` rolls back the SQL statement.
- A transaction deadlock causes `InnoDB` to roll back the entire transaction. Retry the whole transaction when this happens.

  A lock wait timeout causes `InnoDB` to roll back only the single statement that was waiting for the lock and encountered the timeout. (To have the entire transaction roll back, start the server with the `--innodb_rollback_on_timeout` option.) Retry the statement if using the current behavior, or the entire transaction if using `--innodb_rollback_on_timeout`.

  Both deadlocks and lock wait timeouts are normal on busy servers and it is necessary for applications to be aware that they may happen and handle them by retrying. You can make them less likely by doing as little work as possible between the first change to data during a transaction and the commit, so the locks are held for the shortest possible time and for the smallest possible number of rows. Sometimes splitting work between different transactions may be practical and helpful.

  When a transaction rollback occurs due to a deadlock or lock wait timeout, it cancels the effect of the statements within the transaction. But if the start-transaction statement was `START TRANSACTION` or `BEGIN` statement, rollback does not cancel that statement. Further SQL statements become part of the transaction until the occurrence of `COMMIT`, `ROLLBACK`, or some SQL statement that causes an implicit commit.

- A duplicate-key error rolls back the SQL statement, if you have not specified the `IGNORE` option in your statement.
- A `row too long error` rolls back the SQL statement.
- Other errors are mostly detected by the MySQL layer of code (above the `InnoDB` storage engine level), and they roll back the corresponding SQL statement. Locks are not released in a rollback of a single SQL statement.

During implicit rollbacks, as well as during the execution of an explicit `ROLLBACK` SQL statement, `SHOW PROCESSLIST` displays `Rolling back` in the `State` column for the relevant connection.

13.3.13.1. `InnoDB` Error Codes

The following is a nonexhaustive list of common `InnoDB`-specific errors that you may encounter, with information about why each occurs and how to resolve the problem.

- `1005 (ER_CANT_CREATE_TABLE)`

  Cannot create table. If the error message refers to error 150, table creation failed because a foreign key constraint was not correctly formed. If the error message refers to error –1, table creation probably failed because the table includes a column name that matched the name of an internal `InnoDB` table.

- `1016 (ER_CANT_OPEN_FILE)`

  Cannot find the `InnoDB` table from the `InnoDB` data files, although the `.frm` file for the table exists. See Section 13.3.14.4, “Troubleshooting `InnoDB` Data Dictionary Operations”.

- `1114 (ER_RECORD_FILE_FULL)`

  `InnoDB` has run out of free space in the tablespace. Reconfigure the tablespace to add a new data file.

- `1205 (ER_LOCK_WAIT_TIMEOUT)`

  Lock wait timeout expired. Transaction was rolled back.

- `1206 (ER_LOCK_TABLE_FULL)`

  The total number of locks exceeds the lock table size. To avoid this error, increase the value of `innodb_buffer_pool_size`. Within an individual application, a workaround may be to break a large operation into smaller pieces. For example, if the error occurs for a large `INSERT`, perform several smaller `INSERT` operations.

- `1213 (ER_LOCK_DEADLOCK)`

  Transaction deadlock. Rerun the transaction.

- `1216 (ER_NO_REFERENCED_ROW)`

  You are trying to add a row but there is no parent row, and a foreign key constraint fails. Add the parent row first.

- `1217 (ER_ROW_IS_REFERENCED)`

  You are trying to delete a parent row that has children, and a foreign key constraint fails. Delete the children first.

13.3.13.2. Operating System Error Codes

To print the meaning of an operating system error number, use the `perror` program that comes with the MySQL distribution.

- **Linux System Error Codes**

  The following table provides a list of some common Linux system error codes. For a more complete list, see Linux source code.

Number	Macro	Description
1	`EPERM`	Operation not permitted

Number	Macro	Description
2	`ENOENT`	No such file or directory
3	`ESRCH`	No such process
4	`EINTR`	Interrupted system call
5	`EIO`	I/O error
6	`ENXIO`	No such device or address
7	`E2BIG`	Arg list too long
8	`ENOEXEC`	Exec format error
9	`EBADF`	Bad file number
10	`ECHILD`	No child processes
11	`EAGAIN`	Try again
12	`ENOMEM`	Out of memory
13	`EACCES`	Permission denied
14	`EFAULT`	Bad address
15	`ENOTBLK`	Block device required
16	`EBUSY`	Device or resource busy
17	`EEXIST`	File exists
18	`EXDEV`	Cross-device link
19	`ENODEV`	No such device
20	`ENOTDIR`	Not a directory
21	`EISDIR`	Is a directory
22	`EINVAL`	Invalid argument
23	`ENFILE`	File table overflow
24	`EMFILE`	Too many open files
25	`ENOTTY`	Inappropriate ioctl for device
26	`ETXTBSY`	Text file busy
27	`EFBIG`	File too large
28	`ENOSPC`	No space left on device
29	`ESPIPE`	Illegal seek
30	`EROFS`	Read-only file system
31	`EMLINK`	Too many links

- **Windows System Error Codes**

  The following table provides a list of some common Windows system error codes. For a complete list, see the Microsoft Web site.

Number	Macro	Description
1	`ERROR_INVALID_FUNCTION`	Incorrect function.
2	`ERROR_FILE_NOT_FOUND`	The system cannot find the file specified.
3	`ERROR_PATH_NOT_FOUND`	The system cannot find the path specified.
4	`ERROR_TOO_MANY_OPEN_FILES`	The system cannot open the file.
5	`ERROR_ACCESS_DENIE`	Access is denied.

Number	Macro	Description
	`D`	
6	`ERROR_INVALID_HANDLE`	The handle is invalid.
7	`ERROR_ARENA_TRASHED`	The storage control blocks were destroyed.
8	`ERROR_NOT_ENOUGH_MEMORY`	Not enough storage is available to process this command.
9	`ERROR_INVALID_BLOCK`	The storage control block address is invalid.
10	`ERROR_BAD_ENVIRONMENT`	The environment is incorrect.
11	`ERROR_BAD_FORMAT`	An attempt was made to load a program with an incorrect format.
12	`ERROR_INVALID_ACCESS`	The access code is invalid.
13	`ERROR_INVALID_DATA`	The data is invalid.
14	`ERROR_OUTOFMEMORY`	Not enough storage is available to complete this operation.
15	`ERROR_INVALID_DRIVE`	The system cannot find the drive specified.
16	`ERROR_CURRENT_DIRECTORY`	The directory cannot be removed.
17	`ERROR_NOT_SAME_DEVICE`	The system cannot move the file to a different disk drive.
18	`ERROR_NO_MORE_FILES`	There are no more files.
19	`ERROR_WRITE_PROTECT`	The media is write protected.
20	`ERROR_BAD_UNIT`	The system cannot find the device specified.
21	`ERROR_NOT_READY`	The device is not ready.
22	`ERROR_BAD_COMMAND`	The device does not recognize the command.
23	`ERROR_CRC`	Data error (cyclic redundancy check).
24	`ERROR_BAD_LENGTH`	The program issued a command but the command length is incorrect.
25	`ERROR_SEEK`	The drive cannot locate a specific area or track on the disk.
26	`ERROR_NOT_DOS_DISK`	The specified disk or diskette cannot be accessed.
27	`ERROR_SECTOR_NOT_FOUND`	The drive cannot find the sector requested.
28	`ERROR_OUT_OF_PAPER`	The printer is out of paper.
29	`ERROR_WRITE_FAULT`	The system cannot write to the specified device.
30	`ERROR_READ_FAULT`	The system cannot read from the specified device.

Number	Macro	Description
31	`ERROR_GEN_FAILURE`	A device attached to the system is not functioning.
32	`ERROR_SHARING_VIOLATION`	The process cannot access the file because it is being used by another process.
33	`ERROR_LOCK_VIOLATION`	The process cannot access the file because another process has locked a portion of the file.
34	`ERROR_WRONG_DISK`	The wrong diskette is in the drive. Insert %2 (Volume Serial Number: %3) into drive %1.
36	`ERROR_SHARING_BUFFER_EXCEEDED`	Too many files opened for sharing.
38	`ERROR_HANDLE_EOF`	Reached the end of the file.
39	`ERROR_HANDLE_DISK_FULL`	The disk is full.
87	`ERROR_INVALID_PARAMETER`	The parameter is incorrect.
112	`ERROR_DISK_FULL`	The disk is full.
123	`ERROR_INVALID_NAME`	The file name, directory name, or volume label syntax is incorrect.
1450	`ERROR_NO_SYSTEM_RESOURCES`	Insufficient system resources exist to complete the requested service.

13.3.14. `InnoDB` Performance Tuning and Troubleshooting

13.3.14.1. `InnoDB` Performance Tuning Tips

With `InnoDB` becoming the default storage engine in MySQL 5.5 and higher, the tips and guidelines for `InnoDB` tables are now part of the main optimization chapter. See Section 7.5, “Optimizing for `InnoDB` Tables”.

13.3.14.2. `SHOW ENGINE INNODB STATUS` and the `InnoDB` Monitors

`InnoDB` Monitors provide information about the `InnoDB` internal state. This information is useful for performance tuning. Each Monitor can be enabled by creating a table with a special name, which causes `InnoDB` to write Monitor output periodically. Also, output for the standard `InnoDB` Monitor is available on demand through the `SHOW ENGINE INNODB STATUS` SQL statement.

There are several types of `InnoDB` Monitors:

- The standard `InnoDB` Monitor displays the following types of information:
  - Table and record locks held by each active transaction
  - Lock waits of a transactions
  - Semaphore waits of threads
  - Pending file I/O requests
  - Buffer pool statistics
  - Purge and insert buffer merge activity of the main `InnoDB` thread

  For a discussion of `InnoDB` lock modes, see Section 13.3.9.1, “`InnoDB` Lock Modes”.

  To enable the standard `InnoDB` Monitor for periodic output, create a table named `innodb_monitor`. To obtain Monitor output on demand, use the `SHOW ENGINE INNODB STATUS` SQL statement to fetch the output to your client program. If you are using the `mysql` interactive client, the output is more readable if you replace the usual semicolon statement terminator with `\G`:

```
mysql> SHOW ENGINE INNODB STATUS\G
```

- The `InnoDB` Lock Monitor is like the standard Monitor but also provides extensive lock information. To enable this Monitor for periodic output, create a table named `innodb_lock_monitor`.
- The `InnoDB` Tablespace Monitor prints a list of file segments in the shared tablespace and validates the tablespace allocation data structures. To enable this Monitor for periodic output, create a table named `innodb_tablespace_monitor`.
- The `InnoDB` Table Monitor prints the contents of the `InnoDB` internal data dictionary. To enable this Monitor for periodic output, create a table named `innodb_table_monitor`.

To enable an `InnoDB` Monitor for periodic output, use a `CREATE TABLE` statement to create the table associated with the Monitor. For example, to enable the standard `InnoDB` Monitor, create the `innodb_monitor` table:

```
CREATE TABLE innodb_monitor (a INT) ENGINE=INNODB;
```

To stop the Monitor, drop the table:

```
DROP TABLE innodb_monitor;
```

The `CREATE TABLE` syntax is just a way to pass a command to the `InnoDB` engine through MySQL's SQL parser: The only things that matter are the table name `innodb_monitor` and that it be an `InnoDB` table. The structure of the table is not relevant at all for the `InnoDB` Monitor. If you shut down the server, the Monitor does not restart automatically when you restart the server. Drop the Monitor table and issue a new `CREATE TABLE` statement to start the Monitor. (This syntax may change in a future release.)

The `PROCESS` privilege is required to start or stop the `InnoDB` Monitor tables.

When you enable `InnoDB` Monitors for periodic output, `InnoDB` writes their output to the `mysqld` server standard error output (`stderr`). In this case, no output is sent to clients. When switched on, `InnoDB` Monitors print data about every 15 seconds. Server output usually is directed to the error log (see Section 5.2.2, “The Error Log”). This data is useful in performance tuning. On Windows, start the server from a command prompt in a console window with the `--console` option if you want to direct the output to the window rather than to the error log.

`InnoDB` sends diagnostic output to `stderr` or to files rather than to `stdout` or fixed-size memory buffers, to avoid potential buffer overflows. As a side effect, the output of `SHOW ENGINE INNODB STATUS` is written to a status file in the MySQL data directory every fifteen seconds. The name of the file is `innodb_status.pid`, where *`pid`* is the server process ID. `InnoDB` removes the file for a normal shutdown. If abnormal shutdowns have occurred, instances of these status files may be present and must be removed manually. Before removing them, you might want to examine them to see whether they contain useful information about the cause of abnormal shutdowns. The `innodb_status.pid` file is created only if the configuration option `innodb-status-file=1` is set.

`InnoDB` Monitors should be enabled only when you actually want to see Monitor information because output generation does result in some performance decrement. Also, if you enable monitor output by creating the associated table, your error log may become quite large if you forget to remove the table later.

For additional information about `InnoDB` monitors, see:

- Mark Leith: InnoDB Table and Tablespace Monitors

Each monitor begins with a header containing a timestamp and the monitor name. For example:

```
================================================
090407 12:06:19 INNODB TABLESPACE MONITOR OUTPUT
================================================
```

The header for the standard Monitor (`INNODB MONITOR OUTPUT`) is also used for the Lock Monitor because the latter produces the same output with the addition of extra lock information.

The following sections describe the output for each Monitor.

13.3.14.2.1. `InnoDB` Standard Monitor and Lock Monitor Output

The Lock Monitor is the same as the standard Monitor except that it includes additional lock information. Enabling either monitor for periodic output by creating the associated `InnoDB` table turns on the same output stream, but the stream includes the extra information if the Lock Monitor is enabled. For example, if you create the `innodb_monitor` and `innodb_lock_monitor` tables, that turns on a single output stream. The stream includes extra lock information until you disable the Lock Monitor by removing the `innodb_lock_monitor` table.

Example `InnoDB` Monitor output:

```
mysql> SHOW ENGINE INNODB STATUS\G
*************************** 1. row ***************************
Status:
=====================================
030709 13:00:59 INNODB MONITOR OUTPUT
=====================================
Per second averages calculated from the last 18 seconds
----------
BACKGROUND THREAD
----------
srv_master_thread loops: 53 1_second, 44 sleeps, 5 10_second, 7 background,
  7 flush
srv_master_thread log flush and writes: 48
----------
SEMAPHORES
----------
OS WAIT ARRAY INFO: reservation count 413452, signal count 378357
--Thread 32782 has waited at btr0sea.c line 1477 for 0.00 seconds the
semaphore: X-lock on RW-latch at 41a28668 created in file btr0sea.c line 135
a writer (thread id 32782) has reserved it in mode wait exclusive
number of readers 1, waiters flag 1
Last time read locked in file btr0sea.c line 731
Last time write locked in file btr0sea.c line 1347
Mutex spin waits 0, rounds 0, OS waits 0
RW-shared spins 2, rounds 60, OS waits 2
RW-excl spins 0, rounds 0, OS waits 0
Spin rounds per wait: 0.00 mutex, 20.00 RW-shared, 0.00 RW-excl
------------------------
LATEST FOREIGN KEY ERROR
------------------------
030709 13:00:59 Transaction:
TRANSACTION 0 290328284, ACTIVE 0 sec, process no 3195, OS thread id 34831
inserting
15 lock struct(s), heap size 2496, undo log entries 9
MySQL thread id 25, query id 4668733 localhost heikki update
insert into ibtest11a (D, B, C) values (5, 'khDk' ,'khDk')
Foreign key constraint fails for table test/ibtest11a:
,
  CONSTRAINT `0_219242` FOREIGN KEY (`A`, `D`) REFERENCES `ibtest11b` (`A`,
  `D`) ON DELETE CASCADE ON UPDATE CASCADE
Trying to add in child table, in index PRIMARY tuple:
 0: len 4; hex 80000101; asc ....;; 1: len 4; hex 80000005; asc ....;; 2:
 len 4; hex 6b68446b; asc khDk;; 3: len 6; hex 0000114e0edc; asc ...N..;; 4:
 len 7; hex 00000000c3e0a7; asc .......;; 5: len 4; hex 6b68446b; asc khDk;;
But in parent table test/ibtest11b, in index PRIMARY,
the closest match we can find is record:
RECORD: info bits 0 0: len 4; hex 8000015b; asc ...[;; 1: len 4; hex
80000005; asc ....;; 2: len 3; hex 6b6864; asc khd;; 3: len 6; hex
0000111ef3eb; asc ......;; 4: len 7; hex 800001001e0084; asc .......;; 5:
len 3; hex 6b6864; asc khd;;
------------------------
LATEST DETECTED DEADLOCK
------------------------
030709 12:59:58
*** (1) TRANSACTION:
TRANSACTION 0 290252780, ACTIVE 1 sec, process no 3185, OS thread id 30733
inserting
LOCK WAIT 3 lock struct(s), heap size 320, undo log entries 146
MySQL thread id 21, query id 4553379 localhost heikki update
INSERT INTO alex1 VALUES(86, 86, 794,'aA35818','bb','c79166','d4766t',
'e187358f','g84586','h794',date_format('2001-04-03 12:54:22','%Y-%m-%d
%H:%i'),7
*** (1) WAITING FOR THIS LOCK TO BE GRANTED:
RECORD LOCKS space id 0 page no 48310 n bits 568 table test/alex1 index
symbole trx id 0 290252780 lock mode S waiting
Record lock, heap no 324 RECORD: info bits 0 0: len 7; hex 61613335383138;
asc aa35818;; 1:
*** (2) TRANSACTION:
TRANSACTION 0 290251546, ACTIVE 2 sec, process no 3190, OS thread id 32782
inserting
130 lock struct(s), heap size 11584, undo log entries 437
MySQL thread id 23, query id 4554396 localhost heikki update
REPLACE INTO alex1 VALUES(NULL, 32, NULL,'aa3572','','c3572','d6012t','',
NULL,'h396', NULL, NULL, 7.31,7.31,7.31,200)
*** (2) HOLDS THE LOCK(S):
RECORD LOCKS space id 0 page no 48310 n bits 568 table test/alex1 index
symbole trx id 0 290251546 lock_mode X locks rec but not gap
Record lock, heap no 324 RECORD: info bits 0 0: len 7; hex 61613335383138;
asc aa35818;; 1:
*** (2) WAITING FOR THIS LOCK TO BE GRANTED:
RECORD LOCKS space id 0 page no 48310 n bits 568 table test/alex1 index
symbole trx id 0 290251546 lock_mode X locks gap before rec insert intention
waiting
Record lock, heap no 82 RECORD: info bits 0 0: len 7; hex 61613335373230;
asc aa35720;; 1:
*** WE ROLL BACK TRANSACTION (1)
------------
```

```
TRANSACTIONS
------------
Trx id counter 0 290328385
Purge done for trx's n:o < 0 290315608 undo n:o < 0 17
History list length 20
Total number of lock structs in row lock hash table 70
LIST OF TRANSACTIONS FOR EACH SESSION:
---TRANSACTION 0 0, not started, process no 3491, OS thread id 42002
MySQL thread id 32, query id 4668737 localhost heikki
show innodb status
---TRANSACTION 0 290328384, ACTIVE 0 sec, process no 3205, OS thread id
38929 inserting
1 lock struct(s), heap size 320
MySQL thread id 29, query id 4668736 localhost heikki update
insert into speedc values (1519229,1, 'hgjhjgghggjgjgjgjgjggjgjgjgjgjgggjgjg
jlhhgghggggghhjhghgggggghjhghghghghhhhghghghjhhjghjghjkghjghjghjghjfhjfh
---TRANSACTION 0 290328383, ACTIVE 0 sec, process no 3180, OS thread id
28684 committing
1 lock struct(s), heap size 320, undo log entries 1
MySQL thread id 19, query id 4668734 localhost heikki update
insert into speedcm values (1603393,1, 'hgjhjgghggjgjgjgjgjggjgjgjgjgjgggjgj
gjlhhgghggggghhjhghgggggghjhghghghghhhhghghghjhhjghjghjkghjghjghjghjfhjf
---TRANSACTION 0 290328327, ACTIVE 0 sec, process no 3200, OS thread id
36880 starting index read
LOCK WAIT 2 lock struct(s), heap size 320
MySQL thread id 27, query id 4668644 localhost heikki Searching rows for
update
update ibtest11a set B = 'kHdkkkk' where A = 89572
------- TRX HAS BEEN WAITING 0 SEC FOR THIS LOCK TO BE GRANTED:
RECORD LOCKS space id 0 page no 65556 n bits 232 table test/ibtest11a index
PRIMARY trx id 0 290328327 lock_mode X waiting
Record lock, heap no 1 RECORD: info bits 0 0: len 9; hex 73757072656d756d00;
asc supremum.;;
------------------
---TRANSACTION 0 290328284, ACTIVE 0 sec, process no 3195, OS thread id
34831 rollback of SQL statement
ROLLING BACK 14 lock struct(s), heap size 2496, undo log entries 9
MySQL thread id 25, query id 4668733 localhost heikki update
insert into ibtest11a (D, B, C) values (5, 'khDk' ,'khDk')
---TRANSACTION 0 290327208, ACTIVE 1 sec, process no 3190, OS thread id
32782
58 lock struct(s), heap size 5504, undo log entries 159
MySQL thread id 23, query id 4668732 localhost heikki update
REPLACE INTO alex1 VALUES(86, 46, 538,'aa95666','bb','c95666','d9486t',
'e200498f','g86814','h538',date_format('2001-04-03 12:54:22','%Y-%m-%d
%H:%i'),
---TRANSACTION 0 290323325, ACTIVE 3 sec, process no 3185, OS thread id
30733 inserting
4 lock struct(s), heap size 1024, undo log entries 165
MySQL thread id 21, query id 4668735 localhost heikki update
INSERT INTO alex1 VALUES(NULL, 49, NULL,'aa42837','','c56319','d1719t','',
NULL,'h321', NULL, NULL, 7.31,7.31,7.31,200)
--------
FILE I/O
--------
I/O thread 0 state: waiting for i/o request (insert buffer thread)
I/O thread 1 state: waiting for i/o request (log thread)
I/O thread 2 state: waiting for i/o request (read thread)
I/O thread 3 state: waiting for i/o request (write thread)
Pending normal aio reads: 0, aio writes: 0,
 ibuf aio reads: 0, log i/o's: 0, sync i/o's: 0
Pending flushes (fsync) log: 0; buffer pool: 0
151671 OS file reads, 94747 OS file writes, 8750 OS fsyncs
25.44 reads/s, 18494 avg bytes/read, 17.55 writes/s, 2.33 fsyncs/s
-------------------------------------
INSERT BUFFER AND ADAPTIVE HASH INDEX
-------------------------------------
Ibuf for space 0: size 1, free list len 19, seg size 21,
85004 inserts, 85004 merged recs, 26669 merges
Hash table size 207619, used cells 14461, node heap has 16 buffer(s)
1877.67 hash searches/s, 5121.10 non-hash searches/s
---
LOG
---
Log sequence number 18 1212842764
Log flushed up to   18 1212665295
Last checkpoint at  18 1135877290
0 pending log writes, 0 pending chkp writes
4341 log i/o's done, 1.22 log i/o's/second
----------------------
BUFFER POOL AND MEMORY
----------------------
Total memory allocated 84966343; in additional pool allocated 1402624
Buffer pool size   3200
Free buffers       110
Database pages     3074
Modified db pages  2674
Pending reads 0
Pending writes: LRU 0, flush list 0, single page 0
Pages read 171380, created 51968, written 194688
28.72 reads/s, 20.72 creates/s, 47.55 writes/s
Buffer pool hit rate 999 / 1000
--------------
ROW OPERATIONS
--------------
0 queries inside InnoDB, 0 queries in queue
Main thread process no. 3004, id 7176, state: purging
Number of rows inserted 3738558, updated 127415, deleted 33707, read 755779
```

```
1586.13 inserts/s, 50.89 updates/s, 28.44 deletes/s, 107.88 reads/s
----------------------------
END OF INNODB MONITOR OUTPUT
============================
```

`InnoDB` Monitor output is limited to 1MB when produced using the `SHOW ENGINE INNODB STATUS` statement. This limit does not apply to output written to the server's error output.

Some notes on the output sections:

`BACKGROUND THREAD`

The `srv_master_thread` lines shows work done by the main background thread.

`SEMAPHORES`

This section reports threads waiting for a semaphore and statistics on how many times threads have needed a spin or a wait on a mutex or a rw-lock semaphore. A large number of threads waiting for semaphores may be a result of disk I/O, or contention problems inside `InnoDB`. Contention can be due to heavy parallelism of queries or problems in operating system thread scheduling. Setting the `innodb_thread_concurrency` system variable smaller than the default value might help in such situations. The `Spin rounds per wait` line shows the number of spinlock rounds per OS wait for a mutex.

`LATEST FOREIGN KEY ERROR`

This section provides information about the most recent foreign key constraint error. It is not present if no such error has occurred. The contents include the statement that failed as well as information about the constraint that failed and the referenced and referencing tables.

`LATEST DETECTED DEADLOCK`

This section provides information about the most recent deadlock. It is not present if no deadlock has occurred. The contents show which transactions are involved, the statement each was attempting to execute, the locks they have and need, and which transaction `InnoDB` decided to roll back to break the deadlock. The lock modes reported in this section are explained in Section 13.3.9.1, “`InnoDB` Lock Modes”.

`TRANSACTIONS`

If this section reports lock waits, your applications might have lock contention. The output can also help to trace the reasons for transaction deadlocks.

`FILE I/O`

This section provides information about threads that `InnoDB` uses to perform various types of I/O. The first few of these are dedicated to general `InnoDB` processing. The contents also display information for pending I/O operations and statistics for I/O performance.

The number of these threads are controlled by the `innodb_read_io_threads` and `innodb_write_io_threads` parameters. See Section 13.3.4, “`InnoDB` Startup Options and System Variables”.

`INSERT BUFFER AND ADAPTIVE HASH INDEX`

This section shows the status of the `InnoDB` insert buffer and adaptive hash index. (See Section 13.3.11.3, “Insert Buffering”, and Section 13.3.11.4, “Adaptive Hash Indexes”.) The contents include the number of operations performed for each, plus statistics for hash index performance.

`LOG`

This section displays information about the `InnoDB` log. The contents include the current log sequence number, how far the log has been flushed to disk, and the position at which `InnoDB` last took a checkpoint. (See Section 13.3.7.3, “`InnoDB` Checkpoints”.) The section also displays information about pending writes and write performance statistics.

`BUFFER POOL AND MEMORY`

This section gives you statistics on pages read and written. You can calculate from these numbers how many data file I/O operations your queries currently are doing.

For additional information about the operation of the buffer pool, see Section 7.9.1, “The `InnoDB` Buffer Pool”.

`ROW OPERATIONS`

This section shows what the main thread is doing, including the number and performance rate for each type of row operation.

In MySQL 5.5, output from the standard Monitor includes additional sections compared to the output for previous versions. For details, see Section 1.5.3, “Diagnostic and Monitoring Capabilities”.

13.3.14.2.2. `InnoDB` Tablespace Monitor Output

The `InnoDB` Tablespace Monitor prints information about the file segments in the shared tablespace and validates the tablespace allocation data structures. If you use individual tablespaces by enabling `innodb_file_per_table`, the Tablespace Monitor does not describe those tablespaces.

Example `InnoDB` Tablespace Monitor output:

```
================================================
090408 21:28:09 INNODB TABLESPACE MONITOR OUTPUT
================================================
FILE SPACE INFO: id 0
size 13440, free limit 3136, free extents 28
not full frag extents 2: used pages 78, full frag extents 3
first seg id not used 0 23845
SEGMENT id 0 1 space 0; page 2; res 96 used 46; full ext 0
fragm pages 32; free extents 0; not full extents 1: pages 14
SEGMENT id 0 2 space 0; page 2; res 1 used 1; full ext 0
fragm pages 1; free extents 0; not full extents 0: pages 0
SEGMENT id 0 3 space 0; page 2; res 1 used 1; full ext 0
fragm pages 1; free extents 0; not full extents 0: pages 0
...
SEGMENT id 0 15 space 0; page 2; res 160 used 160; full ext 2
fragm pages 32; free extents 0; not full extents 0: pages 0
SEGMENT id 0 488 space 0; page 2; res 1 used 1; full ext 0
fragm pages 1; free extents 0; not full extents 0: pages 0
SEGMENT id 0 17 space 0; page 2; res 1 used 1; full ext 0
fragm pages 1; free extents 0; not full extents 0: pages 0
...
SEGMENT id 0 171 space 0; page 2; res 592 used 481; full ext 7
fragm pages 16; free extents 0; not full extents 2: pages 17
SEGMENT id 0 172 space 0; page 2; res 1 used 1; full ext 0
fragm pages 1; free extents 0; not full extents 0: pages 0
SEGMENT id 0 173 space 0; page 2; res 96 used 44; full ext 0
fragm pages 32; free extents 0; not full extents 1: pages 12
...
SEGMENT id 0 601 space 0; page 2; res 1 used 1; full ext 0
fragm pages 1; free extents 0; not full extents 0: pages 0
NUMBER of file segments: 73
Validating tablespace
Validation ok
---------------------------------------
END OF INNODB TABLESPACE MONITOR OUTPUT
=======================================
```

The Tablespace Monitor output includes information about the shared tablespace as a whole, followed by a list containing a breakdown for each segment within the tablespace.

The tablespace consists of database pages with a default size of 16KB. The pages are grouped into extents of size 1MB (64 consecutive pages).

The initial part of the output that displays overall tablespace information has this format:

```
FILE SPACE INFO: id 0
size 13440, free limit 3136, free extents 28
not full frag extents 2: used pages 78, full frag extents 3
first seg id not used 0 23845
```

Overall tablespace information includes these values:

- `id`: The tablespace ID. A value of 0 refers to the shared tablespace.
- `size`: The current tablespace size in pages.
- `free limit`: The minimum page number for which the free list has not been initialized. Pages at or above this limit are free.
- `free extents`: The number of free extents.
- `not full frag extents`, `used pages`: The number of fragment extents that are not completely filled, and the number of pages in those extents that have been allocated.
- `full frag extents`: The number of completely full fragment extents.
- `first seg id not used`: The first unused segment ID.

Individual segment information has this format:

```
SEGMENT id 0 15 space 0; page 2; res 160 used 160; full ext 2
fragm pages 32; free extents 0; not full extents 0: pages 0
```

Segment information includes these values:

`id`: The segment ID.

`space`, `page`: The tablespace number and page within the tablespace where the segment “inode” is located. A tablespace number of 0 indicates the shared tablespace. `InnoDB` uses inodes to keep track of segments in the tablespace. The other fields displayed for a segment (`id`, `res`, and so forth) are derived from information in the inode.

`res`: The number of pages allocated (reserved) for the segment.

`used`: The number of allocated pages in use by the segment.

`full ext`: The number of extents allocated for the segment that are completely used.

`fragm pages`: The number of initial pages that have been allocated to the segment.

`free extents`: The number of extents allocated for the segment that are completely unused.

`not full extents`: The number of extents allocated for the segment that are partially used.

`pages`: The number of pages used within the not-full extents.

When a segment grows, it starts as a single page, and `InnoDB` allocates the first pages for it individually, up to 32 pages (this is the `fragm pages` value). After that, `InnoDB` allocates complete 64-page extents. `InnoDB` can add up to 4 extents at a time to a large segment to ensure good sequentiality of data.

For the example segment shown earlier, it has 32 fragment pages, plus 2 full extents (64 pages each), for a total of 160 pages used out of 160 pages allocated. The following segment has 32 fragment pages and one partially full extent using 14 pages for a total of 46 pages used out of 96 pages allocated:

```
SEGMENT id 0 1 space 0; page 2; res 96 used 46; full ext 0
fragm pages 32; free extents 0; not full extents 1: pages 14
```

It is possible for a segment that has extents allocated to it to have a `fragm pages` value less than 32 if some of the individual pages have been deallocated subsequent to extent allocation.

13.3.14.2.3. `InnoDB` Table Monitor Output

The `InnoDB` Table Monitor prints the contents of the `InnoDB` internal data dictionary.

The output contains one section per table. The `SYS_FOREIGN` and `SYS_FOREIGN_COLS` sections are for internal data dictionary tables that maintain information about foreign keys. There are also sections for the Table Monitor table and each user-created `InnoDB` table. Suppose that the following two tables have been created in the `test` database:

```
CREATE TABLE parent
(
  par_id    INT NOT NULL,
  fname      CHAR(20),
  lname      CHAR(20),
  PRIMARY KEY (par_id),
  UNIQUE INDEX (lname, fname)
) ENGINE = INNODB;

CREATE TABLE child
(
  par_id      INT NOT NULL,
  child_id    INT NOT NULL,
  name        VARCHAR(40),
  birth       DATE,
  weight      DECIMAL(10,2),
  misc_info   VARCHAR(255),
  last_update TIMESTAMP,
  PRIMARY KEY (par_id, child_id),
  INDEX (name),
  FOREIGN KEY (par_id) REFERENCES parent (par_id)
    ON DELETE CASCADE
    ON UPDATE CASCADE
) ENGINE = INNODB;
```

Then the Table Monitor output will look something like this (reformatted slightly):

```
===========================================
090420 12:09:32 INNODB TABLE MONITOR OUTPUT
===========================================
--------------------------------------
TABLE: name SYS_FOREIGN, id 0 11, columns 7, indexes 3, appr.rows 1
  COLUMNS: ID: DATA_VARCHAR DATA_ENGLISH len 0;
           FOR_NAME: DATA_VARCHAR DATA_ENGLISH len 0;
           REF_NAME: DATA_VARCHAR DATA_ENGLISH len 0;
           N_COLS: DATA_INT len 4;
           DB_ROW_ID: DATA_SYS prtype 256 len 6;
           DB_TRX_ID: DATA_SYS prtype 257 len 6;
  INDEX: name ID_IND, id 0 11, fields 1/6, uniq 1, type 3
   root page 46, appr.key vals 1, leaf pages 1, size pages 1
   FIELDS:  ID DB_TRX_ID DB_ROLL_PTR FOR_NAME REF_NAME N_COLS
  INDEX: name FOR_IND, id 0 12, fields 1/2, uniq 2, type 0
   root page 47, appr.key vals 1, leaf pages 1, size pages 1
   FIELDS:  FOR_NAME ID
  INDEX: name REF_IND, id 0 13, fields 1/2, uniq 2, type 0
   root page 48, appr.key vals 1, leaf pages 1, size pages 1
   FIELDS:  REF_NAME ID
--------------------------------------
TABLE: name SYS_FOREIGN_COLS, id 0 12, columns 7, indexes 1, appr.rows 1
  COLUMNS: ID: DATA_VARCHAR DATA_ENGLISH len 0;
           POS: DATA_INT len 4;
           FOR_COL_NAME: DATA_VARCHAR DATA_ENGLISH len 0;
           REF_COL_NAME: DATA_VARCHAR DATA_ENGLISH len 0;
           DB_ROW_ID: DATA_SYS prtype 256 len 6;
           DB_TRX_ID: DATA_SYS prtype 257 len 6;
  INDEX: name ID_IND, id 0 14, fields 2/6, uniq 2, type 3
   root page 49, appr.key vals 1, leaf pages 1, size pages 1
   FIELDS:  ID POS DB_TRX_ID DB_ROLL_PTR FOR_COL_NAME REF_COL_NAME
--------------------------------------
TABLE: name test/child, id 0 14, columns 10, indexes 2, appr.rows 201
  COLUMNS: par_id: DATA_INT DATA_BINARY_TYPE DATA_NOT_NULL len 4;
           child_id: DATA_INT DATA_BINARY_TYPE DATA_NOT_NULL len 4;
           name: DATA_VARCHAR prtype 524303 len 40;
           birth: DATA_INT DATA_BINARY_TYPE len 3;
           weight: DATA_FIXBINARY DATA_BINARY_TYPE len 5;
           misc_info: DATA_VARCHAR prtype 524303 len 255;
           last_update: DATA_INT DATA_UNSIGNED DATA_BINARY_TYPE DATA_NOT_NULL len 4;
           DB_ROW_ID: DATA_SYS prtype 256 len 6;
           DB_TRX_ID: DATA_SYS prtype 257 len 6;
  INDEX: name PRIMARY, id 0 17, fields 2/9, uniq 2, type 3
   root page 52, appr.key vals 201, leaf pages 5, size pages 6
   FIELDS:  par_id child_id DB_TRX_ID DB_ROLL_PTR name birth weight misc_info last_update
  INDEX: name name, id 0 18, fields 1/3, uniq 3, type 0
   root page 53, appr.key vals 210, leaf pages 1, size pages 1
   FIELDS:  name par_id child_id
  FOREIGN KEY CONSTRAINT test/child_ibfk_1: test/child ( par_id )
             REFERENCES test/parent ( par_id )
--------------------------------------
TABLE: name test/innodb_table_monitor, id 0 15, columns 4, indexes 1, appr.rows 0
  COLUMNS: i: DATA_INT DATA_BINARY_TYPE len 4;
           DB_ROW_ID: DATA_SYS prtype 256 len 6;
           DB_TRX_ID: DATA_SYS prtype 257 len 6;
  INDEX: name GEN_CLUST_INDEX, id 0 19, fields 0/4, uniq 1, type 1
   root page 193, appr.key vals 0, leaf pages 1, size pages 1
   FIELDS:  DB_ROW_ID DB_TRX_ID DB_ROLL_PTR i
--------------------------------------
TABLE: name test/parent, id 0 13, columns 6, indexes 2, appr.rows 299
  COLUMNS: par_id: DATA_INT DATA_BINARY_TYPE DATA_NOT_NULL len 4;
           fname: DATA_CHAR prtype 524542 len 20;
           lname: DATA_CHAR prtype 524542 len 20;
           DB_ROW_ID: DATA_SYS prtype 256 len 6;
           DB_TRX_ID: DATA_SYS prtype 257 len 6;
  INDEX: name PRIMARY, id 0 15, fields 1/5, uniq 1, type 3
   root page 50, appr.key vals 299, leaf pages 2, size pages 3
   FIELDS:  par_id DB_TRX_ID DB_ROLL_PTR fname lname
  INDEX: name lname, id 0 16, fields 2/3, uniq 2, type 2
   root page 51, appr.key vals 300, leaf pages 1, size pages 1
   FIELDS:  lname fname par_id
  FOREIGN KEY CONSTRAINT test/child_ibfk_1: test/child ( par_id )
             REFERENCES test/parent ( par_id )
-----------------------------------
END OF INNODB TABLE MONITOR OUTPUT
==================================
```

For each table, Table Monitor output contains a section that displays general information about the table and specific information about its columns, indexes, and foreign keys.

The general information for each table includes the table name (in `db_name/tbl_name` format except for internal tables), its ID, the number of columns and indexes, and an approximate row count.

The `COLUMNS` part of a table section lists each column in the table. Information for each column indicates its name and data type characteristics. Some internal columns are added by `InnoDB`, such as `DB_ROW_ID` (row ID), `DB_TRX_ID` (transaction ID), and `DB_ROLL_PTR` (a pointer to the rollback/undo data).

- `DATA_xxx`: These symbols indicate the data type. There may be multiple `DATA_xxx` symbols for a given column.
- `prtype`: The column's “precise” type. This field includes information such as the column data type, character set code, nullab-

ility, signedness, and whether it is a binary string. This field is described in the `innobase/include/data0type.h` source file.

- `len`: The column length in bytes.

Each `INDEX` part of the table section provides the name and characteristics of one table index:

- `name`: The index name. If the name is `PRIMARY`, the index is a primary key. If the name is `GEN_CLUST_INDEX`, the index is the clustered index that is created automatically if the table definition doesn't include a primary key or non-`NULL` unique index. See Section 13.3.11.1, "Clustered and Secondary Indexes".
- `id`: The index ID.
- `fields`: The number of fields in the index, as a value in *`m/n`* format:
    - *`m`* is the number of user-defined columns; that is, the number of columns you would see in the index definition in a `CREATE TABLE` statement.
    - *`n`* is the total number of index columns, including those added internally. For the clustered index, the total includes the other columns in the table definition, plus any columns added internally. For a secondary index, the total includes the columns from the primary key that are not part of the secondary index.
- `uniq`: The number of leading fields that are enough to determine index values uniquely.
- `type`: The index type. This is a bit field. For example, 1 indicates a clustered index and 2 indicates a unique index, so a clustered index (which always contains unique values), will have a `type` value of 3. An index with a `type` value of 0 is neither clustered nor unique. The flag values are defined in the `innobase/include/dict0mem.h` source file.
- `root page`: The index root page number.
- `appr. key vals`: The approximate index cardinality.
- `leaf pages`: The approximate number of leaf pages in the index.
- `size pages`: The approximate total number of pages in the index.
- `FIELDS`: The names of the fields in the index. For a clustered index that was generated automatically, the field list begins with the internal `DB_ROW_ID` (row ID) field. `DB_TRX_ID` and `DB_ROLL_PTR` are always added internally to the clustered index, following the fields that comprise the primary key. For a secondary index, the final fields are those from the primary key that are not part of the secondary index.

The end of the table section lists the `FOREIGN KEY` definitions that apply to the table. This information appears whether the table is a referencing or referenced table.

13.3.14.3. `InnoDB` General Troubleshooting

The following general guidelines apply to troubleshooting `InnoDB` problems:

- When an operation fails or you suspect a bug, look at the MySQL server error log (see Section 5.2.2, "The Error Log").
- Issues relating to the `InnoDB` data dictionary include failed `CREATE TABLE` statements (orphaned table files), inability to open `.InnoDB` files, and `SYSTEM CANNOT FIND THE PATH SPECIFIED` errors. For information about these sorts of problems and errors, see Section 13.3.14.4, "Troubleshooting `InnoDB` Data Dictionary Operations".
- When troubleshooting, it is usually best to run the MySQL server from the command prompt, rather than through `mysqld_safe` or as a Windows service. You can then see what `mysqld` prints to the console, and so have a better grasp of what is going on. On Windows, start `mysqld` with the `--console` option to direct the output to the console window.
- Use the `InnoDB` Monitors to obtain information about a problem (see Section 13.3.14.2, "`SHOW ENGINE INNODB STATUS` and the `InnoDB` Monitors"). If the problem is performance-related, or your server appears to be hung, you should use the standard Monitor to print information about the internal state of `InnoDB`. If the problem is with locks, use the Lock Monitor. If the problem is in creation of tables or other data dictionary operations, use the Table Monitor to print the contents of the `InnoDB` internal data dictionary. To see tablespace information use the Tablespace Monitor.
- If you suspect that a table is corrupt, run `CHECK TABLE` on that table.

13.3.14.4. Troubleshooting `InnoDB` Data Dictionary Operations

Information about table definitions is stored both in the `.frm` files, and in the InnoDB data dictionary. If you move `.frm` files around, or if the server crashes in the middle of a data dictionary operation, these sources of information can become inconsistent.

Problem with CREATE TABLE

A symptom of an out-of-sync data dictionary is that a `CREATE TABLE` statement fails. If this occurs, look in the server's error log. If the log says that the table already exists inside the `InnoDB` internal data dictionary, you have an orphaned table inside the `InnoDB` tablespace files that has no corresponding `.frm` file. The error message looks like this:

```
InnoDB: Error: table test/parent already exists in InnoDB internal
InnoDB: data dictionary. Have you deleted the .frm file
InnoDB: and not used DROP TABLE? Have you used DROP DATABASE
InnoDB: for InnoDB tables in MySQL version <= 3.23.43?
InnoDB: See the Restrictions section of the InnoDB manual.
InnoDB: You can drop the orphaned table inside InnoDB by
InnoDB: creating an InnoDB table with the same name in another
InnoDB: database and moving the .frm file to the current database.
InnoDB: Then MySQL thinks the table exists, and DROP TABLE will
InnoDB: succeed.
```

You can drop the orphaned table by following the instructions given in the error message. If you are still unable to use `DROP TABLE` successfully, the problem may be due to name completion in the `mysql` client. To work around this problem, start the `mysql` client with the `--skip-auto-rehash` option and try `DROP TABLE` again. (With name completion on, `mysql` tries to construct a list of table names, which fails when a problem such as just described exists.)

Problem Opening Table

Another symptom of an out-of-sync data dictionary is that MySQL prints an error that it cannot open a `.InnoDB` file:

```
ERROR 1016: Can't open file: 'child2.InnoDB'. (errno: 1)
```

In the error log you can find a message like this:

```
InnoDB: Cannot find table test/child2 from the internal data dictionary
InnoDB: of InnoDB though the .frm file for the table exists. Maybe you
InnoDB: have deleted and recreated InnoDB data files but have forgotten
InnoDB: to delete the corresponding .frm files of InnoDB tables?
```

This means that there is an orphaned `.frm` file without a corresponding table inside `InnoDB`. You can drop the orphaned `.frm` file by deleting it manually.

Problem with Temporary Table

If MySQL crashes in the middle of an `ALTER TABLE` operation, you may end up with an orphaned temporary table inside the `InnoDB` tablespace. Using the Table Monitor, you can see listed a table with a name that begins with `#sql-`. You can perform SQL statements on tables whose name contains the character “`#`” if you enclose the name within backticks. Thus, you can drop such an orphaned table like any other orphaned table using the method described earlier. To copy or rename a file in the Unix shell, you need to put the file name in double quotation marks if the file name contains “`#`”.

Problem with Missing Tablespace

With `innodb_file_per_table` enabled, the following message might occur if the `.frm` or `.ibd` files (or both) are missing:

```
InnoDB: in InnoDB data dictionary has tablespace id N,
InnoDB: but tablespace with that id or name does not exist. Have
InnoDB: you deleted or moved .ibd files?
InnoDB: This may also be a table created with CREATE TEMPORARY TABLE
InnoDB: whose .ibd and .frm files MySQL automatically removed, but the
InnoDB: table still exists in the InnoDB internal data dictionary.
```

If this occurs, try the following procedure to resolve the problem:

1. Create a matching `.frm` file in some other database directory and copy it to the database directory where the orphan table is located.
2. Issue `DROP TABLE` for the original table. That should successfully drop the table and `InnoDB` should print a warning to the error log that the `.ibd` file was missing.

13.3.15. Limits on `InnoDB` Tables

> **Warning**
>
> Do *not* convert MySQL system tables in the `mysql` database from `MyISAM` to `InnoDB` tables! This is an unsupported operation. If you do this, MySQL does not restart until you restore the old system tables from a backup or regenerate them with the `mysql_install_db` script.

> **Warning**
>
> It is not a good idea to configure `InnoDB` to use data files or log files on NFS volumes. Otherwise, the files might be locked by other processes and become unavailable for use by MySQL.

Maximums and Minimums

- A table can contain a maximum of 1000 columns.
- By default, an index key for a single-column index can be up to 767 bytes. The same length limit applies to any index key prefix. See Section 12.1.11, "`CREATE INDEX` Syntax". For example, you might hit this limit with a column prefix index of more than 255 characters on a `TEXT` or `VARCHAR` column, assuming a UTF-8 character set and the maximum of 3 bytes for each character. When the `innodb_large_prefix` configuration option is enabled, this length limit is raised to 3072 bytes, for `InnoDB` tables that use the `DYNAMIC` and `COMPRESSED` row formats.

  When you attempt to specify an index prefix length longer than allowed, the length is silently reduced to the maximum length. This configuration option changes the error handling for some combinations of row format and prefix length longer than the maximum allowed. See `innodb_large_prefix` for details.
- The `InnoDB` internal maximum key length is 3500 bytes, but MySQL itself restricts this to 3072 bytes. This limit applies to the length of the combined index key in a multi-column index.
- The maximum row length, except for variable-length columns (`VARBINARY`, `VARCHAR`, `BLOB` and `TEXT`), is slightly less than half of a database page. That is, the maximum row length is about 8000 bytes. `LONGBLOB` and `LONGTEXT` columns must be less than 4GB, and the total row length, including `BLOB` and `TEXT` columns, must be less than 4GB.

  If a row is less than half a page long, all of it is stored locally within the page. If it exceeds half a page, variable-length columns are chosen for external off-page storage until the row fits within half a page, as described in Section 13.3.12.2, "File Space Management".
- Although `InnoDB` supports row sizes larger than 65,535 bytes internally, MySQL inself imposes a row-size limit of 65,535 for the combined size of all columns:

  ```
  mysql> CREATE TABLE t (a VARCHAR(8000), b VARCHAR(10000),
      -> c VARCHAR(10000), d VARCHAR(10000), e VARCHAR(10000),
      -> f VARCHAR(10000), g VARCHAR(10000)) ENGINE=InnoDB;
  ERROR 1118 (42000): Row size too large. The maximum row size for the
  used table type, not counting BLOBs, is 65535. You have to change some
  columns to TEXT or BLOBs
  ```

  See Section E.9.4, "Table Column-Count and Row-Size Limits".
- On some older operating systems, files must be less than 2GB. This is not a limitation of `InnoDB` itself, but if you require a large tablespace, you will need to configure it using several smaller data files rather than one or a file large data files.
- The combined size of the `InnoDB` log files must be less than 4GB.
- The minimum tablespace size is 10MB. The maximum tablespace size is four billion database pages (64TB). This is also the maximum size for a table.
- The default database page size in `InnoDB` is 16KB. By recompiling the code, you can set it to values ranging from 8KB to 64KB. You must update the values of `UNIV_PAGE_SIZE` and `UNIV_PAGE_SIZE_SHIFT` in the `univ.i` source file.

  > **Note**
  >
  > Changing the page size is not a supported operation and there is no guarantee that `InnoDB` will function normally with a page size other than 16KB. Problems compiling or running InnoDB may occur. In particular, `ROW_FORMAT=COMPRESSED` in the `InnoDB Plugin` assumes that the page size is at most 16KB and uses 14-bit pointers.
  >
  > A version of `InnoDB` built for one page size cannot use data files or log files from a version built for a different page size.

Index Types

- `InnoDB` tables do not support `FULLTEXT` indexes.
- `InnoDB` tables support spatial data types, but not indexes on them.

Restrictions on InnoDB Tables

- `ANALYZE TABLE` determines index cardinality (as displayed in the `Cardinality` column of `SHOW INDEX` output) by doing eight random dives to each of the index trees and updating index cardinality estimates accordingly. Because these are only estimates, repeated runs of `ANALYZE TABLE` may produce different numbers. This makes `ANALYZE TABLE` fast on `InnoDB` tables but not 100% accurate because it does not take all rows into account.

  You can change the number of random dives by modifying the `innodb_stats_sample_pages` system variable. For more information, see Section 13.4.8, "Changes for Flexibility, Ease of Use and Reliability".

  MySQL uses index cardinality estimates only in join optimization. If some join is not optimized in the right way, you can try using `ANALYZE TABLE`. In the few cases that `ANALYZE TABLE` does not produce values good enough for your particular tables, you can use `FORCE INDEX` with your queries to force the use of a particular index, or set the `max_seeks_for_key` system variable to ensure that MySQL prefers index lookups over table scans. See Section 5.1.3, "Server System Variables", and Section C.5.6, "Optimizer-Related Issues".

- `SHOW TABLE STATUS` does not give accurate statistics on `InnoDB` tables, except for the physical size reserved by the table. The row count is only a rough estimate used in SQL optimization.
- `InnoDB` does not keep an internal count of rows in a table because concurrent transactions might "see" different numbers of rows at the same time. To process a `SELECT COUNT(*) FROM t` statement, `InnoDB` scans an index of the table, which takes some time if the index is not entirely in the buffer pool. If your table does not change often, using the MySQL query cache is a good solution. To get a fast count, you have to use a counter table you create yourself and let your application update it according to the inserts and deletes it does. If an approximate row count is sufficient, `SHOW TABLE STATUS` can be used. See Section 13.3.14.1, "`InnoDB` Performance Tuning Tips".
- On Windows, `InnoDB` always stores database and table names internally in lowercase. To move databases in a binary format from Unix to Windows or from Windows to Unix, create all databases and tables using lowercase names.
- For an `AUTO_INCREMENT` column, you must always define an index for the table, and that index must contain just the `AUTO_INCREMENT` column. In `MyISAM` tables, the `AUTO_INCREMENT` column may be part of a multiple-column index.
- While initializing a previously specified `AUTO_INCREMENT` column on a table, `InnoDB` sets an exclusive lock on the end of the index associated with the `AUTO_INCREMENT` column. While accessing the auto-increment counter, `InnoDB` uses a specific `AUTO-INC` table lock mode where the lock lasts only to the end of the current SQL statement, not to the end of the entire transaction. Other clients cannot insert into the table while the `AUTO-INC` table lock is held. See Section 13.3.5.3, "`AUTO_INCREMENT` Handling in `InnoDB`".
- When you restart the MySQL server, `InnoDB` may reuse an old value that was generated for an `AUTO_INCREMENT` column but never stored (that is, a value that was generated during an old transaction that was rolled back).
- When an `AUTO_INCREMENT` integer column runs out of values, a subsequent `INSERT` operation returns a duplicate-key error. This is general MySQL behavior, similar to how `MyISAM` works.
- `DELETE FROM tbl_name` does not regenerate the table but instead deletes all rows, one by one.
- Under some conditions, `TRUNCATE tbl_name` for an `InnoDB` table is mapped to `DELETE FROM tbl_name`. See Section 12.1.27, "`TRUNCATE TABLE` Syntax".
- Currently, cascaded foreign key actions do not activate triggers.
- You cannot create a table with a column name that matches the name of an internal InnoDB column (including `DB_ROW_ID`, `DB_TRX_ID`, `DB_ROLL_PTR`, and `DB_MIX_ID`). The server reports error 1005 and refers to error –1 in the error message. This restriction applies only to use of the names in uppercase.

Locking and Transactions

- `LOCK TABLES` acquires two locks on each table if `innodb_table_locks=1` (the default). In addition to a table lock on the MySQL layer, it also acquires an `InnoDB` table lock. Versions of MySQL before 4.1.2 did not acquire `InnoDB` table locks; the old behavior can be selected by setting `innodb_table_locks=0`. If no `InnoDB` table lock is acquired, `LOCK`

`TABLES` completes even if some records of the tables are being locked by other transactions.

- All `InnoDB` locks held by a transaction are released when the transaction is committed or aborted. Thus, it does not make much sense to invoke `LOCK TABLES` on `InnoDB` tables in `autocommit=1` mode because the acquired `InnoDB` table locks would be released immediately.
- You cannot lock additional tables in the middle of a transaction because `LOCK TABLES` performs an implicit `COMMIT` and `UNLOCK TABLES`.
- The limit of 1023 concurrent data-modifying transactions has been raised in MySQL 5.5 and above. The limit is now 128 * 1023 concurrent transactions that generate undo records. You can remove any workarounds that require changing the proper structure of your transactions, such as committing more frequently.

13.4. New Features of InnoDB 1.1

13.4.1. Introduction to InnoDB 1.1

InnoDB 1.1 combines the familiar reliability and performance of the InnoDB storage engine, with new performance and usability enhancements. InnoDB 1.1 includes all the features that were part of the InnoDB Plugin for MySQL 5.1, plus new features specific to MySQL 5.5 and higher.

Beginning with MySQL version 5.5, InnoDB is the default storage engine, rather than MyISAM, to promote greater data reliability and reducing the chance of corruption.

13.4.1.1. Features of the InnoDB Storage Engine

The InnoDB Storage Engine for MySQL contains several important new features:

- Fast index creation: add or drop indexes without copying the data
- Data compression: shrink tables, to significantly reduce storage and i/o
- New row format: fully off-page storage of long `BLOB`, `TEXT`, and `VARCHAR` columns
- File format management: protects upward and downward compatibility
- `INFORMATION_SCHEMA` tables: information about compression and locking
- Performance and scalability enhancements
- Other changes for flexibility, ease of use and reliability

Upward and Downward Compatibility

Note that the ability to use data compression and the new row format require the use of a new InnoDB file format called Barracuda. The previous file format, used by the built-in InnoDB in MySQL 5.1 and earlier, is now called Antelope and does not support these features, but does support the other features introduced with the InnoDB storage engine.

The InnoDB storage engine is upward compatible from standard InnoDB as built in to, and distributed with, MySQL. Existing databases can be used with the InnoDB Storage Engine for MySQL. The new parameter `innodb_file_format` can help protect upward and downward compatibility between InnoDB versions and database files, allowing users to enable or disable use of new features that can only be used with certain versions of InnoDB.

InnoDB since version 5.0.21 has a safety feature that prevents it from opening tables that are in an unknown format. However, the system tablespace may contain references to new-format tables that confuse the built-in InnoDB in MySQL 5.1 and earlier. These references are cleared in a slow shutdown.

With previous versions of InnoDB, no error would be returned until you try to access a table that is in a format “too new” for the software. To provide early feedback, InnoDB 1.1 checks the system tablespace before startup to ensure that the file format used in the database is supported by the storage engine. See Section 13.4.4.2.1, “Compatibility Check When InnoDB Is Started” for the details.

13.4.1.2. Obtaining and Installing the InnoDB Storage Engine

Starting with MySQL 5.4.2, you do not need to do anything special to get or install the most up-to-date InnoDB storage engine. From that version forward, the InnoDB storage engine in the server is what was formerly known as the InnoDB Plugin. Earlier versions of MySQL required some extra build and configuration steps to get the Plugin-specific features such as fast index creation and table compression.

Report any bugs in the InnoDB storage engine using the My Oracle Support site. For general discussions about InnoDB Storage Engine for MySQL, see http://forums.mysql.com/list.php?22.

13.4.1.3. Viewing the InnoDB Storage Engine Version Number

InnoDB storage engine releases are numbered with version numbers independent of MySQL release numbers. The initial release of the InnoDB storage engine is version 1.0, and it is designed to work with MySQL 5.1. Version 1.1 of the InnoDB storage engine is for MySQL 5.5 and up.

- The first component of the InnoDB storage engine version number designates a major release level.
- The second component corresponds to the MySQL release. The digit 0 corresponds to MySQL 5.1. The digit 1 corresponds to MySQL 5.5.
- The third component indicates the specific release of the InnoDB storage engine (at a given major release level and for a specific MySQL release); only bug fixes and minor functional changes are introduced at this level.

Once you have installed the InnoDB storage engine, you can check its version number in three ways:

- In the error log, it is printed during startup
- `SELECT * FROM information_schema.plugins;`
- `SELECT @@innodb_version;`

The InnoDB storage engine writes its version number to the error log, which can be helpful in diagnosis of errors:

```
091105 12:28:06 InnoDB Plugin 1.0.5 started; log sequence number 46509
```

Note that the `PLUGIN_VERSION` column in the table `INFORMATION_SCHEMA.PLUGINS` does not display the third component of the version number, only the first and second components, as in 1.0.

13.4.1.4. Compatibility Considerations for Downgrade and Backup

Because InnoDB 1.1 supports the “Barracuda” file format, with new on-disk data structures within both the database and log files, pay special attention to file format compatibility with respect to the following scenarios:

- Downgrading from MySQL 5.5 to the MySQL 5.1 or earlier (without the InnoDB Plugin enabled), or otherwise using earlier versions of MySQL with database files created by MySQL 5.5 and higher.
- Using `mysqldump`.
- Using MySQL replication.
- Using MySQL Enterprise Backup or InnoDB Hot Backup.

WARNING: Once you create any tables with the Barracuda file format, take care to avoid crashes and corruptions when using those files with an earlier version of MySQL. It is **strongly** recommended that you use a “slow shutdown” (`SET GLOBAL innodb_fast_shutdown=0`) when stopping the MySQL server before downgrading to MySQL 5.1 or earlier. This ensures that the log files and other system information do not cause consistency issues or startup problems when using a prior version of MySQL.

WARNING: If you dump a database containing compressed tables with `mysqldump`, the dump file may contain `CREATE TABLE` statements that attempt to create compressed tables, or those using `ROW_FORMAT=DYNAMIC` in the new database. Therefore, be sure the new database is running the InnoDB storage engine, with the proper settings for `innodb_file_format` and `innodb_file_per_table`, if you want to have the tables re-created as they exist in the original database. Typically, when the `mysqldump` file is loaded, MySQL and InnoDB ignore `CREATE TABLE` options they do not recognize, and the table(s) are created in a format used by the running server.

WARNING: If you use MySQL replication, ensure all slaves are configured with the InnoDB storage engine, with the same settings for `innodb_file_format` and `innodb_file_per_table`. If you do not do so, and you create tables that require the new Barracuda file format, replication errors may occur. If a slave MySQL server is running an older version of MySQL, it ignores the `CREATE TABLE` options to create a compressed table or one with `ROW_FORMAT=DYNAMIC`, and creates the table uncompressed, with `ROW_FORMAT=COMPACT`.

WARNING: Version 3.0 of InnoDB Hot Backup does not support the new Barracuda file format. Using InnoDB Hot Backup Version 3 to backup databases in this format causes unpredictable behavior. MySQL Enterprise Backup, the successor product to InnoDB Hot Backup, does support tables with the Barracuda file format. You can also back up such databases with `mysqldump`.

13.4.2. Fast Index Creation in the InnoDB Storage Engine

In MySQL 5.5 and higher, or in MySQL 5.1 with the InnoDB Plugin, creating and dropping secondary indexes does not copy the contents of the entire table, making this operation much more efficient than with prior releases.

13.4.2.1. Overview of Fast Index Creation

With MySQL 5.5 and higher, or MySQL 5.1 with the InnoDB Plugin, creating and dropping secondary indexes for InnoDB tables is much faster than before. Historically, adding or dropping an index on a table with existing data could be very slow. The `CREATE INDEX` and `DROP INDEX` statements worked by creating a new, empty table defined with the requested set of indexes, then copying the existing rows to the new table one-by-one, updating the indexes as the rows are inserted. After all rows from the original table were copied, the old table was dropped and the copy was renamed with the name of the original table.

The performance speedup for fast index creation applies to secondary indexes, not to the primary key index. The rows of an InnoDB table are stored in a clustered index organized based on the primary key, forming what some database systems call an “index-organized table”. Because the table structure is so closely tied to the primary key, redefining the primary key still requires copying the data.

This new mechanism also means that you can generally speed the overall process of creating and loading an indexed table by creating the table with only the clustered index, and adding the secondary indexes after the data is loaded.

Although no syntax changes are required in the `CREATE INDEX` or `DROP INDEX` commands, some factors affect the performance, space usage, and semantics of this operation (see Section 13.4.2.6, “Limitations of Fast Index Creation”).

13.4.2.2. Examples of Fast Index Creation

It is possible to create multiple indexes on a table with one `ALTER TABLE` statement. This is relatively efficient, because the clustered index of the table needs to be scanned only once (although the data is sorted separately for each new index). For example:

```
CREATE TABLE T1(A INT PRIMARY KEY, B INT, C CHAR(1)) ENGINE=InnoDB;
INSERT INTO T1 VALUES (1,2,'a'), (2,3,'b'), (3,2,'c'), (4,3,'d'), (5,2,'e');
COMMIT;
ALTER TABLE T1 ADD INDEX (B), ADD UNIQUE INDEX (C);
```

The above statements create table `T1` with the clustered index (primary key) on column `A`, insert several rows, and then build two new indexes on columns `B` and `C`. If there were many rows inserted into `T1` before the `ALTER TABLE` statement, this approach is much more efficient than creating all the secondary indexes before loading the data.

You can also create the indexes one at a time, but then the clustered index of the table is scanned (as well as sorted) once for each `CREATE INDEX` statement. Thus, the following statements are not as efficient as the `ALTER TABLE` statement above, even though neither requires recreating the clustered index for table `T1`.

```
CREATE INDEX B ON T1 (B);
CREATE UNIQUE INDEX C ON T1 (C);
```

Dropping InnoDB secondary indexes also does not require any copying of table data. You can equally quickly drop multiple indexes with a single `ALTER TABLE` statement or multiple `DROP INDEX` statements:

```
ALTER TABLE T1 DROP INDEX B, DROP INDEX C;
```

or:

```
DROP INDEX B ON T1;
DROP INDEX C ON T1;
```

Restructuring the clustered index in InnoDB always requires copying the data in the table. For example, if you create a table without a primary key, InnoDB chooses one for you, which may be the first `UNIQUE` key defined on `NOT NULL` columns, or a system-generated key. Defining a `PRIMARY KEY` later causes the data to be copied, as in the following example:

```
CREATE TABLE T2 (A INT, B INT) ENGINE=InnoDB;
INSERT INTO T2 VALUES (NULL, 1);
ALTER TABLE T2 ADD PRIMARY KEY (B);
```

When you create a `UNIQUE` or `PRIMARY KEY` index, InnoDB must do some extra work. For `UNIQUE` indexes, InnoDB checks that the table contains no duplicate values for the key. For a `PRIMARY KEY` index, InnoDB also checks that none of the `PRIMARY KEY` columns contains a `NULL`. It is best to define the primary key when you create a table, so you need not rebuild the table later.

13.4.2.3. Implementation Details of Fast Index Creation

InnoDB has two types of indexes: the clustered index and secondary indexes. Since the clustered index contains the data values in its B-tree nodes, adding or dropping a clustered index does involve copying the data, and creating a new copy of the table. A secondary index, however, contains only the index key and the value of the primary key. This type of index can be created or dropped without copying the data in the clustered index. Because each secondary index contains copies of the primary key values (used to access the clustered index when needed), when you change the definition of the primary key, all secondary indexes are recreated as well.

Dropping a secondary index is simple. Only the internal InnoDB system tables and the MySQL data dictionary tables are updated to reflect the fact that the index no longer exists. InnoDB returns the storage used for the index to the tablespace that contained it, so that new indexes or additional table rows can use the space.

To add a secondary index to an existing table, InnoDB scans the table, and sorts the rows using memory buffers and temporary files in order by the values of the secondary index key columns. The B-tree is then built in key-value order, which is more efficient than inserting rows into an index in random order. Because the B-tree nodes are split when they fill, building the index in this way results in a higher fill-factor for the index, making it more efficient for subsequent access.

13.4.2.4. Concurrency Considerations for Fast Index Creation

While an InnoDB secondary index is being created or dropped, the table is locked in shared mode. Any writes to the table are blocked, but the data in the table can be read. When you alter the clustered index of a table, the table is locked in exclusive mode, because the data must be copied. Thus, during the creation of a new clustered index, all operations on the table are blocked.

A `CREATE INDEX` or `ALTER TABLE` statement for an InnoDB table always waits for currently executing transactions that are accessing the table to commit or roll back. `ALTER TABLE` statements that redefine an InnoDB primary key wait for all `SELECT` statements that access the table to complete, or their containing transactions to commit. No transactions whose execution spans the creation of the index can be accessing the table, because the original table is dropped when the clustered index is restructured.

Once a `CREATE INDEX` or `ALTER TABLE` statement that creates an InnoDB secondary index begins executing, queries can access the table for read access, but cannot update the table. If an `ALTER TABLE` statement is changing the clustered index for an InnoDB table, all queries wait until the operation completes.

A newly-created InnoDB secondary index contains only the committed data in the table at the time the `CREATE INDEX` or `ALTER TABLE` statement begins to execute. It does not contain any uncommitted values, old versions of values, or values marked for deletion but not yet removed from the old index.

Because a newly-created index contains only information about data current at the time the index was created, queries that need to see data that was deleted or changed before the index was created cannot use the index. The only queries that could be affected by this limitation are those executing in transactions that began before the creation of the index was begun. For such queries, unpredictable results could occur. Newer queries can use the index.

13.4.2.5. How Crash Recovery Works with Fast Index Creation

Although no data is lost if the server crashes while an `ALTER TABLE` statement is executing, the crash recovery process is different for clustered indexes and secondary indexes.

If the server crashes while creating an InnoDB secondary index, upon recovery, MySQL drops any partially created indexes. You must re-run the `ALTER TABLE` or `CREATE INDEX` statement.

When a crash occurs during the creation of an InnoDB clustered index, recovery is more complicated, because the data in the table must be copied to an entirely new clustered index. Remember that all InnoDB tables are stored as clustered indexes. In the following discussion, we use the word table and clustered index interchangeably.

MySQL creates the new clustered index by copying the existing data from the original InnoDB table to a temporary table that has the desired index structure. Once the data is completely copied to this temporary table, the original table is renamed with a different temporary table name. The temporary table comprising the new clustered index is renamed with the name of the original table, and the original table is dropped from the database.

If a system crash occurs while creating a new clustered index, no data is lost, but you must complete the recovery process using the temporary tables that exist during the process. Since it is rare to re-create a clustered index or re-define primary keys on large tables, or to encounter a system crash during this operation, this manual does not provide information on recovering from this scenario. Instead, please see the InnoDB web site: http://www.innodb.com/support/tips.

13.4.2.6. Limitations of Fast Index Creation

Take the following considerations into account when creating or dropping InnoDB indexes:

- During index creation, files are written to the temporary directory (`$TMPDIR` on Unix, `%TEMP%` on Windows, or the value of the `--tmpdir` configuration variable). Each temporary file is large enough to hold one column that makes up the new index, and each one is removed as soon as it is merged into the final index.
- The table is copied, rather than using Fast Index Creation when you create an index on a `TEMPORARY TABLE`. This has been reported as MySQL Bug #39833.
- To avoid consistency issues between the InnoDB data dictionary and the MySQL data dictionary, the table is copied, rather than using Fast Index Creation when you use the `ALTER TABLE ... RENAME COLUMN` syntax.
- The statement `ALTER IGNORE TABLE t ADD UNIQUE INDEX` does not delete duplicate rows. This has been reported as MySQL Bug #40344. The `IGNORE` keyword is ignored. If any duplicate rows exist, the operation fails with the following error message:

  ```
  ERROR 23000: Duplicate entry '347' for key 'pl'
  ```

- As noted above, a newly-created index contains only information about data current at the time the index was created. Therefore, you should not run queries in a transaction that might use a secondary index that did not exist at the beginning of the transaction. There is no way for InnoDB to access “old” data that is consistent with the rest of the data read by the transaction. See the discussion of locking in Section 13.4.2.4, “Concurrency Considerations for Fast Index Creation”.

  Prior to InnoDB storage engine 1.0.4, unexpected results could occur if a query attempts to use an index created after the start of the transaction containing the query. If an old transaction attempts to access a “too new” index, InnoDB storage engine 1.0.4 and later reports an error:

  ```
  ERROR HY000: Table definition has changed, please retry transaction
  ```

  As the error message suggests, committing (or rolling back) the transaction, and restarting it, cures the problem.

- InnoDB storage engine 1.0.2 introduces some improvements in error handling when users attempt to drop indexes. See section Section 13.4.8.6, “Better Error Handling when Dropping Indexes” for details.
- MySQL 5.5 does not support efficient creation or dropping of `FOREIGN KEY` constraints. Therefore, if you use `ALTER TABLE` to add or remove a `REFERENCES` constraint, the child table is copied, rather than using Fast Index Creation.

13.4.3. InnoDB Data Compression

By setting InnoDB configuration options, you can create tables where the data is stored in compressed form. The compression means less data is transferred between disk and memory, and takes up less space in memory. The benefits are amplified for tables with secondary indexes, because index data is compressed also.

13.4.3.1. Overview of Table Compression

Because processors and cache memories have increased in speed more than disk storage devices, many workloads are I/O-bound. Data compression enables smaller database size, reduced I/O, and improved throughput, at the small cost of increased CPU utilization. Compression is especially valuable for read-intensive applications, on systems with enough RAM to keep frequently-used data in memory.

An InnoDB table created with `ROW_FORMAT=COMPRESSED` can use a smaller page size on disk than the usual 16KB default. Smaller pages require less I/O to read from and write to disk, which is especially valuable for SSD devices.

The page size is specified through the `KEY_BLOCK_SIZE` parameter. The different page size means the table must be in its own `.ibd` file rather than the system tablespace, which requires enabling the `innodb_file_per_table` option. The level of compression is the same regardless of the `KEY_BLOCK_SIZE` value. As you specify smaller values for `KEY_BLOCK_SIZE`, you get the I/O benefits of increasingly smaller pages. But if you specify a value that is too small, there is additional overhead to reorganize the pages when data values cannot be compressed enough to fit multiple rows in each page. There is a hard limit on how small `KEY_BLOCK_SIZE` can be for a table, based on the lengths of the key columns for each of its indexes. Specify a value that is too small, and the `CREATE TABLE` or `ALTER TABLE` statement fails.

In the buffer pool, the compressed data is held in small pages, with a page size based on the `KEY_BLOCK_SIZE` value. For extracting or updating the column values, InnoDB also creates a 16KB page in the buffer pool with the uncompressed data. Within the buffer pool, any updates to the uncompressed page are also re-written back to the equivalent compressed page. You might need to size your buffer pool to accommodate the additional data of both compressed and uncompressed pages, although the uncompressed pages are evicted from the buffer pool when space is needed, and then uncompressed again on the next access.

13.4.3.2. Enabling Compression for a Table

The default uncompressed size of InnoDB data pages is 16KB. You can use the attributes `ROW_FORMAT=COMPRESSED`, `KEY_BLOCK_SIZE`, or both in the `CREATE TABLE` and `ALTER TABLE` statements to enable table compression. Depending on the combination of option values, InnoDB uses a page size of 1KB, 2KB, 4KB, 8KB, or 16KB for the `.ibd` file of the table. (The actual compression algorithm is not affected by the `KEY_BLOCK_SIZE` value.)

> **Note**
>
> Compression is applicable to tables, not to individual rows, despite the option name `ROW_FORMAT`.

To create a compressed table, you might use a statement like this:

```
CREATE TABLE name
 (column1 INT PRIMARY KEY)
 ENGINE=InnoDB
 ROW_FORMAT=COMPRESSED
 KEY_BLOCK_SIZE=4;
```

If you specify `ROW_FORMAT=COMPRESSED` but not `KEY_BLOCK_SIZE`, the default compressed page size of 8KB is used. If `KEY_BLOCK_SIZE` is specified, you can omit the attribute `ROW_FORMAT=COMPRESSED`.

Setting `KEY_BLOCK_SIZE=16` typically does not result in much compression, since the normal InnoDB page size is 16KB. This setting may still be useful for tables with many long `BLOB`, `VARCHAR` or `TEXT` columns, because such values often do compress well, and might therefore require fewer “overflow” pages as described in Section 13.4.3.4, “ Compressing BLOB, VARCHAR and TEXT Columns ”.

All indexes of a table (including the clustered index) are compressed using the same page size, as specified in the `CREATE TABLE` or `ALTER TABLE` statement. Table attributes such as `ROW_FORMAT` and `KEY_BLOCK_SIZE` are not part of the `CREATE INDEX` syntax, and are ignored if they are specified (although you see them in the output of the `SHOW CREATE TABLE` statement).

13.4.3.2.1. Configuration Parameters for Compression

Compressed tables are stored in a format that previous versions of InnoDB cannot process. To preserve downward compatibility of database files, compression can be specified only when the Barracuda data file format is enabled using the configuration parameter `innodb_file_format`.

Table compression is also not available for the InnoDB system tablespace. The system tablespace (space 0, the `ibdata*` files) may contain user data, but it also contains internal InnoDB system information, and therefore is never compressed. Thus, compression applies only to tables (and indexes) stored in their own tablespaces.

To use compression, enable the file-per-table mode using the configuration parameter `innodb_file_per_table` and enable the Barracuda disk file format using the parameter `innodb_file_format`. If necessary, you can set these parameters in the MySQL option file `my.cnf` or `my.ini`, or with the `SET` statement without shutting down the MySQL server.

Specifying `ROW_FORMAT=COMPRESSED` or `KEY_BLOCK_SIZE` in `CREATE TABLE` or `ALTER TABLE` statements produces these warnings if the Barracuda file format is not enabled. You can view them with the `SHOW WARNINGS` statement.

Level	Code	Message
Warning	1478	`InnoDB: KEY_BLOCK_SIZE requires innodb_file_per_table.`
Warning	1478	`InnoDB: KEY_BLOCK_SIZE requires innodb_file_format=1`
Warning	1478	`InnoDB: ignoring KEY_BLOCK_SIZE=4.`
Warning	1478	`InnoDB: ROW_FORMAT=COMPRESSED requires innodb_file_per_table.`
Warning	1478	`InnoDB: assuming ROW_FORMAT=COMPACT.`

> **Note**
>
> These messages are only warnings, not errors, and the table is created as if the options were not specified. When InnoDB “strict mode” (see Section 13.4.8.4, “InnoDB Strict Mode”) is enabled, InnoDB generates an error, not a warning, for these cases. In strict mode, the table is not created if the current configuration does not permit using compressed tables.

The “non-strict” behavior is intended to permit you to import a `mysqldump` file into a database that does not support compressed tables, even if the source database contained compressed tables. In that case, MySQL creates the table in `ROW_FORMAT=COMPACT` instead of preventing the operation.

When you import the dump file into a new database, if you want to have the tables re-created as they exist in the original database, ensure the server is running the InnoDB storage engine with the proper settings for the configuration parameters `innodb_file_format` and `innodb_file_per_table`.

13.4.3.2.2. SQL Compression Syntax Warnings and Errors

The attribute `KEY_BLOCK_SIZE` is permitted only when `ROW_FORMAT` is specified as `COMPRESSED` or is omitted. Specifying a `KEY_BLOCK_SIZE` with any other `ROW_FORMAT` generates a warning that you can view with `SHOW WARNINGS`. However, the table is non-compressed; the specified `KEY_BLOCK_SIZE` is ignored).

Level	Code	Message
Warning	1478	`InnoDB: ignoring KEY_BLOCK_SIZE=`*`n`*` unless ROW_FORMAT=COMPRESSED.`

If you are running in InnoDB strict mode, the combination of a `KEY_BLOCK_SIZE` with any `ROW_FORMAT` other than `COMPRESSED` generates an error, not a warning, and the table is not created.

Table 13.4, "Meaning of `CREATE TABLE` and `ALTER TABLE` options" summarizes how the various options on `CREATE TABLE` and `ALTER TABLE` are handled.

Table 13.4. Meaning of `CREATE TABLE` and `ALTER TABLE` options

Option	Usage	Description
`ROW_FORMAT=REDUNDANT`	Storage format used prior to MySQL 5.0.3	Less efficient than `ROW_FORMAT=COMPACT`; for backward compatibility
`ROW_FORMAT=COMPACT`	Default storage format since MySQL 5.0.3	Stores a prefix of 768 bytes of long column values in the clustered index page, with the remaining bytes stored in an overflow page
`ROW_FORMAT=DYNAMIC`	Available only with `innodb_file_format=Barracuda`	Store values within the clustered index page if they fit; if not, stores only a 20-byte pointer to an overflow page (no prefix)
`ROW_FORMAT=COMPRESSED`	Available only with `innodb_file_format=Barracuda`	Compresses the table and indexes using zlib to default compressed page size of 8K bytes; implies `ROW_FORMAT=DYNAMIC`
`KEY_BLOCK_SIZE=`*`n`*	Available only with `innodb_file_format=Barracuda`	Specifies compressed page size of 1, 2, 4, 8 or 16K bytes; implies `ROW_FORMAT=DYNAMIC` and `ROW_FORMAT=COMPRESSED`

Table 13.5, "`CREATE/ALTER TABLE` Warnings and Errors when InnoDB Strict Mode is OFF" summarizes error conditions that occur with certain combinations of configuration parameters and options on the `CREATE TABLE` or `ALTER TABLE` statements, and how the options appear in the output of `SHOW TABLE STATUS`.

When InnoDB strict mode is `OFF`, InnoDB creates or alters the table, but may ignore certain settings, as shown below. You can see the warning messages in the MySQL error log. When InnoDB strict mode is `ON`, these specified combinations of options generate errors, and the table is not created or altered. You can see the full description of the error condition with `SHOW ERRORS`. For example:

```
mysql> CREATE TABLE x (id INT PRIMARY KEY, c INT)

-> ENGINE=INNODB KEY_BLOCK_SIZE=33333;

ERROR 1005 (HY000): Can't create table 'test.x' (errno: 1478)

mysql> SHOW ERRORS;
+-------+------+-------------------------------------------+
| Level | Code | Message                                   |
+-------+------+-------------------------------------------+
| Error | 1478 | InnoDB: invalid KEY_BLOCK_SIZE=33333.     |
| Error | 1005 | Can't create table 'test.x' (errno: 1478) |
+-------+------+-------------------------------------------+
2 rows in set (0.00 sec)
```

Table 13.5. `CREATE/ALTER TABLE` Warnings and Errors when InnoDB Strict Mode is OFF

Syntax	Warning or Error Condition	Resulting `ROW_FORMAT`, as shown in `SHOW TABLE STATUS`
`ROW_FORMAT=REDUNDANT`	None	`REDUNDANT`
`ROW_FORMAT=COMPACT`	None	`COMPACT`
`ROW_FORMAT=COMPRESSED` or `ROW_FORMAT=DYNAMIC` or `KEY_BLOCK_SIZE` is specified	Ignored unless both `innodb_file_format=Barracuda` and `innodb_file_per_table` are enabled	`COMPACT`

Syntax	**Warning or Error Condition**	**Resulting `ROW_FORMAT`, as shown in `SHOW TABLE STATUS`**
Invalid `KEY_BLOCK_SIZE` is specified (not 1, 2, 4, 8 or 16)	`KEY_BLOCK_SIZE` is ignored	the requested one, or `COMPACT` by default
`ROW_FORMAT=COMPRESSED` and valid `KEY_BLOCK_SIZE` are specified	None; `KEY_BLOCK_SIZE` specified is used, not the 8K default	`COMPRESSED`
`KEY_BLOCK_SIZE` is specified with `REDUNDANT`, `COMPACT` or `DYNAMIC` row format	`KEY_BLOCK_SIZE` is ignored	`REDUNDANT`, `COMPACT` or `DYNAMIC`
`ROW_FORMAT` is not one of `REDUNDANT`, `COMPACT`, `DYNAMIC` or `COMPRESSED`	Ignored if recognized by the MySQL parser. Otherwise, an error is issued.	`COMPACT` or N/A

When InnoDB strict mode is ON (`innodb_strict_mode=1`), the InnoDB storage engine rejects invalid `ROW_FORMAT` or `KEY_BLOCK_SIZE` parameters. For compatibility with earlier versions of InnoDB, strict mode is not enabled by default; instead, InnoDB issues warnings (not errors) for ignored invalid parameters.

Note that it is not possible to see the chosen `KEY_BLOCK_SIZE` using `SHOW TABLE STATUS`. The statement `SHOW CREATE TABLE` displays the `KEY_BLOCK_SIZE` (even if it was ignored by InnoDB). The real compressed page size inside InnoDB cannot be displayed by MySQL.

13.4.3.3. Tuning InnoDB Compression

Most often, the internal optimizations in InnoDB described in Section 13.4.3.4, “ InnoDB Data Storage and Compression ” ensure that the system runs well with compressed data. However, because the efficiency of compression depends on the nature of your data, there are some factors you should consider to get best performance. You need to choose which tables to compress, and what compressed page size to use. You might also adjust the size of the buffer pool based on run-time performance characteristics, such as the amount of time the system spends compressing and uncompressing data.

When to Use Compression

In general, compression works best on tables that include a reasonable number of character string columns and where the data is read far more often than it is written. Because there are no guaranteed ways to predict whether or not compression benefits a particular situation, always test with a specific workload and data set running on a representative configuration. Consider the following factors when deciding which tables to compress.

Data Characteristics and Compression

A key determinant of the efficiency of compression in reducing the size of data files is the nature of the data itself. Recall that compression works by identifying repeated strings of bytes in a block of data. Completely randomized data is the worst case. Typical data often has repeated values, and so compresses effectively. Character strings often compress well, whether defined in `CHAR`, `VARCHAR`, `TEXT` or `BLOB` columns. On the other hand, tables containing mostly binary data (integers or floating point numbers) or data that is previously compressed (for example JPEG or PNG images) may not generally compress well, significantly or at all.

You choose whether to turn on compression for each InnoDB tables. A table and all of its indexes use the same (compressed) page size. It might be that the primary key (clustered) index, which contains the data for all columns of a table, compresses more effectively than the secondary indexes. For those cases where there are long rows, the use of compression might result in long column values being stored “off-page”, as discussed in Section 13.4.5.3, “Barracuda File Format: `DYNAMIC` and `COMPRESSED` Row Formats”. Those overflow pages may compress well. Given these considerations, for many applications, some tables compress more effectively than others, and you might find that your workload performs best only with a subset of tables compressed.

Experimenting is the only way to determine whether or not to compress a particular table. InnoDB compresses data in 16K chunks corresponding to the uncompressed page size, and in addition to user data, the page format includes some internal system data that is not compressed. Compression utilities compress an entire stream of data, and so may find more repeated strings across the entire input stream than InnoDB would find in a table compressed in 16K chunks. But you can get a sense of how compression efficiency by using a utility that implements LZ77 compression (such as `gzip` or WinZip) on your data file.

Another way to test compression on a specific table is to copy some data from your uncompressed table to a similar, compressed table (having all the same indexes) and look at the size of the resulting file. When you do so (if nothing else using compression is running), you can examine the ratio of successful compression operations to overall compression operations. (In the `INNODB_CMP` table, compare `COMPRESS_OPS` to `COMPRESS_OPS_OK`. See `INNODB_CMP` for more information.) If a high percentage of compression operations complete successfully, the table might be a good candidate for compression.

Compression and Application and Schema Design

Decide whether to compress data in your application or in the InnoDB table. It is usually not sensible to store data that is compressed by an application in an InnoDB compressed table. Further compression is extremely unlikely, and the attempt to compress just wastes CPU cycles.

Compressing in the Database

The InnoDB table compression is automatic and applies to all columns and index values. The columns can still be tested with operators such as `LIKE`, and sort operations can still use indexes even when the index values are compressed. Because indexes are often a significant fraction of the total size of a database, compression could result in significant savings in storage, I/O or processor time. The compression and decompression operations happen on the database server, which likely is a powerful system that is sized to handle the expected load.

Compressing in the Application

If you compress data such as text in your application, before it is inserted into the database, You might save overhead for data that does not compress well by compressing some columns and not others. This approach uses CPU cycles for compression and uncompression on the client machine rather than the database server, which might be appropriate for a distributed application with many clients, or where the client machine has spare CPU cycles.

Hybrid Approach

Of course, it is possible to combine these approaches. For some applications, it may be appropriate to use some compressed tables and some uncompressed tables. It may be best to externally compress some data (and store it in uncompressed InnoDB tables) and allow InnoDB to compress (some of) the other tables in the application. As always, up-front design and real-life testing are valuable in reaching the right decision.

Workload Characteristics and Compression

In addition to choosing which tables to compress (and the page size), the workload is another key determinant of performance. If the application is dominated by reads, rather than updates, fewer pages need to be reorganized and recompressed after the index page runs out of room for the per-page “modification log” that InnoDB maintains for compressed data. If the updates predominantly change non-indexed columns or those containing `BLOB`s or large strings that happen to be stored “off-page”, the overhead of compression may be acceptable. If the only changes to a table are `INSERT`s that use a monotonically increasing primary key, and there are few secondary indexes, there is little need to reorganize and recompress index pages. Since InnoDB can “delete-mark” and delete rows on compressed pages “in place” by modifying uncompressed data, `DELETE` operations on a table are relatively efficient.

For some environments, the time it takes to load data can be as important as run-time retrieval. Especially in data warehouse environments, many tables may be read-only or read-mostly. In those cases, it might or might not be acceptable to pay the price of compression in terms of increased load time, unless the resulting savings in fewer disk reads or in storage cost is significant.

Fundamentally, compression works best when the CPU time is available for compressing and uncompressing data. Thus, if your workload is I/O bound, rather than CPU-bound, you might find that compression can improve overall performance. When you test your application performance with different compression configurations, test on a platform similar to the planned configuration of the production system.

Configuration Characteristics and Compression

Reading and writing database pages from and to disk is the slowest aspect of system performance. Compression attempts to reduce I/O by using CPU time to compress and uncompress data, and is most effective when I/O is a relatively scarce resource compared to processor cycles.

This is often especially the case when running in a multi-user environment with fast, multi-core CPUs. When a page of a compressed table is in memory, InnoDB often uses an additional 16K in the buffer pool for an uncompressed copy of the page. The adaptive LRU algorithm in the InnoDB storage engine attempts to balance the use of memory between compressed and uncompressed pages to take into account whether the workload is running in an I/O-bound or CPU-bound manner. Still, a configuration with more memory dedicated to the InnoDB buffer pool tends to run better when using compressed tables than a configuration where memory is highly constrained.

Choosing the Compressed Page Size

The optimal setting of the compressed page size depends on the type and distribution of data that the table and its indexes contain. The compressed page size should always be bigger than the maximum record size, or operations may fail as noted in Section 13.4.3.4, “ Compression of B-Tree Pages ”.

Setting the compressed page size too large wastes some space, but the pages do not have to be compressed as often. If the compressed page size is set too small, inserts or updates may require time-consuming recompression, and the B-tree nodes may have to be split more frequently, leading to bigger data files and less efficient indexing.

Typically, you set the compressed page size to 8K or 4K bytes. Given that the maximum InnoDB record size is around 8K, `KEY_BLOCK_SIZE=8` is usually a safe choice.

Monitoring Compression at Runtime

Overall application performance, CPU and I/O utilization and the size of disk files are good indicators of how effective compression is for your application.

To dig deeper into performance considerations for compressed tables, you can monitor compression performance at run time. using the Information Schema tables described in Example 13.1, "Using the Compression Information Schema Tables". These tables reflect the internal use of memory and the rates of compression used overall.

The `INNODB_CMP` tables report information about compression activity for each compressed page size (`KEY_BLOCK_SIZE`) in use. The information in these tables is system-wide, and includes summary data across all compressed tables in your database. You can use this data to help decide whether or not to compress a table by examining these tables when no other compressed tables are being accessed.

The key statistics to consider are the number of, and amount of time spent performing, compression and uncompression operations. Since InnoDB must split B-tree nodes when they are too full to contain the compressed data following a modification, compare the number of "successful" compression operations with the number of such operations overall. Based on the information in the `INNODB_CMP` tables and overall application performance and hardware resource utilization, you might make changes in your hardware configuration, adjust the size of the InnoDB buffer pool, choose a different page size, or select a different set of tables to compress.

If the amount of CPU time required for compressing and uncompressing is high, changing to faster CPUs, or those with more cores, can help improve performance with the same data, application workload and set of compressed tables. Increasing the size of the InnoDB buffer pool might also help performance, so that more uncompressed pages can stay in memory, reducing the need to uncompress pages that exist in memory only in compressed form.

A large number of compression operations overall (compared to the number of `INSERT`, `UPDATE` and `DELETE` operations in your application and the size of the database) could indicate that some of your compressed tables are being updated too heavily for effective compression. If so, choose a larger page size, or be more selective about which tables you compress.

If the number of "successful" compression operations (`COMPRESS_OPS_OK`) is a high percentage of the total number of compression operations (`COMPRESS_OPS`), then the system is likely performing well. If the ratio is low, then InnoDB is reorganizing, recompressing, and splitting B-tree nodes more often than is desirable. In this case, avoid compressing some tables, or increase `KEY_BLOCK_SIZE` for some of the compressed tables. You might turn off compression for tables that cause the number of "compression failures" in your application to be more than 1% or 2% of the total. (Such a failure ratio might be acceptable during a temporary operation such as a data load).

13.4.3.4. How Compression Works in InnoDB

This section describes some internal implementation details about compression in InnoDB. The information presented here may be helpful in tuning for performance, but is not necessary to know for basic use of compression.

Compression Algorithms

Some operating systems implement compression at the file system level. Files are typically divided into fixed-size blocks that are compressed into variable-size blocks, which easily leads into fragmentation. Every time something inside a block is modified, the whole block is recompressed before it is written to disk. These properties make this compression technique unsuitable for use in an update-intensive database system.

InnoDB implements compression with the help of the well-known zlib library, which implements the LZ77 compression algorithm. This compression algorithm is mature, robust, and efficient in both CPU utilization and in reduction of data size. The algorithm is "lossless", so that the original uncompressed data can always be reconstructed from the compressed form. LZ77 compression works by finding sequences of data that are repeated within the data to be compressed. The patterns of values in your data determine how well it compresses, but typical user data often compresses by 50% or more.

Unlike compression performed by an application, or compression features of some other database management systems, InnoDB compression applies both to user data and to indexes. In many cases, indexes can constitute 40-50% or more of the total database size, so this difference is significant. When compression is working well for a data set, the size of the InnoDB data files (the `.idb` files) is 25% to 50% of the uncompressed size or possibly smaller. Depending on the workload, this smaller database can in turn lead to a reduction in I/O, and an increase in throughput, at a modest cost in terms of increased CPU utilization.

InnoDB Data Storage and Compression

All user data in InnoDB is stored in pages comprising a B-tree index (the clustered index). In some other database systems, this type of index is called an "index-organized table". Each row in the index node contains the values of the (user-specified or system-generated) primary key and all the other columns of the table.

Secondary indexes in InnoDB are also B-trees, containing pairs of values: the index key and a pointer to a row in the clustered index. The pointer is in fact the value of the primary key of the table, which is used to access the clustered index if columns other than the index key and primary key are required. Secondary index records must always fit on a single B-tree page.

The compression of B-tree nodes (of both clustered and secondary indexes) is handled differently from compression of overflow pages used to store long `VARCHAR`, `BLOB`, or `TEXT` columns, as explained in the following sections.

Compression of B-Tree Pages

Because they are frequently updated, B-tree pages require special treatment. It is important to minimize the number of times B-tree nodes are split, as well as to minimize the need to uncompress and recompress their content.

One technique InnoDB uses is to maintain some system information in the B-tree node in uncompressed form, thus facilitating certain in-place updates. For example, this allows rows to be delete-marked and deleted without any compression operation.

In addition, InnoDB attempts to avoid unnecessary uncompression and recompression of index pages when they are changed. Within each B-tree page, the system keeps an uncompressed “modification log” to record changes made to the page. Updates and inserts of small records may be written to this modification log without requiring the entire page to be completely reconstructed.

When the space for the modification log runs out, InnoDB uncompresses the page, applies the changes and recompresses the page. If recompression fails, the B-tree nodes are split and the process is repeated until the update or insert succeeds.

Generally, InnoDB requires that each B-tree page can accommodate at least two records. For compressed tables, this requirement has been relaxed. Leaf pages of B-tree nodes (whether of the primary key or secondary indexes) only need to accommodate one record, but that record must fit in uncompressed form, in the per-page modification log. Starting with InnoDB storage engine version 1.0.2, and if InnoDB strict mode is `ON`, the InnoDB storage engine checks the maximum row size during `CREATE TABLE` or `CREATE INDEX`. If the row does not fit, the following error message is issued: `ERROR HY000: Too big row`.

If you create a table when InnoDB strict mode is OFF, and a subsequent `INSERT` or `UPDATE` statement attempts to create an index entry that does not fit in the size of the compressed page, the operation fails with `ERROR 42000: Row size too large`. (This error message does not name the index for which the record is too large, or mention the length of the index record or the maximum record size on that particular index page.) To solve this problem, rebuild the table with `ALTER TABLE` and select a larger compressed page size (`KEY_BLOCK_SIZE`), shorten any column prefix indexes, or disable compression entirely with `ROW_FORMAT=DYNAMIC` or `ROW_FORMAT=COMPACT`.

Compressing BLOB, VARCHAR and TEXT Columns

In a clustered index, `BLOB`, `VARCHAR` and `TEXT` columns that are not part of the primary key may be stored on separately allocated (“overflow”) pages. We call these off-page columns whose values are stored on singly-linked lists of overflow pages.

For tables created in `ROW_FORMAT=DYNAMIC` or `ROW_FORMAT=COMPRESSED`, the values of `BLOB`, `TEXT` or `VARCHAR` columns may be stored fully off-page, depending on their length and the length of the entire row. For columns that are stored off-page, the clustered index record only contains 20-byte pointers to the overflow pages, one per column. Whether any columns are stored off-page depends on the page size and the total size of the row. When the row is too long to fit entirely within the page of the clustered index, InnoDB chooses the longest columns for off-page storage until the row fits on the clustered index page. As noted above, if a row does not fit by itself on a compressed page, an error occurs.

Tables created in previous versions of InnoDB use the Antelope file format, which supports only `ROW_FORMAT=REDUNDANT` and `ROW_FORMAT=COMPACT`. In these formats, InnoDB stores the first 768 bytes of `BLOB`, `VARCHAR` and `TEXT` columns in the clustered index record along with the primary key. The 768-byte prefix is followed by a 20-byte pointer to the overflow pages that contain the rest of the column value.

When a table is in `COMPRESSED` format, all data written to overflow pages is compressed “as is”; that is, InnoDB applies the zlib compression algorithm to the entire data item. Other than the data, compressed overflow pages contain an uncompressed header and trailer comprising a page checksum and a link to the next overflow page, among other things. Therefore, very significant storage savings can be obtained for longer `BLOB`, `TEXT` or `VARCHAR` columns if the data is highly compressible, as is often the case with text data (but not previously compressed images).

The overflow pages are of the same size as other pages. A row containing ten columns stored off-page occupies ten overflow pages, even if the total length of the columns is only 8K bytes. In an uncompressed table, ten uncompressed overflow pages occupy 160K bytes. In a compressed table with an 8K page size, they occupy only 80K bytes. Thus, it is often more efficient to use compressed table format for tables with long column values.

Using a 16K compressed page size can reduce storage and I/O costs for `BLOB`, `VARCHAR` or `TEXT` columns, because such data often compress well, and might therefore require fewer “overflow” pages, even though the B-tree nodes themselves take as many pages as in the uncompressed form.

Compression and the InnoDB Buffer Pool

In a compressed InnoDB table, every compressed page (whether 1K, 2K, 4K or 8K) corresponds to an uncompressed page of 16K bytes. To access the data in a page, InnoDB reads the compressed page from disk if it is not already in the buffer pool, then uncompresses the page to its original 16K byte form. This section describes how InnoDB manages the buffer pool with respect to pages of compressed tables.

To minimize I/O and to reduce the need to uncompress a page, at times the buffer pool contains both the compressed and uncompressed form of a database page. To make room for other required database pages, InnoDB may “evict” from the buffer pool an uncompressed page, while leaving the compressed page in memory. Or, if a page has not been accessed in a while, the compressed form of the page may be written to disk, to free space for other data. Thus, at any given time, the buffer pool may contain both the compressed and uncompressed forms of the page, or only the compressed form of the page, or neither.

InnoDB keeps track of which pages to keep in memory and which to evict using a least-recently-used (LRU) list, so that “hot” or frequently accessed data tends to stay in memory. When compressed tables are accessed, InnoDB uses an adaptive LRU algorithm to achieve an appropriate balance of compressed and uncompressed pages in memory. This adaptive algorithm is sensitive to whether the system is running in an I/O-bound or CPU-bound manner. The goal is to avoid spending too much processing time uncompressing pages when the CPU is busy, and to avoid doing excess I/O when the CPU has spare cycles that can be used for uncompressing compressed pages (that may already be in memory). When the system is I/O-bound, the algorithm prefers to evict the uncompressed copy of a page rather than both copies, to make more room for other disk pages to become memory resident. When the system is CPU-bound, InnoDB prefers to evict both the compressed and uncompressed page, so that more memory can be used for “hot” pages and reducing the need to uncompress data in memory only in compressed form.

Compression and the InnoDB Log Files

Before a compressed page is written to a database file, InnoDB writes a copy of the page to the redo log (if it has been recompressed since the last time it was written to the database). This is done to ensure that redo logs will always be usable, even if a future version of InnoDB uses a slightly different compression algorithm. Therefore, some increase in the size of log files, or a need for more frequent checkpoints, can be expected when using compression. The amount of increase in the log file size or checkpoint frequency depends on the number of times compressed pages are modified in a way that requires reorganization and recompression.

Note that the redo log file format (and the database file format) are different from previous releases when using compression. The MySQL Enterprise Backup product does support this latest Barracuda file format for compressed InnoDB tables. The older InnoDB Hot Backup product can only back up tables using the file format Antelope, and thus does not support InnoDB tables that use compression.

13.4.4. InnoDB File-Format Management

As InnoDB evolves, new on-disk data structures are sometimes required to support new features. Features such as compressed tables (see Section 13.4.3, “InnoDB Data Compression”), and long variable-length columns stored off-page (see Section 13.4.5, “How InnoDB Stores Variable-Length Columns”) require data file formats that are not compatible with prior versions of InnoDB. These features both require use of the new Barracuda file format.

> **Note**
>
> All other new features are compatible with the original Antelope file format and do not require the Barracuda file format.

This section discusses how to specify the file format for new InnoDB tables, compatibility of different file formats between MySQL releases,

Named File Formats

InnoDB 1.1 has the idea of a named file format and a configuration parameter to enable the use of features that require use of that format. The new file format is the Barracuda format, and the original InnoDB file format is called Antelope. Compressed tables and the new row format that stores long columns “off-page” require the use of the Barracuda file format or newer. Future versions of InnoDB may introduce a series of file formats, identified with the names of animals, in ascending alphabetic order.

13.4.4.1. Enabling File Formats

The configuration parameter `innodb_file_format` controls whether such statements as `CREATE TABLE` and `ALTER TABLE` can be used to create tables that depend on support for the Barracuda file format.

Although Oracle recommends using the Barracuda format for new tables where practical, in MySQL 5.5 the default file format is still Antelope, for maximum compatibility with replication configurations containing different MySQL releases.

The file format is a dynamic, global parameter that can be specified in the MySQL option file (`my.cnf` or `my.ini`) or changed with the `SET GLOBAL` command.

13.4.4.2. Verifying File Format Compatibility

InnoDB 1.1 incorporates several checks to guard against the possible crashes and data corruptions that might occur if you run an older release of the MySQL server on InnoDB data files using a newer file format. These checks take place when the server is started, and when you first access a table. This section describes these checks, how you can control them, and error and warning conditions that might arise.

Backward Compatibility

Considerations of backward compatibility only apply when using a recent version of InnoDB (the InnoDB Plugin, or MySQL 5.5 and higher with InnoDB 1.1) alongside an older one (MySQL 5.1 or earlier, with the built-in InnoDB rather than the InnoDB Plugin). To minimize the chance of compatibility issues, you can standardize on the InnoDB Plugin for all your MySQL 5.1 and earlier database servers.

In general, a newer version of InnoDB may create a table or index that cannot safely be read or written with a prior version of InnoDB without risk of crashes, hangs, wrong results or corruptions. InnoDB 1.1 includes a mechanism to guard against these conditions, and to help preserve compatibility among database files and versions of InnoDB. This mechanism lets you take advantage of some new features of an InnoDB release (such as performance improvements and bug fixes), and still preserve the option of using your database with a prior version of InnoDB, by preventing accidental use of new features that create downward-incompatible disk files.

If a version of InnoDB supports a particular file format (whether or not that format is the default), you can query and update any table that requires that format or an earlier format. Only the creation of new tables using new features is limited based on the particular file format enabled. Conversely, if a tablespace contains a table or index that uses a file format that is not supported by the currently running software, it cannot be accessed at all, even for read access.

The only way to “downgrade” an InnoDB tablespace to an earlier file format is to copy the data to a new table, in a tablespace that uses the earlier format. This can be done with the `ALTER TABLE` statement, as described in Section 13.4.4.4, “Downgrading the File Format”.

The easiest way to determine the file format of an existing InnoDB tablespace is to examine the properties of the table it contains, using the `SHOW TABLE STATUS` command or querying the table `INFORMATION_SCHEMA.TABLES`. If the `Row_format` of the table is reported as `'Compressed'` or `'Dynamic'`, the tablespace containing the table uses the Barracuda format. Otherwise, it uses the prior InnoDB file format, Antelope.

Internal Details

Every InnoDB per-table tablespace (represented by a `*.ibd` file) file is labeled with a file format identifier. The system tablespace (represented by the `ibdata` files) is tagged with the “highest” file format in use in a group of InnoDB database files, and this tag is checked when the files are opened.

Creating a compressed table, or a table with `ROW_FORMAT=DYNAMIC`, updates the file header for the corresponding `.ibd` file and the table type in the InnoDB data dictionary with the identifier for the Barracuda file format. From that point forward, the table cannot be used with a version of InnoDB that does not support this new file format. To protect against anomalous behavior, InnoDB version 5.0.21 and later performs a compatibility check when the table is opened. (In many cases, the `ALTER TABLE` statement recreates a table and thus changes its properties. The special case of adding or dropping indexes without rebuilding the table is described in Section 13.4.2, “Fast Index Creation in the InnoDB Storage Engine”.)

Definition of ib-file set

To avoid confusion, for the purposes of this discussion we define the term “ib-file set” to mean the set of operating system files that InnoDB manages as a unit. The ib-file set includes the following files:

- The system tablespace (one or more `ibdata` files) that contain internal system information (including internal catalogs and undo information) and may include user data and indexes.
- Zero or more single-table tablespaces (also called “file per table” files, named `*.ibd` files).
- InnoDB log files; usually two, `ib_logfile0` and `ib_logfile1`. Used for crash recovery and in backups.

An “ib-file set” does not include the corresponding `.frm` files that contain metadata about InnoDB tables. The `.frm` files are created and managed by MySQL, and can sometimes get out of sync with the internal metadata in InnoDB.

Multiple tables, even from more than one database, can be stored in a single “ib-file set”. (In MySQL, a “database” is a logical collection of tables, what other systems refer to as a “schema” or “catalog”.)

13.4.4.2.1. Compatibility Check When InnoDB Is Started

To prevent possible crashes or data corruptions when InnoDB opens an ib-file set, it checks that it can fully support the file formats in use within the ib-file set. If the system is restarted following a crash, or a “fast shutdown” (i.e., `innodb_fast_shutdown` is greater than zero), there may be on-disk data structures (such as redo or undo entries, or doublewrite pages) that are in a “too-new” format for the current software. During the recovery process, serious damage can be done to your data files if these data structures are accessed. The startup check of the file format occurs before any recovery process begins, thereby preventing consistency issues with the new tables or startup problems for the MySQL server.

Beginning with version InnoDB 1.0.1, the system tablespace records an identifier or tag for the “highest” file format used by any table in any of the tablespaces that is part of the ib-file set. Checks against this file format tag are controlled by the configuration parameter `innodb_file_format_check`, which is `ON` by default.

If the file format tag in the system tablespace is newer or higher than the highest version supported by the particular currently executing software and if `innodb_file_format_check` is `ON`, the following error is issued when the server is started:

```
InnoDB: Error: the system tablespace is in a
file format that this version doesn't support
```

You can also set `innodb_file_format` to a file format name. Doing so prevents InnoDB from starting if the current software does not support the file format specified. It also sets the “high water mark” to the value you specify. The ability to set `innodb_file_format_check` will be useful (with future releases of InnoDB) if you manually “downgrade” all of the tables in an ib-file set (as described in Section 13.4.11, “Downgrading the InnoDB Storage Engine”). You can then rely on the file format check at startup if you subsequently use an older version of InnoDB to access the ib-file set.

In some limited circumstances, you might want to start the server and use an ib-file set that is in a “too new” format (one that is not supported by the software you are using). If you set the configuration parameter `innodb_file_format_check` to `OFF`, InnoDB opens the database, but issues this warning message in the error log:

```
InnoDB: Warning: the system tablespace is in a
file format that this version doesn't support
```

Note

This is a very dangerous setting, as it permits the recovery process to run, possibly corrupting your database if the previous shutdown was a crash or “fast shutdown”. You should only set `innodb_file_format_check` to `OFF` if you are sure that the previous shutdown was done with `innodb_fast_shutdown=0`, so that essentially no recovery process occurs. In a future release, this parameter setting may be renamed from `OFF` to `UNSAFE`. (However, until there are newer releases of InnoDB that support additional file formats, even disabling the startup checking is in fact “safe”.)

The parameter `innodb_file_format_check` affects only what happens when a database is opened, not subsequently. Conversely, the parameter `innodb_file_format` (which enables a specific format) only determines whether or not a new table can be created in the enabled format and has no effect on whether or not a database can be opened.

The file format tag is a “high water mark”, and as such it is increased after the server is started, if a table in a “higher” format is created or an existing table is accessed for read or write (assuming its format is supported). If you access an existing table in a format higher than the format the running software supports, the system tablespace tag is not updated, but table-level compatibility checking applies (and an error is issued), as described in Section 13.4.4.2.2, “Compatibility Check When a Table Is Opened”. Any time the high water mark is updated, the value of `innodb_file_format_check` is updated as well, so the command `SELECT @@innodb_file_format_check;` displays the name of the newest file format known to be used by tables in the currently open ib-file set and supported by the currently executing software.

To best illustrate this behavior, consider the scenario described in Table 13.6, “InnoDB Data File Compatibility and Related InnoDB Parameters”. Imagine that some future version of InnoDB supports the Cheetah format and that an ib-file set has been used with that version.

Table 13.6. InnoDB Data File Compatibility and Related InnoDB Parameters

innodb file format check	innodb file format	Highest file format used in ib-file set	Highest file format supported by InnoDB	Result
`OFF`	`Antelope` or `Barracuda`	`Barracuda`	`Barracuda`	Database can be opened; tables can be created which require Antelope or Barracuda file format
`OFF`	`Antelope` or `Barracuda`	`Cheetah`	`Barracuda`	Database can be opened with a warning, since the database contains files in a “too new” format; tables can be created in Antelope or Barracuda file format; tables in Cheetah format cannot be accessed
`OFF`	`Cheetah`	`Barracuda`	`Barracuda`	Database cannot be opened; `innodb_file_format` cannot be set to Cheetah
`ON`	`Antelope` or `Barracuda`	`Barracuda`	`Barracuda`	Database can be opened; tables can be created in Antelope or Barracuda file format
`ON`	`Antelope` or	`Cheetah`	`Barracuda`	Database cannot be opened, since the database contains files in a

innodb file format check	innodb file format	Highest file format used in ib-file set	Highest file format supported by InnoDB	Result
	`Barracuda`			“too new” format (Cheetah)
`ON`	`Cheetah`	`Barracuda`	`Barracuda`	Database cannot be opened; `innodb_file_format` cannot be set to Cheetah

13.4.4.2.2. Compatibility Check When a Table Is Opened

When a table is first accessed, InnoDB (including some releases prior to InnoDB 1.0) checks that the file format of the tablespace in which the table is stored is fully supported. This check prevents crashes or corruptions that would otherwise occur when tables using a “too new” data structure are encountered.

All tables using any file format supported by a release can be read or written (assuming the user has sufficient privileges). The setting of the system configuration parameter `innodb_file_format` can prevent creating a new table that uses specific file formats, even if they are supported by a given release. Such a setting might be used to preserve backward compatibility, but it does not prevent accessing any table that uses any supported format.

As noted in Section 13.4.4, “InnoDB File-Format Management” [1200], versions of MySQL older than 5.0.21 cannot reliably use database files created by newer versions if a new file format was used when a table was created. To prevent various error conditions or corruptions, InnoDB checks file format compatibility when it opens a file (for example, upon first access to a table). If the currently running version of InnoDB does not support the file format identified by the table type in the InnoDB data dictionary, MySQL reports the following error:

```
ERROR 1146 (42S02): Table 'test.t1' doesn't exist
```

InnoDB also writes a message to the error log:

```
InnoDB: table test/t1: unknown table type 33
```

The table type should be equal to the tablespace flags, which contains the file format version as discussed in Section 13.4.4.3, “Identifying the File Format in Use”.

Versions of InnoDB prior to MySQL 4.1 did not include table format identifiers in the database files, and versions prior to MySQL 5.0.21 did not include a table format compatibility check. Therefore, there is no way to ensure proper operations if a table in a “too new” format is used with versions of InnoDB prior to 5.0.21.

The file format management capability in InnoDB 1.0 and higher (tablespace tagging and run-time checks) allows InnoDB to verify as soon as possible that the running version of software can properly process the tables existing in the database.

If you permit InnoDB to open a database containing files in a format it does not support (by setting the parameter `innodb_file_format_check` to `OFF`), the table-level checking described in this section still applies.

Users are *strongly* urged not to use database files that contain Barracuda file format tables with releases of InnoDB older than the MySQL 5.1 with the InnoDB Plugin. It is possible to “downgrade” such tables to the Antelope format with the procedure described in Section 13.4.4.4, “Downgrading the File Format”.

13.4.4.3. Identifying the File Format in Use

After you enable a given `innodb_file_format`, this change applies only to newly created tables rather than existing ones. If you do create a new table, the tablespace containing the table is tagged with the “earliest” or “simplest” file format that is required for the table's features. For example, if you enable file format Barracuda, and create a new table that is not compressed and does not use `ROW_FORMAT=DYNAMIC`, the new tablespace that contains the table is tagged as using file format Antelope.

It is easy to identify the file format used by a given tablespace or table. The table uses the Barracuda format if the `Row_format` reported by `SHOW CREATE TABLE` or `INFORMATION_SCHEMA.TABLES` is one of `'Compressed'` or `'Dynamic'`. (The `Row_format` is a separate column; ignore the contents of the `Create_options` column, which may contain the string `ROW_FORMAT`.) If the table in a tablespace uses neither of those features, the file uses the format supported by prior releases of InnoDB, now called file format Antelope. Then, the `Row_format` is one of `'Redundant'` or `'Compact'`.

Internal Details

The file format identifier is written as part of the tablespace flags (a 32-bit number) in the `*.ibd` file in the 4 bytes starting at position 54 of the file, most significant byte first. (The first byte of the file is byte zero.) On some systems, you can display these bytes in hexadecimal with the command `od -t x1 -j 54 -N 4 tablename.ibd`. If all bytes are zero, the tablespace uses the Antelope file format (which is the format used by the standard InnoDB storage engine up to version 5.1). Otherwise, the least significant bit should be set in the tablespace flags, and the file format identifier is written in the bits 5 through 11. (Divide the tablespace flags by 32 and take the remainder after dividing the integer part of the result by 128.)

13.4.4.4. Downgrading the File Format

Each InnoDB tablespace file (with a name matching `*.ibd`) is tagged with the file format used to create its table and indexes. The way to downgrade the tablespace is to re-create the table and its indexes. The easiest way to recreate a table and its indexes is to use the command:

```
ALTER TABLE t ROW_FORMAT=COMPACT;
```

on each table that you want to downgrade. The `COMPACT` row format uses the file format Antelope. It was introduced in MySQL 5.0.3.

13.4.4.5. Future InnoDB File Formats

The file format used by the standard built-in InnoDB in MySQL 5.1 is the Antelope format. The file format introduced with InnoDB Plugin 1.0 is the Barracuda format. Although no new features have been announced that would require additional new file formats, the InnoDB file format mechanism allows for future enhancements.

For the sake of completeness, these are the file format names that might be used for future file formats: Antelope, Barracuda, Cheetah, Dragon, Elk, Fox, Gazelle, Hornet, Impala, Jaguar, Kangaroo, Leopard, Moose, Nautilus, Ocelot, Porpoise, Quail, Rabbit, Shark, Tiger, Urchin, Viper, Whale, Xenops, Yak and Zebra. These file formats correspond to the internal identifiers 0..25.

13.4.5. How InnoDB Stores Variable-Length Columns

This section discusses how certain InnoDB features, such as table compression and off-page storage of long columns, are controlled by the `ROW_FORMAT` clause of the `CREATE TABLE` statement. It discusses considerations for choosing the right row format and compatibility of row formats between MySQL releases.

13.4.5.1. Overview of InnoDB Row Storage

The storage for rows and associated columns affects performance for queries and DML operations. As more rows fit into a single disk page, queries and index lookups can work faster, less cache memory is required in the InnoDB buffer pool, and less I/O is required to write out updated values for the numeric and short string columns.

All data in InnoDB is stored in database pages that make up a B-tree index (the clustered index organized according to the primary key columns). Table data and indexes both use this type of structure. The nodes of the index data structure contain the values of all the columns in that row (for the clustered index) or the index columns and the primary key columns (for secondary indexes).

Variable-length columns are an exception to this rule. Columns such as `BLOB` and `VARCHAR` that are too long to fit on a B-tree page are stored on separately allocated disk pages called overflow pages. We call such columns off-page column. The values of these columns are stored on singly-linked lists of overflow pages, and each such column has its own list of one or more overflow pages. In some cases, all or a prefix of the long column value is stored in the B-tree, to avoid wasting storage and eliminating the need to read a separate page.

The Barracuda file format provides a new option (`KEY_BLOCK_SIZE`) to control how much column data is stored in the clustered index, and how much is placed on overflow pages.

13.4.5.2. Specifying the Row Format for a Table

You specify the row format for a table with the `ROW_FORMAT` clause of the `CREATE TABLE` and `ALTER TABLE` statements.

13.4.5.3. Barracuda File Format: `DYNAMIC` and `COMPRESSED` Row Formats

When `innodb_file_format` is set to Barracuda and a table is created with `ROW_FORMAT=DYNAMIC` or `ROW_FORMAT=COMPRESSED`, long column values are stored fully off-page, and the clustered index record contains only a 20-byte pointer to the overflow page.

Whether any columns are stored off-page depends on the page size and the total size of the row. When the row is too long, InnoDB chooses the longest columns for off-page storage until the clustered index record fits on the B-tree page.

The `DYNAMIC` row format maintains the efficiency of storing the entire row in the index node if it fits (as do the `COMPACT` and `REDUNDANT` formats), but this new format avoids the problem of filling B-tree nodes with a large number of data bytes of long columns. The `DYNAMIC` format is based on the idea that if a portion of a long data value is stored off-page, it is usually most efficient to store all of the value off-page. With `DYNAMIC` format, shorter columns are likely to remain in the B-tree node, minimizing the number of overflow pages needed for any given row.

The `COMPRESSED` row format uses similar internal details for off-page storage as the `DYNAMIC` row format, with additional storage and performance considerations from the table and index data being compressed and using smaller page sizes. For full details about the `COMPRESSED` row format, see Section 13.4.3, “InnoDB Data Compression”.

13.4.5.4. Antelope File Format: `COMPACT` and `REDUNDANT` Row Formats

Early versions of InnoDB used an unnamed file format (now called Antelope) for database files. With that format, tables were defined with `ROW_FORMAT=COMPACT` (or `ROW_FORMAT=REDUNDANT`) and InnoDB stored up to the first 768 bytes of variable-length columns (such as `BLOB` and `VARCHAR`) in the index record within the B-tree node, with the remainder stored on the overflow pages.

To preserve compatibility with those prior versions, tables created with the newest InnoDB use the prefix format, unless one of `ROW_FORMAT=DYNAMIC` or `ROW_FORMAT=COMPRESSED` is specified (or implied) on the `CREATE TABLE` statement.

With the Antelope file format, if the value of a column is 768 bytes or less, no overflow page is needed, and some savings in I/O may result, since the value is in the B-tree node. This works well for relatively short `BLOB`s, but may cause B-tree nodes to fill with data rather than key values, reducing their efficiency. Tables with many `BLOB` columns could cause B-tree nodes to become too full of data, and contain too few rows, making the entire index less efficient than if the rows were shorter or if the column values were stored off-page.

13.4.6. InnoDB `INFORMATION_SCHEMA` tables

The `INFORMATION_SCHEMA` is a MySQL feature that helps you monitor server activity to diagnose capacity and performance issues. Several InnoDB-related `INFORMATION_SCHEMA` tables (`INNODB_CMP`, `INNODB_CMP_RESET`, `INNODB_CMPMEM`, `INNODB_CMPMEM_RESET`, `INNODB_TRX`, `INNODB_LOCKS` and `INNODB_LOCK_WAITS`) contain live information about compressed InnoDB tables, the compressed InnoDB buffer pool, all transactions currently executing inside InnoDB, the locks that transactions hold and those that are blocking transactions waiting for access to a resource (a table or row).

The Information Schema tables are themselves plugins to the MySQL server, and must be activated by `INSTALL` statements. If they are installed, but the InnoDB storage engine plugin is not installed, these tables appear to be empty.

This section describes the InnoDB-related Information Schema tables and shows some examples of their use.

13.4.6.1. Information Schema Tables about Compression

Two new pairs of Information Schema tables provided by the InnoDB storage engine can give you some insight into how well compression is working overall. One pair of tables contains information about the number of compression operations and the amount of time spent performing compression. Another pair of tables contains information on the way memory is allocated for compression.

13.4.6.1.1. `INNODB_CMP` and `INNODB_CMP_RESET`

The tables `INNODB_CMP` and `INNODB_CMP_RESET` contain status information on the operations related to compressed tables, which are covered in Section 13.4.3, “InnoDB Data Compression”. The compressed page size is in the column `PAGE_SIZE`.

These two tables have identical contents, but reading from `INNODB_CMP_RESET` resets the statistics on compression and uncompression operations. For example, if you archive the output of `INNODB_CMP_RESET` every 60 minutes, you see the statistics for each hourly period. If you monitor the output of `INNODB_CMP` (making sure never to read `INNODB_CMP_RESET`), you see the cumulated statistics since InnoDB was started.

For the table definition, see Table 18.1, “Columns of `INNODB_CMP` and `INNODB_CMP_RESET`”.

13.4.6.1.2. `INNODB_CMPMEM` and `INNODB_CMPMEM_RESET`

The tables `INNODB_CMPMEM` and `INNODB_CMPMEM_RESET` contain status information on the compressed pages that reside in the buffer pool. Please consult Section 13.4.3, “InnoDB Data Compression” for further information on compressed tables and the use of the buffer pool. The tables `INNODB_CMP` and `INNODB_CMP_RESET` should provide more useful statistics on compression.

Internal Details

The InnoDB storage engine uses a so-called “buddy allocator” system to manage memory allocated to pages of various sizes, from 1KB to 16KB. Each row of the two tables described here corresponds to a single page size, except for rows with `PAGE_SIZE<1024`, which are implementation artifacts. The smallest blocks (`PAGE_SIZE=64` or `PAGE_SIZE=128`, depending on the server platform) are used for keeping track of compressed pages for which no uncompressed page has been allocated in the buffer pool. Other blocks of `PAGE_SIZE<1024` should never be allocated (`PAGES_USED=0`). They exist because the memory allocator allocates smaller blocks by splitting bigger ones into halves.

These two tables have identical contents, but reading from `INNODB_CMPMEM_RESET` resets the statistics on relocation operations. For example, if every 60 minutes you archived the output of `INNODB_CMPMEM_RESET`, it would show the hourly statistics. If you never read `INNODB_CMPMEM_RESET` and monitored the output of `INNODB_CMPMEM` instead, it would show the cumulated statistics since InnoDB was started.

For the table definition, see Table 18.2, “Columns of INNODB_CMPMEM and INNODB_CMPMEM_RESET”.

13.4.6.1.3. Using the Compression Information Schema Tables

Example 13.1. Using the Compression Information Schema Tables

The following is sample output from a database that contains compressed tables (see Section 13.4.3, “InnoDB Data Compression”, `INNODB_CMP`, and `INNODB_CMPMEM`).

The following table shows the contents of `INFORMATION_SCHEMA.INNODB_CMP` under light load. The only compressed page size that the buffer pool contains is 8K. Compressing or uncompressing pages has consumed less than a second since the time the statistics were reset, because the columns `COMPRESS_TIME` and `UNCOMPRESS_TIME` are zero.

page size	compress ops	compress ops ok	compress time	uncompress ops	uncompress time
1024	0	0	0	0	0
2048	0	0	0	0	0
4096	0	0	0	0	0
8192	1048	921	0	61	0
16384	0	0	0	0	0

According to `INNODB_CMPMEM`, there are 6169 compressed 8KB pages in the buffer pool. The only other allocated block size is 64 bytes. The smallest `PAGE_SIZE` in `INNODB_CMPMEM` is used for block descriptors of those compressed pages for which no uncompressed page exists in the buffer pool. We see that there are 5910 such pages. Indirectly, we see that 259 (6169-5910) compressed pages also exist in the buffer pool in uncompressed form.

The following table shows the contents of `INFORMATION_SCHEMA.INNODB_CMPMEM` under light load. We can see that some memory is unusable due to fragmentation of the InnoDB memory allocator for compressed pages: `SUM(PAGE_SIZE*PAGES_FREE)=6784`. This is because small memory allocation requests are fulfilled by splitting bigger blocks, starting from the 16K blocks that are allocated from the main buffer pool, using the buddy allocation system. The fragmentation is this low, because some allocated blocks have been relocated (copied) to form bigger adjacent free blocks. This copying of `SUM(PAGE_SIZE*RELOCATION_OPS)` bytes has consumed less than a second `(SUM(RELOCATION_TIME)=0)`.

page size	pages used	pages free	relocation ops	relocation time
64	5910	0	2436	0
128	0	1	0	0
256	0	0	0	0
512	0	1	0	0
1024	0	0	0	0
2048	0	1	0	0
4096	0	1	0	0
8192	6169	0	5	0
16384	0	0	0	0

13.4.6.2. Information Schema Tables about Transactions

Three InnoDB-related Information Schema tables make it easy to monitor transactions and diagnose possible locking problems. The three tables are `INNODB_TRX`, `INNODB_LOCKS` and `INNODB_LOCK_WAITS`.

13.4.6.2.1. `INNODB_TRX`

Contains information about every transaction currently executing inside InnoDB, including whether the transaction is waiting for a lock, when the transaction started, and the particular SQL statement the transaction is executing.

For the table definition, see Table 18.3, “`INNODB_TRX` Columns”.

13.4.6.2.2. `INNODB_LOCKS`

Each transaction in InnoDB that is waiting for another transaction to release a lock (`INNODB_TRX.TRX_STATE='LOCK`

`WAIT'`) is blocked by exactly one “blocking lock request”. That blocking lock request is for a row or table lock held by another transaction in an incompatible mode. The waiting or blocked transaction cannot proceed until the other transaction commits or rolls back, thereby releasing the requested lock. For every blocked transaction, `INNODB_LOCKS` contains one row that describes each lock the transaction has requested, and for which it is waiting. `INNODB_LOCKS` also contains one row for each lock that is blocking another transaction, whatever the state of the transaction that holds the lock (`'RUNNING'`, `'LOCK WAIT'`, `'ROLLING BACK'` or `'COMMITTING'`). The lock that is blocking a transaction is always held in a mode (read vs. write, shared vs. exclusive) incompatible with the mode of requested lock.

For the table definition, see Table 18.4, “`INNODB_LOCKS` Columns”.

13.4.6.2.3. `INNODB_LOCK_WAITS`

Using this table, you can tell which transactions are waiting for a given lock, or for which lock a given transaction is waiting. This table contains one or more rows for each *blocked* transaction, indicating the lock it has requested and the lock(s) that is (are) blocking that request. The `REQUESTED_LOCK_ID` refers to the lock that a transaction is requesting, and the `BLOCKING_LOCK_ID` refers to the lock (held by another transaction) that is preventing the first transaction from proceeding. For any given blocked transaction, all rows in `INNODB_LOCK_WAITS` have the same value for `REQUESTED_LOCK_ID` and different values for `BLOCKING_LOCK_ID`.

For the table definition, see Table 18.5, “`INNODB_LOCK_WAITS` Columns”.

13.4.6.2.4. Using the Transaction Information Schema Tables

Example 13.2. Identifying Blocking Transactions

It is sometimes helpful to be able to identify which transaction is blocking another. You can use the Information Schema tables to find out which transaction is waiting for another, and which resource is being requested.

Suppose you have the following scenario, with three users running concurrently. Each user (or session) corresponds to a MySQL thread, and executes one transaction after another. Consider the state of the system when these users have issued the following commands, but none has yet committed its transaction:

- `User A:`

  ```
  BEGIN;
  SELECT a FROM t FOR UPDATE;
  SELECT SLEEP(100);
  ```

- `User B:`

  ```
  SELECT b FROM t FOR UPDATE;
  ```

- `User C:`

  ```
  SELECT c FROM t FOR UPDATE;
  ```

In this scenario, you may use this query to see who is waiting for whom:

```
SELECT r.trx_id waiting_trx_id,
       r.trx_mysql_thread_id waiting_thread,
       r.trx_query waiting_query,
       b.trx_id blocking_trx_id,
       b.trx_mysql_thread_id blocking_thread,
       b.trx_query blocking_query
   FROM       information_schema.innodb_lock_waits w
   INNER JOIN information_schema.innodb_trx b  ON
    b.trx_id = w.blocking_trx_id
  INNER JOIN information_schema.innodb_trx r  ON
    r.trx_id = w.requesting_trx_id;
```

waiting trx id	waiting thread	waiting query	blocking trx id	blocking thread	blocking query
`A4`	`6`	`SELECT b FROM t FOR UPDATE`	`A3`	`5`	`SELECT SLEEP(100)`
`A5`	`7`	`SELECT c FROM t FOR UPDATE`	`A3`	`5`	`SELECT SLEEP(100)`
`A5`	`7`	`SELECT c FROM t FOR UPDATE`	`A4`	`6`	`SELECT b FROM t FOR UPDATE`

In the above result, you can identify users by the “waiting query” or “blocking query”. As you can see:

- User B (trx id `'A4'`, thread `6`) and User C (trx id `'A5'`, thread `7`) are both waiting for User A (trx id `'A3'`, thread `5`).
- User C is waiting for User B as well as User A.

You can see the underlying data in the tables `INNODB_TRX`, `INNODB_LOCKS`, and `INNODB_LOCK_WAITS`.

The following table shows some sample Contents of INFORMATION_SCHEMA.INNODB_TRX.

trx id	**trx state**	**trx started**	**trx requested lock id**	**trx wait started**	**trx weight**	**trx mysql thread id**	**trx query**
`A3`	`RUNNING`	`2008-01-15 16:44:54`	`NULL`	`NULL`	`2`	`5`	`SELECT SLEEP(100)`
`A4`	`LOCK WAIT`	`2008-01-15 16:45:09`	`A4:1:3:2`	`2008-01-15 16:45:09`	`2`	`6`	`SELECT b FROM t FOR UPDATE`
`A5`	`LOCK WAIT`	`2008-01-15 16:45:14`	`A5:1:3:2`	`2008-01-15 16:45:14`	`2`	`7`	`SELECT c FROM t FOR UPDATE`

The following table shows some sample contents of `INFORMATION_SCHEMA.INNODB_LOCKS`.

lock id	**lock trx id**	**lock mode**	**lock type**	**lock table**	**lock index**	**lock space**	**lock page**	**lock rec**	**lock data**
`A3:1:3:2`	`A3`	`X`	`RECORD`	`` `test`.`t` ``	`` `PRIMARY` ``	`1`	`3`	`2`	`0x0200`
`A4:1:3:2`	`A4`	`X`	`RECORD`	`` `test`.`t` ``	`` `PRIMARY` ``	`1`	`3`	`2`	`0x0200`
`A5:1:3:2`	`A5`	`X`	`RECORD`	`` `test`.`t` ``	`` `PRIMARY` ``	`1`	`3`	`2`	`0x0200`

The following table shows some sample contents of `INFORMATION_SCHEMA.INNODB_LOCK_WAITS`.

requesting trx id	**requested lock id**	**blocking trx id**	**blocking lock id**
`A4`	`A4:1:3:2`	`A3`	`A3:1:3:2`
`A5`	`A5:1:3:2`	`A3`	`A3:1:3:2`
`A5`	`A5:1:3:2`	`A4`	`A4:1:3:2`

Example 13.3. More Complex Example of Transaction Data in Information Schema Tables

Sometimes you would like to correlate the internal InnoDB locking information with session-level information maintained by MySQL. For example, you might like to know, for a given InnoDB transaction ID, the corresponding MySQL session ID and name of the user that may be holding a lock, and thus blocking another transaction.

The following output from the `INFORMATION_SCHEMA` tables is taken from a somewhat loaded system.

As can be seen in the following tables, there are several transactions running.

The following `INNODB_LOCKS` and `INNODB_LOCK_WAITS` tables shows that:

- Transaction *`77F`* (executing an `INSERT`) is waiting for transactions *`77E`*, *`77D`* and *`77B`* to commit.
- Transaction *`77E`* (executing an INSERT) is waiting for transactions *`77D`* and *`77B`* to commit.
- Transaction *`77D`* (executing an INSERT) is waiting for transaction *`77B`* to commit.
- Transaction *`77B`* (executing an INSERT) is waiting for transaction *`77A`* to commit.
- Transaction *`77A`* is running, currently executing `SELECT`.
- Transaction *`E56`* (executing an `INSERT`) is waiting for transaction *`E55`* to commit.
- Transaction *`E55`* (executing an `INSERT`) is waiting for transaction *`19C`* to commit.
- Transaction *`19C`* is running, currently executing an `INSERT`.

Note that there may be an inconsistency between queries shown in the two tables `INNODB_TRX.TRX_QUERY` and `PROCESSLIST.INFO`. The current transaction ID for a thread, and the query being executed in that transaction, may be different in these two tables for any given thread. See Section 13.4.6.3.3, “Possible Inconsistency with `PROCESSLIST`” for an explanation.

The following table shows the contents of `INFORMATION_SCHEMA.PROCESSLIST` in a loaded system.

ID	USER	HOST	DB	COMMAND	TIME	STATE	INFO
384	root	localhost	test	Query	10	update	insert into t2 values …
257	root	localhost	test	Query	3	update	insert into t2 values …
130	root	localhost	test	Query	0	update	insert into t2 values …
61	root	localhost	test	Query	1	update	insert into t2 values …
8	root	localhost	test	Query	1	update	insert into t2 values …
4	root	localhost	test	Query	0	preparing	SELECT * FROM processlist
2	root	localhost	test	Sleep	566		NULL

The following table shows the contents of `INFORMATION_SCHEMA.INNODB_TRX` in a loaded system.

trx id	trx state	trx started	trx requested lock id	trx wait started	trx weight	trx mysql thread id	trx query
77F	LOCK WAIT	2008-01-15 13:10:16	*77F*:806	2008-01-15 13:10:16	1	876	insert into t09 (D, B, C) values …
77E	LOCK WAIT	2008-01-15 13:10:16	*77E*:806	2008-01-15 13:10:16	1	875	insert into t09 (D, B, C) values …
77D	LOCK WAIT	2008-01-15 13:10:16	*77D*:806	2008-01-15 13:10:16	1	874	insert into t09 (D, B, C) values …
77B	LOCK WAIT	2008-01-15 13:10:16	*77B*:733:12:1	2008-01-15 13:10:16	4	873	insert into t09 (D, B, C) values …
77A	RUNNING	2008-01-15 13:10:16	NULL	NULL	4	872	select b, c from t09 where …
E56	LOCK WAIT	2008-01-15 13:10:06	*E56*:743:6:2	2008-01-15 13:10:06	5	384	insert into t2 values …
E55	LOCK WAIT	2008-01-15 13:10:06	*E55*:743:38:2	2008-01-15 13:10:13	965	257	insert into t2 values …
19C	RUNNING	2008-01-15 13:09:10	NULL	NULL	2900	130	insert into t2 values …
E15	RUNNING	2008-01-15 13:08:59	NULL	NULL	5395	61	insert into t2 values …
51D	RUNNING	2008-01-15 13:08:47	NULL	NULL	9807	8	insert into t2 values …

The following table shows the contents of `INFORMATION_SCHEMA.INNODB_LOCK_WAITS` in a loaded system

requesting trx id	requested lock id	blocking trx id	blocking lock id
77F	*77F*:806	*77E*	*77E*:806
77F	*77F*:806	*77D*	*77D*:806
77F	*77F*:806	*77B*	*77B*:806
77E	*77E*:806	*77D*	*77D*:806
77E	*77E*:806	*77B*	*77B*:806
77D	*77D*:806	*77B*	*77B*:806
77B	*77B*:733:12:1	*77A*	*77A*:733:12:1

requesting trx id	requested lock id	blocking trx id	blocking lock id
`E56`	`E56`:743:6:2	`E55`	`E55`:743:6:2
`E55`	`E55`:743:38:2	`19C`	`19C`:743:38:2

The following table shows the contents of `INFORMATION_SCHEMA.INNODB_LOCKS` in a loaded system.

lock id	lock trx id	lock mode	lock type	lock table	lock index	lock space	lock page	lock rec	lock data
`77F`:806	`77F`	`AUTO_INC`	`TABLE`	`` `test`.`t09` ``	`NULL`	`NULL`	`NULL`	`NULL`	`NULL`
`77E`:806	`77E`	`AUTO_INC`	`TABLE`	`` `test`.`t09` ``	`NULL`	`NULL`	`NULL`	`NULL`	`NULL`
`77D`:806	`77D`	`AUTO_INC`	`TABLE`	`` `test`.`t09` ``	`NULL`	`NULL`	`NULL`	`NULL`	`NULL`
`77B`:806	`77B`	`AUTO_INC`	`TABLE`	`` `test`.`t09` ``	`NULL`	`NULL`	`NULL`	`NULL`	`NULL`
`77B`:733:12:1	`77B`	`X`	`RECORD`	`` `test`.`t09` ``	`` `PRIMARY` ``	`733`	`12`	`1`	`supremum pseudo-record`
`77A`:733:12:1	`77A`	`X`	`RECORD`	`` `test`.`t09` ``	`` `PRIMARY` ``	`733`	`12`	`1`	`supremum pseudo-record`
`E56`:743:6:2	`E56`	`S`	`RECORD`	`` `test`.`t2` ``	`` `PRIMARY` ``	`743`	`6`	`2`	`0, 0`
`E55`:743:6:2	`E55`	`X`	`RECORD`	`` `test`.`t2` ``	`` `PRIMARY` ``	`743`	`6`	`2`	`0, 0`
`E55`:743:38:2	`E55`	`S`	`RECORD`	`` `test`.`t2` ``	`` `PRIMARY` ``	`743`	`38`	`2`	`1922, 1922`
`19C`:743:38:2	`19C`	`X`	`RECORD`	`` `test`.`t2` ``	`` `PRIMARY` ``	`743`	`38`	`2`	`1922, 1922`

13.4.6.3. Special Locking Considerations for InnoDB `INFORMATION_SCHEMA` Tables

13.4.6.3.1. Understanding InnoDB Locking

When a transaction updates a row in a table, or locks it with `SELECT FOR UPDATE`, InnoDB establishes a list or queue of locks on that row. Similarly, InnoDB maintains a list of locks on a table for table-level locks transactions hold. If a second transaction wants to update a row or lock a table already locked by a prior transaction in an incompatible mode, InnoDB adds a lock request for the row to the corresponding queue. For a lock to be acquired by a transaction, all incompatible lock requests previously entered into the lock queue for that row or table must be removed (the transactions holding or requesting those locks either commit or roll back).

A transaction may have any number of lock requests for different rows or tables. At any given time, a transaction may be requesting a lock that is held by another transaction, in which case it is blocked by that other transaction. The requesting transaction must wait for the transaction that holds the blocking lock to commit or rollback. If a transaction is not waiting for a a lock, it is in the `'RUNNING'` state. If a transaction is waiting for a lock, it is in the `'LOCK WAIT'` state.

The table `INNODB_LOCKS` holds one or more row for each `'LOCK WAIT'` transaction, indicating the lock request(s) that is (are) preventing its progress. This table also contains one row describing each lock in a queue of locks pending for a given row or table. The table `INNODB_LOCK_WAITS` shows which locks already held by a transaction are blocking locks requested by other transactions.

13.4.6.3.2. Granularity of `INFORMATION_SCHEMA` Data

The data exposed by the transaction and locking tables represent a glimpse into fast-changing data. This is not like other (user) tables, where the data only changes when application-initiated updates occur. The underlying data is internal system-managed data, and can change very quickly.

For performance reasons, and to minimize the chance of misleading `JOIN`s between the `INFORMATION_SCHEMA` tables, InnoDB collects the required transaction and locking information into an intermediate buffer whenever a `SELECT` on any of the tables is issued. This buffer is refreshed only if more than 0.1 seconds has elapsed since the last time the buffer was read. The data needed to fill the three tables is fetched atomically and consistently and is saved in this global internal buffer, forming a point-in-time “snapshot”. If multiple table accesses occur within 0.1 seconds (as they almost certainly do when MySQL processes a join among these tables), then the same snapshot is used to satisfy the query.

A correct result is returned when you `JOIN` any of these tables together in a single query, because the data for the three tables comes from the same snapshot. Because the buffer is not refreshed with every query of any of these tables, if you issue separate queries against these tables within a tenth of a second, the results are the same from query to query. On the other hand, two separate queries of the same or different tables issued more than a tenth of a second apart may see different results, since the data come from different snapshots.

Because InnoDB must temporarily stall while the transaction and locking data is collected, too frequent queries of these tables can negatively impact performance as seen by other users.

As these tables contain sensitive information (at least `INNODB_LOCKS.LOCK_DATA` and `INNODB_TRX.TRX_QUERY`), for security reasons, only the users with the `PROCESS` privilege are allowed to `SELECT` from them.

13.4.6.3.3. Possible Inconsistency with `PROCESSLIST`

As just described, while the transaction and locking data is correct and consistent when these `INFORMATION_SCHEMA` tables are populated, the underlying data changes so fast that similar glimpses at other, similarly fast-changing data, may not be in sync. Thus, you should be careful in comparing the data in the InnoDB transaction and locking tables with that in the MySQL table `PROCESSLIST`. The data from the `PROCESSLIST` table does not come from the same snapshot as the data about locking and transactions. Even if you issue a single `SELECT` (`JOIN`ing `INNODB_TRX` and `PROCESSLIST`, for example), the content of those tables is generally not consistent. `INNODB_TRX` may reference rows that are not present in `PROCESSLIST` or the currently executing SQL query of a transaction, shown in `INNODB_TRX.TRX_QUERY` may be different from the one in `PROCESSLIST.INFO`. The query in `INNODB_TRX` is always consistent with the rest of `INNODB_TRX`, `INNODB_LOCKS` and `INNODB_LOCK_WAITS` when the data comes from the same snapshot.

13.4.7. InnoDB Performance and Scalability Enhancements

This section discusses recent InnoDB enhancements to performance and scalability, covering the performance features in InnoDB 1.1 with MySQL 5.5, and the features in the InnoDB Plugin for MySQL 5.1. This information is useful to any DBA or developer who is concerned with performance and scalability. Although some of the enhancements do not require any action on your part, knowing this information can still help you diagnose performance issues more quickly and modernize systems and applications that rely on older, inefficient behavior.

13.4.7.1. Overview of InnoDB Performance

InnoDB has always been highly efficient, and includes several unique architectural elements to assure high performance and scalability. The latest InnoDB storage engine includes new features that take advantage of advances in operating systems and hardware platforms, such as multi-core processors and improved memory allocation systems. In addition, new configuration options let you better control some InnoDB internal subsystems to achieve the best performance with your workload.

Starting with MySQL 5.5 and InnoDB 1.1, the built-in InnoDB storage engine within MySQL is upgraded to the full feature set and performance of the former InnoDB Plugin. This change makes these performance and scalability enhancements available to a much wider audience than before, and eliminates the separate installation step of the InnoDB Plugin. After learning about the InnoDB performance features in this section, continue with Chapter 7, *Optimization* to learn the best practices for overall MySQL performance, and Section 7.5, “Optimizing for `InnoDB` Tables” in particular for InnoDB tips and guidelines.

13.4.7.2. Faster Locking for Improved Scalability

In MySQL and InnoDB, multiple threads of execution access shared data structures. InnoDB synchronizes these accesses with its own implementation of mutexes and read/write locks. InnoDB has historically protected the internal state of a read/write lock with an InnoDB mutex. On Unix and Linux platforms, the internal state of an InnoDB mutex is protected by a Pthreads mutex, as in IEEE Std 1003.1c (POSIX.1c).

On many platforms, there is a more efficient way to implement mutexes and read/write locks. Atomic operations can often be used to synchronize the actions of multiple threads more efficiently than Pthreads. Each operation to acquire or release a lock can be done in fewer CPU instructions, and thus result in less wasted time when threads are contending for access to shared data structures. This in turn means greater scalability on multi-core platforms.

InnoDB implements mutexes and read/write locks with the built-in functions provided by the GNU Compiler Collection (GCC) for atomic memory access instead of using the Pthreads approach previously used. More specifically, an InnoDB that is compiled with GCC version 4.1.2 or later uses the atomic builtins instead of a `pthread_mutex_t` to implement InnoDB mutexes and read/write locks.

On 32-bit Microsoft Windows, InnoDB has implemented mutexes (but not read/write locks) with hand-written assembler instructions. Beginning with Microsoft Windows 2000, functions for Interlocked Variable Access are available that are similar to the built-in functions provided by GCC. On Windows 2000 and higher, InnoDB makes use of the Interlocked functions. Unlike the old hand-written assembler code, the new implementation supports read/write locks and 64-bit platforms.

Solaris 10 introduced library functions for atomic operations, and InnoDB uses these functions by default. When MySQL is compiled on Solaris 10 with a compiler that does not support the built-in functions provided by the GNU Compiler Collection (GCC) for atomic memory access, InnoDB uses the library functions.

This change improves the scalability of InnoDB on multi-core systems. This feature is enabled out-of-the-box on the platforms where it is supported. You do not have to set any parameter or option to take advantage of the improved performance. On platforms where the GCC, Windows, or Solaris functions for atomic memory access are not available, InnoDB uses the traditional Pthreads method of implementing mutexes and read/write locks.

When MySQL starts, InnoDB writes a message to the log file indicating whether atomic memory access is used for mutexes, for mutexes and read/write locks, or neither. If suitable tools are used to build InnoDB and the target CPU supports the atomic operations required, InnoDB uses the built-in functions for mutexing. If, in addition, the compare-and-swap operation can be used on thread identifiers (`pthread_t`), then InnoDB uses the instructions for read-write locks as well.

Note: If you are building from source, ensure that the build process properly takes advantage of your platform capabilities. If the build is not able to automatically use instructions for atomic memory access where available, consult this Support Tip on the InnoDB website for additional steps.

For more information about the performance implications of locking, see Section 7.10, “Optimizing Locking Operations”.

13.4.7.3. Using Operating System Memory Allocators

When InnoDB was developed, the memory allocators supplied with operating systems and run-time libraries were often lacking in performance and scalability. At that time, there were no memory allocator libraries tuned for multi-core CPUs. Therefore, InnoDB implemented its own memory allocator in the `mem` subsystem. This allocator is guarded by a single mutex, which may become a bottleneck. InnoDB also implements a wrapper interface around the system allocator (`malloc` and `free`) that is likewise guarded by a single mutex.

Today, as multi-core systems have become more widely available, and as operating systems have matured, significant improvements have been made in the memory allocators provided with operating systems. New memory allocators perform better and are more scalable than they were in the past. The leading high-performance memory allocators include `Hoard`, `libumem`, `mtmalloc`, `ptmalloc`, `tbbmalloc`, and `TCMalloc`. Most workloads, especially those where memory is frequently allocated and released (such as multi-table joins), benefit from using a more highly tuned memory allocator as opposed to the internal, InnoDB-specific memory allocator.

You can control whether InnoDB uses its own memory allocator or an allocator of the operating system, by setting the value of the system configuration parameter `innodb_use_sys_malloc` in the MySQL option file (`my.cnf` or `my.ini`). If set to `ON` or `1` (the default), InnoDB uses the `malloc` and `free` functions of the underlying system rather than manage memory pools itself. This parameter is not dynamic, and takes effect only when the system is started. To continue to use the InnoDB memory allocator, set `innodb_use_sys_malloc` to `0`.

> **Note**
>
> When the InnoDB memory allocator is disabled, InnoDB ignores the value of the parameter `innodb_additional_mem_pool_size`. The InnoDB memory allocator uses an additional memory pool for satisfying allocation requests without having to fall back to the system memory allocator. When the InnoDB memory allocator is disabled, all such allocation requests are fulfilled by the system memory allocator.
>
> On Unix-like systems that use dynamic linking, replacing the memory allocator may be as easy as making the environment variable `LD_PRELOAD` or `LD_LIBRARY_PATH` point to the dynamic library that implements the allocator. On other systems, some relinking may be necessary. Please refer to the documentation of the memory allocator library of your choice.
>
> Since InnoDB cannot track all memory use when the system memory allocator is used (`innodb_use_sys_malloc` is `ON`), the section “BUFFER POOL AND MEMORY” in the output of the `SHOW ENGINE INNODB STATUS` command only includes the buffer pool statistics in the “Total memory allocated”. Any memory allocated using the `mem` subsystem or using `ut_malloc` is excluded.

For more information about the performance implications of InnoDB memory usage, see Section 7.9, “Buffering and Caching”.

13.4.7.4. Controlling InnoDB Change Buffering

When `INSERT`, `UPDATE`, and `DELETE` operations are done to a table, often the values of indexed columns (particularly the values of secondary keys) are not in sorted order, requiring substantial I/O to bring secondary indexes up to date. InnoDB has an insert buffer that caches changes to secondary index entries when the relevant page is not in the buffer pool, thus avoiding I/O operations by not reading in the page from the disk. The buffered changes are merged when the page is loaded to the buffer pool, and the updated page is later flushed to disk using the normal mechanism. The InnoDB main thread merges buffered changes when the server is nearly idle, and during a slow shutdown.

Because it can result in fewer disk reads and writes, this feature is most valuable for workloads that are I/O-bound, for example applications with a high volume of DML operations such as bulk inserts.

However, the insert buffer occupies a part of the buffer pool, reducing the memory available to cache data pages. If the working set almost fits in the buffer pool, or if your tables have relatively few secondary indexes, it may be useful to disable insert buffering. If the working set entirely fits in the buffer pool, insert buffering does not impose any extra overhead, because it only applies to pages that are not in the buffer pool.

You can control the extent to which InnoDB performs insert buffering with the system configuration parameter `innodb_change_buffering`. You can turn on and off buffering for inserts, delete operations (when index records are initially marked for deletion) and purge operations (when index records are physically deleted). An update operation is represented as a combination of an insert and a delete. In MySQL 5.5 and higher, the default value is changed from `inserts` to `all`.

The allowed values of `innodb_change_buffering` are:

- **`all`**

  The default value: buffer inserts, delete-marking operations, and purges.

- **`none`**

  Do not buffer any operations.

- **`inserts`**

  Buffer insert operations.

- **`deletes`**

  Buffer delete-marking operations.

- **`changes`**

  Buffer both inserts and delete-marking.

- **`purges`**

  Buffer the physical deletion operations that happen in the background.

You can set the value of this parameter in the MySQL option file (`my.cnf` or `my.ini`) or change it dynamically with the `SET GLOBAL` command, which requires the `SUPER` privilege. Changing the setting affects the buffering of new operations; the merging of already buffered entries is not affected.

For more information about speeding up `INSERT`, `UPDATE`, and `DELETE` statements, see Section 7.2.2, “Optimizing DML Statements”.

13.4.7.5. Controlling Adaptive Hash Indexing

If a table fits almost entirely in main memory, the fastest way to perform queries on it is to use hash indexes rather than B-tree lookups. MySQL monitors searches on each index defined for an InnoDB table. If it notices that certain index values are being accessed frequently, it automatically builds an in-memory hash table for that index. Based on the observed pattern of searches, it builds a hash index using a prefix of the index key. The prefix of the key can be any length, and it may be that only some of the values in the B-tree appear in the hash index. Hash indexes are built on demand for those pages of the index that are often accessed.

This adaptive hash index mechanism allows InnoDB to take advantage of large amounts of memory, something typically done only by database systems specifically designed for databases that reside entirely in memory. Normally, the automatic building and use of adaptive hash indexes improves performance. However, sometimes, the read/write lock that guards access to the adaptive hash index may become a source of contention under heavy workloads, such as multiple concurrent joins.

You can monitor the use of the adaptive hash index and the contention for its use in the “SEMAPHORES” section of the output of the `SHOW ENGINE INNODB STATUS` command. If you see many threads waiting on an RW-latch created in `btr0sea.c`, then it might be useful to disable adaptive hash indexing.

The configuration parameter `innodb_adaptive_hash_index` can be set to disable or enable the adaptive hash index. See Section 13.4.8.2.4, “Dynamically Changing `innodb_adaptive_hash_index`” for details.

For more information about the performance characteristics of hash indexes, see Section 7.3.8, “Comparison of B-Tree and Hash Indexes”.

13.4.7.6. Changes Regarding Thread Concurrency

InnoDB uses operating system threads to process requests from user transactions. (Transactions may issue many requests to InnoDB before they commit or roll back.) On modern operating systems and servers with multi-core processors, where context switching is efficient, most workloads run well without any limit on the number of concurrent threads. Scalability improvements in MySQL 5.5 and up reduce the need to limit the number of concurrently executing threads inside InnoDB.

In situations where it is helpful to minimize context switching between threads, InnoDB can use a number of techniques to limit the number of concurrently executing operating system threads (and thus the number of requests that are processed at any one time). When InnoDB receives a new request from a user session, if the number of threads concurrently executing is at a pre-defined limit, the new request sleeps for a short time before it tries again. A request that cannot be rescheduled after the sleep is put in a first-in/first-out queue and eventually is processed. Threads waiting for locks are not counted in the number of concurrently executing threads.

You can limit the number of concurrent threads by setting the configuration parameter `innodb_thread_concurrency`. Once the number of executing threads reaches this limit, additional threads sleep for a number of microseconds, set by the configuration parameter `innodb_thread_sleep_delay`, before being placed into the queue.

The default value for `innodb_thread_concurrency` and the implied default limit on the number of concurrent threads has been changed in various releases of MySQL and InnoDB. Currently, the default value of `innodb_thread_concurrency` is `0`, so that by default there is no limit on the number of concurrently executing threads, as shown in Table 13.7, "Changes to `innodb_thread_concurrency`".

Table 13.7. Changes to `innodb_thread_concurrency`

InnoDB Version	MySQL Version	Default value	Default limit of concurrent threads	Value to allow unlimited threads
Built-in	Earlier than 5.1.11	20	No limit	20 or higher
Built-in	5.1.11 and newer	8	8	0
InnoDB before 1.0.3	(corresponding to Plugin)	8	8	0
InnoDB 1.0.3 and newer	(corresponding to Plugin)	0	No limit	0

Note that InnoDB causes threads to sleep only when the number of concurrent threads is limited. When there is no limit on the number of threads, all contend equally to be scheduled. That is, if `innodb_thread_concurrency` is `0`, the value of `innodb_thread_sleep_delay` is ignored.

When there is a limit on the number of threads, InnoDB reduces context switching overhead by permitting multiple requests made during the execution of a single SQL statement to enter InnoDB without observing the limit set by `innodb_thread_concurrency`. Since an SQL statement (such as a join) may comprise multiple row operations within InnoDB, InnoDB assigns "tickets" that allow a thread to be scheduled repeatedly with minimal overhead.

When a new SQL statement starts, a thread has no tickets, and it must observe `innodb_thread_concurrency`. Once the thread is entitled to enter InnoDB, it is assigned a number of tickets that it can use for subsequently entering InnoDB. If the tickets run out, `innodb_thread_concurrency` is observed again and further tickets are assigned. The number of tickets to assign is specified by the global option `innodb_concurrency_tickets`, which is 500 by default. A thread that is waiting for a lock is given one ticket once the lock becomes available.

The correct values of these variables depend on your environment and workload. Try a range of different values to determine what value works for your applications. Before limiting the number of concurrently executing threads, review configuration options that may improve the performance of InnoDB on multi-core and multi-processor computers, such as innodb_use_sys_malloc and innodb_adaptive_hash_index.

For general performance information about MySQL thread handling, see Section 7.11.5.1, "How MySQL Uses Threads for Client Connections".

13.4.7.7. Changes in the Read-Ahead Algorithm

A read-ahead request is an I/O request to prefetch multiple pages in the buffer pool asynchronously, in anticipation that these pages will be needed soon. InnoDB uses or has used two read-ahead algorithms to improve I/O performance:

Linear read-ahead is based on the access pattern of the pages in the buffer pool, not just their number. You can control when InnoDB performs a read-ahead operation by adjusting the number of sequential page accesses required to trigger an asynchronous read request, using the configuration parameter `innodb_read_ahead_threshold`. Before this parameter was added, InnoDB would only calculate whether to issue an asynchronous prefetch request for the entire next extent when it read in the last page of the current extent.

Random read-ahead is a former technique that has now been removed as of MySQL 5.5. If a certain number of pages from the same extent (64 consecutive pages) were found in the buffer pool, InnoDB asynchronously issued a request to prefetch the remaining pages of the extent. Random read-ahead added unnecessary complexity to the InnoDB code and often resulted in performance degradation rather than improvement. This feature is no longer part of InnoDB, and users should generally see equivalent or improved performance.

If the number of pages read from an extent of 64 pages is greater or equal to `innodb_read_ahead_threshold`, InnoDB initiates an asynchronous read-ahead operation of the entire following extent. Thus, this parameter controls how sensitive InnoDB is to the pattern of page accesses within an extent in deciding whether to read the following extent asynchronously. The higher the value, the more strict the access pattern check. For example, if you set the value to 48, InnoDB triggers a linear read-ahead request only when 48 pages in the current extent have been accessed sequentially. If the value is 8, InnoDB would trigger an asynchronous read-ahead even if as few as 8 pages in the extent were accessed sequentially.

The new configuration parameter `innodb_read_ahead_threshold` can be set to any value from 0-64. The default value is 56, meaning that an asynchronous read-ahead is performed only when 56 of the 64 pages in the extent are accessed sequentially. You can set the value of this parameter in the MySQL option file (my.cnf or my.ini), or change it dynamically with the `SET GLOBAL` command, which requires the `SUPER` privilege.

The `SHOW ENGINE INNODB STATUS` command displays statistics to help you evaluate the effectiveness of the read-ahead algorithm. See Section 13.4.8.8, “More Read-Ahead Statistics” for more information.

For more information about I/O performance, see Section 7.5.7, “Optimizing `InnoDB` Disk I/O” and Section 7.11.3, “Optimizing Disk I/O”.

13.4.7.8. Multiple Background I/O Threads

InnoDB uses background threads to service various types of I/O requests. You can configure the number of background threads that service read and write I/O on data pages, using the configuration parameters `innodb_read_io_threads` and `innodb_write_io_threads`. These parameters signify the number of background threads used for read and write requests respectively. They are effective on all supported platforms. You can set the value of these parameters in the MySQL option file (`my.cnf` or `my.ini`); you cannot change them dynamically. The default value for these parameters is `4` and the permissible values range from `1-64`.

These parameters replace `innodb_file_io_threads` from earlier versions of MySQL. If you try to set a value for this obsolete parameter, a warning is written to the log file and the value is ignored. This parameter only applied to Windows platforms. (On non-Windows platforms, there was only one thread each for read and write.)

The purpose of this change is to make InnoDB more scalable on high end systems. Each background thread can handle up to 256 pending I/O requests. A major source of background I/O is theread-ahead requests. InnoDB tries to balance the load of incoming requests in such way that most of the background threads share work equally. InnoDB also attempts to allocate read requests from the same extent to the same thread to increase the chances of coalescing the requests together. If you have a high end I/O subsystem and you see more than 64 × `innodb_read_io_threads` pending read requests in `SHOW ENGINE INNODB STATUS`, you might gain by increasing the value of `innodb_read_io_threads`.

For more information about InnoDB I/O performance, see Section 7.5.7, “Optimizing `InnoDB` Disk I/O”.

13.4.7.9. Asynchronous I/O on Linux

Starting in InnoDB 1.1 with MySQL 5.5, the asynchronous I/O capability that InnoDB has had on Windows systems is now available on Linux systems. (Other Unix-like systems continue to use synchronous I/O calls.) This feature improves the scalability of heavily I/O-bound systems, which typically show many pending reads/writes in the output of the command `SHOW ENGINE INNODB STATUS\G`.

Running with a large number of `InnoDB` I/O threads, and especially running multiple such instances on the same server machine, can exceed capacity limits on Linux systems. In this case, you can fix the error:

```
EAGAIN: The specified maxevents exceeds the user's limit of available events.
```

by writing a higher limit to `/proc/sys/fs/aio-max-nr`.

In general, if a problem with the asynchronous I/O subsystem in the OS prevents InnoDB from starting, set the option `innodb_use_native_aio=0` in the configuration file. This new configuration option applies to Linux systems only, and cannot be changed once the server is running.

For more information about InnoDB I/O performance, see Section 7.5.7, “Optimizing `InnoDB` Disk I/O”.

13.4.7.10. Group Commit

InnoDB, like any other ACID-compliant database engine, flushes the redo log of a transaction before it is committed. Historically, InnoDB used group commit functionality to group multiple such flush requests together to avoid one flush for each commit. With group commit, InnoDB issues a single write to the log file to perform the commit action for multiple user transactions that commit at about the same time, significantly improving throughput.

Group commit in InnoDB worked until MySQL 4.x, and works once again with MySQL 5.1 with the InnoDB Plugin, and MySQL 5.5 and higher. The introduction of support for the distributed transactions and Two Phase Commit (2PC) in MySQL 5.0 interfered with the InnoDB group commit functionality. This issue is now resolved.

The group commit functionality inside InnoDB works with the Two Phase Commit protocol in MySQL. Re-enabling of the group commit functionality fully ensures that the ordering of commit in the MySQL binlog and the InnoDB logfile is the same as it was before. It means it is **totally safe to use MySQL Enterprise Backup with InnoDB 1.0.4** (that is, the InnoDB Plugin with MySQL 5.1) and above. When the binlog is enabled, you typically also set the configuration option `sync_binlog=0`, because group commit for the binary log is only supported if it is set to 0.

Group commit is transparent; you do not need to do anything to take advantage of this significant performance improvement.

For more information about performance of `COMMIT` and other transactional operations, see Section 7.5.2, “Optimizing `InnoDB` Transaction Management”.

13.4.7.11. Controlling the Master Thread I/O Rate

The master thread in InnoDB is a thread that performs various tasks in the background. Most of these tasks are I/O related, such as flushing dirty pages from the buffer pool or writing changes from the insert buffer to the appropriate secondary indexes. The master thread attempts to perform these tasks in a way that does not adversely affect the normal working of the server. It tries to estimate the free I/O bandwidth available and tune its activities to take advantage of this free capacity. Historically, InnoDB has used a hard coded value of 100 IOPs (input/output operations per second) as the total I/O capacity of the server.

The parameter `innodb_io_capacity` indicates the overall I/O capacity available to InnoDB. This parameter should be set to approximately the number of I/O operations that the system can perform per second. The value depends on your system configuration. When `innodb_io_capacity` is set, the master threads estimates the I/O bandwidth available for background tasks based on the set value. Setting the value to `100` reverts to the old behavior.

You can set the value of `innodb_io_capacity` to any number 100 or greater. The default value is `200`, reflecting that the performance of typical modern I/O devices is higher than in the early days of MySQL. Typically, values around the previous default of 100 are appropriate for consumer-level storage devices, such as hard drives up to 7200 RPMs. Faster hard drives, RAID configurations, and SSDs benefit from higher values.

You can set the value of this parameter in the MySQL option file (`my.cnf` or `my.ini`) or change it dynamically with the `SET GLOBAL` command, which requires the `SUPER` privilege.

For more information about InnoDB I/O performance, see Section 7.5.7, “Optimizing `InnoDB` Disk I/O”.

13.4.7.12. Controlling the Flushing Rate of Dirty Pages

InnoDB performs certain tasks in the background, including flushing of dirty pages (those pages that have been changed but are not yet written to the database files) from the buffer pool, a task performed by the master thread. Currently, InnoDB aggressively flushes buffer pool pages if the percentage of dirty pages in the buffer pool exceeds `innodb_max_dirty_pages_pct`.

InnoDB uses a new algorithm to estimate the required rate of flushing, based on the speed of redo log generation and the current rate of flushing. The intent is to smooth overall performance by ensuring that buffer flush activity keeps up with the need to keep the buffer pool “clean”. Automatically adjusting the rate of flushing can help to avoid steep dips in throughput, when excessive buffer pool flushing limits the I/O capacity available for ordinary read and write activity.

InnoDB uses its log files in a circular fashion. Before reusing a portion of a log file, InnoDB flushes to disk all dirty buffer pool pages whose redo entries are contained in that portion of the log file, a process known as a sharp checkpoint. If a workload is write-intensive, it generates a lot of redo information, all written to the log file. If all available space in the log files is used up, a sharp checkpoint occurs, causing a temporary reduction in throughput. This situation can happen even though `innodb_max_dirty_pages_pct` is not reached.

InnoDB uses a heuristic-based algorithm to avoid such a scenario, by measuring the number of dirty pages in the buffer pool and the rate at which redo is being generated. Based on these numbers, InnoDB decides how many dirty pages to flush from the buffer pool each second. This self-adapting algorithm is able to deal with sudden changes in the workload.

Internal benchmarking has also shown that this algorithm not only maintains throughput over time, but can also improve overall throughput significantly.

Because adaptive flushing is a new feature that can significantly affect the I/O pattern of a workload, a new configuration parameter lets you turn off this feature. The default value of the boolean parameter `innodb_adaptive_flushing` is `TRUE`, enabling the new algorithm. You can set the value of this parameter in the MySQL option file (`my.cnf` or `my.ini`) or change it dynamically with the `SET GLOBAL` command, which requires the `SUPER` privilege.

For more information about InnoDB I/O performance, see Section 7.5.7, “Optimizing `InnoDB` Disk I/O”.

13.4.7.13. Using the PAUSE Instruction in InnoDB Spin Loops

Synchronization inside InnoDB frequently involves the use of spin loops: while waiting, InnoDB executes a tight loop of instructions repeatedly to avoid having the InnoDB process and threads be rescheduled by the operating system. If the spin loops are executed too quickly, system resources are wasted, imposing a performance penalty on transaction throughput. Most modern processors implement the `PAUSE` instruction for use in spin loops, so the processor can be more efficient.

InnoDB uses a `PAUSE` instruction in its spin loops on all platforms where such an instruction is available. This technique increases overall performance with CPU-bound workloads, and has the added benefit of minimizing power consumption during the execution of the spin loops.

You do not have to do anything to take advantage of this performance improvement.

For performance considerations for InnoDB locking operations, see Section 7.10, “Optimizing Locking Operations”.

13.4.7.14. Control of Spin Lock Polling

Many InnoDB mutexes and rw-locks are reserved for a short time. On a multi-core system, it can be more efficient for a thread to continuously check if it can acquire a mutex or rw-lock for a while before sleeping. If the mutex or rw-lock becomes available during this polling period, the thread can continue immediately, in the same time slice. However, too-frequent polling by multiple threads of a shared object can cause “cache ping pong”, different processors invalidating portions of each others' cache. InnoDB minimizes this issue by waiting a random time between subsequent polls. The delay is implemented as a busy loop.

You can control the maximum delay between testing a mutex or rw-lock using the parameter `innodb_spin_wait_delay`. The duration of the delay loop depends on the C compiler and the target processor. (In the 100MHz Pentium era, the unit of delay was one microsecond.) On a system where all processor cores share a fast cache memory, you might reduce the maximum delay or disable the busy loop altogether by setting `innodb_spin_wait_delay=0`. On a system with multiple processor chips, the effect of cache invalidation can be more significant and you might increase the maximum delay.

The default value of `innodb_spin_wait_delay` is `6`. The spin wait delay is a dynamic global parameter that you can specify in the MySQL option file (`my.cnf` or `my.ini`) or change at runtime with the command `SET GLOBAL innodb_spin_wait_delay=`*`delay`*, where *`delay`* is the desired maximum delay. Changing the setting requires the `SUPER` privilege.

For performance considerations for InnoDB locking operations, see Section 7.10, “Optimizing Locking Operations”.

13.4.7.15. Making Buffer Pool Scan Resistant

Rather than using a strictly LRU algorithm, InnoDB uses a technique to minimize the amount of data that is brought into the buffer pool and never accessed again. The goal is to make sure that frequently accessed (“hot”) pages remain in the buffer pool, even as read-ahead and full table scans bring in new blocks that might or might not be accessed afterward.

Newly read blocks are inserted into the middle of the list representing the buffer pool. of the LRU list. All newly read pages are inserted at a location that by default is `3/8` from the tail of the LRU list. The pages are moved to the front of the list (the most-recently used end) when they are accessed in the buffer pool for the first time. Thus pages that are never accessed never make it to the front portion of the LRU list, and “age out” sooner than with a strict LRU approach. This arrangement divides the LRU list into two segments, where the pages downstream of the insertion point are considered “old” and are desirable victims for LRU eviction.

For an explanation of the inner workings of the InnoDB buffer pool and the specifics of its LRU replacement algorithm, see Section 7.9.1, “The `InnoDB` Buffer Pool”.

You can control the insertion point in the LRU list, and choose whether InnoDB applies the same optimization to blocks brought into the buffer pool by table or index scans. The configuration parameter `innodb_old_blocks_pct` controls the percentage of “old” blocks in the LRU list. The default value of `innodb_old_blocks_pct` is `37`, corresponding to the original fixed ratio of 3/8. The value range is `5` (new pages in the buffer pool age out very quickly) to `95` (only 5% of the buffer pool is reserved for hot pages, making the algorithm close to the familiar LRU strategy).

The optimization that keeps the buffer pool from being churned by read-ahead can avoid similar problems due to table or index scans. In these scans, a data page is typically accessed a few times in quick succession and is never touched again. The configuration parameter `innodb_old_blocks_time` specifies the time window (in milliseconds) after the first access to a page during which it can be accessed without being moved to the front (most-recently used end) of the LRU list. The default value of `innodb_old_blocks_time` is `0`, corresponding to the original behavior of moving a page to the most-recently used end of the buffer pool list when it is first accessed in the buffer pool. Increasing this value makes more and more blocks likely to age out faster from the buffer pool.

Both the new parameters `innodb_old_blocks_pct` and `innodb_old_blocks_time` are dynamic, global and can be specified in the MySQL option file (`my.cnf` or `my.ini`) or changed at runtime with the `SET GLOBAL` command. Changing the setting requires the `SUPER` privilege.

To help you gauge the effect of setting these parameters, the `SHOW ENGINE INNODB STATUS` command reports additional statistics. The `BUFFER POOL AND MEMORY` section now looks like:

```
Total memory allocated 1107296256; in additional pool allocated 0
Dictionary memory allocated 80360
Buffer pool size   65535
Free buffers       0
Database pages     63920
Old database pages 23600
Modified db pages  34969
Pending reads 32
Pending writes: LRU 0, flush list 0, single page 0
Pages made young 414946, not young 2930673
1274.75 youngs/s, 16521.90 non-youngs/s
Pages read 486005, created 3178, written 160585
2132.37 reads/s, 3.40 creates/s, 323.74 writes/s
Buffer pool hit rate 950 / 1000, young-making rate 30 / 1000 not 392 / 1000
Pages read ahead 1510.10/s, evicted without access 0.00/s
LRU len: 63920, unzip_LRU len: 0
I/O sum[43690]:cur[221], unzip sum[0]:cur[0]
```

- `Old database pages` is the number of pages in the “old” segment of the LRU list.
- `Pages made young` and `not young` is the total number of “old” pages that have been made young or not respectively.
- `youngs/s` and `non-young/s` is the rate at which page accesses to the “old” pages have resulted in making such pages young or otherwise respectively since the last invocation of the command.
- `young-making rate` and `not` provides the same rate but in terms of overall buffer pool accesses instead of accesses just to the “old” pages.

Because the effects of these parameters can vary widely based on your hardware configuration, your data, and the details of your workload, always benchmark to verify the effectiveness before changing these settings in any performance-critical or production environment.

In mixed workloads where most of the activity is OLTP type with periodic batch reporting queries which result in large scans, setting the value of `innodb_old_blocks_time` during the batch runs can help keep the working set of the normal workload in the buffer pool.

When scanning large tables that cannot fit entirely in the buffer pool, setting `innodb_old_blocks_pct` to a small value keeps the data that is only read once from consuming a significant portion of the buffer pool. For example, setting `innodb_old_blocks_pct=5` restricts this data that is only read once to 5% of the buffer pool.

When scanning small tables that do fit into memory, there is less overhead for moving pages around within the buffer pool, so you can leave `innodb_old_blocks_pct` at its default value, or even higher, such as `innodb_old_blocks_pct=50`.

The effect of the `innodb_old_blocks_time` parameter is harder to predict than the `innodb_old_blocks_pct` parameter, is relatively small, and varies more with the workload. To arrive at an optimal value, conduct your own benchmarks if the performance improvement from adjusting `innodb_old_blocks_pct` is not sufficient.

For more information about the InnoDB buffer pool, see Section 7.9.1, “The `InnoDB` Buffer Pool”.

13.4.7.16. Improvements to Crash Recovery Performance

A number of optimizations speed up certain steps of the recovery that happens on the next startup after a crash. In particular, scanning the redo log and applying the redo log are faster than in MySQL 5.1 and earlier, due to improved algorithms for memory management. You do not need to take any actions to take advantage of this performance enhancement. If you kept the size of your redo log files artificially low because recovery took a long time, you can consider increasing the file size.

For more information about InnoDB recovery, see Section 13.3.7.1, “The `InnoDB` Recovery Process”.

13.4.7.17. Integration with MySQL PERFORMANCE_SCHEMA

Starting with InnoDB 1.1 with MySQL 5.5, you can profile certain internal InnoDB operations using the MySQL Performance Schema feature. This type of tuning is primarily for expert users, those who push the limits of MySQL performance, read the MySQL source code, and evaluate optimization strategies to overcome performance bottlenecks. DBAs can also use this feature for capacity planning, to see whether their typical workload encounters any performance bottlenecks with a particular combination of CPU, RAM, and disk storage; and if so, to judge whether performance can be improved by increasing the capacity of some part of the system.

To use this feature to examine InnoDB performance:

- You must be running MySQL 5.5 or higher. You must build the database server from source, enabling the Performance Schema feature by building with the `--with-perfschema` option. Since the Performance Schema feature introduces some performance overhead, you should use it on a test or development system rather than on a production system.

- You must be running InnoDB 1.1 or higher.

- You must be generally familiar with how to use the Performance Schema feature, for example to query tables in the `performance_schema` database.

- Examine the following kinds of InnoDB objects by querying the appropriate `performance_schema` tables. The items associated with InnoDB all contain the substring `innodb` in the `NAME` column.

  For the definitions of the `*_instances` tables, see Section 19.7.2, "Performance Schema Instance Tables". For the definitions of the `*_summary_*` tables, see Section 19.7.4, "Performance Schema Summary Tables". For the definition of the `thread` table, see Section 19.7.5, "Performance Schema Miscellaneous Tables". For the definition of the `*_current_*` and `*_history_*` tables, see Section 19.7.3, "Performance Schema Wait Event Tables".

  - Mutexes in the `mutex_instances` table. (Mutexes and RW-locks related to the `InnoDB` buffer pool are not included in this coverage; the same applies to the output of the `SHOW ENGINE INNODB MUTEX` command.)

  - RW-locks in the `rwlock_instances` table.

  - RW-locks in the `rwlock_instances` table.

  - File I/O operations in the `file_instances`, `file_summary_by_event_name`, and `file_summary_by_instance` tables.

  - Threads in the `PROCESSLIST` table.

- During performance testing, examine the performance data in the `events_waits_current` and `events_waits_history_long` tables. If you are interested especially in InnoDB-related objects, use the clause `where name like "%innodb%"` to see just those entries; otherwise, examine the performance statistics for the overall MySQL server.

- You must be running MySQL 5.5, with the Performance Schema enabled by building with the `--with-perfschema` build option.

For more information about the MySQL Performance Schema, see Chapter 19, *MySQL Performance Schema*.

13.4.7.18. Improvements to Performance from Multiple Buffer Pools

This performance enhancement is primarily useful for people with a large buffer pool size, typically in the multi-gigabyte range. To take advantage of this speedup, you must set the new `innodb_buffer_pool_instances` configuration option, and you might also adjust the `innodb_buffer_pool_size` value.

When the InnoDB buffer pool is large, many data requests can be satisfied by retrieving from memory. You might encounter bottlenecks from multiple threads trying to access the buffer pool at once. Starting in InnoDB 1.1 and MySQL 5.5, you can enable multiple buffer pools to minimize this contention. Each page that is stored in or read from the buffer pool is assigned to one of the buffer pools randomly, using a hashing function. Each buffer pool manages its own free lists, flush lists, LRUs, and all other data structures connected to a buffer pool, and is protected by its own buffer pool mutex.

To enable this feature, set the `innodb_buffer_pool_instances` configuration option to a value greater than 1 (the default) up to 64 (the maximum). This option only takes effect when you set the `innodb_buffer_pool_size` to a size of 1 gigabyte or more. The total size you specify is divided up among all the buffer pools. We recommend specifying a combination of `innodb_buffer_pool_instances` and `innodb_buffer_pool_size` so that each buffer pool instance is at least 1 gigabyte.

For more information about the InnoDB buffer pool, see Section 7.9.1, "The `InnoDB` Buffer Pool".

13.4.7.19. Better Scalability with Multiple Rollback Segments

Starting in InnoDB 1.1 with MySQL 5.5, the limit on concurrent transactions is greatly expanded, removing a bottleneck with the InnoDB rollback segment that affected high-capacity systems. The limit applies to concurrent transactions that change any data; read-only transactions do not count against that maximum.

The single rollback segment is now divided into 128 segments, each of which can support up to 1023 transactions that perform writes, for a total of approximately 128K concurrent transactions. The original transaction limit was 1023.

Each transaction is assigned to one of the rollback segments, and remains tied to that rollback segment for the duration. This enhancement improves both scalability (higher number of concurrent transactions) and performance (less contention when different transactions access the rollback segments).

To take advantage of this feature, you do not need to create any new database or tables, or reconfigure anything. You must do a slow shutdown before upgrading from MySQL 5.1 or earlier, or some time afterward. InnoDB makes the required changes inside the system tablespace automatically, the first time you restart after performing a slow shutdown.

For more information about performance of InnoDB under high transactional load, see Section 7.5.2, “Optimizing `InnoDB` Transaction Management”.

13.4.7.20. Better Scalability with Improved Purge Scheduling

Starting in InnoDB 1.1 with MySQL 5.5, the purge operations (a type of garbage collection) that InnoDB performs automatically can be done in a separate thread, rather than as part of the master thread. This change improves scalability, because the main database operations run independently from maintenance work happening in the background.

To enable this feature, set the configuration option `innodb_purge_threads=1`, as opposed to the default of 0, which combines the purge operation into the master thread.

You might not notice a significant speedup, because the purge thread might encounter new types of contention; the single purge thread really lays the groundwork for further tuning and possibly multiple purge threads in the future. There is another new configuration option, `innodb_purge_batch_size` with a default of 20 and maximum of 5000. This option is mainly intended for experimentation and tuning of purge operations, and should not be interesting to typical users.

For more information about InnoDB I/O performance, see Section 7.5.7, “Optimizing `InnoDB` Disk I/O”.

13.4.7.21. Improved Log Sys Mutex

This is another performance improvement that comes for free, with no user action or configuration needed. The details here are intended for performance experts who delve into the InnoDB source code, or interpret reports with keywords such as “mutex” and “log_sys”.

The mutex known as the log sys mutex has historically done double duty, controlling access to internal data structures related to log records and the LSN, as well as pages in the buffer pool that are changed when a mini-transaction is committed. Starting in InnoDB 1.1 with MySQL 5.5, these two kinds of operations are protected by separate mutexes, with a new `log_buf` mutex controlling writes to buffer pool pages due to mini-transactions.

For performance considerations for InnoDB locking operations, see Section 7.10, “Optimizing Locking Operations”.

13.4.7.22. Separate Flush List Mutex

Starting with InnoDB 1.1 with MySQL 5.5, concurrent access to the buffer pool is faster. Operations involving the flush list, a data structure related to the buffer pool, are now controlled by a separate mutex and do not block access to the buffer pool. You do not need to configure anything to take advantage of this speedup; it is fully automatic.

For more information about the InnoDB buffer pool, see Section 7.9.1, “The `InnoDB` Buffer Pool”.

13.4.8. Changes for Flexibility, Ease of Use and Reliability

This chapter describes several recently added InnoDB features that offer new flexibility and improve ease of use, reliability and performance. The Barracuda file format improves efficiency for storing large variable-length columns, and enables table compression. Configuration options that once were unchangeable after startup, are now flexible and can be changed dynamically. Some improvements are automatic, such as faster and more efficient `TRUNCATE TABLE`. Others allow you the flexibility to control InnoDB behavior; for example, you can control whether certain problems cause errors or just warnings. And informational messages and error reporting continue to be made more user-friendly.

13.4.8.1. The Barracuda File Format

InnoDB has started using named file formats to improve compatibility in upgrade and downgrade situations, or heterogeneous systems running different levels of MySQL. Many important InnoDB features, such as table compression and the `DYNAMIC` row format for more efficient BLOB storage, require creating tables in the Barracuda file format. The original file format, which previously didn't have a name, is known now as Antelope.

To create new tables that take advantage of the Barracuda features, enable that file format using the configuration parameter `innodb_file_format`. The value of this parameter determines whether a newly created table or index can use compression or the new `DYNAMIC` row format.

To preclude the use of new features that would make your database inaccessible to the built-in InnoDB in MySQL 5.1 and prior releases, omit `innodb_file_format` or set it to Antelope.

You can set the value of `innodb_file_format` on the command line when you start `mysqld`, or in the option file `my.cnf` (Unix operating systems) or `my.ini` (Windows). You can also change it dynamically with the `SET GLOBAL` statement.

For more information about managing file formats, see Section 13.4.4, “InnoDB File-Format Management”.

13.4.8.2. Dynamic Control of System Configuration Parameters

In MySQL 5.5 and higher, you can change certain system configuration parameters without shutting down and restarting the server, as was necessary in MySQL 5.1 and lower. This increases uptime, and makes it easier to test and prototype new SQL and application code. The following sections explain these parameters.

13.4.8.2.1. Dynamically Changing `innodb_file_per_table`

Since MySQL version 4.1, InnoDB has provided two alternatives for how tables are stored on disk. You can create a new table and its indexes in the shared system tablespace, physically stored in the ibdata files. Or, you can store a new table and its indexes in a separate tablespace (a .ibd file). The storage layout for each InnoDB table is determined by the the configuration parameter `innodb_file_per_table` at the time the table is created.

In MySQL 5.5 and higher, the configuration parameter `innodb_file_per_table` is dynamic, and can be set `ON` or `OFF` using the `SET GLOBAL`. Previously, the only way to set this parameter was in the MySQL option file (`my.cnf` or `my.ini`), and changing it required shutting down and restarting the server.

The default setting is `OFF`, so new tables and indexes are created in the system tablespace. Dynamically changing the value of this parameter requires the `SUPER` privilege and immediately affects the operation of all connections.

Tables created when `innodb_file_per_table` is enabled can use the Barracuda file format, and `TRUNCATE` returns the disk space for those tables to the operating system. The Barracuda file format in turn enables features such as table compression and the `DYNAMIC` row format. Tables created when `innodb_file_per_table` is off cannot use these features. To take advantage of those features for an existing table, you can turn on the file-per-table setting and run `ALTER TABLE` *`t`* `ENGINE=INNODB` for that table.

When you redefine the primary key for an InnoDB table, the table is re-created using the current settings for `innodb_file_per_table` and `innodb_file_format`. This behavior does not apply when adding or dropping InnoDB secondary indexes, as explained in Section 13.4.2, “Fast Index Creation in the InnoDB Storage Engine”. When a secondary index is created without rebuilding the table, the index is stored in the same file as the table data, regardless of the current `innodb_file_per_table` setting.

13.4.8.2.2. Dynamically Changing `innodb_stats_on_metadata`

In MySQL 5.5 and higher, you can change the setting of `innodb_stats_on_metadata` dynamically at runtime, to control whether or not InnoDB performs statistics gathering when metadata statements are executed. To change the setting, issue the statement `SET GLOBAL innodb_stats_on_metadata=`*`mode`*, where *`mode`* is either `ON` or `OFF` (or `1` or `0`). Changing this setting requires the `SUPER` privilege and immediately affects the operation of all connections.

This setting is related to the feature described in Section 13.4.8.5, “Controlling Optimizer Statistics Estimation”.

13.4.8.2.3. Dynamically Changing `innodb_lock_wait_timeout`

The length of time a transaction waits for a resource, before giving up and rolling back the statement, is determined by the value of the configuration parameter `innodb_lock_wait_timeout`. (In MySQL 5.0.12 and earlier, the entire transaction was rolled back, not just the statement.) Your application can try the statement again (usually after waiting for a while), or roll back the entire transaction and restart.

The error returned when the timeout period is exceeded is:

```
ERROR HY000: Lock wait timeout exceeded; try restarting transaction
```

In MySQL 5.5 and higher, the configuration parameter `innodb_lock_wait_timeout` can be set at runtime with the `SET GLOBAL` or `SET SESSION` statement. Changing the `GLOBAL` setting requires the `SUPER` privilege and affects the operation of all clients that subsequently connect. Any client can change the `SESSION` setting for `innodb_lock_wait_timeout`, which affects only that client.

In MySQL 5.1 and earlier, the only way to set this parameter was in the MySQL option file (`my.cnf` or `my.ini`), and changing it required shutting down and restarting the server.

13.4.8.2.4. Dynamically Changing `innodb_adaptive_hash_index`

As described in Section 13.4.7.5, “Controlling Adaptive Hash Indexing”, it may be desirable, depending on your workload, to dynamically enable or disable the adaptive hash indexing scheme InnoDB uses to improve query performance.

The start-up option `innodb_adaptive_hash_index` allows the adaptive hash index to be disabled. It is enabled by default. You can modify this parameter through the `SET GLOBAL` statement, without restarting the server. Changing the setting requires the `SUPER` privilege.

Disabling the adaptive hash index empties the hash table immediately. Normal operations can continue while the hash table is emptied, and executing queries that were using the hash table access the index B-trees directly instead. When the adaptive hash index is re-enabled, the hash table is populated again during normal operation.

13.4.8.3. `TRUNCATE TABLE` Reclaims Space

When you truncate a table that is stored in a `.ibd` file of its own (because `innodb_file_per_table` was enabled when the table was created), and if the table is not referenced in a `FOREIGN KEY` constraint, the table is dropped and re-created in a new `.ibd` file. This operation is much faster than deleting the rows one by one. The operating system can reuse the disk space, in contrast to tables within the InnoDB system tablespace, where only InnoDB can use the space after they are truncated. Physical backups can also be smaller, without big blocks of unused space in the middle of the system tablespace.

Previous versions of InnoDB would re-use the existing `.ibd` file, thus releasing the space only to InnoDB for storage management, but not to the operating system. Note that when the table is truncated, the count of rows affected by the `TRUNCATE TABLE` statement is an arbitrary number.

> **Note**
>
> If there is a referential constraint between two columns in the same table, that table can still be truncated using this fast technique.
>
> If there are referential constraints between the table being truncated and other tables, the truncate operation fails. This is a change to the previous behavior, which would transform the `TRUNCATE` operation to a `DELETE` operation that removed all the rows and triggered `ON DELETE` operations on child tables.

13.4.8.4. InnoDB Strict Mode

To guard against ignored typos and syntax errors in SQL, or other unintended consequences of various combinations of operational modes and SQL statements, InnoDB provides a strict mode of operations. In this mode, InnoDB raises error conditions in certain cases, rather than issuing a warning and processing the specified statement (perhaps with unintended behavior). This is analogous to `sql_mode` in MySQL, which controls what SQL syntax MySQL accepts, and determines whether it silently ignores errors, or validates input syntax and data values. Since strict mode is relatively new, some statements that execute without errors with earlier versions of MySQL might generate errors unless you disable strict mode.

The setting of InnoDB strict mode affects the handling of syntax errors on the `CREATE TABLE`, `ALTER TABLE` and `CREATE INDEX` statements. The strict mode also enables a record size check, so that an `INSERT` or `UPDATE` never fails due to the record being too large for the selected page size.

We recommend running in strict mode when using the `ROW_FORMAT` and `KEY_BLOCK_SIZE` clauses on `CREATE TABLE`, `ALTER TABLE`, and `CREATE INDEX` statements. Without strict mode, InnoDB ignores conflicting clauses and creates the table or index, with only a warning in the message log. The resulting table might have different behavior than you intended, such as having no compression when you tried to create a compressed table. When InnoDB strict mode is on, such problems generate an immediate error and the table or index is not created, avoiding a troubleshooting session later.

InnoDB strict mode is set with the configuration parameter `innodb_strict_mode`, which can be specified as `on` or `off`. You can set the value on the command line when you start `mysqld`, or in the configuration file `my.cnf` or `my.ini`. You can also enable or disable InnoDB strict mode at run time with the statement `SET [GLOBAL|SESSION] innodb_strict_mode=`*`mode`*, where *`mode`* is either `ON` or `OFF`. Changing the `GLOBAL` setting requires the `SUPER` privilege and affects the operation of all clients that subsequently connect. Any client can change the `SESSION` setting for `innodb_strict_mode`, and the setting affects only that client.

13.4.8.5. Controlling Optimizer Statistics Estimation

The MySQL query optimizer uses estimated statistics about key distributions to choose the indexes for an execution plan, based on the relative selectivity of the index. Certain operations cause InnoDB to sample random pages from each index on a table to estimate the cardinality of the index. (This technique is known as random dives.) These operations include the `ANALYZE TABLE` statement, the `SHOW TABLE STATUS` statement, and accessing the table for the first time after a restart.

To give you control over the quality of the statistics estimate (and thus better information for the query optimizer), you can now change the number of sampled pages using the parameter `innodb_stats_sample_pages`. Previously, the number of sampled pages was always 8, which could be insufficient to produce an accurate estimate, leading to poor index choices by the query optimizer. This technique is especially important for large tables and tables used in joins. Unnecessary full table scans for such tables can be a substantial performance issue.

You can set the global parameter `innodb_stats_sample_pages`, at run time. The default value for this parameter is 8, preserving the same behavior as in past releases.

> **Note**
>
> The value of `innodb_stats_sample_pages` affects the index sampling for *all* tables and indexes. There are the following potentially significant impacts when you change the index sample size:
>
> - Small values like 1 or 2 can result in very inaccurate estimates of cardinality.
> - Increasing the `innodb_stats_sample_pages` value might require more disk reads. Values much larger than 8 (say, 100), can cause a big slowdown in the time it takes to open a table or execute `SHOW TABLE STATUS`.
> - The optimizer might choose very different query plans based on different estimates of index selectivity.

To disable the cardinality estimation for metadata statements such as `SHOW TABLE STATUS`, execute the statement `SET GLOBAL innodb_stats_on_metadata=OFF` (or `0`). The ability to set this option dynamically is also relatively new.

All InnoDB tables are opened, and the statistics are re-estimated for all associated indexes, when the `mysql` client starts if the auto-rehash setting is set on (the default). To improve the start up time of the `mysql` client, you can turn auto-rehash off. The auto-rehash feature enables automatic name completion of database, table, and column names for interactive users.

Whatever value of `innodb_stats_sample_pages` works best for a system, set the option and leave it at that value. Choose a value that results in reasonably accurate estimates for all tables in your database without requiring excessive I/O. Because the statistics are automatically recalculated at various times other than on execution of `ANALYZE TABLE`, it does not make sense to increase the index sample size, run `ANALYZE TABLE`, then decrease sample size again. The more accurate statistics calculated by `ANALYZE` running with a high value of `innodb_stats_sample_pages` can be wiped away later.

Although it is not possible to specify the sample size on a per-table basis, smaller tables generally require fewer index samples than larger tables do. If your database has many large tables, consider using a higher value for `innodb_stats_sample_pages` than if you have mostly smaller tables.

13.4.8.6. Better Error Handling when Dropping Indexes

For optimal performance with DML statements, InnoDB requires an index to exist on foreign key columns, so that `UPDATE` and `DELETE` operations on a parent table can easily check whether corresponding rows exist in the child table. MySQL creates or drops such indexes automatically when needed, as a side-effect of `CREATE TABLE`, `CREATE INDEX`, and `ALTER TABLE` statements.

When you drop an index, InnoDB checks whether the index is not used for checking a foreign key constraint. It is still OK to drop the index if there is another index that can be used to enforce the same constraint. InnoDB prevents you from dropping the last index that can enforce a particular referential constraint.

The message that reports this error condition is:

```
ERROR 1553 (HY000): Cannot drop index 'fooIdx':
needed in a foreign key constraint
```

This message is friendlier than the earlier message it replaces:

```
ERROR 1025 (HY000): Error on rename of './db2/#sql-18eb_3'
to './db2/foo'(errno: 150)
```

A similar change in error reporting applies to an attempt to drop the primary key index. For tables without an explicit `PRIMARY KEY`, InnoDB creates an implicit clustered index using the first columns of the table that are declared `UNIQUE` and `NOT NULL`. When you drop such an index, InnoDB automatically copies the table and rebuilds the index using a different `UNIQUE NOT NULL` group of columns or a system-generated key. Since this operation changes the primary key, it uses the slow method of copying the table and re-creating the index, rather than the Fast Index Creation technique from Section 13.4.2.3, “Implementation Details of Fast Index Creation”.

Previously, an attempt to drop an implicit clustered index (the first `UNIQUE NOT NULL` index) failed if the table did not contain a `PRIMARY KEY`:

```
ERROR 42000: This table type requires a primary key
```

13.4.8.7. More Compact Output of `SHOW ENGINE INNODB MUTEX`

The statement `SHOW ENGINE INNODB MUTEX` displays information about InnoDB mutexes and rw-locks. Although this information is useful for tuning on multi-core systems, the amount of output can be overwhelming on systems with a big buffer pool. There is one mutex and one rw-lock in each 16K buffer pool block, and there are 65,536 blocks per gigabyte. It is unlikely that a single block mutex or rw-lock from the buffer pool could become a performance bottleneck.

`SHOW ENGINE INNODB MUTEX` now skips the mutexes and rw-locks of buffer pool blocks. It also does not list any mutexes or rw-locks that have never been waited on (`os_waits=0`). Thus, `SHOW ENGINE INNODB MUTEX` only displays information about mutexes and rw-locks outside of the buffer pool that have caused at least one OS-level wait.

13.4.8.8. More Read-Ahead Statistics

As described in Section 13.4.7.7, “Changes in the Read-Ahead Algorithm”, a read-ahead request is an asynchronous I/O request issued in anticipation that a page will be used in the near future. Knowing how many pages are read through this read-ahead mechanism, and how many of them are evicted from the buffer pool without ever being accessed, can be useful to help fine-tune the parameter `innodb_read_ahead_threshold`.

`SHOW STATUS` output displays the global status variables `Innodb_buffer_pool_read_ahead` and `Innodb_buffer_pool_read_ahead_evicted`. These variables indicate the number of pages brought into the buffer pool by read-ahead requests, and the number of such pages evicted from the buffer pool without ever being accessed respectively. These counters provide global values since the last server restart.

`SHOW INNODB STATUS` also shows the rate at which the read-ahead pages are read in and the rate at which such pages are evicted without being accessed. The per-second averages are based on the statistics collected since the last invocation of `SHOW INNODB STATUS` and are displayed in the `BUFFER POOL AND MEMORY` section of the output.

Since the InnoDB read-ahead mechanism has been simplified to remove random read-ahead, the status variables `Innodb_buffer_pool_read_ahead_rnd` and `Innodb_buffer_pool_read_ahead_seq` are no longer part of the `SHOW STATUS` output.

13.4.9. Installing the InnoDB Storage Engine

When you use the InnoDB storage engine 1.1 and above, with MySQL 5.5 and above, you do not need to do anything special to install: everything comes configured as part of the MySQL source and binary distributions. This is a change from earlier releases of the InnoDB Plugin, where you were required to match up MySQL and InnoDB version numbers and update your build and configuration processes.

The InnoDB storage engine is included in the MySQL distribution, starting from MySQL 5.1.38. From MySQL 5.1.46 and up, this is the only download location for the InnoDB storage engine; it is not available from the InnoDB web site.

If you used any scripts or configuration files with the earlier InnoDB storage engine from the InnoDB web site, be aware that the filename of the shared library as supplied by MySQL is `ha_innodb_plugin.so` or `ha_innodb_plugin.dll`, as opposed to `ha_innodb.so` or `ha_innodb.dll` in the older Plugin downloaded from the InnoDB web site. You might need to change the applicable file names in your startup or configuration scripts.

Because the InnoDB storage engine has now replaced the built-in InnoDB, you no longer need to specify options like `--ignore-builtin-innodb` and `--plugin-load` during startup.

To take best advantage of current InnoDB features, we recommend specifying the following options in your configuration file:

```
innodb_file_per_table=1
innodb_file_format=barracuda
innodb_strict_mode=1
```

For information about these new features, see Section 13.4.8.2.1, “Dynamically Changing `innodb_file_per_table`”, Section 13.4.4, “InnoDB File-Format Management”, and Section 13.4.8.4, “InnoDB Strict Mode”. You might need to continue to use the previous values for these parameters in some replication and similar configurations involving both new and older versions of MySQL.

13.4.10. Upgrading the InnoDB Storage Engine

Prior to MySQL 5.5, some upgrade scenarios involved upgrading the separate instance of InnoDB known as the InnoDB Plugin. In MySQL 5.5 and higher, the features of the InnoDB Plugin have been folded back into built-in InnoDB, so the upgrade procedure for InnoDB is the same as the one for the MySQL server. For details, see Section 2.11.1, “Upgrading MySQL”.

13.4.11. Downgrading the InnoDB Storage Engine

13.4.11.1. Overview

Prior to MySQL 5.5, some downgrade scenarios involved switching the separate instance of InnoDB known as the InnoDB Plugin back to the built-in InnoDB storage engine. In MySQL 5.5 and higher, the features of the InnoDB Plugin have been folded back into built-in InnoDB, so the downgrade procedure for InnoDB is the same as the one for the MySQL server. For details, see Section 2.11.2, “Downgrading MySQL”.

13.4.12. InnoDB Storage Engine Change History

13.4.12.1. Changes in InnoDB Storage Engine 1.x

Since InnoDB 1.1 is tightly integrated with MySQL 5.5, for changes after the initial InnoDB 1.1 release, see the MySQL 5.5 Reference Manual, Section D.1, “Changes in Release 5.5.x (Production)”.

13.4.12.2. Changes in InnoDB Storage Engine 1.1 (April 13, 2010)

For an overview of the changes, see this introduction article for MySQL 5.5 with InnoDB 1.1. The following is a condensed version of the change log.

Fix for bug #52580: Crash in ha_innobase::open on executing INSERT with concurrent ALTER TABLE.

Change in MySQL bug #51557 releases the mutex LOCK_open before ha_innobase::open(), causing racing condition for index translation table creation. Fix it by adding dict_sys mutex for the operation.

Add support for multiple buffer pools.

Fix Bug #26590: MySQL does not allow more than 1023 open transactions. Create additional rollback segments on startup. Reduce the upper limit of total rollback segments from 256 to 128. This is because we can't use the sign bit. It has not caused problems in the past because we only created one segment. InnoDB has always had the capability to use the additional rollback segments, therefore this patch is backward compatible. The only requirement to maintain backward compatibility has been to ensure that the additional segments are created after the double write buffer. This is to avoid breaking assumptions in the existing code.

Implement Performance Schema in InnoDB. Objects in four different modules in InnoDB have been performance instrumented, these modules are: mutexes, rwlocks, file I/O, and threads We mostly preserved the existing APIs, but APIs would point to instrumented function wrappers if performance schema is defined. There are 4 different defines that controls the instrumentation of each module. The feature is off by default, and will be compiled in with special build option, and requre configure option to turn it on when server boots.

Implement the buf_pool_watch for DeleteBuffering in the page hash table. This serves two purposes. It allows multiple watches to be set at the same time (by multiple purge threads) and it removes a race condition when the read of a block completes about the time the buffer pool watch is being set.

Introduce a new mutex to protect flush_list. Redesign mtr_commit() in a way that log_sys mutex is not held while all mtr_memos are popped and is released just after the modified blocks are inserted into the flush_list. This should reduce contention on log_sys mutex.

Implement the global variable `innodb_change_buffering`, with the following values:

- `none`: buffer nothing
- `inserts`: buffer inserts (like InnoDB so far)
- `deletes`: buffer delete-marks
- `changes`: buffer inserts and delete-marks
- `purges`: buffer delete-marks and deletes
- `all`: buffer all operations (insert, delete-mark, delete)

The default is `all`. All values except `none` and `inserts` will make InnoDB write new-format records to the insert buffer, even for inserts.

Provide support for native AIO on Linux.

13.4.12.3. Changes in InnoDB Plugin 1.0.x

The InnoDB 1.0.x releases that accompany MySQL 5.1 have their own change history. Changes up to InnoDB 1.0.8 are listed at http://dev.mysql.com/doc/innodb-plugin/1.0/en/innodb-changes.html. Changes from InnoDB 1.0.9 and up are listed in Changes in Release 5.1.x (Production), incorporated into the main MySQL change log.

13.4.13. Third-Party Software

Oracle acknowledges that certain Third Party and Open Source software has been used to develop or is incorporated in the InnoDB storage engine. This appendix includes required third-party license information.

13.4.13.1. Performance Patches from Google

Oracle gratefully acknowledges the following contributions from Google, Inc. to improve InnoDB performance:

- Replacing InnoDB's use of Pthreads mutexes with calls to GCC atomic builtins, as discussed in Section 13.4.7.2, "Faster Locking for Improved Scalability". This change means that InnoDB mutex and and rw-lock operations take less CPU time, and improves throughput on those platforms where the atomic operations are available.
- Controlling master thread `I/O` rate, as discussed in Section 13.4.7.11, "Controlling the Master Thread I/O Rate". The master thread in InnoDB is a thread that performs various tasks in the background. Historically, InnoDB has used a hard coded value as the total `I/O` capacity of the server. With this change, user can control the number of `I/O` operations that can be performed per second based on their own workload.

Changes from the Google contributions were incorporated in the following source code files: `btr0cur.c`, `btr0sea.c`, `buf0buf.c`, `buf0buf.ic`, `ha_innodb.cc`, `log0log.c`, `log0log.h`, `os0sync.h`, `row0sel.c`, `srv0srv.c`, `srv0srv.h`, `srv0start.c`, `sync0arr.c`, `sync0rw.c`, `sync0rw.h`, `sync0rw.ic`, `sync0sync.c`, `sync0sync.h`, `sync0sync.ic`, and `univ.i`.

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13.4.13.2. Multiple Background I/O Threads Patch from Percona

Oracle gratefully acknowledges the contribution of Percona, Inc. to improve InnoDB performance by implementing configurable background threads, as discussed in Section 13.4.7.8, "Multiple Background I/O Threads". InnoDB uses background threads to service various types of I/O requests. The change provides another way to make InnoDB more scalable on high end systems.

Changes from the Percona, Inc. contribution were incorporated in the following source code files: `ha_innodb.cc`, `os0file.c`, `os0file.h`, `srv0srv.c`, `srv0srv.h`, and `srv0start.c`.

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```

13.4.13.3. Performance Patches from Sun Microsystems

Oracle gratefully acknowledges the following contributions from Sun Microsystems, Inc. to improve InnoDB performance:

- Introducing the PAUSE instruction inside spin loops, as discussed in Section 13.4.7.13, “Using the PAUSE Instruction in InnoDB Spin Loops”. This change increases performance in high concurrency, CPU-bound workloads.
- Enabling inlining of functions and prefetch with Sun Studio.

Changes from the Sun Microsystems, Inc. contribution were incorporated in the following source code files: `univ.i`, `ut0ut.c`, and `ut0ut.h`.

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```

13.4.14. List of Parameters Changed in InnoDB 1.1 and InnoDB Plugin 1.0

13.4.14.1. New Parameters

Throughout the course of development, InnoDB 1.1 and its predecessor the InnoDB Plugin introduced new configuration parameters. The following table summarizes those parameters:

Table 13.8. InnoDB 1.1 New Parameter Summary

Name	Cmd-Line	Option File	System Var	Scope	Dynamic	Default
`innodb_adaptive_flushing`	`YES`	`YES`	`YES`	`GLOBAL`	`YES`	`TRUE`
`innodb_buffer_pool_instances`	`YES`	`YES`	`YES`	`GLOBAL`	`YES`	`TRUE`
`innodb_change_buffering`	`YES`	`YES`	`YES`	`GLOBAL`	`YES`	`inserts`
`innodb_file_format`	`YES`	`YES`	`YES`	`GLOBAL`	`YES`	`Antelope`
`innodb_file_format_check`	`YES`	`YES`	`YES`	`GLOBAL`	`NO`	`1`
`innodb_file_format_max`	`YES`	`YES`	`YES`	`GLOBAL`	`YES`	`Antelope` for a new database; `Barracuda` if any tables using

Name	Cmd-Line	Option File	System Var	Scope	Dynamic	Default
						that file format exist in the database
`innodb_io_capacity`	YES	YES	YES	GLOBAL	YES	200
`innodb_old_blocks_pct`	YES	YES	YES	GLOBAL	YES	37
`innodb_old_blocks_time`	YES	YES	YES	GLOBAL	YES	0
`innodb_purge_batch_size`	YES	YES	YES	GLOBAL	YES	0
`innodb_purge_threads`	YES	YES	YES	GLOBAL	YES	0
`innodb_read_ahead_threshold`	YES	YES	YES	GLOBAL	YES	56
`innodb_read_io_threads`	YES	YES	YES	GLOBAL	NO	4
`innodb_spin_wait_delay`	YES	YES	YES	GLOBAL	YES	6
`innodb_stats_sample_pages`	YES	YES	YES	GLOBAL	YES	8
`innodb_strict_mode`	YES	YES	YES	GLOBAL|SESSION	YES	FALSE
`innodb_use_native_aio`	YES	YES	YES	GLOBAL	NO	TRUE
`innodb_use_sys_malloc`	YES	YES	YES	GLOBAL	NO	TRUE
`innodb_write_io_threads`	YES	YES	YES	GLOBAL	NO	4

- **`innodb_adaptive_flushing`**

  Whether InnoDB uses a new algorithm to estimate the required rate of flushing. The default value is `TRUE`. This parameter was added in InnoDB storage engine 1.0.4. See Section 13.4.7.12, “Controlling the Flushing Rate of Dirty Pages” for more information.

- **`innodb_change_buffering`**

  Whether InnoDB performs insert buffering. The default value is `"inserts"` (buffer insert operations). This parameter was added in InnoDB storage engine 1.0.3. See Section 13.4.7.4, “Controlling InnoDB Change Buffering” for more information.

- **`innodb_file_format`**

  The default file format for new InnoDB tables. The default is Antelope. To enable support for table compression, change it to Barracuda. This parameter was added in InnoDB storage engine 1.0.1. See Section 13.4.4.1, “Enabling File Formats” for more information.

- **`innodb_file_format_check`** and **`innodb_file_format_max`**

  Controls whether InnoDB performs file format compatibility checking when opening a database. The default value is `innodb-file-format-check=1`, with `innodb_file_format_max` set to the highest format that is used in the database (either Barracuda or Antelope). See Section 13.4.4.2.1, “Compatibility Check When InnoDB Is Started” for more information.

- **`innodb_io_capacity`**

  The number of `I/O` operations that can be performed per second. The allowable value range is any number 100 or greater, and the default value is `200`. This parameter was added in InnoDB storage engine 1.0.4. To reproduce the earlier behavior, use a value of 100. See Section 13.4.7.11, “Controlling the Master Thread I/O Rate” for more information.

- **`innodb_old_blocks_pct`**

  Controls the desired percentage of “old” blocks in the LRU list of the buffer pool. The default value is `37` and the allowable value range is `5 to 95`. This parameter was added in InnoDB storage engine 1.0.5. See Section 13.4.7.15, “Making Buffer Pool Scan Resistant” for more information.

- **`innodb_old_blocks_time`**

  The time in milliseconds since the first access to a block during which it can be accessed again without being made “young”. The default value is `0` which means that blocks are moved to the “young” end of the LRU list at the first access. This parameter was added in InnoDB storage engine 1.0.5. See Section 13.4.7.15, “Making Buffer Pool Scan Resistant” for more information.

- **`innodb_read_ahead_threshold`**

Control the sensitivity of the linear read ahead. The allowable value range is `0` to `64` and the default value is `56`. This parameter was added in InnoDB storage engine 1.0.4. See Section 13.4.7.7, “Changes in the Read-Ahead Algorithm” for more information.

- **`innodb_read_io_threads`**

  The number of background `I/O` threads used for reads. The allowable value range is `1` to `64` and the default value is `4`. This parameter was added in InnoDB storage engine 1.0.4. See Section 13.4.7.8, “Multiple Background I/O Threads” for more information.

- **`innodb_spin_wait_delay`**

  Maximum delay between polling for a spin lock. The allowable value range is `0` (meaning unlimited) or positive integers and the default value is `6`. This parameter was added in InnoDB storage engine 1.0.4. See Section 13.4.7.14, “Control of Spin Lock Polling” for more information.

- **`innodb_stats_sample_pages`**

  The number of index pages to sample when calculating statistics. The allowable value range is `1-unlimited` and the default value is `8`. This parameter was added in InnoDB storage engine 1.0.2. See Section 13.4.8.5, “Controlling Optimizer Statistics Estimation” for more information.

- **`innodb_strict_mode`**

  Whether InnoDB raises error conditions in certain cases, rather than issuing a warning. This parameter was added in InnoDB storage engine 1.0.2. See Section 13.4.8.4, “InnoDB Strict Mode” for more information.

- **`innodb_use_sys_malloc`**

  Whether InnoDB uses its own memory allocator or an allocator of the operating system. The default value is `ON` (use an allocator of the underlying system). This parameter was added in InnoDB storage engine 1.0.3. See Section 13.4.7.3, “Using Operating System Memory Allocators” for more information.

- **`innodb_write_io_threads`**

  The number of background `I/O` threads used for writes. The allowable value range is `1` to `64` and the default value is `4`. This parameter was added in InnoDB storage engine 1.0.4. See Section 13.4.7.8, “Multiple Background I/O Threads” for more information.

13.4.14.2. Deprecated Parameters

Beginning in InnoDB storage engine 1.0.4, the following configuration parameter has been removed:

- **`innodb_file_io_threads`**

  This parameter has been replaced by two new parameters `innodb_read_io_threads` and `innodb_write_io_threads`. See Section 13.4.7.8, “Multiple Background I/O Threads” for more information.

13.4.14.3. Parameters with New Defaults

For better out-of-the-box performance, the following InnoDB configuration parameters have new default values since MySQL 5.1:

Table 13.9. InnoDB Parameters with New Defaults

Name	Old Default	New Default
`innodb_additional_mem_pool_size`	`1MB`	`8MB`
`innodb_buffer_pool_size`	`8MB`	`128MB`
`innodb_change_buffering`	`inserts`	`all`
`innodb_file_format_check`	`ON`	`1`
`innodb_log_buffer_size`	`1MB`	`8MB`
`innodb_max_dirty_pages_pct`	`90`	`75`
`innodb_sync_spin_loops`	`20`	`30`
`innodb_thread_concurrency`	`8`	`0`

13.5. The `MyISAM` Storage Engine

Before MySQL 5.5.5, `MyISAM` is the default storage engine. (The default was changed to `InnoDB` in MySQL 5.5.5.) `MyISAM` is based on the older (and no longer available) `ISAM` storage engine but has many useful extensions.

Table 13.10. `MyISAM` Storage Engine Features

Storage limits	256TB	**Transactions**	No	**Locking granularity**	Table
MVCC	No	**Geospatial data type support**	Yes	**Geospatial indexing support**	Yes
B-tree indexes	Yes	**Hash indexes**	No	**Full-text search indexes**	Yes
Clustered indexes	No	**Data caches**	No	**Index caches**	Yes
Compressed data	Yes[a]	**Encrypted data**[b]	Yes	**Cluster database support**	No
Replication support[c]	Yes	**Foreign key support**	No	**Backup / point-in-time recovery**[d]	Yes
Query cache support	Yes	**Update statistics for data dictionary**	Yes		

[a] Compressed MyISAM tables are supported only when using the compressed row format. Tables using the compressed row format with MyISAM are read only.
[b] Implemented in the server (via encryption functions), rather than in the storage engine.
[c] Implemented in the server, rather than in the storage product.
[d] Implemented in the server, rather than in the storage product.

Each `MyISAM` table is stored on disk in three files. The files have names that begin with the table name and have an extension to indicate the file type. An `.frm` file stores the table format. The data file has an `.MYD` (`MYData`) extension. The index file has an `.MYI` (`MYIndex`) extension.

To specify explicitly that you want a `MyISAM` table, indicate that with an `ENGINE` table option:

```
CREATE TABLE t (i INT) ENGINE = MYISAM;
```

As of MySQL 5.5.5, it is normally necessary to use `ENGINE` to specify the `MyISAM` storage engine because `InnoDB` is the default engine. Before 5.5.5, this is unnecessary because `MyISAM` is the default engine unless the default has been changed. To ensure that `MyISAM` is used in situations where the default might have been changed, include the `ENGINE` option explicitly.

You can check or repair `MyISAM` tables with the `mysqlcheck` client or `myisamchk` utility. You can also compress `MyISAM` tables with `myisampack` to take up much less space. See Section 4.5.3, “`mysqlcheck` — A Table Maintenance Program”, Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”, and Section 4.6.5, “`myisampack` — Generate Compressed, Read-Only MyISAM Tables”.

`MyISAM` tables have the following characteristics:

- All data values are stored with the low byte first. This makes the data machine and operating system independent. The only requirements for binary portability are that the machine uses two's-complement signed integers and IEEE floating-point format. These requirements are widely used among mainstream machines. Binary compatibility might not be applicable to embedded systems, which sometimes have peculiar processors.

  There is no significant speed penalty for storing data low byte first; the bytes in a table row normally are unaligned and it takes little more processing to read an unaligned byte in order than in reverse order. Also, the code in the server that fetches column values is not time critical compared to other code.

- All numeric key values are stored with the high byte first to permit better index compression.

- Large files (up to 63-bit file length) are supported on file systems and operating systems that support large files.

- There is a limit of $(2^{32})^2$ (1.844E+19) rows in a `MyISAM` table.

- The maximum number of indexes per `MyISAM` table is 64.

  The maximum number of columns per index is 16.

- The maximum key length is 1000 bytes. This can also be changed by changing the source and recompiling. For the case of a key longer than 250 bytes, a larger key block size than the default of 1024 bytes is used.

- When rows are inserted in sorted order (as when you are using an `AUTO_INCREMENT` column), the index tree is split so that the high node only contains one key. This improves space utilization in the index tree.

- Internal handling of one `AUTO_INCREMENT` column per table is supported. `MyISAM` automatically updates this column for `INSERT` and `UPDATE` operations. This makes `AUTO_INCREMENT` columns faster (at least 10%). Values at the top of the sequence are not reused after being deleted. (When an `AUTO_INCREMENT` column is defined as the last column of a multiple-column index, reuse of values deleted from the top of a sequence does occur.) The `AUTO_INCREMENT` value can be reset with `ALTER TABLE` or `myisamchk`.
- Dynamic-sized rows are much less fragmented when mixing deletes with updates and inserts. This is done by automatically combining adjacent deleted blocks and by extending blocks if the next block is deleted.
- `MyISAM` supports concurrent inserts: If a table has no free blocks in the middle of the data file, you can `INSERT` new rows into it at the same time that other threads are reading from the table. A free block can occur as a result of deleting rows or an update of a dynamic length row with more data than its current contents. When all free blocks are used up (filled in), future inserts become concurrent again. See Section 7.10.3, “Concurrent Inserts”.
- You can put the data file and index file in different directories on different physical devices to get more speed with the `DATA DIRECTORY` and `INDEX DIRECTORY` table options to `CREATE TABLE`. See Section 12.1.14, “`CREATE TABLE` Syntax”.
- `BLOB` and `TEXT` columns can be indexed.
- `NULL` values are permitted in indexed columns. This takes 0 to 1 bytes per key.
- Each character column can have a different character set. See Section 9.1, “Character Set Support”.
- There is a flag in the `MyISAM` index file that indicates whether the table was closed correctly. If `mysqld` is started with the `--myisam-recover-options` option, `MyISAM` tables are automatically checked when opened, and are repaired if the table wasn't closed properly.
- `myisamchk` marks tables as checked if you run it with the `--update-state` option. `myisamchk --fast` checks only those tables that don't have this mark.
- `myisamchk --analyze` stores statistics for portions of keys, as well as for entire keys.
- `myisampack` can pack `BLOB` and `VARCHAR` columns.

`MyISAM` also supports the following features:

- Support for a true `VARCHAR` type; a `VARCHAR` column starts with a length stored in one or two bytes.
- Tables with `VARCHAR` columns may have fixed or dynamic row length.
- The sum of the lengths of the `VARCHAR` and `CHAR` columns in a table may be up to 64KB.
- Arbitrary length `UNIQUE` constraints.

Additional Resources

- A forum dedicated to the `MyISAM` storage engine is available at http://forums.mysql.com/list.php?21.

13.5.1. `MyISAM` Startup Options

The following options to `mysqld` can be used to change the behavior of `MyISAM` tables. For additional information, see Section 5.1.2, “Server Command Options”.

Table 13.11. `MyISAM` Option/Variable Reference

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
bulk_insert_buffer_size	Yes	Yes	Yes		Both	Yes
concurrent_insert	Yes	Yes	Yes		Global	Yes
delay-key-write	Yes	Yes			Global	Yes
- *Variable*: delay_key_write			Yes		Global	Yes
have_rtree_keys			Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
key_buffer_size	Yes	Yes	Yes		Global	Yes
log-isam	Yes	Yes				
myisam-block-size	Yes	Yes				
myisam_data_pointer_size	Yes	Yes	Yes		Global	Yes
myisam_max_sort_file_size	Yes	Yes	Yes		Global	Yes
myisam_mmap_size	Yes	Yes	Yes		Global	No
myisam-recover	Yes	Yes				
- *Variable*: myisam_recover_options						
myisam-recover-options	Yes	Yes				
- *Variable*: myisam_recover_options						
myisam_recover_options			Yes		Global	No
myisam_repair_threads	Yes	Yes	Yes		Both	Yes
myisam_sort_buffer_size	Yes	Yes	Yes		Both	Yes
myisam_stats_method	Yes	Yes	Yes		Both	Yes
myisam_use_mmap	Yes	Yes	Yes		Global	Yes
skip-concurrent-insert	Yes	Yes				
- *Variable*: concurrent_insert						
tmp_table_size	Yes	Yes	Yes		Both	Yes

- `--myisam-recover-options=mode`

  Set the mode for automatic recovery of crashed `MyISAM` tables.

- `--delay-key-write=ALL`

  Don't flush key buffers between writes for any `MyISAM` table.

  > **Note**
  >
  > If you do this, you should not access `MyISAM` tables from another program (such as from another MySQL server or with `myisamchk`) when the tables are in use. Doing so risks index corruption. Using `--external-locking` does not eliminate this risk.

The following system variables affect the behavior of `MyISAM` tables. For additional information, see Section 5.1.3, “Server System Variables”.

- `bulk_insert_buffer_size`

  The size of the tree cache used in bulk insert optimization.

  > **Note**
  >
  > This is a limit *per thread*!

- `myisam_max_sort_file_size`

  The maximum size of the temporary file that MySQL is permitted to use while re-creating a `MyISAM` index (during `REPAIR TABLE`, `ALTER TABLE`, or `LOAD DATA INFILE`). If the file size would be larger than this value, the index is created using the key cache instead, which is slower. The value is given in bytes.

- `myisam_sort_buffer_size`

  Set the size of the buffer used when recovering tables.

Automatic recovery is activated if you start `mysqld` with the `--myisam-recover-options` option. In this case, when the server opens a `MyISAM` table, it checks whether the table is marked as crashed or whether the open count variable for the table is not 0 and you are running the server with external locking disabled. If either of these conditions is true, the following happens:

- The server checks the table for errors.
- If the server finds an error, it tries to do a fast table repair (with sorting and without re-creating the data file).
- If the repair fails because of an error in the data file (for example, a duplicate-key error), the server tries again, this time re-creating the data file.
- If the repair still fails, the server tries once more with the old repair option method (write row by row without sorting). This method should be able to repair any type of error and has low disk space requirements.

If the recovery wouldn't be able to recover all rows from previously completed statements and you didn't specify `FORCE` in the value of the `--myisam-recover-options` option, automatic repair aborts with an error message in the error log:

```
Error: Couldn't repair table: test.g00pages
```

If you specify `FORCE`, a warning like this is written instead:

```
Warning: Found 344 of 354 rows when repairing ./test/g00pages
```

Note that if the automatic recovery value includes `BACKUP`, the recovery process creates files with names of the form *`tbl_name-datetime`*`.BAK`. You should have a `cron` script that automatically moves these files from the database directories to backup media.

13.5.2. Space Needed for Keys

`MyISAM` tables use B-tree indexes. You can roughly calculate the size for the index file as `(key_length+4)/0.67`, summed over all keys. This is for the worst case when all keys are inserted in sorted order and the table doesn't have any compressed keys.

String indexes are space compressed. If the first index part is a string, it is also prefix compressed. Space compression makes the index file smaller than the worst-case figure if a string column has a lot of trailing space or is a `VARCHAR` column that is not always used to the full length. Prefix compression is used on keys that start with a string. Prefix compression helps if there are many strings with an identical prefix.

In `MyISAM` tables, you can also prefix compress numbers by specifying the `PACK_KEYS=1` table option when you create the table. Numbers are stored with the high byte first, so this helps when you have many integer keys that have an identical prefix.

13.5.3. `MyISAM` Table Storage Formats

`MyISAM` supports three different storage formats. Two of them, fixed and dynamic format, are chosen automatically depending on the type of columns you are using. The third, compressed format, can be created only with the `myisampack` utility (see Section 4.6.5, “`myisampack` — Generate Compressed, Read-Only MyISAM Tables”).

When you use `CREATE TABLE` or `ALTER TABLE` for a table that has no `BLOB` or `TEXT` columns, you can force the table format to `FIXED` or `DYNAMIC` with the `ROW_FORMAT` table option.

See Section 12.1.14, “`CREATE TABLE` Syntax”, for information about `ROW_FORMAT`.

You can decompress (unpack) compressed `MyISAM` tables using `myisamchk --unpack`; see Section 4.6.3, “`myisamchk` — MyISAM Table-Maintenance Utility”, for more information.

13.5.3.1. Static (Fixed-Length) Table Characteristics

Static format is the default for `MyISAM` tables. It is used when the table contains no variable-length columns (`VARCHAR`, `VARBINARY`, `BLOB`, or `TEXT`). Each row is stored using a fixed number of bytes.

Of the three `MyISAM` storage formats, static format is the simplest and most secure (least subject to corruption). It is also the fastest of the on-disk formats due to the ease with which rows in the data file can be found on disk: To look up a row based on a row number in the index, multiply the row number by the row length to calculate the row position. Also, when scanning a table, it is very easy to read a constant number of rows with each disk read operation.

The security is evidenced if your computer crashes while the MySQL server is writing to a fixed-format `MyISAM` file. In this case, `myisamchk` can easily determine where each row starts and ends, so it can usually reclaim all rows except the partially written one. Note that `MyISAM` table indexes can always be reconstructed based on the data rows.

> **Note**
>
> Fixed-length row format is only available for tables without `BLOB` or `TEXT` columns. Creating a table with these columns with an explicit `ROW_FORMAT` clause will not raise an error or warning; the format specification will be ignored.

Static-format tables have these characteristics:

- `CHAR` and `VARCHAR` columns are space-padded to the specified column width, although the column type is not altered. `BINARY` and `VARBINARY` columns are padded with `0x00` bytes to the column width.
- Very quick.
- Easy to cache.
- Easy to reconstruct after a crash, because rows are located in fixed positions.
- Reorganization is unnecessary unless you delete a huge number of rows and want to return free disk space to the operating system. To do this, use `OPTIMIZE TABLE` or `myisamchk -r`.
- Usually require more disk space than dynamic-format tables.

13.5.3.2. Dynamic Table Characteristics

Dynamic storage format is used if a `MyISAM` table contains any variable-length columns (`VARCHAR`, `VARBINARY`, `BLOB`, or `TEXT`), or if the table was created with the `ROW_FORMAT=DYNAMIC` table option.

Dynamic format is a little more complex than static format because each row has a header that indicates how long it is. A row can become fragmented (stored in noncontiguous pieces) when it is made longer as a result of an update.

You can use `OPTIMIZE TABLE` or `myisamchk -r` to defragment a table. If you have fixed-length columns that you access or change frequently in a table that also contains some variable-length columns, it might be a good idea to move the variable-length columns to other tables just to avoid fragmentation.

Dynamic-format tables have these characteristics:

- All string columns are dynamic except those with a length less than four.
- Each row is preceded by a bitmap that indicates which columns contain the empty string (for string columns) or zero (for numeric columns). Note that this does not include columns that contain `NULL` values. If a string column has a length of zero after trailing space removal, or a numeric column has a value of zero, it is marked in the bitmap and not saved to disk. Nonempty strings are saved as a length byte plus the string contents.
- Much less disk space usually is required than for fixed-length tables.
- Each row uses only as much space as is required. However, if a row becomes larger, it is split into as many pieces as are required, resulting in row fragmentation. For example, if you update a row with information that extends the row length, the row becomes fragmented. In this case, you may have to run `OPTIMIZE TABLE` or `myisamchk -r` from time to time to improve performance. Use `myisamchk -ei` to obtain table statistics.
- More difficult than static-format tables to reconstruct after a crash, because rows may be fragmented into many pieces and links (fragments) may be missing.
- The expected row length for dynamic-sized rows is calculated using the following expression:

```
3
+ (number of columns + 7) / 8
+ (number of char columns)
+ (packed size of numeric columns)
+ (length of strings)
+ (number of NULL columns + 7) / 8
```

There is a penalty of 6 bytes for each link. A dynamic row is linked whenever an update causes an enlargement of the row. Each new link is at least 20 bytes, so the next enlargement probably goes in the same link. If not, another link is created. You can find the number of links using `myisamchk -ed`. All links may be removed with `OPTIMIZE TABLE` or `myisamchk -r`.

13.5.3.3. Compressed Table Characteristics

Compressed storage format is a read-only format that is generated with the `myisampack` tool. Compressed tables can be uncompressed with `myisamchk`.

Compressed tables have the following characteristics:

- Compressed tables take very little disk space. This minimizes disk usage, which is helpful when using slow disks (such as CD-ROMs).
- Each row is compressed separately, so there is very little access overhead. The header for a row takes up one to three bytes depending on the biggest row in the table. Each column is compressed differently. There is usually a different Huffman tree for each column. Some of the compression types are:
  - Suffix space compression.
  - Prefix space compression.
  - Numbers with a value of zero are stored using one bit.
  - If values in an integer column have a small range, the column is stored using the smallest possible type. For example, a `BIGINT` column (eight bytes) can be stored as a `TINYINT` column (one byte) if all its values are in the range from `-128` to `127`.
  - If a column has only a small set of possible values, the data type is converted to `ENUM`.
  - A column may use any combination of the preceding compression types.
- Can be used for fixed-length or dynamic-length rows.

> **Note**
>
> While a compressed table is read only, and you cannot therefore update or add rows in the table, DDL (Data Definition Language) operations are still valid. For example, you may still use `DROP` to drop the table, and `TRUNCATE TABLE` to empty the table.

13.5.4. `MyISAM` Table Problems

The file format that MySQL uses to store data has been extensively tested, but there are always circumstances that may cause database tables to become corrupted. The following discussion describes how this can happen and how to handle it.

13.5.4.1. Corrupted `MyISAM` Tables

Even though the `MyISAM` table format is very reliable (all changes to a table made by an SQL statement are written before the statement returns), you can still get corrupted tables if any of the following events occur:

- The `mysqld` process is killed in the middle of a write.
- An unexpected computer shutdown occurs (for example, the computer is turned off).
- Hardware failures.
- You are using an external program (such as `myisamchk`) to modify a table that is being modified by the server at the same time.
- A software bug in the MySQL or `MyISAM` code.

Typical symptoms of a corrupt table are:

- You get the following error while selecting data from the table:

```
Incorrect key file for table: '...'. Try to repair it
```

- Queries don't find rows in the table or return incomplete results.

You can check the health of a `MyISAM` table using the `CHECK TABLE` statement, and repair a corrupted `MyISAM` table with `REPAIR TABLE`. When `mysqld` is not running, you can also check or repair a table with the `myisamchk` command. See Section 12.4.2.2, "`CHECK TABLE` Syntax", Section 12.4.2.5, "`REPAIR TABLE` Syntax", and Section 4.6.3, "`myisamchk` — MyISAM Table-Maintenance Utility".

If your tables become corrupted frequently, you should try to determine why this is happening. The most important thing to know is whether the table became corrupted as a result of a server crash. You can verify this easily by looking for a recent `restarted mysqld` message in the error log. If there is such a message, it is likely that table corruption is a result of the server dying. Otherwise, corruption may have occurred during normal operation. This is a bug. You should try to create a reproducible test case that demonstrates the problem. See Section C.5.4.2, "What to Do If MySQL Keeps Crashing", and MySQL Internals: Porting.

13.5.4.2. Problems from Tables Not Being Closed Properly

Each `MyISAM` index file (`.MYI` file) has a counter in the header that can be used to check whether a table has been closed properly. If you get the following warning from `CHECK TABLE` or `myisamchk`, it means that this counter has gone out of sync:

```
clients are using or haven't closed the table properly
```

This warning doesn't necessarily mean that the table is corrupted, but you should at least check the table.

The counter works as follows:

- The first time a table is updated in MySQL, a counter in the header of the index files is incremented.
- The counter is not changed during further updates.
- When the last instance of a table is closed (because a `FLUSH TABLES` operation was performed or because there is no room in the table cache), the counter is decremented if the table has been updated at any point.
- When you repair the table or check the table and it is found to be okay, the counter is reset to zero.
- To avoid problems with interaction with other processes that might check the table, the counter is not decremented on close if it was zero.

In other words, the counter can become incorrect only under these conditions:

- A `MyISAM` table is copied without first issuing `LOCK TABLES` and `FLUSH TABLES`.
- MySQL has crashed between an update and the final close. (Note that the table may still be okay, because MySQL always issues writes for everything between each statement.)
- A table was modified by `myisamchk --recover` or `myisamchk --update-state` at the same time that it was in use by `mysqld`.
- Multiple `mysqld` servers are using the table and one server performed a `REPAIR TABLE` or `CHECK TABLE` on the table while it was in use by another server. In this setup, it is safe to use `CHECK TABLE`, although you might get the warning from other servers. However, `REPAIR TABLE` should be avoided because when one server replaces the data file with a new one, this is not known to the other servers.

  In general, it is a bad idea to share a data directory among multiple servers. See Section 5.6, "Running Multiple MySQL Instances on One Machine", for additional discussion.

13.6. The `MEMORY` Storage Engine

The `MEMORY` storage engine creates tables with contents that are stored in memory. Formerly, these were known as `HEAP` tables. `MEMORY` is the preferred term, although `HEAP` remains supported for backward compatibility.

Table 13.12. `MEMORY` Storage Engine Features

Storage limits	RAM	**Transactions**	No	**Locking granularity**	Table
MVCC	No	**Geospatial data type support**	No	**Geospatial indexing support**	No
B-tree indexes	Yes	**Hash indexes**	Yes	**Full-text search indexes**	No
Clustered indexes	No	**Data caches**	N/A	**Index caches**	N/A
Compressed data	No	**Encrypted data**[a]	Yes	**Cluster database support**	No
Replication support[b]	Yes	**Foreign key support**	No	**Backup / point-in-time recovery**[c]	Yes
Query cache support	Yes	**Update statistics for data dictionary**	Yes		

[a] Implemented in the server (via encryption functions), rather than in the storage engine.
[b] Implemented in the server, rather than in the storage product.
[c] Implemented in the server, rather than in the storage product.

`MEMORY` compared with MySQL Cluster. Developers looking to deploy applications that use the `MEMORY` storage engine should consider whether MySQL Cluster is a better choice. A typical use case for the `MEMORY` engine involves these characteristics:

- Operations such as session management or caching
- In-memory storage for fast access and low latency
- A read-only or read-mostly data access pattern (limited updates)

However, `MEMORY` performance is constrained by contention resulting from single-thread execution and table lock overhead when processing updates. This limits scalability when load increases, particularly for statement mixes that include writes. Also, `MEMORY` does not preserve table contents across server restarts.

MySQL Cluster offers the same features as the `MEMORY` engine with higher performance levels, and provides additional features not available with `MEMORY`:

- Row-level locking and multiple-thread operation for low contention between clients
- Scalability even with statement mixes that include writes
- Optional disk-backed operation for data durability
- Shared-nothing architecture and multiple-host operation with no single point of failure, enabling 99.999% availability
- Automatic data distribution across nodes; application developers need not craft custom sharding or partitioning solutions
- Support for variable-length data types (including `BLOB` and `TEXT`) not supported by `MEMORY`

For a white paper with more detailed comparison of the `MEMORY` storage engine and MySQL Cluster, see Scaling Web Services with MySQL Cluster: An Alternative to the MySQL Memory Storage Engine. This white paper includes a performance study of the two technologies and a step-by-step guide describing how existing `MEMORY` users can migrate to MySQL Cluster.

The `MEMORY` storage engine associates each table with one disk file. The file name begins with the table name and has an extension of `.frm` to indicate that it stores the table definition.

To specify that you want to create a `MEMORY` table, indicate that with an `ENGINE` table option:

```
CREATE TABLE t (i INT) ENGINE = MEMORY;
```

As indicated by the engine name, `MEMORY` tables are stored in memory. They use hash indexes by default, which makes them very fast, and very useful for creating temporary tables. However, when the server shuts down, all rows stored in `MEMORY` tables are lost. The tables themselves continue to exist because their definitions are stored in `.frm` files on disk, but they are empty when the server restarts.

This example shows how you might create, use, and remove a `MEMORY` table:

```
mysql> CREATE TABLE test ENGINE=MEMORY
    ->     SELECT ip,SUM(downloads) AS down
    ->     FROM log_table GROUP BY ip;
mysql> SELECT COUNT(ip),AVG(down) FROM test;
mysql> DROP TABLE test;
```

`MEMORY` tables have the following characteristics:

- Space for `MEMORY` tables is allocated in small blocks. Tables use 100% dynamic hashing for inserts. No overflow area or extra key space is needed. No extra space is needed for free lists. Deleted rows are put in a linked list and are reused when you insert new data into the table. `MEMORY` tables also have none of the problems commonly associated with deletes plus inserts in hashed tables.
- `MEMORY` tables can have up to 64 indexes per table, 16 columns per index and a maximum key length of 3072 bytes.
- The `MEMORY` storage engine supports both `HASH` and `BTREE` indexes. You can specify one or the other for a given index by adding a `USING` clause as shown here:

  ```
  CREATE TABLE lookup
      (id INT, INDEX USING HASH (id))
      ENGINE = MEMORY;
  CREATE TABLE lookup
      (id INT, INDEX USING BTREE (id))
      ENGINE = MEMORY;
  ```

  For general characteristics of B-tree and hash indexes, see Section 7.3.1, “How MySQL Uses Indexes”.
- If a `MEMORY` table hash index has a high degree of key duplication (many index entries containing the same value), updates to the table that affect key values and all deletes are significantly slower. The degree of this slowdown is proportional to the degree of duplication (or, inversely proportional to the index cardinality). You can use a `BTREE` index to avoid this problem.
- `MEMORY` tables can have nonunique keys. (This is an uncommon feature for implementations of hash indexes.)
- Columns that are indexed can contain `NULL` values.
- `MEMORY` tables use a fixed-length row-storage format. Variable-length types such as `VARCHAR` are stored using a fixed length.
- `MEMORY` tables cannot contain `BLOB` or `TEXT` columns.
- `MEMORY` includes support for `AUTO_INCREMENT` columns.
- `MEMORY` supports `INSERT DELAYED`. See Section 12.2.5.2, “`INSERT DELAYED` Syntax”.
- Non-`TEMPORARY` `MEMORY` tables are shared among all clients, just like any other non-`TEMPORARY` table.
- `MEMORY` table contents are stored in memory, which is a property that `MEMORY` tables share with internal temporary tables that the server creates on the fly while processing queries. However, the two types of tables differ in that `MEMORY` tables are not subject to storage conversion, whereas internal temporary tables are:
  - `MEMORY` tables are never converted to disk tables. If an internal temporary table becomes too large, the server automatically converts it to on-disk storage, as described in Section 7.4.3.3, “How MySQL Uses Internal Temporary Tables”.
  - The maximum size of `MEMORY` tables is limited by the `max_heap_table_size` system variable, which has a default value of 16MB. To have larger (or smaller) `MEMORY` tables, you must change the value of this variable. The value in effect for `CREATE TABLE` is the value used for the life of the table. (If you use `ALTER TABLE` or `TRUNCATE TABLE`, the value in effect at that time becomes the new maximum size for the table. A server restart also sets the maximum size of existing `MEMORY` tables to the global `max_heap_table_size` value.) You can set the size for individual tables as described later in this section.
- The server needs sufficient memory to maintain all `MEMORY` tables that are in use at the same time.
- Memory is not reclaimed if you delete individual rows from a `MEMORY` table. Memory is reclaimed only when the entire table is deleted. Memory that was previously used for rows that have been deleted will be re-used for new rows only within the same table. To free up the memory used by rows that have been deleted, use `ALTER TABLE ENGINE=MEMORY` to force a table rebuild.

  To free all the memory used by a `MEMORY` table when you no longer require its contents, you should execute `DELETE` or `TRUNCATE TABLE` to remove all rows, or remove the table altogether using `DROP TABLE`.
- If you want to populate a `MEMORY` table when the MySQL server starts, you can use the `--init-file` option. For example, you can put statements such as `INSERT INTO ... SELECT` or `LOAD DATA INFILE` into this file to load the table from a persistent data source. See Section 5.1.2, “Server Command Options”, and Section 12.2.6, “`LOAD DATA INFILE` Syntax”.
- A server's `MEMORY` tables become empty when it is shut down and restarted. However, if the server is a replication master, its slave are not aware that these tables have become empty, so they returns out-of-date content if you select data from these tables. To handle this, when a `MEMORY` table is used on a master for the first time since it was started, a `DELETE` statement is written to the master's binary log automatically, thus synchronizing the slave to the master again. Note that even with this strategy, the

slave still has outdated data in the table during the interval between the master's restart and its first use of the table. However, if you use the `--init-file` option to populate the `MEMORY` table on the master at startup, it ensures that this time interval is zero.

- The memory needed for one row in a `MEMORY` table is calculated using the following expression:

  ```
  SUM_OVER_ALL_BTREE_KEYS(max_length_of_key + sizeof(char*) * 4)
  + SUM_OVER_ALL_HASH_KEYS(sizeof(char*) * 2)
  + ALIGN(length_of_row+1, sizeof(char*))
  ```

  `ALIGN()` represents a round-up factor to cause the row length to be an exact multiple of the `char` pointer size. `sizeof(char*)` is 4 on 32-bit machines and 8 on 64-bit machines.

As mentioned earlier, the `max_heap_table_size` system variable sets the limit on the maximum size of `MEMORY` tables. To control the maximum size for individual tables, set the session value of this variable before creating each table. (Do not change the global `max_heap_table_size` value unless you intend the value to be used for `MEMORY` tables created by all clients.) The following example creates two `MEMORY` tables, with a maximum size of 1MB and 2MB, respectively:

```
mysql> SET max_heap_table_size = 1024*1024;
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE TABLE t1 (id INT, UNIQUE(id)) ENGINE = MEMORY;
Query OK, 0 rows affected (0.01 sec)

mysql> SET max_heap_table_size = 1024*1024*2;
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE TABLE t2 (id INT, UNIQUE(id)) ENGINE = MEMORY;
Query OK, 0 rows affected (0.00 sec)
```

Both tables will revert to the server's global `max_heap_table_size` value if the server restarts.

You can also specify a `MAX_ROWS` table option in `CREATE TABLE` statements for `MEMORY` tables to provide a hint about the number of rows you plan to store in them. This does not enable the table to grow beyond the `max_heap_table_size` value, which still acts as a constraint on maximum table size. For maximum flexibility in being able to use `MAX_ROWS`, set `max_heap_table_size` at least as high as the value to which you want each `MEMORY` table to be able to grow.

Additional Resources

- A forum dedicated to the `MEMORY` storage engine is available at http://forums.mysql.com/list.php?92.

13.7. The CSV Storage Engine

The `CSV` storage engine stores data in text files using comma-separated values format.

The `CSV` storage engine is always compiled into the MySQL server.

To examine the source for the `CSV` engine, look in the `storage/csv` directory of a MySQL source distribution.

When you create a `CSV` table, the server creates a table format file in the database directory. The file begins with the table name and has an `.frm` extension. The storage engine also creates a data file. Its name begins with the table name and has a `.CSV` extension. The data file is a plain text file. When you store data into the table, the storage engine saves it into the data file in comma-separated values format.

```
mysql> CREATE TABLE test (i INT NOT NULL, c CHAR(10) NOT NULL)
    -> ENGINE = CSV;
Query OK, 0 rows affected (0.12 sec)

mysql> INSERT INTO test VALUES(1,'record one'),(2,'record two');
Query OK, 2 rows affected (0.00 sec)
Records: 2  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM test;
+------+------------+
| i    | c          |
+------+------------+
|    1 | record one |
|    2 | record two |
+------+------------+
2 rows in set (0.00 sec)
```

Creating a CSV table also creates a corresponding Metafile that stores the state of the table and the number of rows that exist in the table. The name of this file is the same as the name of the table with the extension `CSM`.

If you examine the `test.CSV` file in the database directory created by executing the preceding statements, its contents should look like this:

```
"1","record one"
"2","record two"
```

This format can be read, and even written, by spreadsheet applications such as Microsoft Excel or StarOffice Calc.

13.7.1. Repairing and Checking CSV Tables

The CSV storage engines supports the `CHECK` and `REPAIR` statements to verify and if possible repair a damaged CSV table.

When running the `CHECK` statement, the CSV file will be checked for validity by looking for the correct field separators, escaped fields (matching or missing quotation marks), the correct number of fields compared to the table definition and the existence of a corresponding CSV metafile. The first invalid row discovered will report an error. Checking a valid table produces output like that shown below:

```
mysql> check table csvtest;
+--------------+-------+----------+----------+
| Table        | Op    | Msg_type | Msg_text |
+--------------+-------+----------+----------+
| test.csvtest | check | status   | OK       |
+--------------+-------+----------+----------+
1 row in set (0.00 sec)
```

A check on a corrupted table returns a fault:

```
mysql> check table csvtest;
+--------------+-------+----------+----------+
| Table        | Op    | Msg_type | Msg_text |
+--------------+-------+----------+----------+
| test.csvtest | check | error    | Corrupt  |
+--------------+-------+----------+----------+
1 row in set (0.01 sec)
```

If the check fails, the table is marked as crashed (corrupt). Once a table has been marked as corrupt, it is automatically repaired when you next run `CHECK` or execute a `SELECT` statement. The corresponding corrupt status and new status will be displayed when running `CHECK`:

```
mysql> check table csvtest;
+--------------+-------+----------+----------------------------+
| Table        | Op    | Msg_type | Msg_text                   |
+--------------+-------+----------+----------------------------+
| test.csvtest | check | warning  | Table is marked as crashed |
| test.csvtest | check | status   | OK                         |
+--------------+-------+----------+----------------------------+
2 rows in set (0.08 sec)
```

To repair a table you can use `REPAIR`, this copies as many valid rows from the existing CSV data as possible, and then replaces the existing CSV file with the recovered rows. Any rows beyond the corrupted data are lost.

```
mysql> repair table csvtest;
+--------------+--------+----------+----------+
| Table        | Op     | Msg_type | Msg_text |
+--------------+--------+----------+----------+
| test.csvtest | repair | status   | OK       |
+--------------+--------+----------+----------+
1 row in set (0.02 sec)
```

> **Warning**
>
> Note that during repair, only the rows from the CSV file up to the first damaged row are copied to the new table. All other rows from the first damaged row to the end of the table are removed, even valid rows.

13.7.2. CSV Limitations

The `CSV` storage engine does not support indexing.

Partitioning is not supported for tables using the `CSV` storage engine.

Tables using the `CSV` storage engine cannot be created with `NULL` columns. However, for backward compatibility, you can continue to use such tables that were created in previous MySQL releases. (Bug #32050)

13.8. The `ARCHIVE` Storage Engine

The `ARCHIVE` storage engine is used for storing large amounts of data without indexes in a very small footprint.

Table 13.13. `ARCHIVE` Storage Engine Features

Storage limits	None	**Transactions**	No	**Locking granularity**	Row
MVCC	No	**Geospatial data type support**	Yes	**Geospatial indexing support**	No
B-tree indexes	No	**Hash indexes**	No	**Full-text search indexes**	No
Clustered indexes	No	**Data caches**	No	**Index caches**	No
Compressed data	Yes	**Encrypted data**[a]	Yes	**Cluster database support**	No
Replication support[b]	Yes	**Foreign key support**	No	**Backup / point-in-time recovery**[c]	Yes
Query cache support	Yes	**Update statistics for data dictionary**	Yes		

[a] Implemented in the server (via encryption functions), rather than in the storage engine.
[b] Implemented in the server, rather than in the storage product.
[c] Implemented in the server, rather than in the storage product.

The `ARCHIVE` storage engine is included in MySQL binary distributions. To enable this storage engine if you build MySQL from source, invoke `CMake` with the `-DWITH_ARCHIVE_STORAGE_ENGINE` option.

To examine the source for the `ARCHIVE` engine, look in the `storage/archive` directory of a MySQL source distribution.

You can check whether the `ARCHIVE` storage engine is available with the `SHOW ENGINES` statement.

When you create an `ARCHIVE` table, the server creates a table format file in the database directory. The file begins with the table name and has an `.frm` extension. The storage engine creates other files, all having names beginning with the table name. The data file has an extension of `.ARZ`. An `.ARN` file may appear during optimization operations.

The `ARCHIVE` engine supports `INSERT` and `SELECT`, but not `DELETE`, `REPLACE`, or `UPDATE`. It does support `ORDER BY` operations, `BLOB` columns, and basically all but spatial data types (see Section 11.17.4.1, “MySQL Spatial Data Types”). The `ARCHIVE` engine uses row-level locking.

The `ARCHIVE` engine supports the `AUTO_INCREMENT` column attribute. The `AUTO_INCREMENT` column can have either a unique or nonunique index. Attempting to create an index on any other column results in an error. The `ARCHIVE` engine also supports the `AUTO_INCREMENT` table option in `CREATE TABLE` and `ALTER TABLE` statements to specify the initial sequence value for a new table or reset the sequence value for an existing table, respectively.

The `ARCHIVE` engine ignores `BLOB` columns if they are not requested and scans past them while reading.

Storage: Rows are compressed as they are inserted. The `ARCHIVE` engine uses `zlib` lossless data compression (see http://www.zlib.net/). You can use `OPTIMIZE TABLE` to analyze the table and pack it into a smaller format (for a reason to use `OPTIMIZE TABLE`, see later in this section). The engine also supports `CHECK TABLE`. There are several types of insertions that are used:

- An `INSERT` statement just pushes rows into a compression buffer, and that buffer flushes as necessary. The insertion into the buffer is protected by a lock. A `SELECT` forces a flush to occur, unless the only insertions that have come in were `INSERT DELAYED` (those flush as necessary). See Section 12.2.5.2, “`INSERT DELAYED` Syntax”.
- A bulk insert is visible only after it completes, unless other inserts occur at the same time, in which case it can be seen partially. A `SELECT` never causes a flush of a bulk insert unless a normal insert occurs while it is loading.

Retrieval: On retrieval, rows are uncompressed on demand; there is no row cache. A `SELECT` operation performs a complete table scan: When a `SELECT` occurs, it finds out how many rows are currently available and reads that number of rows. `SELECT` is performed as a consistent read. Note that lots of `SELECT` statements during insertion can deteriorate the compression, unless only bulk or delayed inserts are used. To achieve better compression, you can use `OPTIMIZE TABLE` or `REPAIR TABLE`. The number of rows in `ARCHIVE` tables reported by `SHOW TABLE STATUS` is always accurate. See Section 12.4.2.4, “`OPTIMIZE TABLE` Syntax”, Section 12.4.2.5, “`REPAIR TABLE` Syntax”, and Section 12.4.5.37, “`SHOW TABLE STATUS` Syntax”.

Additional Resources

- A forum dedicated to the `ARCHIVE` storage engine is available at http://forums.mysql.com/list.php?112.

13.9. The `BLACKHOLE` Storage Engine

The `BLACKHOLE` storage engine acts as a “black hole” that accepts data but throws it away and does not store it. Retrievals always return an empty result:

```
mysql> CREATE TABLE test(i INT, c CHAR(10)) ENGINE = BLACKHOLE;
Query OK, 0 rows affected (0.03 sec)

mysql> INSERT INTO test VALUES(1,'record one'),(2,'record two');
Query OK, 2 rows affected (0.00 sec)
Records: 2  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM test;
Empty set (0.00 sec)
```

To enable the `BLACKHOLE` storage engine if you build MySQL from source, invoke `CMake` with the `-DWITH_BLACKHOLE_STORAGE_ENGINE` option.

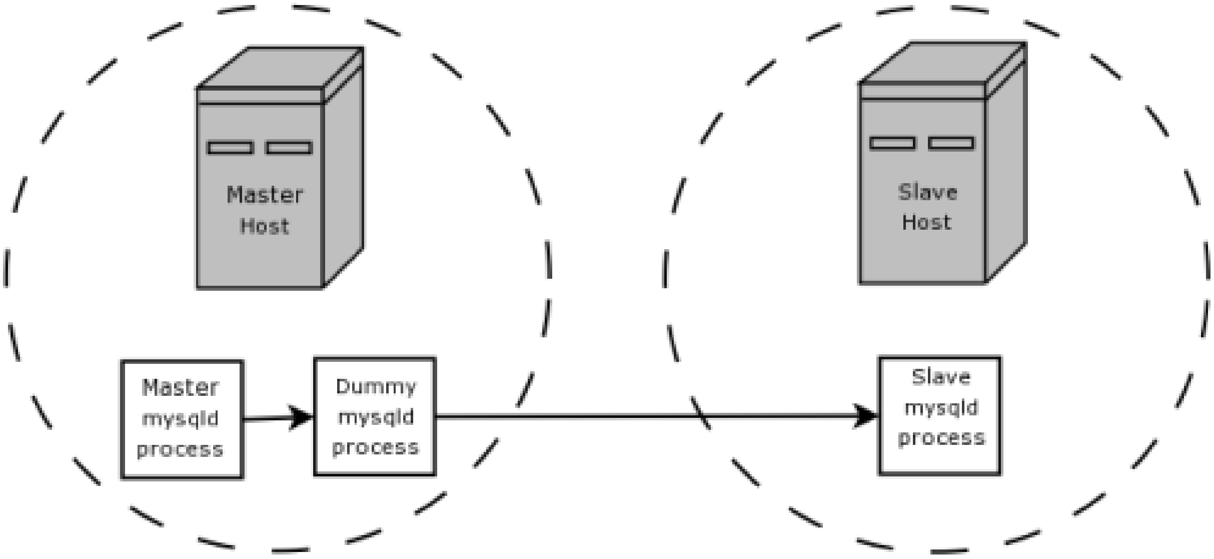
To examine the source for the `BLACKHOLE` engine, look in the `sql` directory of a MySQL source distribution.

When you create a `BLACKHOLE` table, the server creates a table format file in the database directory. The file begins with the table name and has an `.frm` extension. There are no other files associated with the table.

The `BLACKHOLE` storage engine supports all kinds of indexes. That is, you can include index declarations in the table definition.

You can check whether the `BLACKHOLE` storage engine is available with the `SHOW ENGINES` statement.

Inserts into a `BLACKHOLE` table do not store any data, but if the binary log is enabled, the SQL statements are logged (and replicated to slave servers). This can be useful as a repeater or filter mechanism. Suppose that your application requires slave-side filtering rules, but transferring all binary log data to the slave first results in too much traffic. In such a case, it is possible to set up on the master host a “dummy” slave process whose default storage engine is `BLACKHOLE`, depicted as follows:



The master writes to its binary log. The “dummy” `mysqld` process acts as a slave, applying the desired combination of `replicate-do-*` and `replicate-ignore-*` rules, and writes a new, filtered binary log of its own. (See Section 15.1.3, “Replication and Binary Logging Options and Variables”.) This filtered log is provided to the slave.

The dummy process does not actually store any data, so there is little processing overhead incurred by running the additional `mysqld` process on the replication master host. This type of setup can be repeated with additional replication slaves.

`INSERT` triggers for `BLACKHOLE` tables work as expected. However, because the `BLACKHOLE` table does not actually store any data, `UPDATE` and `DELETE` triggers are not activated: The `FOR EACH ROW` clause in the trigger definition does not apply because there are no rows.

Other possible uses for the `BLACKHOLE` storage engine include:

- Verification of dump file syntax.
- Measurement of the overhead from binary logging, by comparing performance using `BLACKHOLE` with and without binary logging enabled.
- `BLACKHOLE` is essentially a “no-op” storage engine, so it could be used for finding performance bottlenecks not related to the storage engine itself.

The `BLACKHOLE` engine is transaction-aware, in the sense that committed transactions are written to the binary log and rolled-back transactions are not.

Blackhole Engine and Auto Increment Columns

The Blackhole engine is a no-op engine. Any operations performed on a table using Blackhole will have no effect. This should be born in mind when considering the behavior of primary key columns that auto increment. The engine will not automatically increment field values, and does not retain auto increment field state. This has important implications in replication.

Consider the following replication scenario where all three of the following conditions apply:

1. On a master server there is a blackhole table with an auto increment field that is a primary key.
2. On a slave the same table exists but using the MyISAM engine.
3. Inserts are performed into the master's table without explicitly setting the auto increment value in the `INSERT` statement itself or through using a `SET INSERT_ID` statement.

In this scenario replication will fail with a duplicate entry error on the primary key column.

In statement based replication, the value of `INSERT_ID` in the context event will always be the same. Replication will therefore fail due to trying insert a row with a duplicate value for a primary key column.

In row based replication, the value that the engine returns for the row always be the same for each insert. This will result in the slave attempting to replay two insert log entries using the same value for the primary key column, and so replication will fail.

Column Filtering

When using row-based replication, (`binlog_format=ROW`), a slave where the last columns are missing from a table is supported, as described in the section Section 15.4.1.6, “Replication with Differing Table Definitions on Master and Slave”.

This filtering works on the slave side, that is, the columns are copied to the slave before they are filtered out. There are at least two cases where it is not desirable to copy the columns to the slave:

1. If the data is confidential, so the slave server should not have access to it.
2. If the master has many slaves, filtering before sending to the slaves may reduce network traffic.

Master column filtering can be achieved using the `BLACKHOLE` engine. This is carried out in a way similar to how master table filtering is achieved - by using the `BLACKHOLE` engine and the option `--replicate-[do|ignore]-table`.

The setup for the master is:

```
CREATE TABLE t1 (public_col_1, ..., public_col_N,
                 secret_col_1, ..., secret_col_M) ENGINE=MyISAM;
```

The setup for the trusted slave is:

```
CREATE TABLE t1 (public_col_1, ..., public_col_N) ENGINE=BLACKHOLE;
```

The setup for the untrusted slave is:

```
CREATE TABLE t1 (public_col_1, ..., public_col_N) ENGINE=MyISAM;
```

13.10. The `MERGE` Storage Engine

The `MERGE` storage engine, also known as the `MRG_MyISAM` engine, is a collection of identical `MyISAM` tables that can be used as one. “Identical” means that all tables have identical column and index information. You cannot merge `MyISAM` tables in which the columns are listed in a different order, do not have exactly the same columns, or have the indexes in different order. However, any or all of the `MyISAM` tables can be compressed with `myisampack`. See Section 4.6.5, “`myisampack` — Generate Compressed, Read-Only MyISAM Tables”. Differences in table options such as `AVG_ROW_LENGTH`, `MAX_ROWS`, or `PACK_KEYS` do not matter.

An alternative to a `MERGE` table is a partitioned table, which stores partitions of a single table in separate files. Partitioning enables some operations to be performed more efficiently and is not limited to the `MyISAM` storage engine. For more information, see Chapter 16, *Partitioning*.

When you create a `MERGE` table, MySQL creates two files on disk. The files have names that begin with the table name and have an extension to indicate the file type. An `.frm` file stores the table format, and an `.MRG` file contains the names of the underlying `MyISAM` tables that should be used as one. The tables do not have to be in the same database as the `MERGE` table.

You can use `SELECT`, `DELETE`, `UPDATE`, and `INSERT` on `MERGE` tables. You must have `SELECT`, `DELETE`, and `UPDATE` privileges on the `MyISAM` tables that you map to a `MERGE` table.

> **Note**
>
> The use of `MERGE` tables entails the following security issue: If a user has access to `MyISAM` table *`t`*, that user can create a `MERGE` table *`m`* that accesses *`t`*. However, if the user's privileges on *`t`* are subsequently revoked, the user can continue to access *`t`* by doing so through *`m`*.

Use of `DROP TABLE` with a `MERGE` table drops only the `MERGE` specification. The underlying tables are not affected.

To create a `MERGE` table, you must specify a `UNION=(list-of-tables)` option that indicates which `MyISAM` tables to use. You can optionally specify an `INSERT_METHOD` option to control how inserts into the `MERGE` table take place. Use a value of `FIRST` or `LAST` to cause inserts to be made in the first or last underlying table, respectively. If you specify no `INSERT_METHOD` option or if you specify it with a value of `NO`, inserts into the `MERGE` table are not permitted and attempts to do so result in an error.

The following example shows how to create a `MERGE` table:

```
mysql> CREATE TABLE t1 (
    ->    a INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    ->    message CHAR(20)) ENGINE=MyISAM;
mysql> CREATE TABLE t2 (
    ->    a INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    ->    message CHAR(20)) ENGINE=MyISAM;
mysql> INSERT INTO t1 (message) VALUES ('Testing'),('table'),('t1');
mysql> INSERT INTO t2 (message) VALUES ('Testing'),('table'),('t2');
mysql> CREATE TABLE total (
    ->    a INT NOT NULL AUTO_INCREMENT,
    ->    message CHAR(20), INDEX(a))
    ->    ENGINE=MERGE UNION=(t1,t2) INSERT_METHOD=LAST;
```

Note that column `a` is indexed as a `PRIMARY KEY` in the underlying `MyISAM` tables, but not in the `MERGE` table. There it is indexed but not as a `PRIMARY KEY` because a `MERGE` table cannot enforce uniqueness over the set of underlying tables. (Similarly, a column with a `UNIQUE` index in the underlying tables should be indexed in the `MERGE` table but not as a `UNIQUE` index.)

After creating the `MERGE` table, you can use it to issue queries that operate on the group of tables as a whole:

```
mysql> SELECT * FROM total;
+---+---------+
| a | message |
+---+---------+
| 1 | Testing |
| 2 | table   |
| 3 | t1      |
| 1 | Testing |
| 2 | table   |
| 3 | t2      |
+---+---------+
```

To remap a `MERGE` table to a different collection of `MyISAM` tables, you can use one of the following methods:

- `DROP` the `MERGE` table and re-create it.
- Use `ALTER TABLE tbl_name UNION=(...)` to change the list of underlying tables.

  It is also possible to use `ALTER TABLE ... UNION=()` (that is, with an empty `UNION` clause) to remove all of the underlying tables.

The underlying table definitions and indexes must conform closely to the definition of the `MERGE` table. Conformance is checked when a table that is part of a `MERGE` table is opened, not when the `MERGE` table is created. If any table fails the conformance checks, the operation that triggered the opening of the table fails. This means that changes to the definitions of tables within a

`MERGE` may cause a failure when the `MERGE` table is accessed. The conformance checks applied to each table are:

- The underlying table and the `MERGE` table must have the same number of columns.
- The column order in the underlying table and the `MERGE` table must match.
- Additionally, the specification for each corresponding column in the parent `MERGE` table and the underlying tables are compared and must satisfy these checks:
  - The column type in the underlying table and the `MERGE` table must be equal.
  - The column length in the underlying table and the `MERGE` table must be equal.
  - The column of the underlying table and the `MERGE` table can be `NULL`.
- The underlying table must have at least as many indexes as the `MERGE` table. The underlying table may have more indexes than the `MERGE` table, but cannot have fewer.

  > **Note**
  >
  > A known issue exists where indexes on the same columns must be in identical order, in both the `MERGE` table and the underlying `MyISAM` table. See Bug #33653.

  Each index must satisfy these checks:

  - The index type of the underlying table and the `MERGE` table must be the same.
  - The number of index parts (that is, multiple columns within a compound index) in the index definition for the underlying table and the `MERGE` table must be the same.
  - For each index part:
    - Index part lengths must be equal.
    - Index part types must be equal.
    - Index part languages must be equal.
    - Check whether index parts can be `NULL`.

If a `MERGE` table cannot be opened or used because of a problem with an underlying table, `CHECK TABLE` displays information about which table caused the problem.

Additional Resources

- A forum dedicated to the `MERGE` storage engine is available at http://forums.mysql.com/list.php?93.

13.10.1. `MERGE` Table Advantages and Disadvantages

`MERGE` tables can help you solve the following problems:

- Easily manage a set of log tables. For example, you can put data from different months into separate tables, compress some of them with `myisampack`, and then create a `MERGE` table to use them as one.
- Obtain more speed. You can split a large read-only table based on some criteria, and then put individual tables on different disks. A `MERGE` table structured this way could be much faster than using a single large table.
- Perform more efficient searches. If you know exactly what you are looking for, you can search in just one of the underlying tables for some queries and use a `MERGE` table for others. You can even have many different `MERGE` tables that use overlapping sets of tables.
- Perform more efficient repairs. It is easier to repair individual smaller tables that are mapped to a `MERGE` table than to repair a single large table.
- Instantly map many tables as one. A `MERGE` table need not maintain an index of its own because it uses the indexes of the individual tables. As a result, `MERGE` table collections are *very* fast to create or remap. (You must still specify the index definitions

when you create a `MERGE` table, even though no indexes are created.)

- If you have a set of tables from which you create a large table on demand, you can instead create a `MERGE` table from them on demand. This is much faster and saves a lot of disk space.

- Exceed the file size limit for the operating system. Each `MyISAM` table is bound by this limit, but a collection of `MyISAM` tables is not.

- You can create an alias or synonym for a `MyISAM` table by defining a `MERGE` table that maps to that single table. There should be no really notable performance impact from doing this (only a couple of indirect calls and `memcpy()` calls for each read).

The disadvantages of `MERGE` tables are:

- You can use only identical `MyISAM` tables for a `MERGE` table.

- Some `MyISAM` features are unavailable in `MERGE` tables. For example, you cannot create `FULLTEXT` indexes on `MERGE` tables. (You can create `FULLTEXT` indexes on the underlying `MyISAM` tables, but you cannot search the `MERGE` table with a full-text search.)

- If the `MERGE` table is nontemporary, all underlying `MyISAM` tables must be nontemporary. If the `MERGE` table is temporary, the `MyISAM` tables can be any mix of temporary and nontemporary.

- `MERGE` tables use more file descriptors than `MyISAM` tables. If 10 clients are using a `MERGE` table that maps to 10 tables, the server uses (10 × 10) + 10 file descriptors. (10 data file descriptors for each of the 10 clients, and 10 index file descriptors shared among the clients.)

- Index reads are slower. When you read an index, the `MERGE` storage engine needs to issue a read on all underlying tables to check which one most closely matches a given index value. To read the next index value, the `MERGE` storage engine needs to search the read buffers to find the next value. Only when one index buffer is used up does the storage engine need to read the next index block. This makes `MERGE` indexes much slower on `eq_ref` searches, but not much slower on `ref` searches. For more information about `eq_ref` and `ref`, see Section 12.8.2, “`EXPLAIN` Syntax”.

13.10.2. `MERGE` Table Problems

The following are known problems with `MERGE` tables:

- In versions of MySQL Server prior to 5.1.23, it was possible to create temporary merge tables with nontemporary child MyISAM tables.

  From versions 5.1.23, MERGE children were locked through the parent table. If the parent was temporary, it was not locked and so the children were not locked either. Parallel use of the MyISAM tables corrupted them.

- If you use `ALTER TABLE` to change a `MERGE` table to another storage engine, the mapping to the underlying tables is lost. Instead, the rows from the underlying `MyISAM` tables are copied into the altered table, which then uses the specified storage engine.

- The `INSERT_METHOD` table option for a `MERGE` table indicates which underlying `MyISAM` table to use for inserts into the `MERGE` table. However, use of the `AUTO_INCREMENT` table option for that `MyISAM` table has no effect for inserts into the `MERGE` table until at least one row has been inserted directly into the `MyISAM` table.

- A `MERGE` table cannot maintain uniqueness constraints over the entire table. When you perform an `INSERT`, the data goes into the first or last `MyISAM` table (as determined by the `INSERT_METHOD` option). MySQL ensures that unique key values remain unique within that `MyISAM` table, but not over all the underlying tables in the collection.

- Because the `MERGE` engine cannot enforce uniqueness over the set of underlying tables, `REPLACE` does not work as expected. The two key facts are:

  - `REPLACE` can detect unique key violations only in the underlying table to which it is going to write (which is determined by the `INSERT_METHOD` option). This differs from violations in the `MERGE` table itself.

  - If `REPLACE` detects a unique key violation, it will change only the corresponding row in the underlying table it is writing to; that is, the first or last table, as determined by the `INSERT_METHOD` option.

  Similar considerations apply for `INSERT ... ON DUPLICATE KEY UPDATE`.

- `MERGE` tables do not support partitioning. That is, you cannot partition a `MERGE` table, nor can any of a `MERGE` table's underlying `MyISAM` tables be partitioned.

- You should not use `ANALYZE TABLE`, `REPAIR TABLE`, `OPTIMIZE TABLE`, `ALTER TABLE`, `DROP TABLE`, `DELETE` without a `WHERE` clause, or `TRUNCATE TABLE` on any of the tables that are mapped into an open `MERGE` table. If you do so, the `MERGE` table may still refer to the original table and yield unexpected results. To work around this problem, ensure that no `MERGE` tables remain open by issuing a `FLUSH TABLES` statement prior to performing any of the named operations.

  The unexpected results include the possibility that the operation on the `MERGE` table will report table corruption. If this occurs after one of the named operations on the underlying `MyISAM` tables, the corruption message is spurious. To deal with this, issue a `FLUSH TABLES` statement after modifying the `MyISAM` tables.

- `DROP TABLE` on a table that is in use by a `MERGE` table does not work on Windows because the `MERGE` storage engine's table mapping is hidden from the upper layer of MySQL. Windows does not permit open files to be deleted, so you first must flush all `MERGE` tables (with `FLUSH TABLES`) or drop the `MERGE` table before dropping the table.

- The definition of the `MyISAM` tables and the `MERGE` table are checked when the tables are accessed (for example, as part of a `SELECT` or `INSERT` statement). The checks ensure that the definitions of the tables and the parent `MERGE` table definition match by comparing column order, types, sizes and associated indexes. If there is a difference between the tables, an error is returned and the statement fails. Because these checks take place when the tables are opened, any changes to the definition of a single table, including column changes, column ordering, and engine alterations will cause the statement to fail.

- The order of indexes in the `MERGE` table and its underlying tables should be the same. If you use `ALTER TABLE` to add a `UNIQUE` index to a table used in a `MERGE` table, and then use `ALTER TABLE` to add a nonunique index on the `MERGE` table, the index ordering is different for the tables if there was already a nonunique index in the underlying table. (This happens because `ALTER TABLE` puts `UNIQUE` indexes before nonunique indexes to facilitate rapid detection of duplicate keys.) Consequently, queries on tables with such indexes may return unexpected results.

- If you encounter an error message similar to `ERROR 1017 (HY000): CAN'T FIND FILE: 'TBL_NAME.MRG' (ERRNO: 2)`, it generally indicates that some of the underlying tables do not use the `MyISAM` storage engine. Confirm that all of these tables are `MyISAM`.

- The maximum number of rows in a `MERGE` table is 2^{64} (~1.844E+19; the same as for a `MyISAM` table). It is not possible to merge multiple `MyISAM` tables into a single `MERGE` table that would have more than this number of rows.

- The `MERGE` storage engine does not support `INSERT DELAYED` statements.

- Use of underlying `MyISAM` tables of differing row formats with a parent `MERGE` table is currently known to fail. See Bug #32364.

- You cannot change the union list of a nontemporary `MERGE` table when `LOCK TABLES` is in effect. The following does *not* work:

  ```
  CREATE TABLE m1 ... ENGINE=MRG_MYISAM ...;
  LOCK TABLES t1 WRITE, t2 WRITE, m1 WRITE;
  ALTER TABLE m1 ... UNION=(t1,t2) ...;
  ```

  However, you can do this with a temporary `MERGE` table.

- You cannot create a `MERGE` table with `CREATE ... SELECT`, neither as a temporary `MERGE` table, nor as a nontemporary `MERGE` table. For example:

  ```
  CREATE TABLE m1 ... ENGINE=MRG_MYISAM ... SELECT ...;
  ```

  Attempts to do this result in an error: *`tbl_name`* is not `BASE TABLE`.

- In some cases, differing `PACK_KEYS` table option values among the `MERGE` and underlying tables cause unexpected results if the underlying tables contain `CHAR` or `BINARY` columns. As a workaround, use `ALTER TABLE` to ensure that all involved tables have the same `PACK_KEYS` value. (Bug #50646)

13.11. The `FEDERATED` Storage Engine

The `FEDERATED` storage engine lets you access data from a remote MySQL database without using replication or cluster technology. Querying a local `FEDERATED` table automatically pulls the data from the remote (federated) tables. No data is stored on the local tables.

To include the `FEDERATED` storage engine if you build MySQL from source, invoke `CMake` with the `-DWITH_FEDERATED_STORAGE_ENGINE` option.

The `FEDERATED` storage engine is not enabled by default in the running server; to enable `FEDERATED`, you must start the MySQL server binary using the `--federated` option.

To examine the source for the `FEDERATED` engine, look in the `storage/federated` directory of a MySQL source distribution.

13.11.1. `FEDERATED` Storage Engine Overview

When you create a table using one of the standard storage engines (such as `MyISAM`, `CSV` or `InnoDB`), the table consists of the table definition and the associated data. When you create a `FEDERATED` table, the table definition is the same, but the physical storage of the data is handled on a remote server.

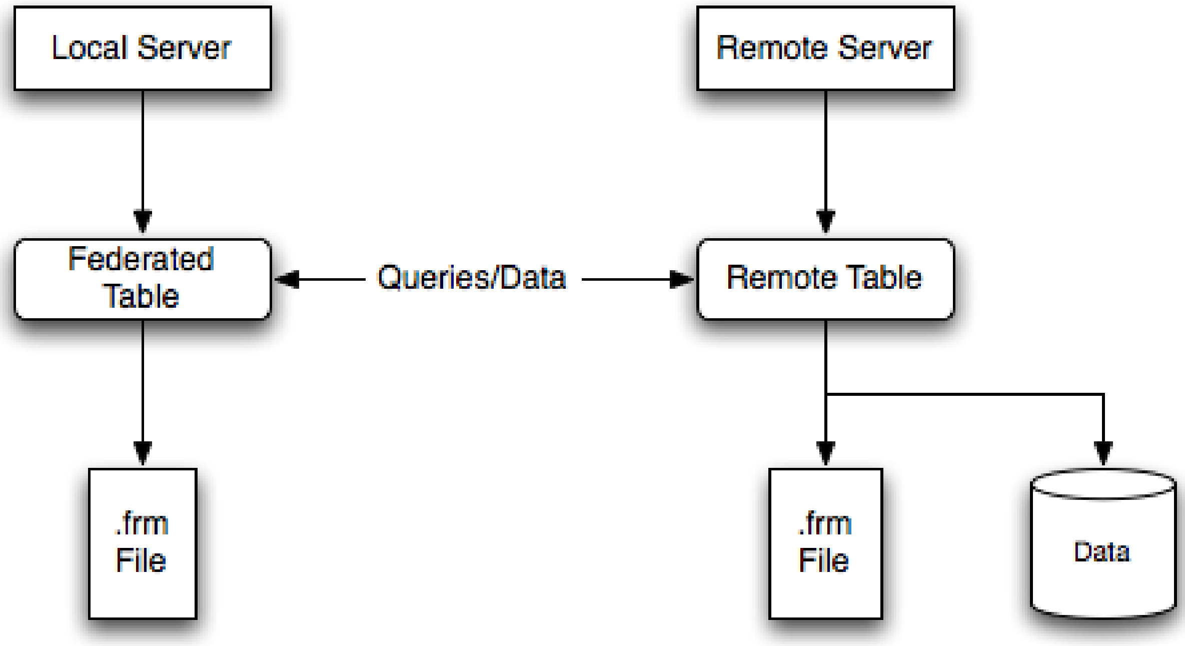
A `FEDERATED` table consists of two elements:

- A *remote server* with a database table, which in turn consists of the table definition (stored in the `.frm` file) and the associated table. The table type of the remote table may be any type supported by the remote `mysqld` server, including `MyISAM` or `InnoDB`.
- A *local server* with a database table, where the table definition matches that of the corresponding table on the remote server. The table definition is stored within the `.frm` file. However, there is no data file on the local server. Instead, the table definition includes a connection string that points to the remote table.

When executing queries and statements on a `FEDERATED` table on the local server, the operations that would normally insert, update or delete information from a local data file are instead sent to the remote server for execution, where they update the data file on the remote server or return matching rows from the remote server.

The basic structure of a `FEDERATED` table setup is shown in Figure 13.2, “`FEDERATED` Table Structure”.

Figure 13.2. `FEDERATED` Table Structure



When a client issues an SQL statement that refers to a `FEDERATED` table, the flow of information between the local server (where the SQL statement is executed) and the remote server (where the data is physically stored) is as follows:

1. The storage engine looks through each column that the `FEDERATED` table has and constructs an appropriate SQL statement that refers to the remote table.
2. The statement is sent to the remote server using the MySQL client API.
3. The remote server processes the statement and the local server retrieves any result that the statement produces (an affected-rows count or a result set).

4. If the statement produces a result set, each column is converted to internal storage engine format that the `FEDERATED` engine expects and can use to display the result to the client that issued the original statement.

The local server communicates with the remote server using MySQL client C API functions. It invokes `mysql_real_query()` to send the statement. To read a result set, it uses `mysql_store_result()` and fetches rows one at a time using `mysql_fetch_row()`.

13.11.2. How to Create `FEDERATED` Tables

To create a `FEDERATED` table you should follow these steps:

1. Create the table on the remote server. Alternatively, make a note of the table definition of an existing table, perhaps using the `SHOW CREATE TABLE` statement.
2. Create the table on the local server with an identical table definition, but adding the connection information that links the local table to the remote table.

For example, you could create the following table on the remote server:

```
CREATE TABLE test_table (
    id     INT(20) NOT NULL AUTO_INCREMENT,
    name   VARCHAR(32) NOT NULL DEFAULT '',
    other  INT(20) NOT NULL DEFAULT '0',
    PRIMARY KEY  (id),
    INDEX name (name),
    INDEX other_key (other)
)
ENGINE=MyISAM
DEFAULT CHARSET=latin1;
```

To create the local table that will be federated to the remote table, there are two options available. You can either create the local table and specify the connection string (containing the server name, login, password) to be used to connect to the remote table using the `CONNECTION`, or you can use an existing connection that you have previously created using the `CREATE SERVER` statement.

> **Important**
>
> When you create the local table it *must* have an identical field definition to the remote table.

> **Note**
>
> You can improve the performance of a `FEDERATED` table by adding indexes to the table on the host. The optimization will occur because the query sent to the remote server will include the contents of the `WHERE` clause and will be sent to the remote server and subsequently executed locally. This reduces the network traffic that would otherwise request the entire table from the server for local processing.

13.11.2.1. Creating a `FEDERATED` Table Using `CONNECTION`

To use the first method, you must specify the `CONNECTION` string after the engine type in a `CREATE TABLE` statement. For example:

```
CREATE TABLE federated_table (
    id     INT(20) NOT NULL AUTO_INCREMENT,
    name   VARCHAR(32) NOT NULL DEFAULT '',
    other  INT(20) NOT NULL DEFAULT '0',
    PRIMARY KEY  (id),
    INDEX name (name),
    INDEX other_key (other)
)
ENGINE=FEDERATED
DEFAULT CHARSET=latin1
CONNECTION='mysql://fed_user@remote_host:9306/federated/test_table';
```

> **Note**
>
> `CONNECTION` replaces the `COMMENT` used in some previous versions of MySQL.

The `CONNECTION` string contains the information required to connect to the remote server containing the table that will be used to physically store the data. The connection string specifies the server name, login credentials, port number and database/table information. In the example, the remote table is on the server `remote_host`, using port 9306. The name and port number should match the host name (or IP address) and port number of the remote MySQL server instance you want to use as your remote table.

The format of the connection string is as follows:

```
scheme://user_name[:password]@host_name[:port_num]/db_name/tbl_name
```

Where:

- `scheme`: A recognized connection protocol. Only `mysql` is supported as the `scheme` value at this point.
- `user_name`: The user name for the connection. This user must have been created on the remote server, and must have suitable privileges to perform the required actions (`SELECT`, `INSERT`, `UPDATE`, and so forth) on the remote table.
- `password`: (Optional) The corresponding password for `user_name`.
- `host_name`: The host name or IP address of the remote server.
- `port_num`: (Optional) The port number for the remote server. The default is 3306.
- `db_name`: The name of the database holding the remote table.
- `tbl_name`: The name of the remote table. The name of the local and the remote table do not have to match.

Sample connection strings:

```
CONNECTION='mysql://username:password@hostname:port/database/tablename'
CONNECTION='mysql://username@hostname/database/tablename'
CONNECTION='mysql://username:password@hostname/database/tablename'
```

13.11.2.2. Creating a `FEDERATED` Table Using `CREATE SERVER`

If you are creating a number of `FEDERATED` tables on the same server, or if you want to simplify the process of creating `FEDERATED` tables, you can use the `CREATE SERVER` statement to define the server connection parameters, just as you would with the `CONNECTION` string.

The format of the `CREATE SERVER` statement is:

```
CREATE SERVER
server_name
FOREIGN DATA WRAPPER wrapper_name
OPTIONS (option [, option] ...)
```

The `server_name` is used in the connection string when creating a new `FEDERATED` table.

For example, to create a server connection identical to the `CONNECTION` string:

```
CONNECTION='mysql://fed_user@remote_host:9306/federated/test_table';
```

You would use the following statement:

```
CREATE SERVER fedlink
FOREIGN DATA WRAPPER mysql
OPTIONS (USER 'fed_user', HOST 'remote_host', PORT 9306, DATABASE 'federated');
```

To create a `FEDERATED` table that uses this connection, you still use the `CONNECTION` keyword, but specify the name you used in the `CREATE SERVER` statement.

```
CREATE TABLE test_table (
    id     INT(20) NOT NULL AUTO_INCREMENT,
    name   VARCHAR(32) NOT NULL DEFAULT '',
    other  INT(20) NOT NULL DEFAULT '0',
    PRIMARY KEY  (id),
    INDEX name (name),
    INDEX other_key (other)
)
ENGINE=FEDERATED
DEFAULT CHARSET=latin1
CONNECTION='fedlink/test_table';
```

The connection name in this example contains the name of the connection (`fedlink`) and the name of the table (`test_table`) to link to, separated by a slash. If you specify only the connection name without a table name, the table name of the local table is used instead.

For more information on `CREATE SERVER`, see Section 12.1.13, “`CREATE SERVER` Syntax”.

The `CREATE SERVER` statement accepts the same arguments as the `CONNECTION` string. The `CREATE SERVER` statement updates the rows in the `mysql.servers` table. See the following table for information on the correspondence between parameters in a connection string, options in the `CREATE SERVER` statement, and the columns in the `mysql.servers` table. For reference, the format of the `CONNECTION` string is as follows:

```
scheme://user_name[:password]@host_name[:port_num]/db_name/tbl_name
```

Description	**`CONNECTION` string**	**`CREATE SERVER` option**	**`mysql.servers` column**
Connection scheme	*`scheme`*	`wrapper_name`	`Wrapper`
Remote user	*`user_name`*	`USER`	`Username`
Remote password	*`password`*	`PASSWORD`	`Password`
Remote host	*`host_name`*	`HOST`	`Host`
Remote port	*`port_num`*	`PORT`	`Port`
Remote database	*`db_name`*	`DATABASE`	`Db`

13.11.3. `FEDERATED` Storage Engine Notes and Tips

You should be aware of the following points when using the `FEDERATED` storage engine:

- `FEDERATED` tables may be replicated to other slaves, but you must ensure that the slave servers are able to use the user/password combination that is defined in the `CONNECTION` string (or the row in the `mysql.servers` table) to connect to the remote server.

The following items indicate features that the `FEDERATED` storage engine does and does not support:

- The remote server must be a MySQL server.
- The remote table that a `FEDERATED` table points to *must* exist before you try to access the table through the `FEDERATED` table.
- It is possible for one `FEDERATED` table to point to another, but you must be careful not to create a loop.
- A `FEDERATED` table does not support indexes per se. Because access to the table is handled remotely, it is the remote table that supports the indexes. Care should be taken when creating a `FEDERATED` table since the index definition from an equivalent `MyISAM` or other table may not be supported. For example, creating a `FEDERATED` table with an index prefix on `VARCHAR`, `TEXT` or `BLOB` columns will fail. The following definition in `MyISAM` is valid:

  ```
  CREATE TABLE `T1`(`A` VARCHAR(100),UNIQUE KEY(`A`(30))) ENGINE=MYISAM;
  ```

  The key prefix in this example is incompatible with the `FEDERATED` engine, and the equivalent statement will fail:

  ```
  CREATE TABLE `T1`(`A` VARCHAR(100),UNIQUE KEY(`A`(30))) ENGINE=FEDERATED
    CONNECTION='MYSQL://127.0.0.1:3306/TEST/T1';
  ```

  If possible, you should try to separate the column and index definition when creating tables on both the remote server and the local server to avoid these index issues.
- Internally, the implementation uses `SELECT`, `INSERT`, `UPDATE`, and `DELETE`, but not `HANDLER`.
- The `FEDERATED` storage engine supports `SELECT`, `INSERT`, `UPDATE`, `DELETE`, `TRUNCATE TABLE`, and indexes. It does not support `ALTER TABLE`, or any Data Definition Language statements that directly affect the structure of the table, other than `DROP TABLE`. The current implementation does not use prepared statements.
- `FEDERATED` accepts `INSERT ... ON DUPLICATE KEY UPDATE` statements, but if a duplicate-key violation occurs, the statement fails with an error.
- Performance on a `FEDERATED` table when performing bulk inserts (for example, on a `INSERT INTO ... SELECT ...` statement) is slower than with other table types because each selected row is treated as an individual `INSERT` statement on the `FEDERATED` table.

- Transactions are not supported.
- `FEDERATED` performs bulk-insert handling such that multiple rows are sent to the remote table in a batch. This provides a performance improvement and enables the remote table to perform improvement. Also, if the remote table is transactional, it enables the remote storage engine to perform statement rollback properly should an error occur. This capability has the following limitations:
  - The size of the insert cannot exceed the maximum packet size between servers. If the insert exceeds this size, it is broken into multiple packets and the rollback problem can occur.
  - Bulk-insert handling does not occur for `INSERT ... ON DUPLICATE KEY UPDATE`.
- There is no way for the `FEDERATED` engine to know if the remote table has changed. The reason for this is that this table must work like a data file that would never be written to by anything other than the database system. The integrity of the data in the local table could be breached if there was any change to the remote database.
- When using a `CONNECTION` string, you cannot use an '@' character in the password. You can get round this limitation by using the `CREATE SERVER` statement to create a server connection.
- The `insert_id` and `timestamp` options are not propagated to the data provider.
- Any `DROP TABLE` statement issued against a `FEDERATED` table drops only the local table, not the remote table.
- `FEDERATED` tables do not work with the query cache.
- User-defined partitioning is not supported for `FEDERATED` tables.

13.11.4. `FEDERATED` Storage Engine Resources

The following additional resources are available for the `FEDERATED` storage engine:

- A forum dedicated to the `FEDERATED` storage engine is available at http://forums.mysql.com/list.php?105.

13.12. The `EXAMPLE` Storage Engine

The `EXAMPLE` storage engine is a stub engine that does nothing. Its purpose is to serve as an example in the MySQL source code that illustrates how to begin writing new storage engines. As such, it is primarily of interest to developers.

To enable the `EXAMPLE` storage engine if you build MySQL from source, invoke `CMake` with the `-DWITH_EXAMPLE_STORAGE_ENGINE` option.

To examine the source for the `EXAMPLE` engine, look in the `storage/example` directory of a MySQL source distribution.

When you create an `EXAMPLE` table, the server creates a table format file in the database directory. The file begins with the table name and has an `.frm` extension. No other files are created. No data can be stored into the table. Retrievals return an empty result.

```
mysql> CREATE TABLE test (i INT) ENGINE = EXAMPLE;
Query OK, 0 rows affected (0.78 sec)

mysql> INSERT INTO test VALUES(1),(2),(3);
ERROR 1031 (HY000): Table storage engine for 'test' doesn't »
                    have this option

mysql> SELECT * FROM test;
Empty set (0.31 sec)
```

The `EXAMPLE` storage engine does not support indexing.

13.13. Other Storage Engines

Other storage engines may be available from third parties and community members that have used the Custom Storage Engine interface.

You can find more information on the list of third party storage engines on the MySQL Forge Storage Engines page.

> **Note**
>
> Third party engines are not supported by MySQL. For further information, documentation, installation guides, bug re-

porting or for any help or assistance with these engines, please contact the developer of the engine directly.

Third party engines that are known to be available include the following; please see the MySQL Forge links provided for more information:

- **PrimeBase XT (PBXT)**: PBXT has been designed for modern, web-based, high concurrency environments.
- **RitmarkFS**: RitmarkFS enables you to access and manipulate the file system using SQL queries. RitmarkFS also supports file system replication and directory change tracking.
- **Distributed Data Engine**: The Distributed Data Engine is an Open Source project that is dedicated to provide a Storage Engine for distributed data according to workload statistics.
- **mdbtools**: A pluggable storage engine that enables read-only access to Microsoft Access `.mdb` database files.
- **solidDB for MySQL**: solidDB Storage Engine for MySQL is an open source, transactional storage engine for MySQL Server. It is designed for mission-critical implementations that require a robust, transactional database. solidDB Storage Engine for MySQL is a multi-threaded storage engine that supports full ACID compliance with all expected transaction isolation levels, row-level locking, and Multi-Version Concurrency Control (MVCC) with nonblocking reads and writes.
- **BLOB Streaming Engine (MyBS)**: The Scalable BLOB Streaming infrastructure for MySQL will transform MySQL into a scalable media server capable of streaming pictures, films, MP3 files and other binary and text objects (BLOBs) directly in and out of the database.

For more information on developing a customer storage engine that can be used with the Pluggable Storage Engine Architecture, see Writing a Custom Storage Engine on MySQL Forge.

Chapter 14. High Availability and Scalability

MySQL is deployed into many applications demanding availability and scalability.

Availability refers to the ability to cope with, and if necessary recover from, failures on the host, including failures of MySQL, the operating system, or the hardware and maintenance activity that may otherwise cause downtime. Scalability refers to the ability to spread both the database and the load of your application queries across multiple MySQL servers.

Because each application has different operational and availability requirements, MySQL offers a range of certified and supported solutions, delivering the appropriate levels of High Availability (HA) and scalability to meet service level requirements. Such solutions extend from replication, through virtualization and geographically redundant, multi-data center solutions delivering 99.999% uptime.

Selecting the right high availability solution for an application largely depends on:

- The level of availability required.
- The type of application being deployed.
- Accepted best practices within your own environment.

The primary solutions supported by MySQL include:

- MySQL Replication. Learn more: http://dev.mysql.com/doc/refman/5.5/en/replication.html
- MySQL Cluster. Learn more: http://dev.mysql.com/doc/refman/5.1/en/mysql-cluster.html
- Oracle VM Template for MySQL. Learn more: Section 14.1, “Oracle VM Template for MySQL Enterprise Edition”.

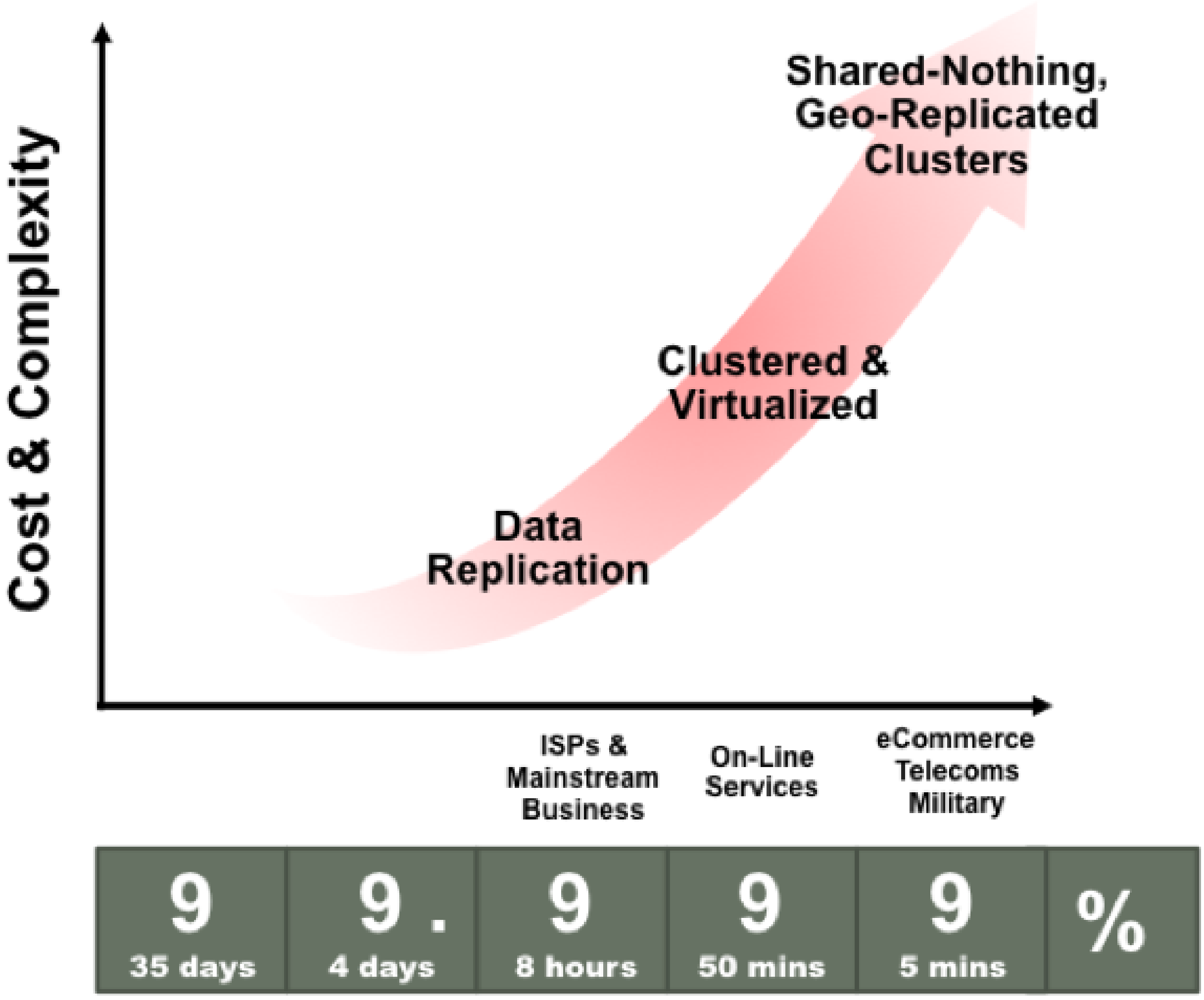
Further options are available using third-party solutions such as DRBD (Distributed Replicated Block Device) and Heartbeat, and more complex scenarios can be solved through a combination of these technologies.

Each architecture used to achieve highly available database services is differentiated by the levels of uptime it offers. These architectures can be grouped into three main categories:

- Data Replication.
- Clustered & Virtualized Systems.
- Shared-Nothing, Geographically-Replicated Clusters.

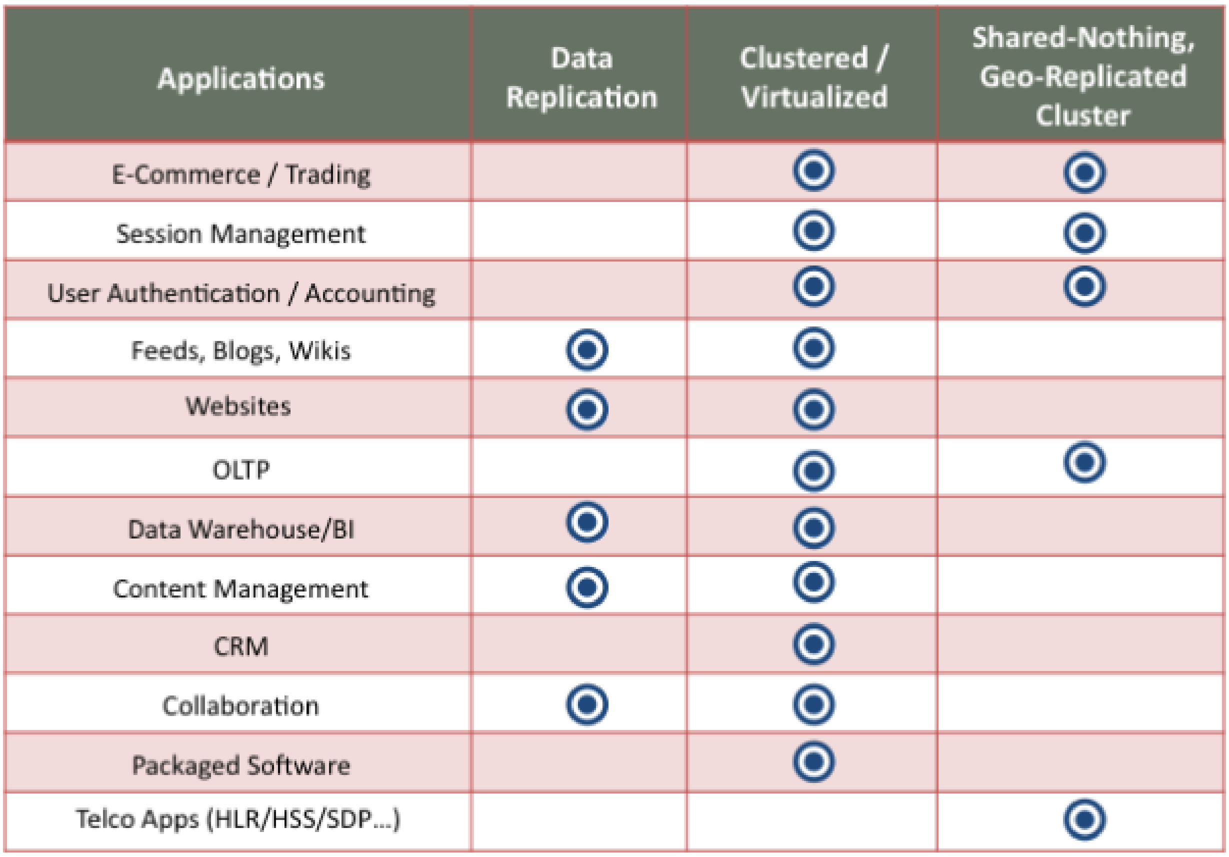
As illustrated in the following figure, each of these architectures offers progressively higher levels of uptime, which must be balanced against potentially greater levels of cost and complexity that each can incur. Simply deploying a high availability architecture is not a guarantee of actually delivering HA. In fact, a poorly implemented and maintained shared-nothing cluster could easily deliver lower levels of availability than a simple data replication solution.

Figure 14.1. Tradeoffs: Cost and Complexity versus Availability



The following figure maps common application types to architectures, based on best practices observed from the MySQL user base. It serves as a reference point to investigate which HA architectures can best serve your requirements.

Figure 14.2. High Availability Architectures for Common Application Types



Applications	Data Replication	Clustered / Virtualized	Shared-Nothing, Geo-Replicated Cluster
E-Commerce / Trading		◉	◉
Session Management		◉	◉
User Authentication / Accounting		◉	◉
Feeds, Blogs, Wikis	◉	◉	
Websites	◉	◉	
OLTP		◉	◉
Data Warehouse/BI	◉	◉	
Content Management	◉	◉	
CRM		◉	
Collaboration	◉	◉	
Packaged Software		◉	
Telco Apps (HLR/HSS/SDP...)			◉

The following table compares the HA and Scalability capabilities of the various MySQL solutions:

Requirement	MySQL Replication	MySQL Replication + Linux Heartbeat	Heartbeat + DRBD	Oracle VM Template	MySQL Cluster
Availability					
Platform Support	All Supported by MySQL Server	Linux	Linux	Oracle Linux	All Supported by MySQL Cluster
Automated IP Failover	No	Yes	Yes	Yes	Depends on Connector and Configuration
Automated Database Failover	No	No	Yes	Yes	Yes
Automatic Data Resynchronization	No	No	Yes	N/A - Shared Storage	Yes
Typical Failover Time	User / Script Dependent	Configuration Dependent, 60 seconds and Above	Configuration Dependent, 60 seconds and Above	Configuration Dependent, 60 seconds and Above	1 Second and Less
Synchronous Replication	No, Asynchronous and Semisynchronous	No, Asynchronous and Semisynchronous	Yes	N/A - Shared Storage	Yes
Shared Storage	No, Distributed	No, Distributed	No, Distributed	Yes	No, Distributed
Geographic redundancy support	Yes	Yes	Yes, via MySQL Replication	Yes, via MySQL Replication	Yes, via MySQL Replication
Update Schema On-Line	No	No	No	No	Yes
Scalability					
Number of Nodes	One Master, Multiple Slaves	One Master, Multiple Slaves	One Active (primary), one Passive (secondary)	One Active (primary), one Passive (secondary)	255

Requirement	MySQL Replication	MySQL Replication + Linux Heartbeat	Heartbeat + DRBD	Oracle VM Template	MySQL Cluster
			Node	Node	
Built-in Load Balancing	Reads, via MySQL Replication	Reads, via MySQL Replication	Reads, via MySQL Replication	Reads, via MySQL Replication & During Failover	Yes, Reads and Writes
Supports Read-Intensive Workloads	Yes	Yes	Yes	Yes	Yes
Supports Write-Intensive Workloads	Yes, via Application-Level Sharding	Yes, via Application-Level Sharding	Yes, via Application-Level Sharding to Multiple Active/Passive Pairs	Yes, via Application-Level Sharding to Multiple Active/Passive Pairs	Yes, via Auto-Sharding
Scale On-Line (add nodes, repartition, etc.)	No	No	No	No	Yes

14.1. Oracle VM Template for MySQL Enterprise Edition

Virtualization is a key technology to enable data center efficiency and high availability while providing the foundation for cloud computing. Integrating MySQL Enterprise Edition with Oracle Linux, the Oracle VM Template is the fastest, easiest, and most reliable way to provision virtualized MySQL instances, enabling users to meet the explosive demand for highly available services.

The Oracle VM Template enables rapid deployment and eliminates manual configuration efforts. It provides a pre-installed and pre-configured virtualized MySQL 5.5 Enterprise Edition software image running on Oracle Linux and Oracle VM, certified for production use. The MySQL software image has undergone extensive integration and quality assurance testing as part of the development process.

In addition to rapid provisioning, MySQL users also benefit from the integrated high availability features of Oracle VM which are designed to enable organizations to meet stringent SLA (Service Level Agreement) demands through a combination of:

- **Automatic recovery from failures**, with Oracle VM automatically restarting failed instances on available servers in the server pool after outages of the physical server, VM or MySQL database.
- **Live Migration**, enabling operations staff to move running instances of MySQL to alternative hosts within a server pool when they need to perform maintenance operations.

Instructions for the creation, deployment and use of the Oracle VM Template for MySQL Enterprise Edition are available from:

- The Oracle VM Template for MySQL Enterprise Edition whitepaper: http://www.mysql.com/why-mysql/white-papers/mysql_wp_oracle-vm-template-for-mee.php.
- The README file accompanying the download of the Template.

To download the Oracle VM Template for MySQL Enterprise, go to http://edelivery.oracle.com/oraclevm and follow these instructions:

- Complete your registration information (Name, Company Name, Email Address and Country) and click on the download agreement.
- Select "Oracle VM Templates" from the "Select a Product Pack" pull-down menu and click "Go".
- Select MySQL Enterprise from the list of Oracle VM Templates.
- Download and unzip the files and refer to the README for further instructions.

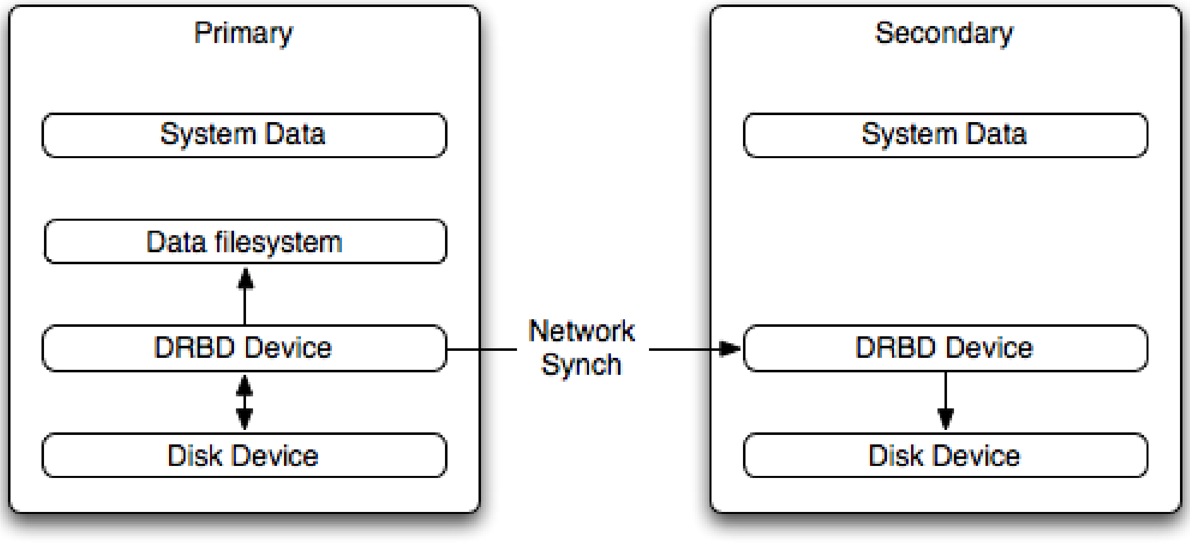
14.2. Using MySQL with DRBD

The Distributed Replicated Block Device (DRBD) is a Linux Kernel module that constitutes a distributed storage system. You can use DRBD to share block devices between Linux servers and, in turn, share file systems and data.

DRBD implements a block device which can be used for storage and which is replicated from a primary server to one or more secondary servers. The distributed block device is handled by the DRBD service. Writes to the DRBD block device are distributed among the servers. Each DRBD service writes the information from the DRBD block device to a local physical block device (hard disk).

On the primary data writes are written both to the underlying physical block device and distributed to the secondary DRBD services. On the secondary, the writes received through DRBD and written to the local physical block device. On both the primary and the secondary, reads from the DRBD block device are handled by the underlying physical block device. The information is shared between the primary DRBD server and the secondary DRBD server synchronously and at a block level, and this means that DRBD can be used in high-availability solutions where you need failover support.

Figure 14.3. DRBD Architecture Overview



When used with MySQL, DRBD can be used to ensure availability in the event of a failure. MySQL is configured to store information on the DRBD block device, with one server acting as the primary and a second machine available to operate as an immediate replacement in the event of a failure.

For automatic failover support you can combine DRBD with the Linux Heartbeat project, which manages the interfaces on the two servers and automatically configures the secondary (passive) server to replace the primary (active) server in the event of a failure. You can also combine DRBD with MySQL Replication to provide both failover and scalability within your MySQL environment.

For information on how to configure DRBD and MySQL, including Heartbeat support, see Section 14.2.1, “Configuring the DRBD Environment”.

An FAQ for using DRBD and MySQL is available. See Section B.14, “MySQL 5.5 FAQ: MySQL, DRBD, and Heartbeat”.

> **Note**
>
> Because DRBD is a Linux Kernel module it is currently not supported on platforms other than Linux.

14.2.1. Configuring the DRBD Environment

To set up DRBD, MySQL and Heartbeat you need to follow a number of steps that affect the operating system, DRBD and your MySQL installation.

Before starting the installation process, be aware of the following information, terms and requirements on using DRBD:

- DRBD is a solution for enabling high-availability, and therefore you need to ensure that the two machines within your DRBD setup are as identically configured as possible so that the secondary machine can act as a direct replacement for the primary machine in the event of system failure.
- DRBD works through two (or more) servers, each called a *node*

- The node that contains the primary data, has read/write access to the data, and in an HA environment is the currently active node is called the *primary*.
- The server to which the data is replicated is referred as *secondary*.
- A collection of nodes that are sharing information are referred to as a *DRBD cluster*.
- For DRBD to operate you must have a block device on which the information can be stored on *each* DRBD node. The *lower level* block device can be a physical disk partition, a partition from a volume group or RAID device or any other block device.

  Typically you use a spare partition on which the physical data is stored. On the primary node, this disk holds the raw data that you want replicated. On the secondary nodes, the disk holds the data replicated to the secondary server by the DRBD service. Ideally, the size of the partition on the two DRBD servers should be identical, but this is not necessary as long as there is enough space to hold the data that you want distributed between the two servers.
- For the distribution of data to work, DRBD is used to create a logical block device that uses the lower level block device for the actual storage of information. To store information on the distributed device, a file system is created on the DRBD logical block device.
- When used with MySQL, once the file system has been created, you move the MySQL data directory (including InnoDB data files and binary logs) to the new file system.
- When you set up the secondary DRBD server, you set up the physical block device and the DRBD logical block device that stores the data. The block device data is then copied from the primary to the secondary server.

The overview for the installation and configuration sequence is as follows:

1. First you need to set up your operating system and environment. This includes setting the correct host name, updating the system and preparing the available packages and software required by DRBD, and configuring a physical block device to be used with the DRBD block device. See Section 14.2.1.1, “Setting Up Your Operating System for DRBD”.
2. Installing DRBD requires installing or compiling the DRBD source code and then configuring the DRBD service to set up the block devices to be shared. See Section 14.2.1.2, “Installing and Configuring DRBD”.
3. Once DRBD has been configured, you must alter the configuration and storage location of the MySQL data. See Section 14.2.2, “Configuring MySQL for DRBD”.

You may optionally want to configure high availability using the Linux Heartbeat service. See Section 14.3, “Using Linux HA Heartbeat”, for more information.

14.2.1.1. Setting Up Your Operating System for DRBD

To set your Linux environment for using DRBD there are a number of system configuration steps that you must follow.

- Make sure that the primary and secondary DRBD servers have the correct host name, and that the host names are unique. You can verify this by using the `uname` command:

  ```
  shell> uname -n
  drbd-one
  ```

  If the host name is not set correctly, edit the appropriate file (usually `/etc/sysconfig/network`, `/etc/hostname`, or `/etc/conf.d/hostname`) and set the name correctly.
- Each DRBD node must have a unique IP address. Make sure that the IP address information is set correctly within the network configuration and that the host name and IP address has been set correctly within the `/etc/hosts` file.
- Although you can rely on the DNS or NIS system for host resolving, in the event of a major network failure these services may not be available. If possible, add the IP address and host name of each DRBD node into the `/etc/hosts` file for each machine. This ensures that the node information can always be determined even if the DNS/NIS servers are unavailable.
- As a general rule, the faster your network connection the better. Because the block device data is exchanged over the network, everything that is written to the local disk on the DRBD primary is also written to the network for distribution to the DRBD secondary.

  For tips on configuring a faster network connection see Section 14.2.3, “Optimizing Performance and Reliability”.
- You must have a spare disk or disk partition that you can use as the physical storage location for the DRBD data that is replic-

ated. You do not have to have a complete disk available, a partition on an existing disk is acceptable.

If the disk is unpartitioned, partition the disk using `fdisk`, `cfdisk` or other partitioning solution. Do not create a file system on the new partition.

Remember that you must have a physical disk available for the storage of the replicated information on each DRBD node. Ensure that the physical partition on the DRBD secondary is at least as big as the partitions on the DRBD primary node. Ideally the partitions that are used on each node should have identical sizes, although this is not strictly necessary.

- If possible, upgrade your system to the latest available Linux kernel for your distribution. Once the kernel has been installed, you must reboot to make the kernel active. To use DRBD, you must also install the relevant kernel development and header files that are required for building kernel modules. Platform specification information for this is available later in this section.

Before you compile or install DRBD, you must make sure the following tools and files are in place:

- Kernel header files
- Kernel source files
- GCC Compiler
- `glib 2`
- `flex`

Here are some operating system specific tips for setting up your installation:

- **Tips for Red Hat (including CentOS and Fedora)**:

  Use `up2date` or `yum` to update and install the latest kernel and kernel header files:

  ```
  root-shell> up2date kernel-smp-devel kernel-smp
  ```

  Reboot. If you are going to build DRBD from source, then update your system with the required development packages:

  ```
  root-shell> up2date glib-devel openssl-devel libgcrypt-devel glib2-devel \
  pkgconfig ncurses-devel rpm-build rpm-devel redhat-rpm-config gcc \
  gcc-c++ bison flex gnutls-devel lm_sensors-devel net-snmp-devel \
  python-devel bzip2-devel libselinux-devel perl-DBI
  ```

  If you are going to use the pre-built DRBD RPMs:

  ```
  root-shell> up2date gnutls lm_sensors net-snmp ncurses libgcrypt glib2 openssl glib
  ```

- **Tips for Debian, Ubuntu, Kubuntu**:

  Use `apt-get` to install the kernel packages

  ```
  root-shell> apt-get install linux-headers linux-image-server
  ```

  If you are going to use the pre-built Debian packages for DRBD, you do not need any additional packages.

  If you want to build DRBD from source, use the following command to install the required components:

  ```
  root-shell> apt-get install devscripts flex bison build-essential \
  dpkg-dev kernel-package debconf-utils dpatch debhelper \
  libnet1-dev e2fslibs-dev libglib2.0-dev automake1.9 \
  libgnutls-dev libtool libltdl3 libltdl3-dev
  ```

- **Tips for Gentoo**:

  Gentoo is a source based Linux distribution and therefore many of the source files and components that you need are either already installed or are installed automatically by `emerge`.

  To install DRBD 0.8.x, you must unmask the `sys-cluster/drbd` build by adding the following line to `/etc/portage/package.keywords`:

  ```
  sys-cluster/drbd ~x86
  ```

```
sys-cluster/drbd-kernel ~x86
```

To enable the DRBD kernel module, you must rebuild your kernel, although the method depends on the kernel version you are using. Determine your current kernel version using `uname -a`.

- For Linux kernels lower than 2.6.33, enable the userspace kernelspace linker to build and load the DRBD kernel driver. To enable the kernelspace linker, rebuild the kernel with this option. The best way to do this is to use `genkernel` with the `--menuconfig` option to select the option and then rebuild the kernel. For example, at the command line as `root`:

  ```
  root-shell> genkernel --menuconfig all
  ```

  Then through the menu options, select DEVICE DRIVERS, CONNECTOR - UNIFIED USERSPACE <-> KERNELSPACE LINKER and finally press 'y' or 'space' to select the CONNECTOR - UNIFIED USERSPACE <-> KERNELSPACE LINKER option. After you exit the menu configuration, the kernel is rebuilt and installed. If this is a new kernel, update your bootloader to point to the kernel if the kernel version is different than your current kernel version. Now reboot to enable the new kernel.

- For Linux Kernel 2.6.33 and later, DRBD is included within the kernel sources. To enable the DRBD module you must rebuild your kernel. The best way to do this is to use `genkernel` with the `--menuconfig` option to select the option and then rebuild the kernel. For example, at the command line as `root`:

  ```
  root-shell> genkernel --menuconfig all
  ```

  Then through the menu options, select DEVICE DRIVERS, BLOCK DEVICES, and then DRBD DISTRIBUTED REPLICATED BLOCK DEVICE SUPPORT. After you exit the menu configuration, the kernel is rebuilt and installed. If this is a new kernel, update your bootloader to point to the kernel if the kernel version is different than your current kernel version. Now reboot to enable the new kernel.

14.2.1.2. Installing and Configuring DRBD

To install DRBD you can choose either the pre-built binary installation packages or you can use the source packages and build from source. If you want to build from source you must have installed the source and development packages.

If you are installing using a binary distribution then you must ensure that the kernel version number of the binary package matches your currently active kernel. You can use `uname` to find out this information:

```
shell> uname -r
2.6.20-gentoo-r6
```

Once DRBD has been built and installed, you need to edit the `/etc/drbd.conf` file and then run a number of commands to build the block device and set up the replication.

Although the steps below are split into those for the primary node and the secondary node, it should be noted that the configuration files for all nodes should be identical, and many of the same steps have to be repeated on each node to enable the DRBD block device.

Building from source:

To download and install from the source code:

1. Download the source code.
2. Unpack the package:

   ```
   shell> tar zxf drbd-8.3.0.tar.gz
   ```

3. Change to the extracted directory, and then run `make` to build the DRBD driver:

   ```
   shell> cd drbd-8.3.0
   shell> make
   ```

4. Install the kernel driver and commands:

   ```
   shell> make install
   ```

Binary Installation:

- **SUSE Linux Enterprise Server (SLES)**

  For SUSE, use `yast`:

  ```
  shell> yast -i drbd
  ```

  Alternatively:

  ```
  shell> rug install drbd
  ```

- **Debian**

  Use `apt-get` to install the modules. You do not need to install any other components.

  ```
  shell> apt-get install drbd8-utils drbd8-module
  ```

- **Debian 3.1 and 4.0**

  You must install the `module-assistant` to build the DRBD kernel module, in addition to the DRBD components.

  ```
  shell> apt-get install drbd0.7-utils drbd0.7-module-source \
    build-essential module-assistant
  shell> module-assistant auto-install drbd0.7
  ```

- **CentOS**

  DRBD can be installed using yum:

  ```
  shell> yum install drbd kmod-drbd
  ```

- **Ubuntu**

  You must enable the universe component for your preferred Ubuntu mirror in `/etc/apt/sources.list`, and then issue these commands:

  ```
  shell> apt-get update
  shell> apt-get install drbd8-utils drbd8-module-source \
    build-essential module-assistant
  shell> module-assistant auto-install drbd8
  ```

- **Gentoo**

  You can now `emerge` DRBD 0.8.x into your Gentoo installation:

  ```
  root-shell> emerge drbd
  ```

  Once `drbd` has been downloaded and installed, you need to decompress and copy the default configuration file from `/usr/share/doc/drbd-8.0.7/drbd.conf.bz2` into `/etc/drbd.conf`.

14.2.1.3. Setting Up a DRBD Primary Node

To set up a DRBD primary node you need to configure the DRBD service, create the first DRBD block device and then create a file system on the device so that you can store files and data.

The DRBD configuration file `/etc/drbd.conf` defines a number of parameters for your DRBD configuration, including the frequency of updates and block sizes, security information and the definition of the DRBD devices that you want to create.

The key elements to configure are the `on` sections which specify the configuration of each node.

To follow the configuration, the sequence below shows only the changes from the default `drbd.conf` file. Configurations within the file can be both global or tied to specific resource.

1. Set the synchronization rate between the two nodes. This is the rate at which devices are synchronized in the background after a disk failure, device replacement or during the initial setup. Keep this in check compared to the speed of your network connection. Gigabit Ethernet can support up to 125 MB/second, 100Mbps Ethernet slightly less than a tenth of that (12MBps). If

you are using a shared network connection, rather than a dedicated, then gauge accordingly.

To set the synchronization rate, edit the `rate` setting within the `syncer` block:

```
syncer {
    rate 10M;
}
```

You may additionally want to set the `al-extents` parameter. The default for this parameter is 257.

For more detailed information on synchronization, the effects of the synchronization rate and the effects on network performance, see Section 14.2.3.2, “Optimizing the Synchronization Rate”.

2. Set up some basic authentication. DRBD supports a simple password hash exchange mechanism. This helps to ensure that only those hosts with the same shared secret are able to join the DRBD node group.

```
cram-hmac-alg “sha1”;
shared-secret "shared-string";
```

3. Now you must configure the host information. Remember that you must have the node information for the primary and secondary nodes in the `drbd.conf` file on each host. You need to configure the following information for each node:

   - `device`: The path of the logical block device that is created by DRBD.
   - `disk`: The block device that stores the data.
   - `address`: The IP address and port number of the host that holds this DRBD device.
   - `meta-disk`: The location where the metadata about the DRBD device is stored. If you set this to `internal`, DRBD uses the physical block device to store the information, by recording the metadata within the last sections of the disk. The exact size depends on the size of the logical block device you have created, but it may involve up to 128MB.

   A sample configuration for our primary server might look like this:

```
on drbd-one {
device /dev/drbd0;
disk /dev/hdd1;
address 192.168.0.240:8888;
meta-disk internal;
}
```

   The `on` configuration block should be repeated for the secondary node (and any further) nodes:

```
on drbd-two {
device /dev/drbd0;
disk /dev/hdd1;
address 192.168.0.241:8888;
meta-disk internal;
}
```

   The IP address of each `on` block must match the IP address of the corresponding host. Do not set this value to the IP address of the corresponding primary or secondary in each case.

4. Before starting the primary node, create the metadata for the devices:

```
root-shell> drbdadm create-md all
```

5. You are now ready to start DRBD:

```
root-shell> /etc/init.d/drbd start
```

   DRBD should now start and initialize, creating the DRBD devices that you have configured.

6. DRBD creates a standard block device - to make it usable, you must create a file system on the block device just as you would with any standard disk partition. Before you can create the file system, you must mark the new device as the primary device (that is, where the data is written and stored), and initialize the device. Because this is a destructive operation, you must specify the command line option to overwrite the raw data:

```
root-shell> drbdadm -- --overwrite-data-of-peer primary all
```

   If you are using a version of DRBD 0.7.x or earlier, then you need to use a different command-line option:

```
root-shell> drbdadm -- --do-what-I-say primary all
```

Now create a file system using your chosen file system type:

```
root-shell> mkfs.ext3 /dev/drbd0
```

7. You can now mount the file system and if necessary copy files to the mount point:

```
root-shell> mkdir /mnt/drbd
root-shell> mount /dev/drbd0 /mnt/drbd
root-shell> echo "DRBD Device" >/mnt/drbd/samplefile
```

Your primary node is now ready to use. Next, configure your secondary node or nodes.

14.2.1.4. Setting Up a DRBD Secondary Node

The configuration process for setting up a secondary node is the same as for the primary node, except that you do not have to create the file system on the secondary node device, as this information is automatically transferred from the primary node.

To set up a secondary node:

1. Copy the `/etc/drbd.conf` file from your primary node to your secondary node. It should already contain all the information and configuration that you need, since you had to specify the secondary node IP address and other information for the primary node configuration.
2. Create the DRBD metadata on the underlying disk device:

```
root-shell> drbdadm create-md all
```

3. Start DRBD:

```
root-shell> /etc/init.d/drbd start
```

Once DRBD has started, it starts to copy the data from the primary node to the secondary node. Even with an empty file system this takes some time, since DRBD is copying the block information from a block device, not simply copying the file system data.

You can monitor the progress of the copy between the primary and secondary nodes by viewing the output of `/proc/drbd`:

```
root-shell> cat /proc/drbd
version: 8.0.4 (api:86/proto:86)
SVN Revision: 2947 build by root@drbd-one, 2007-07-30 16:43:05
 0: cs:SyncSource st:Primary/Secondary ds:UpToDate/Inconsistent C r---
    ns:252284 nr:0 dw:0 dr:257280 al:0 bm:15 lo:0 pe:7 ua:157 ap:0
        [==>................] sync'ed: 12.3% (1845088/2097152)K
        finish: 0:06:06 speed: 4,972 (4,580) K/sec
        resync: used:1/31 hits:15901 misses:16 starving:0 dirty:0 changed:16
        act_log: used:0/257 hits:0 misses:0 starving:0 dirty:0 changed:0
```

You can monitor the synchronization process by using the `watch` command to run the command at specific intervals:

```
root-shell> watch -n 10 'cat /proc/drbd'
```

14.2.1.5. Monitoring DRBD Device

Once the primary and secondary machines are configured and synchronized, you can get the status information about your DRBD device by viewing the output from `/proc/drbd`:

```
root-shell> cat /proc/drbd
version: 8.0.4 (api:86/proto:86)
SVN Revision: 2947 build by root@drbd-one, 2007-07-30 16:43:05
 0: cs:Connected st:Primary/Secondary ds:UpToDate/UpToDate C r---
    ns:2175704 nr:0 dw:99192 dr:2076641 al:33 bm:128 lo:0 pe:0 ua:0 ap:0
        resync: used:0/31 hits:134841 misses:135 starving:0 dirty:0 changed:135
        act_log: used:0/257 hits:24765 misses:33 starving:0 dirty:0 changed:33
```

The first line provides the version/revision and build information.

The second line starts the detailed status information for an individual resource. The individual field headings are as follows:

- cs: connection state
- st: node state (local/remote)
- ld: local data consistency
- ds: data consistency
- ns: network send
- nr: network receive
- dw: disk write
- dr: disk read
- pe: pending (waiting for ack)
- ua: unack'd (still need to send ack)
- al: access log write count

In the previous example, the information shown indicates that the nodes are connected, the local node is the primary (because it is listed first), and the local and remote data is up to date with each other. The remainder of the information is statistical data about the device, and the data exchanged that kept the information up to date.

You can also get the status information for DRBD by using the startup script with the `status` option:

```
root-shell> /etc/init.d/drbd status
 * status:  started
 * drbd driver loaded OK; device status: ...
version: 8.3.0 (api:88/proto:86-89)
GIT-hash: 9ba8b93e24d842f0dd3fb1f9b90e8348ddb95829 build by root@gentoo1.vmbear, 2009-03-14 23:00:06
 0: cs:Connected ro:Secondary/Secondary ds:UpToDate/UpToDate C r---
    ns:0 nr:0 dw:0 dr:8385604 al:0 bm:0 lo:0 pe:0 ua:0 ap:0 ep:1 wo:b oos:0
```

The information and statistics are the same.

14.2.1.6. Managing your DRBD Installation

For administration, the main command is `drbdadm`. There are a number of commands supported by this tool the control the connectivity and status of the DRBD devices.

> **Note**
>
> For convenience, a bash completion script is available that provides tab completion for options to `drbdadm`. The file `drbdadm.bash_completion` can be found within the standard DRBD source package within the `scripts` directory. To enable, copy the file to `/etc/bash_completion.d/drbdadm`. You can load it manually by using:
>
> ```
> shell> source /etc/bash_completion.d/drbdadm
> ```

The most common commands are those to set the primary/secondary status of the local device. You can manually set this information for a number of reasons, including when you want to check the physical status of the secondary device (since you cannot mount a DRBD device in primary mode), or when you are temporarily moving the responsibility of keeping the data in check to a different machine (for example, during an upgrade or physical move of the normal primary node). You can set state of all local device to be the primary using this command:

```
root-shell> drbdadm primary all
```

Or switch the local device to be the secondary using:

```
root-shell> drbdadm secondary all
```

To change only a single DRBD resource, specify the resource name instead of `all`.

You can temporarily disconnect the DRBD nodes:

```
root-shell> drbdadm disconnect all
```

Reconnect them using `connect`:

```
root-shell> drbdadm connect all
```

For other commands and help with `drbdadm` see the DRBD documentation.

14.2.1.7. Additional DRBD Configuration Options

Additional options you may want to configure:

- `protocol`: Specifies the level of consistency to be used when information is written to the block device. The option is similar in principle to the `innodb_flush_log_at_trx_commit` option within MySQL. Three levels are supported:
  - `A`: Data is considered written when the information reaches the TCP send buffer and the local physical disk. There is no guarantee that the data has been written to the remote server or the remote physical disk.
  - `B`: Data is considered written when the data has reached the local disk and the remote node's network buffer. The data has reached the remote server, but there is no guarantee it has reached the remote server's physical disk.
  - `C`: Data is considered written when the data has reached the local disk and the remote node's physical disk.

  The preferred and recommended protocol is C, as it is the only protocol which ensures the consistency of the local and remote physical storage.
- `size`: If you do not want to use the entire partition space with your DRBD block device then you can specify the size of the DRBD device to be created. The size specification can include a quantifier. For example, to set the maximum size of the DRBD partition to 1GB you would use:

  ```
  size 1G;
  ```

With the configuration file suitably configured and ready to use, you now need to populate the lower-level device with the metadata information, and then start the DRBD service.

14.2.2. Configuring MySQL for DRBD

Once you have configured DRBD and have an active DRBD device and file system, you can configure MySQL to use the chosen device to store the MySQL data.

When performing a new installation of MySQL, you can either select to install MySQL entirely onto the DRBD device, or just configure the data directory to be located on the new file system.

In either case, the files and installation must take place on the primary node, because that is the only DRBD node on which you can mount the DRBD device file system as read/write.

Store the following files and information on your DRBD device:

- MySQL data files, including the binary log, and InnoDB data files.
- MySQL configuration file (`my.cnf`).

To set up MySQL to use your new DRBD device and file system:

1. If you are migrating an existing MySQL installation, stop MySQL:

   ```
   shell> mysqladmin shutdown
   ```

2. Copy the `my.cnf` onto the DRBD device. If you are not already using a configuration file, copy one of the sample configuration files from the MySQL distribution.

   ```
   root-shell> mkdir /mnt/drbd/mysql
   root-shell> cp /etc/my.cnf /mnt/drbd/mysql
   ```

3. Copy your MySQL data directory to the DRBD device and mounted file system.

   ```
   root-shell> cp -R /var/lib/mysql /drbd/mysql/data
   ```

4. Edit the configuration file to reflect the change of directory by setting the value of the `datadir` option. If you have not already enabled the binary log, also set the value of the `log-bin` option.

```
datadir = /drbd/mysql/data
  log-bin = mysql-bin
```

5. Create a symbolic link from `/etc/my.cnf` to the new configuration file on the DRBD device file system.

```
root-shell> ln -s /drbd/mysql/my.cnf /etc/my.cnf
```

6. Now start MySQL and check that the data that you copied to the DRBD device file system is present.

```
root-shell> /etc/init.d/mysql start
```

Your MySQL data should now be located on the file system running on your DRBD device. The data is physically stored on the underlying device that you configured for the DRBD device. Meanwhile, the content of your MySQL databases is copied to the secondary DRBD node.

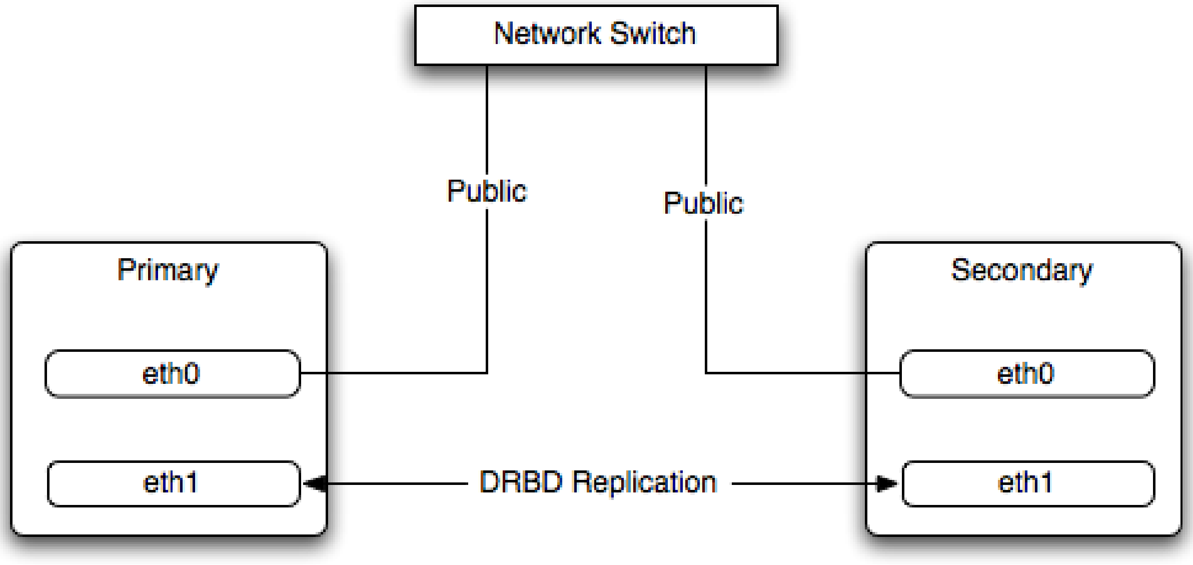
Note that you cannot access the information on your secondary node, as a DRBD device working in secondary mode is not available for use.

14.2.3. Optimizing Performance and Reliability

Because of the nature of the DRBD system, the critical requirements are for a very fast exchange of the information between the two hosts. To ensure that your DRBD setup is available to switch over in the event of a failure as quickly as possible, you must transfer the information between the two hosts using the fastest method available.

Typically, a dedicated network circuit should be used for exchanging DRBD data between the two hosts. Use a separate, additional, network interface for your standard network connection. For an example of this layout, see Figure 14.4, “DRBD Architecture Using Separate Network Interfaces”.

Figure 14.4. DRBD Architecture Using Separate Network Interfaces



The dedicated DRBD network interfaces should be configured to use a nonrouted TCP/IP network configuration. For example, you might want to set the primary to use 192.168.0.1 and the secondary 192.168.0.2. These networks and IP addresses should not be part of normal network subnet.

> **Note**
>
> The preferred setup, whenever possible, is to use a direct cable connection (using a crossover cable with Ethernet, for example) between the two machines. This eliminates the risk of loss of connectivity due to switch failures.

14.2.3.1. Using Bonded Ethernet Network Interfaces

For a set-up where there is a high-throughput of information being written, you may want to use bonded network interfaces. This is where you combine the connectivity of more than one network port, increasing the throughput linearly according to the number of bonded connections.

Bonding also provides an additional benefit in that with multiple network interfaces effectively supporting the same communications channel, a fault within a single network interface in a bonded group does not stop communication. For example, imagine you have a bonded setup with four network interfaces providing a single interface channel between two DRBD servers. If one network interface fails, communication can continue on the other three without interruption, although at a lower speed.

To enable bonded connections you must enable bonding within the kernel. You then need to configure the module to specify the bonded devices and then configure each new bonded device just as you would a standard network device:

- To configure the bonded devices, edit the `/etc/modprobe.conf` file (Red Hat) or add a file to the `/etc/modprobe.d` directory. In each case, you define the parameters for the kernel module. First, specify each bonding device:

  ```
  alias bond0 bonding
  ```

  You can then configure additional parameters for the kernel module. Typical parameters are the `mode` option and the `miimon` option.

  The `mode` option specifies how the network interfaces are used. The default setting is 0, which means that each network interface is used in a round-robin fashion (this supports aggregation and fault tolerance). Using setting 1 sets the bonding mode to active-backup. This means that only one network interface is used as a time, but that the link automatically fails over to a new interface if the primary interface fails. This settings only supports fault-tolerance.

  The `miimon` option enables the MII link monitoring. A positive value greater than zero indicates the monitoring frequency in milliseconds for checking each slave network interface that is configured as part of the bonded interface. A typical value is 100.

  You set th options within the module parameter file, and you must set the options for each bonded device individually:

  ```
  options bond0 miimon=100 mode=1
  ```

- Reboot your server to enable the bonded devices.

- Configure the network device parameters. There are two parts to this, you need to setup the bonded device configuration, and then configure the original network interfaces as 'slaves' of the new bonded interface.

  - For Red Hat Linux:

    Edit the configuration file for the bonded device. For device `bond0` this would be `/etc/sysconfig/network-scripts/ifcfg-bond0`:

    ```
    DEVICE=bond0
    BOOTPROTO=none
    ONBOOT=yes
    GATEWAY=192.168.0.254
    NETWORK=192.168.0.0
    NETMASK=255.255.255.0
    IPADDR=192.168.0.1
    USERCTL=no
    ```

    Then for each network interface that you want to be part of the bonded device, configure the interface as a slave to the 'master' bond. For example, the configuration of `eth0` in `/etc/sysconfig/network-scripts/ifcfg-eth0` might look like this::

    ```
    DEVICE=eth0
    BOOTPROTO=none
    HWADDR=00:11:22:33:44:55
    ONBOOT=yes
    TYPE=Ethernet
    MASTER=bond0
    SLAVE=yes
    ```

  - For Debian Linux:

    Edit the `/etc/iftab` file and configure the logical name and MAC address for each devices. For example:

    ```
    eth0 mac 00:11:22:33:44:55
    ```

Now you need to set the configuration of the devices in `/etc/network/interfaces`:

```
auto bond0
    iface bond0 inet static
    address 192.168.0.1
    netmask 255.255.255.0
    network 192.168.0.0
    gateway 192.168.0.254
    up /sbin/ifenslave bond0 eth0
    up /sbin/ifenslave bond0 eth1
```

- For Gentoo:

  Use `emerge` to add the `net-misc/ifenslave` package to your system.

  Edit the `/etc/conf.d/net` file and specify the network interface slaves in a bond, the dependencies and then the configuration for the bond itself. A sample configuration might look like this:

  ```
  slaves_bond0="eth0 eth1 eth2"

  config_bond0=( "192.168.0.1 netmask 255.255.255.0"  )

  depend_bond0() {
  need net.eth0 net.eth1 net.eth2
  }
  ```

  Then make sure that you add the new network interface to list of interfaces configured during boot:

  ```
  root-shell> rc-update add default net.bond0
  ```

Once the bonded devices are configured, reboot your systems.

You can monitor the status of a bonded connection using the `/proc` file system:

```
root-shell> cat /proc/net/bonding/bond0
Bonding Mode: fault-tolerance (active-backup)
Primary Slave: None
Currently Active Slave: eth1
MII Status: up
MII Polling Interval (ms): 100
Up Delay (ms): 200
Down Delay (ms): 200
Slave Interface: eth1
MII Status: up
Link Failure Count: 0
Permanent HW addr: 00:11:22:33:44:55
Slave Interface: eth2
MII Status: up
Link Failure Count: 0
Permanent HW addr: 00:11:22:33:44:56
```

14.2.3.2. Optimizing the Synchronization Rate

The `syncer rate` configuration parameter should be configured with care as the synchronization rate can have a significant effect on the performance of the DRBD setup in the event of a node or disk failure where the information is being synchronized from the Primary to the Secondary node.

In DRBD, there are two distinct ways of data being transferred between peer nodes:

- *Replication* refers to the transfer of modified blocks being transferred from the primary to the secondary node. This happens automatically when the block is modified on the primary node, and the replication process uses whatever bandwidth is available over the replication link. The replication process cannot be throttled, because you want to transfer of the block information to happen as quickly as possible during normal operation.
- *Synchronization* refers to the process of bringing peers back in sync after some sort of outage, due to manual intervention, node failure, disk swap, or the initial setup. Synchronization is limited to the `syncer rate` configured for the DRBD device.

Both replication and synchronization can take place at the same time. For example, the block devices can be synchronized while they are actively being used by the primary node. Any I/O that updates on the primary node automatically triggers replication of the modified block. In the event of a failure within an HA environment, it is highly likely that synchronization and replication will take place at the same time.

Unfortunately, if the synchronization rate is set too high, then the synchronization process uses up all the available network bandwidth between the primary and secondary nodes. In turn, the bandwidth available for replication of changed blocks is zero, which stalls replication and blocks I/O, and ultimately the application fails or degrades.

To avoid enabling the `syncer rate` to consume the available network bandwidth and prevent the replication of changed blocks, set the `syncer rate` to less than the maximum network bandwidth.

Avoid setting the sync rate to more than 30% of the maximum bandwidth available to your device and network bandwidth. For example, if your network bandwidth is based on Gigabit ethernet, you should achieve 110MB/s. Assuming your disk interface is capable of handling data at 110MB/s or more, then the sync rate should be configured as `33M` (33MB/s). If your disk system works at a rate lower than your network interface, use 30% of your disk interface speed.

Depending on the application, you may wish to limit the synchronization rate. For example, on a busy server you may wish to configure a significantly slower synchronization rate to ensure the replication rate is not affected.

The `al-extents` parameter controls the number of 4MB blocks of the underlying disk that can be written to at the same time. Increasing this parameter lowers the frequency of the metadata transactions required to log the changes to the DRBD device, which in turn lowers the number of interruptions in your I/O stream when synchronizing changes. This can lower the latency of changes to the DRBD device. However, if a crash occurs on your primary, then all of the blocks in the activity log (that is, the number of `al-extents` blocks) must be completely resynchronized before replication can continue.

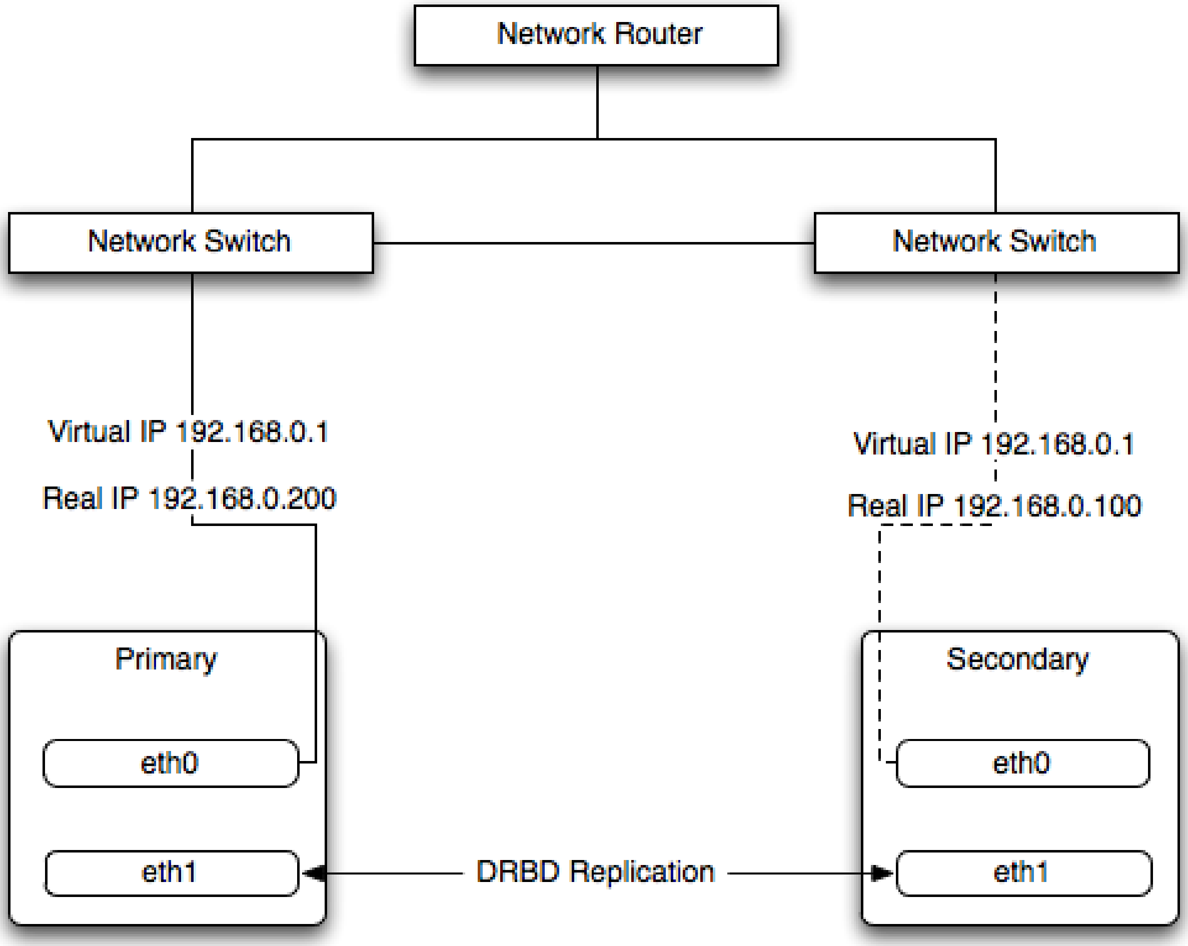
14.3. Using Linux HA Heartbeat

The Heartbeat program provides a basis for verifying the availability of resources on one or more systems within a cluster. In this context a resource includes MySQL, the file systems on which the MySQL data is being stored and, if you are using DRBD, the DRBD device being used for the file system. Heartbeat also manages a virtual IP address, and the virtual IP address should be used for all communication to the MySQL instance.

A cluster within the context of Heartbeat is defined as two computers notionally providing the same service. By definition, each computer in the cluster is physically capable of providing the same services as all the others in the cluster. However, because the cluster is designed for high-availability, only one of the servers is actively providing the service at any one time. Each additional server within the cluster is a “hot-spare” that can be brought into service in the event of a failure of the master, its next connectivity or the connectivity of the network in general.

The basics of Heartbeat are very simple. Within the Heartbeat cluster (see Figure 14.5, “Heartbeat Architecture”, each machine sends a 'heartbeat' signal to the other hosts in the cluster. The other cluster nodes monitor this heartbeat. The heartbeat can be transmitted over many different systems, including shared network devices, dedicated network interfaces and serial connections. Failure to get a heartbeat from a node is treated as failure of the node. Although we do not know the reason for the failure (it could be an OS failure, a hardware failure in the server, or a failure in the network switch), it is safe to assume that if no heartbeat is produced there is a fault.

Figure 14.5. Heartbeat Architecture



In addition to checking the heartbeat from the server, the system can also check the connectivity (using `ping`) to another host on the network, such as the network router. This enables Heartbeat to detect a failure of communication between a server and the router (and therefore failure of the server, since it is no longer capable of providing the necessary service), even if the heartbeat between the servers in the clusters is working fine.

In the event of a failure, the resources on the failed host are disabled, and the resources on one of the replacement hosts is enabled instead. In addition, the Virtual IP address for the cluster is redirected to the new host in place of the failed device.

When used with MySQL and DRBD, the MySQL data is replicated from the master to the slave using the DRBD device, but MySQL is only running on the master. When the master fails, the slave switches the DRBD devices to be primary, the file systems on those devices are mounted, and MySQL is started. The original master (if still available) has its resources disabled, which means shutting down MySQL and unmounting the file systems and switching the DRBD device to secondary.

14.3.1. Heartbeat Configuration

Heartbeat configuration requires three files located in `/etc/ha.d`. The `ha.cf` contains the main heartbeat configuration, including the list of the nodes and times for identifying failures. `haresources` contains the list of resources to be managed within the cluster. The `authkeys` file contains the security information for the cluster.

The contents of these files should be identical on each host within the Heartbeat cluster. It is important that you keep these files in sync across all the hosts. Any changes in the information on one host should be copied to the all the others.

For these examples n example of the `ha.cf` file is shown below:

```
logfacility local0
keepalive 500ms
deadtime 10
warntime 5
initdead 30
mcast bond0 225.0.0.1 694 2 0
mcast bond1 225.0.0.2 694 1 0
auto_failback off
```

```
node drbd1
node drbd2
```

The individual lines in the file can be identified as follows:

- `logfacility`: Sets the logging, in this case setting the logging to use `syslog`.
- `keepalive`: Defines how frequently the heartbeat signal is sent to the other hosts.
- `deadtime`— the delay in seconds before other hosts in the cluster are considered 'dead' (failed).
- `warntime`: The delay in seconds before a warning is written to the log that a node cannot be contacted.
- `initdead`: The period in seconds to wait during system startup before the other host is considered to be down.
- `mcast`: Defines a method for sending a heartbeat signal. In the above example, a multicast network address is being used over a bonded network device. If you have multiple clusters then the multicast address for each cluster should be unique on your network. Other choices for the heartbeat exchange exist, including a serial connection.

  If you are using multiple network interfaces (for example, one interface for your server connectivity and a secondary or bonded interface for your DRBD data exchange), use both interfaces for your heartbeat connection. This decreases the chance of a transient failure causing a invalid failure event.
- `auto_failback`: Sets whether the original (preferred) server should be enabled again if it becomes available. Switching this to `on` may cause problems if the preferred went offline and then comes back on line again. If the DRBD device has not been synced properly, or if the problem with the original server happens again you may end up with two different datasets on the two servers, or with a continually changing environment where the two servers flip-flop as the preferred server reboots and then starts again.
- `node`: Sets the nodes within the Heartbeat cluster group. There should be one `node` for each server.

An optional additional set of information provides the configuration for a ping test that checks the connectivity to another host. Use this to ensure that you have connectivity on the public interface for your servers, so the ping test should be to a reliable host such as a router or switch. The additional lines specify the destination machine for the `ping`, which should be specified as an IP address, rather than a host name; the command to run when a failure occurs, the authority for the failure and the timeout before an nonresponse triggers a failure. A sample configure is shown below:

```
ping 10.0.0.1
respawn hacluster /usr/lib64/heartbeat/ipfail
apiauth ipfail gid=haclient uid=hacluster
deadping 5
```

In the above example, the `ipfail` command, which is part of the Heartbeat solution, is called on a failure and 'fakes' a fault on the currently active server. You need to configure the user and group ID under which the command is executed (using the `apiauth`). The failure is triggered after 5 seconds.

> **Note**
>
> The `deadping` value must be less than the `deadtime` value.

The `authkeys` file holds the authorization information for the Heartbeat cluster. The authorization relies on a single unique 'key' that is used to verify the two machines in the Heartbeat cluster. The file is used only to confirm that the two machines are in the same cluster and is used to ensure that the multiple clusters can co-exist within the same network.

14.3.2. Using Heartbeat with MySQL and DRBD

To use Heartbeat in combination with MySQL, use DRBD (see Section 14.2, “Using MySQL with DRBD”) or another solution that enables sharing the MySQL database files in event of a system failure. In these examples, DRBD is used as the data sharing solution.

Heartbeat manages the configuration of different resources to manage the switching between two servers in the event of a failure. The resource configuration defines the individual services that should be brought up (or taken down) in the event of a failure.

The `haresources` file within `/etc/ha.d` defines the resources that should be managed, and the individual resource mentioned in this file in turn relates to scripts located within `/etc/ha.d/resource.d`. The resource definition is defined all on one line:

```
drbd1 drbddisk Filesystem::/dev/drbd0::/drbd::ext3 mysql 10.0.0.100
```

The line is notionally split by whitespace. The first entry (`drbd1`) is the name of the preferred host; that is the server that is normally responsible for handling the service. The last field is virtual IP address or name that should be used to share the service. This is the IP address that should be used to connect to the MySQL server. It is automatically allocated to the server that is active when Heartbeat starts.

The remaining fields between these two fields define the resources that should be managed. Each Field should contain the name of the resource (and each name should refer to a script within `/etc/ha.d/resource.d`). In the event of a failure, these resources are started on the backup server by calling the corresponding script (with a single argument, `start`), in order from left to right. If there are additional arguments to the script, you can use a double colon to separate each additional argument.

In the above example, we manage the following resources:

- `drbddisk`: The DRBD resource script, this switches the DRBD disk on the secondary host into primary mode, making the device read/write.
- `Filesystem`: Manages the Filesystem resource. In this case we have supplied additional arguments to specify the DRBD device, mount point and file system type. When executed this should mount the specified file system.
- `mysql`: Manages the MySQL instances and starts the MySQL server. Copy the `mysql.resource` file from the `support-files` directory from any MySQL release into the `/etc/ha.d/resources.d` directory.

  If this file is not available in your distribution, you can use the following as the contents of the `/etc/ha.d/resource.d/mysql.resource` file:

```
#!/bin/bash
#
# This script is inteded to be used as resource script by heartbeat
#
# Mar 2006 by Monty Taylor
#
###

. /etc/ha.d/shellfuncs

case "$1" in
    start)
        res=`/etc/init.d/mysql start`
        ret=$?
        ha_log $res
        exit $ret
        ;;
    stop)
        res=`/etc/init.d/mysql stop`
        ret=$?
        ha_log $res
        exit $ret
        ;;
    status)
        if [[ `ps -ef | grep '[m]ysqld'` > 1 ]] ; then
           echo "running"
        else
           echo "stopped"
        fi
        ;;
    *)
        echo "Usage: mysql {start|stop|status}"
        exit 1
        ;;
esac

exit 0
```

If you want to be notified of the failure by email, you can add another line to the `haresources` file with the address for warnings and the warning text:

```
MailTo::youremail@address.com::DRBDFailure
```

With the Heartbeat configuration in place, copy the `haresources`, `authkeys` and `ha.cf` files from your primary and secondary servers to make sure that the configuration is identical. Then start the Heartbeat service, either by calling `/etc/init.d/heartbeat start` or by rebooting both primary and secondary servers.

You can test the configuration by running a manual failover, connect to the primary node and run:

```
root-shell> /usr/lib64/heartbeat/hb_standby
```

This causes the current node to relinquish its resources cleanly to the other node.

14.3.3. Using Heartbeat with DRBD and `dopd`

As a further extension to using DRBD and Heartbeat together, you can enable `dopd`. The `dopd` daemon handles the situation where a DRBD node is out of date compared to the master and prevents the slave from being promoted to master in the event of a failure. This stops a situation where you have two machines that have been masters ending up different data on the underlying device.

For example, imagine that you have a two server DRBD setup, master and slave. If the DRBD connectivity between master and slave fails, then the slave is out of the sync with the master. If Heartbeat identifies a connectivity issue for master and then switches over to the slave, the slave DRBD device is promoted to the primary device, even though the data on the slave and the master is not in synchronization.

In this situation, with `dopd` enabled, the connectivity failure between the master and slave would be identified and the metadata on the slave would be set to `Outdated`. Heartbeat refuses to switch over to the slave even if the master failed. In a dual-host solution this would effectively render the cluster out of action, as there is no additional fail over server. In an HA cluster with three or more servers, control would be passed to the slave that has an up to date version of the DRBD device data.

To enable `dopd`, you need to modify the Heartbeat configuration and specify `dopd` as part of the commands executed during the monitoring process. Add the following lines to your `ha.cf` file:

```
respawn hacluster /usr/lib/heartbeat/dopd
apiauth dopd gid=haclient uid=hacluster
```

Make sure you make the same modification on both your primary and secondary nodes.

Reload the Heartbeat configuration:

```
root-shell> /etc/init.d/heartbeat reload
```

Modify your DRBD configuration by configuration the `outdate-peer` option. Add the configuration line into the `common` section of `/etc/drbd.conf` on both hosts. An example of the full block is shown below:

```
common {
  handlers {
    outdate-peer "/usr/lib/heartbeat/drbd-peer-outdater";
  }
}
```

Finally, set the `fencing` option on your DRBD configured resources:

```
resource my-resource {
  disk {
    fencing    resource-only;
  }
}
```

Now reload your DRBD configuration:

```
root-shell> drbdadmin adjust all
```

You can test the system by unplugging your DRBD link and monitoring the output from `/proc/drbd`.

14.3.4. Dealing with System Level Errors

Because a kernel panic or oops may indicate potential problem with your server, configure your server to remove itself from the cluster in the event of a problem. Typically on a kernel panic, your system automatically triggers a hard reboot. For a kernel oops, a reboot may not happen automatically, but the issue that caused that oops may still lead to potential problems.

You can force a reboot by setting the `kernel.panic` and `kernel.panic_on_oops` parameters of the kernel control file `/etc/sysctl.conf`. For example:

```
 kernel.panic_on_oops = 1
 kernel.panic = 1
```

You can also set these parameters during runtime by using the `sysctl` command. You can either specify the parameters on the command line:

```
shell> sysctl -w kernel.panic=1
```

Or you can edit your `sysctl.conf` file and then reload the configuration information:

```
shell> sysctl -p
```

Setting both these parameters to a positive value (representing the number of seconds to wait before rebooting), causes the system to reboot. Your second heartbeat node should then detect that the server is down and then switch over to the failover host.

14.4. Using MySQL within an Amazon EC2 Instance

The Amazon Elastic Compute Cloud (EC2) service provides virtual servers that you can build and deploy to run a variety of different applications and services, including MySQL. The EC2 service is based around the Xen framework, supporting x86, Linux based, platforms with individual instances of a virtual machine referred to as an Amazon Machine Image (AMI). You have complete (root) access to the AMI instance that you create, enabling you to configure and install your AMI in any way you choose.

To use EC2, you create an AMI based on the configuration and applications that you want to use and upload the AMI to the Amazon Simple Storage Service (S3). From the S3 resource, you can deploy one or more copies of the AMI to run as an instance within the EC2 environment. The EC2 environment provides management and control of the instance and contextual information about the instance while it is running.

Because you can create and control the AMI, the configuration, and the applications, you can deploy and create any environment you choose. This includes a basic MySQL server in addition to more extensive replication, HA and scalability scenarios that enable you to take advantage of the EC2 environment, and the ability to deploy additional instances as the demand for your MySQL services and applications grow.

To aid the deployment and distribution of work, three different Amazon EC2 instances are available, small (identified as `m1.small`), large (`m1.large`) and extra large (`m1.xlarge`). The different types provide different levels of computing power measured in EC2 computer units (ECU). A summary of the different instance configurations is shown here.

	Small	**Large**	**Extra Large**
Platform	32-bit	64-bit	64-bit
CPU cores	1	2	4
ECUs	1	4	8
RAM	1.7GB	7.5GB	15GB
Storage	150GB	840GB	1680GB
I/O Performance	Medium	High	High

The typical model for deploying and using MySQL within the EC2 environment is to create a basic AMI that you can use to hold your database data and application. Once the basic environment for your database and application has been created you can then choose to deploy the AMI to a suitable instance. Here the flexibility of having an AMI that can be re-deployed from the small to the large or extra large EC2 instance makes it easy to upgrade the hardware environment without rebuilding your application or database stack.

To get started with MySQL on EC2, including information on how to set up and install MySQL within an EC2 installation and how to port and migrate your data to the running instance, see Section 14.4.1, “Setting Up MySQL on an EC2 AMI”.

For tips and advice on how to create a scalable EC2 environment using MySQL, including guides on setting up replication, see Section 14.4.3, “Deploying a MySQL Database Using EC2”.

14.4.1. Setting Up MySQL on an EC2 AMI

There are many different ways of setting up an EC2 AMI with MySQL, including using any of the pre-configured AMIs supplied by Amazon.

The default *Getting Started* AMI provided by Amazon uses Fedora Core 4, and you can install MySQL by using `yum`:

```
shell> yum install mysql
```

This installs both the MySQL server and the Perl DBD::mysql driver for the Perl DBI API.

Alternatively, you can use one of the AMIs that include MySQL within the standard installation.

Finally, you can also install a standard version of MySQL downloaded from the MySQL Web site. The installation process and instructions are identical to any other installation of MySQL on Linux. See Chapter 2, *Installing and Upgrading MySQL*.

The standard configuration for MySQL places the data files in the default location, `/var/lib/mysql`. The default data directory on an EC2 instance is `/mnt` (although on the large and extra large instance you can alter this configuration). You must edit `/etc/my.cnf` to set the `datadir` option to point to the larger storage area.

> **Important**
>
> The first time you use the main storage location within an EC2 instance it needs to be initialized. The initialization process starts automatically the first time you write to the device. You can start using the device right away, but the write performance of the new device is significantly lower on the initial writes until the initialization process has finished.
>
> To avoid this problem when setting up a new instance, you should start the initialization process before populating your MySQL database. One way to do this is to use `dd` to write to the file system:
>
> ```
> root-shell> dd if=/dev/zero of=initialize bs=1024M count=50
> ```
>
> The preceding creates a 50GB on the file system and starts the initialization process. Delete the file once the process has finished.
>
> The initialization process can be time-consuming. On the small instance, initialization takes between two and three hours. For the large and extra large drives, the initialization can be 10 or 20 hours, respectively.

In addition to configuring the correct storage location for your MySQL data files, also consider setting the following other settings in your instance before you save the instance configuration for deployment:

- Set the MySQL server ID, so that when you use it for replication, the ID information is set correctly.
- Enabling binary logging, so that replication can be initialized without starting and stopping the server.
- Set the caching and memory parameters for your storage engines. There are no limitations or restrictions on what storage engines you use in your EC2 environment. Choose a configuration, possibly using one of the standard configurations provided with MySQL appropriate for the instance on which you expect to deploy. The large and extra large instances have RAM that can be dedicated to caching. Be aware that if you choose to install `memcached` on the servers as part of your application stack you must ensure there is enough memory for both MySQL and `memcached`.

Once you have configured your AMI with MySQL and the rest of your application stack, save the AMI so that you can deploy and reuse the instance.

Once you have your application stack configured in an AMI, populating your MySQL database with data should be performed by creating a dump of your database using `mysqldump`, transferring the dump to the EC2 instance, and then reloading the information into the EC2 instance database.

Before using your instance with your application in a production situation, be aware of the limitations of the EC2 instance environment. See Section 14.4.2, “EC2 Instance Limitations”. To begin using your MySQL AMI, consult the notes on deployment. See Section 14.4.3, “Deploying a MySQL Database Using EC2”.

14.4.2. EC2 Instance Limitations

Be aware of the following limitations of the EC2 instances before deploying your applications. Although these shouldn't affect your ability to deploy within the Amazon EC2 environment, they may alter the way you setup and configure your environment to support your application.

- Data stored within instances is not persistent. If you create an instance and populate the instance with data, then the data only remains in place while the machine is running, and does not survive a reboot. If you shut down the instance, any data it contained is lost.

  To ensure that you do not lose information, take regular backups using `mysqldump`. If the data being stored is critical, consider using replication to keep a “live” backup of your data in the event of a failure. When creating a backup, write the data to the Amazon S3 service to avoid the transfer charges applied when copying data offsite.
- EC2 instances are not persistent. If the hardware on which an instance is running fails, the instance is shut down. This can lead to loss of data or service.
- If you want to use replication with your EC2 instances to a non-EC2 environment, be aware of the transfer costs to and from the EC2 service. Data transfer between different EC2 instances is free, so using replication within the EC2 environment does not incur additional charges.

- Certain HA features are either not directly supported, or have limiting factors or problems that may reduce their utility. For example, using DRBD or MySQL Cluster may not work. The default storage configuration is also not redundant. You can use software-based RAID to improve redundancy, but this implies a further performance hit.

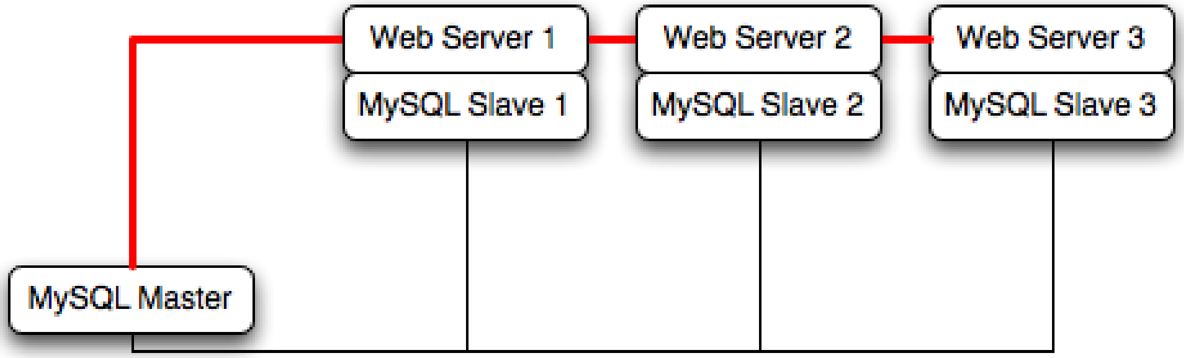
14.4.3. Deploying a MySQL Database Using EC2

Because you cannot guarantee the uptime and availability of your EC2 instances, when deploying MySQL within the EC2 environment, use an approach that enables you to easily distribute work among your EC2 instances. There are a number of ways of doing this. Using sharding techniques, where you split the application across multiple servers dedicating specific blocks of your dataset and users to different servers is an effective way of doing this. As a general rule, it is easier to create more EC2 instances to support more users than to upgrade the instance to a larger machine.

The EC2 architecture works best when you treat the EC2 instances as temporary, cache-based solutions, rather than as a long-term, high availability solution. In addition to using multiple machines, take advantage of other services, such as `memcached` to provide additional caching for your application to help reduce the load on the MySQL server so that it can concentrate on writes. On the large and extra large instances within EC2, the RAM available can provide a large memory cache for data.

Most types of scale-out topology that you would use with your own hardware can be used and applied within the EC2 environment. However, use the limitations and advice already given to ensure that any potential failures do not lose you any data. Also, because the relative power of each EC2 instance is so low, be prepared to alter your application to use sharding and add further EC2 instances to improve the performance of your application.

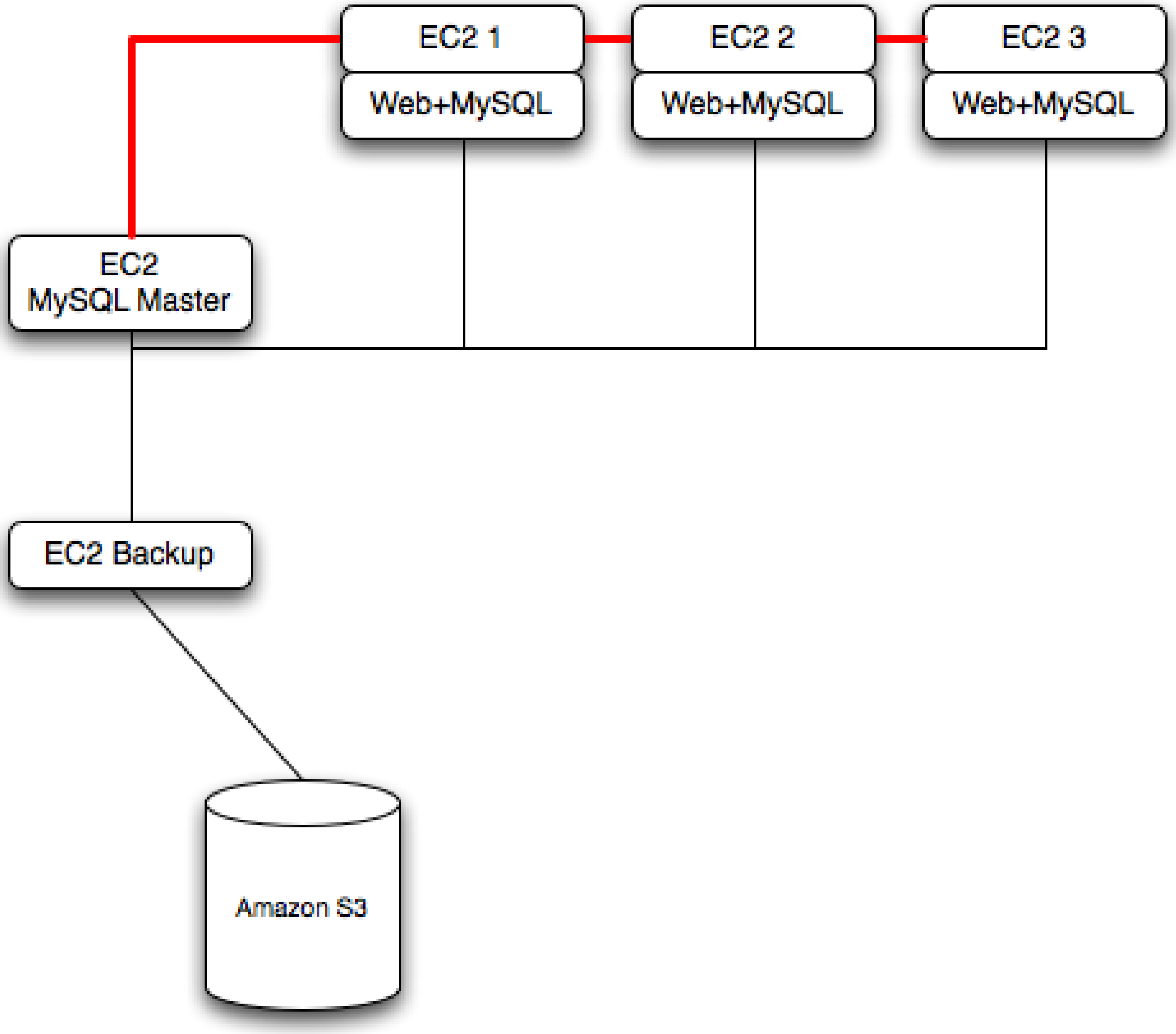
For example, take the typical scale-out environment shown following, where a single master replicates to one or more slaves (three in this example), with a web server running on each replication slave.



You can reproduce this structure completely within the EC2 environment, using an EC2 instance for the master, and one instance for each of the web and MySQL slave servers.

> **Note**
>
> Within the EC2 environment, internal (private) IP addresses used by the EC2 instances are constant. Always use these internal addresses and names when communicating between instances. Only use public IP addresses when communicating with the outside world - for example, when publicizing your application.

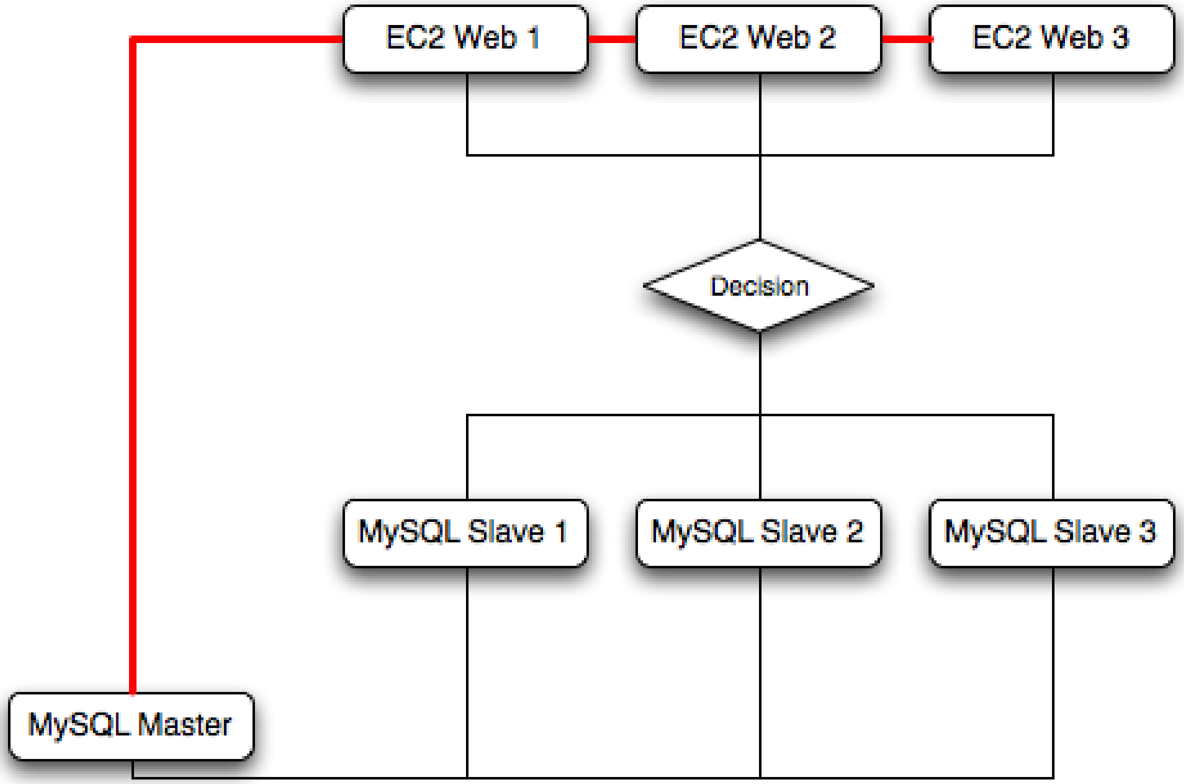
To ensure reliability of your database, add at least one replication slave dedicated to providing an active backup and storage to the Amazon S3 facility. You can see an example of this in the following topology.



Using `memcached` within your EC2 instances should provide better performance. The large and extra large instances have a significant amount of RAM. To use `memcached` in your application, when loading information from the database, first check whether the item exists in the cache. If the data you are looking for exists in the cache, use it. If not, reload the data from the database and populate the cache.

Sharding divides up data in your entire database by allocating individual machines or machine groups to provide a unique set of data according to an appropriate group. For example, you might put all users with a surname ending in the letters A-D onto a single server. When a user connects to the application and their surname is known, queries can be redirected to the appropriate MySQL server.

When using sharding with EC2, separate the web server and MySQL server into separate EC2 instances, and then apply the sharding decision logic into your application. Once you know which MySQL server you should be using for accessing the data you then distribute queries to the appropriate server. You can see a sample of this in the following illustration.



> **Warning**
>
> With sharding and EC2, be careful that the potential for failure of an instance does not affect your application. If the EC2 instance that provides the MySQL server for a particular shard fails, then all of the data on that shard becomes unavailable.

14.5. Using ZFS Replication

To support high availability environments, providing an instant copy of the information on both the currently active machine and the hot backup is a critical part of the HA solution. There are many solutions to this problem, including Chapter 15, *Replication* and Section 14.2, "Using MySQL with DRBD".

The ZFS file system provides functionality that enables you to create a snapshot of the file system contents and to then transfer the snapshot to another machine and extract the snapshot to recreate the file system. You can create a snapshot at any time, and you can create as many snapshots as you like. By continually creating, transferring and restoring snapshots you can provide synchronization between one ore more machines in a fashion similar to DRBD.

To understand the replication solution within ZFS, you must first understand the ZFS environment. Below is a simple Solaris system running with a single ZFS pool, mounted at `/scratchpool`:

```
Filesystem             size   used  avail capacity  Mounted on
/dev/dsk/c0d0s0        4.6G   3.7G   886M    82%    /
/devices                 0K     0K     0K     0%    /devices
ctfs                     0K     0K     0K     0%    /system/contract
proc                     0K     0K     0K     0%    /proc
mnttab                   0K     0K     0K     0%    /etc/mnttab
swap                   1.4G   892K   1.4G     1%    /etc/svc/volatile
objfs                    0K     0K     0K     0%    /system/object
/usr/lib/libc/libc_hwcap1.so.1
                       4.6G   3.7G   886M    82%    /lib/libc.so.1
fd                       0K     0K     0K     0%    /dev/fd
swap                   1.4G    40K   1.4G     1%    /tmp
swap                   1.4G    28K   1.4G     1%    /var/run
/dev/dsk/c0d0s7         26G   913M    25G     4%    /export/home
scratchpool             16G    24K    16G     1%    /scratchpool
```

The MySQL data is stored in a directory on `/scratchpool`. To help demonstrate some of the basic replication functionality, there are also other items stored in `/scratchpool` as well:

```
total 17
```

```
drwxr-xr-x  31 root     bin           50 Jul 21 07:32 DTT/
drwxr-xr-x   4 root     bin            5 Jul 21 07:32 SUNWmlib/
drwxr-xr-x  14 root     sys           16 Nov  5 09:56 SUNWspro/
drwxrwxrwx  19 1000     1000          40 Nov  6 19:16 emacs-22.1/
```

To create a snapshot of the file system, you use `zfs snapshot`, and then specify the pool and the snapshot name:

```
root-shell> zfs snapshot scratchpool@snap1
```

To get a list of snapshots already taken:

```
root-shell> zfs list -t snapshot
NAME                    USED  AVAIL  REFER  MOUNTPOINT
scratchpool@snap1          0      -  24.5K  -
scratchpool@snap2          0      -  24.5K  -
```

The snapshots themselves are stored within the file system metadata, and the space required to keep them varies as time goes on because of the way the snapshots are created. The initial creation of a snapshot is really quick, because instead of taking an entire copy of the data and metadata required to hold the entire snapshot, ZFS merely records the point in time and metadata of when the snapshot was created.

As more changes to the original file system are made, the size of the snapshot increases because more space is required to keep the record of the old blocks. Furthermore, if you create lots of snapshots, say one per day, and then delete the snapshots from earlier in the week, the size of the newer snapshots may also increase, as the changes that make up the newer state have to be included in the more recent snapshots, rather than being spread over the seven snapshots that make up the week.

The only issue, from a backup perspective, is that snapshots exist within the confines of the original file system. To get the snapshot out into a format that you can copy to another file system, tape, etc. you use the `zfs send` command to create a stream version of the snapshot.

For example, to write out the snapshot to a file:

```
root-shell> zfs send scratchpool@snap1 >/backup/scratchpool-snap1
```

Or tape:

```
root-shell> zfs send scratchpool@snap1 >/dev/rmt/0
```

You can also write out the incremental changes between two snapshots using `zfs send`:

```
root-shell> zfs send scratchpool@snap1 scratchpool@snap2 >/backup/scratchpool-changes
```

To recover a snapshot, you use `zfs recv` which applies the snapshot information either to a new file system, or to an existing one.

14.5.1. Using ZFS for File System Replication

Because `zfs send` and `zfs recv` use streams to exchange data, you can use them to replicate information from one system to another by combining `zfs send`, `ssh`, and `zfs recv`.

For example, if a snapshot of the `scratchpool` file system has been created and this needs to be copied to a new system or file system called `slavepool`. You would use the following command, combining the snapshot of `scratchpool`, the transmission to the slave machine (using `ssh`), and the recovery of the snapshot on the slave using `zfs recv`:

```
root-shell> zfs send scratchpool@snap1 |ssh mc@slave pfexec zfs recv -F slavepool
```

The first part, `zfs send scratchpool@snap1`, streams the snapshot, the second, `ssh mc@slave`, and the third, `pfexec zfs recv -F slavepool`, receives the streamed snapshot data and writes it to slavepool. In this instance, I've specified the `-F` option which forces the snapshot data to be applied, and is therefore destructive. This is fine, as I'm creating the first version of my replicated file system.

On the slave machine, the replicated file system contains the exact same content:

```
root-shell> ls -al /slavepool/
total 23
drwxr-xr-x   6 root     root           7 Nov  8 09:13 ./
drwxr-xr-x  29 root     root          34 Nov  9 07:06 ../
drwxr-xr-x  31 root     bin           50 Jul 21 07:32 DTT/
drwxr-xr-x   4 root     bin            5 Jul 21 07:32 SUNWmlib/
drwxr-xr-x  14 root     sys           16 Nov  5 09:56 SUNWspro/
drwxrwxrwx  19 1000     1000          40 Nov  6 19:16 emacs-22.1/
```

Once a snapshot has been created, to synchronize the file system again, you need to create a new snapshot, and then use the incremental snapshot feature of `zfs send` to send the changes between the two snapshots to the slave machine again:

```
root-shell> zfs send -i scratchpool@snapshot1 scratchpool@snapshot2 |ssh mc@192.168.0.93 pfexec zfs recv slavepool
```

Without further modification, this operation fails, because the file system on the slave machine can currently be modified, and you can't apply the incremental changes to a destination file system that has changed. It is the metadata that has changed. The metadata about the file system, like the last time it was accessed - in this case, it is our `ls` that caused the problem.

To prevent changes on the slave file system, you must set the file system on the slave to be read-only:

```
root-shell> zfs set readonly=on slavepool
```

Setting `readonly` means that you cannot change the file system on the slave by normal means, including the file system metadata. Operations that would normally update metadata (like our `ls`) silently perform their function without attempting to update the file system state.

In essence, the slave file system is nothing but a static copy of the original file system. However, even when configured to to be read-only, a file system can have snapshots applied to it. Now the file system is read only, re-run the initial copy:

```
root-shell> zfs send scratchpool@snap1 |ssh mc@slave pfexec zfs recv -F slavepool
```

Now you can make changes to the original file system and replicate them to the slave.

14.5.2. Configuring MySQL for ZFS Replication

Configuring MySQL on the source file system is a case of creating the data on the file system that you intend to replicate. The configuration file in the example below has been updated to use `/scratchpool/mysql-data` as the data directory, and now you can initialize the tables:

```
root-shell> mysql_install_db --defaults-file=/etc/mysql/5.0/my.cnf --user=mysql
```

To synchronize the initial information, perform a new snapshot and then send an incremental snapshot to the slave using `zfs send`:

```
root-shell> zfs snapshot scratchpool@snap2
root-shell> zfs send -i scratchpool@snap1 scratchpool@snap2|ssh mc@192.168.0.93 pfexec zfs recv slavepool
```

Doublecheck that the slave has the data by looking at the MySQL data directory on the `slavepool`:

```
root-shell> ls -al /slavepool/mysql-data/
```

Now you can start up MySQL, create some data, and then replicate the changes using `zfs send`/ `zfs recv` to the slave to synchronize the changes.

The rate at which you perform the synchronization depends on your application and environment. The limitation is the speed required to perform the snapshot and then to send the changes over the network.

To automate the process, create a script that performs the snapshot, send, and receive operation, and then use `cron` to synchronize the changes at set times or intervals. For automated operations, see Tim Foster's zfs replication tool.

14.5.3. Handling MySQL Recovery with ZFS

When using ZFS replication to provide a constant copy of your data, ensure that you can recover your tables, either manually or automatically, in the event of a failure of the original system.

In the event of a failure, follow this sequence:

1. Stop the script on the master, if it is still up and running.
2. Set the slave file system to be read/write:

   ```
   root-shell> zfs set readonly=off slavepool
   ```

3. Start up `mysqld` on the slave. If you are using `InnoDB`, `Falcon` or `Maria` you get auto-recovery, if it is needed, to make

sure the table data is correct, as shown here when I started up from our mid-INSERT snapshot:

```
InnoDB: The log sequence number in ibdata files does not match
InnoDB: the log sequence number in the ib_logfiles!
081109 15:59:59  InnoDB: Database was not shut down normally!
InnoDB: Starting crash recovery.
InnoDB: Reading tablespace information from the .ibd files...
InnoDB: Restoring possible half-written data pages from the doublewrite
InnoDB: buffer...
081109 16:00:03  InnoDB: Started; log sequence number 0 1142807951
081109 16:00:03 [Note] /slavepool/mysql-5.0.67-solaris10-i386/bin/mysqld: ready for connections.
Version: '5.0.67'  socket: '/tmp/mysql.sock'  port: 3306  MySQL Community Server (GPL)
```

On MyISAM, or other tables, you might need to run `REPAIR TABLE`, and you might even have lost some information. Use a recovery-capable storage engine and a regular synchronization schedule to reduce the risk for significant data loss.

14.6. Using MySQL with `memcached`

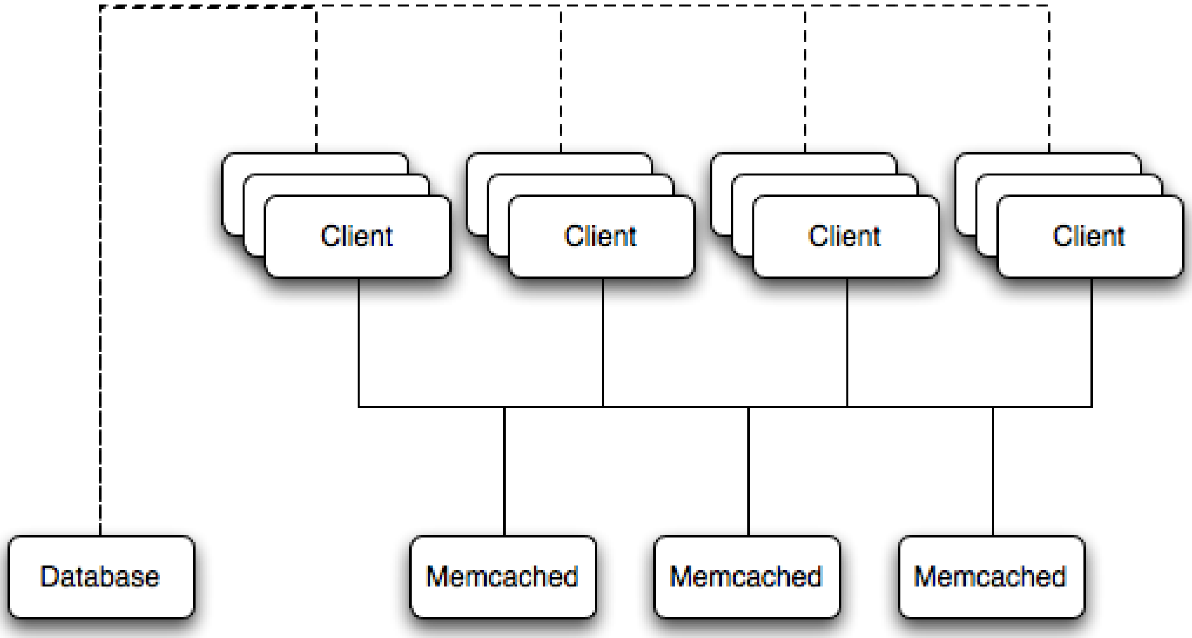
The largest problem with scalability within a typical environment is the speed with which you can access information. For frequently accessed information, using MySQL can be slow because each access of information requires execution of the SQL query and recovery of the information from the database. This also means that queries on tables that are locked or blocking may delay your query and reduce the speed of recovery of information.

`memcached` is a simple, yet highly scalable key-based cache that stores data and objects wherever dedicated or spare RAM is available for very quick access by applications. To use, you run `memcached` on one or more hosts and then use the shared cache to store objects. Because each host's RAM is storing information, the access speed is much faster than loading the information from disk. This can provide a significant performance boost in retrieving data versus loading the data natively from a database. Also, because the cache is just a repository for information, you can use the cache to store any data, including complex structures that would normally require a significant amount of effort to create, but in a ready-to-use format, helping to reduce the load on your MySQL servers.

The typical usage environment is to modify your application so that information is read from the cache provided by `memcached`. If the information isn't in `memcached`, then the data is loaded from the MySQL database and written into the cache so that future requests for the same object benefit from the cached data.

For a typical deployment layout, see Figure 14.6, “`memcached` Architecture Overview”.

Figure 14.6. `memcached` Architecture Overview



In the example structure, any of the clients can contact one of the `memcached` servers to request a given key. Each client is configured to talk to all of the servers shown in the illustration. Within the client, when the request is made to store the information, the key used to reference the data is hashed and this hash is then used to select one of the `memcached` servers. The selection of the `memcached` server takes place on the client before the server is contacted, keeping the process lightweight.

The same algorithm is used again when a client requests the same key. The same key generates the same hash, and the same `memcached` server is selected as the source for the data. Using this method, the cached data is spread among all of the `memcached` servers, and the cached information is accessible from any client. The result is a distributed, memory-based, cache that can return information, particularly complex data and structures, much faster than natively reading the information from the database.

The data held within a `memcached` server is never stored on disk (only in RAM, which means there is no persistence of data), and the RAM cache is always populated from the backing store (a MySQL database). If a `memcached` server fails, the data can always be recovered from the MySQL database, albeit at a slower speed than loading the information from the cache.

In April 2011, MySQL announced the preview of a new memcached interface for the InnoDB and MySQL Cluster storage engines.

Using the memcached API, web services can directly access the InnoDB and MySQL Cluster storage engines without transformations to SQL, ensuring low latency and high throughput for read/write queries. Operations such as SQL parsing are eliminated and more of the server's hardware resources (CPU, memory and I/O) are dedicated to servicing the query within the storage engine itself.

These are targeted to be incorporated into future MySQL 5.6 Milestone and MySQL Cluster Development Releases.

You can learn more about these interfaces from this Dev Zone article: http://dev.mysql.com/tech-resources/articles/nosql-to-mysql-with-memcached.html.

14.6.1. Installing `memcached`

You can build and install `memcached` from the source code directly, or you can use an existing operating system package or installation.

Installing `memcached` from a Binary Distribution

To install `memcached` on a Red Hat, or Fedora host, use `yum`:

```
root-shell> yum install memcached
```

Note

On CentOS, you may be able to obtain a suitable RPM from another source, or use the source tarball.

To install `memcached` on a Debian or Ubuntu host, use `apt-get`:

```
root-shell> apt-get install memcached
```

To install `memcached` on a Gentoo host, use `emerge`:

```
root-shell> emerge install memcached
```

Building `memcached` from Source

On other Unix-based platforms, including Solaris, AIX, HP-UX and Mac OS X, and Linux distributions not mentioned already, you must install from source. For Linux, make sure you have a 2.6-based kernel, which includes the improved `epoll` interface. For all platforms, ensure that you have `libevent` 1.1 or higher installed. You can obtain `libevent` from `libevent` web page.

You can obtain the source for `memcached` from `memcached` Web site.

To build `memcached`, follow these steps:

1. Extract the `memcached` source package:

   ```
   shell> gunzip -c memcached-1.2.5.tar.gz | tar xf -
   ```

2. Change to the `memcached-1.2.5 directory:`

   ```
   shell> cd memcached-1.2.5
   ```

3. Run `configure`

   ```
   shell> ./configure
   ```

Some additional options you may want to specify to `configure`:

- `--prefix`

  If you want to specify a different installation directory, use the `--prefix` option:

  ```
  shell> ./configure --prefix=/opt
  ```

  The default is to use the `/usr/local` directory.

- `--with-libevent`

  If you have installed `libevent` and `configure` cannot find the library, use the `--with-libevent` option to specify the location of the installed library.

- `--enable-64bit`

  To build a 64-bit version of `memcached` (which enables you to use a single instance with a large RAM allocation), use `--enable-64bit`.

- `--enable-threads`

  To enable multi-threading support in `memcached`, which improves the response times on servers with a heavy load, use `--enable-threads`. You must have support for the POSIX threads within your operating system to enable thread support. For more information on the threading support, see Section 14.6.2.7, “`memcached` thread Support”.

- `--enable-dtrace`

  `memcached` includes a range of DTrace threads that can be used to monitor and benchmark a `memcached` instance. For more information, see Section 14.6.2.5, “Using `memcached` and DTrace”.

4. Run `make` to build `memcached`:

   ```
   shell> make
   ```

5. Run `make install` to install `memcached`:

   ```
   shell> make install
   ```

14.6.2. Using `memcached`

To start using `memcached`, you must start the `memcached` service on one or more servers. Running `memcached` sets up the server, allocates the memory and starts listening for connections from clients.

> **Note**
>
> You do not need to be privileged user (`root`) to run `memcached` unless you want to listen on one of the privileged TCP/IP ports (below 1024). You must, however, use a user that has not had their memory limits restricted using `setrlimit` or similar.

To start the server, run `memcached` as a nonprivileged (that is, non-`root`) user:

```
shell> memcached
```

By default, `memcached` uses the following settings:

- Memory allocation of 64MB
- Listens for connections on all network interfaces, using port 11211
- Supports a maximum of 1024 simultaneous connections

Typically, you would specify the full combination of options that you want when starting `memcached`, and normally provide a startup script to handle the initialization of `memcached`. For example, the following line starts `memcached` with a maximum of 1024MB RAM for the cache, listening on port 11211 on the IP address 192.168.0.110, running has a background daemon:

```
shell> memcached -d -m 1024 -p 11211 -l 192.168.0.110
```

To ensure that `memcached` is started up on boot, check the init script and configuration parameters.

`memcached` supports the following options:

- `-u user`

  If you start `memcached` as `root`, use the `-u` option to specify the user for executing `memcached`:

  ```
  shell> memcached -u memcache
  ```

- `-m memory`

  Set the amount of memory allocated to `memcached` for object storage. Default is 64MB.

  To increase the amount of memory allocated for the cache, use the `-m` option to specify the amount of RAM to be allocated (in megabytes). The more RAM you allocate, the more data you can store and therefore the more effective your cache is.

  > **Warning**
  >
  > Do not specify a memory allocation larger than your available RAM. If you specify too large a value, then some RAM allocated for `memcached` uses swap space, and not physical RAM. This may lead to delays when storing and retrieving values, because data is swapped to disk, instead of storing the data directly in RAM.
  >
  > You can use the output of the `vmstat` command to get the free memory, as shown in `free` column:
  >
  > ```
  > shell> vmstat
  > kthr      memory            page            disk          faults      cpu
  > r b w   swap  free  re  mf pi po fr de sr s1 s2 -- --   in   sy   cs us sy id
  > 0 0 0 5170504 3450392 2  7  2  0  0  0  4  0  0  0  0  296   54  199  0  0 100
  > ```

  For example, to allocate 3GB of RAM:

  ```
  shell> memcached -m 3072
  ```

  On 32-bit x86 systems where you are using PAE to access memory above the 4GB limit, you cannot allocate RAM beyond the maximum process size. You can get around this by running multiple instances of `memcached`, each listening on a different port:

  ```
  shell> memcached -m 1024 -p11211
  shell> memcached -m 1024 -p11212
  shell> memcached -m 1024 -p11213
  ```

  > **Note**
  >
  > On all systems, particularly 32-bit, ensure that you leave enough room for both `memcached` application in addition to the memory setting. For example, if you have a dedicated `memcached` host with 4GB of RAM, do not set the memory size above 3500MB. Failure to do this may cause either a crash or severe performance issues.

- `-l interface`

  Specify a network interface/address to listen for connections. The default is to listen on all available address (`INADDR_ANY`).

  ```
  shell> memcached -l 192.168.0.110
  ```

  Support for IPv6 address support was added in `memcached` 1.2.5.

- `-p port`

  Specify the TCP port to use for connections. Default is 18080.

  ```
  shell> memcached -p 18080
  ```

- `-U port`

  Specify the UDP port to use for connections. Default is 11211, 0 switches UDP off.

  ```
  shell> memcached -U 18080
  ```

- `-s socket`

  Specify a Unix socket to listen on.

  If you are running `memcached` on the same server as the clients, you can disable the network interface and use a local UNIX socket using the `-s` option:

  ```
  shell> memcached -s /tmp/memcached
  ```

  Using a UNIX socket automatically disables network support, and saves network ports (allowing more ports to be used by your web server or other process).

- `-a mask`

  Specify the access mask to be used for the Unix socket, in octal. Default is 0700.

- `-c connections`

  Specify the maximum number of simultaneous connections to the `memcached` service. The default is 1024.

  ```
  shell> memcached -c 2048
  ```

  Use this option, either to reduce the number of connections (to prevent overloading `memcached` service) or to increase the number to make more effective use of the server running `memcached` server.

- `-t threads`

  Specify the number of threads to use when processing incoming requests.

  By default, `memcached` is configured to use 4 concurrent threads. The threading improves the performance of storing and retrieving data in the cache, using a locking system to prevent different threads overwriting or updating the same values. You may want to increase or decrease the number of threads, use the `-t` option:

  ```
  shell> memcached -t 8
  ```

- `-d`

  Run `memcached` as a daemon (background) process:

  ```
  shell> memcached -d
  ```

- `-r`

  Maximize the size of the core file limit. In the event of a failure, this attempts to dump the entire memory space to disk as a core file, up to any limits imposed by `setrlimit`.

- `-M`

  Return an error to the client when the memory has been exhausted. This replaces the normal behavior of removing older items from the cache to make way for new items.

- `-k`

  Lock down all paged memory. This reserves the memory before use, instead of allocating new slabs of memory as new items are stored in the cache.

  > **Note**
  >
  > There is a user-level limit on how much memory you can lock. Trying to allocate more than the available memory fails. You can set the limit for the user you started the daemon with (not for the `-u user` user) within the shell by using `ulimit -S -l NUM_KB`

- `-v`

  Verbose mode. Prints errors and warnings while executing the main event loop.

- `-vv`

  Very verbose mode. In addition to information printed by `-v`, also prints each client command and the response.

- `-vvv`

  Extremely verbose mode. In addition to information printed by `-vv`, also show the internal state transitions.

- `-h`

  Print the help message and exit.

- `-i`

  Print the `memcached` and `libevent` license.

- `-I mem`

  Specify the maximum size permitted for storing an object within the `memcached` instance. The size supports a unit postfix (`k` for kilobytes, `m` for megabytes). For example, to increase the maximum supported object size to 32MB:

  ```
  shell> memcached -I 32m
  ```

  The maximum object size you can specify is 128MB, the default remains at 1MB.

  This option was added in 1.4.2.

- `-b`

  Set the backlog queue limit. The backlog queue configures how many network connections can be waiting to be processed by `memcached`. Increasing this limit may reduce errors received by the client that it is not able to connect to the `memcached` instance, but does not improve the performance of the server. The default is 1024.

- `-P pidfile`

  Save the process ID of the `memcached` instance into `file`.

- `-f`

  Set the chunk size growth factor. When allocating new memory chunks, the allocated size of new chunks is determined by multiplying the default slab size by this factor.

  To see the effects of this option without extensive testing, use the `-vv` command-line option to show the calculated slab sizes. For more information, see Section 14.6.2.8, “`memcached` Logs”.

- `-n bytes`

  The minimum space allocated for the key+value+flags information. The default is 48 bytes.

- `-L`

  On systems that support large memory pages, enables large memory page use. Using large memory pages enables `memcached` to allocate the item cache in one large chunk, which can improve the performance by reducing the number misses when accessing memory.

- `-C`

  Disable the use of compare and swap (CAS) operations.

  This option was added in `memcached` 1.3.x.

- `-D char`

  Set the default character to be used as a delimiter between the key prefixes and IDs. This is used for the per-prefix statistics reporting (see Section 14.6.4, “Getting `memcached` Statistics”). The default is the colon (`:`). If this option is used, statistics collection is turned on automatically. If not used, you can enable stats collection by sending the `stats detail on` command to the server.

  This option was added in `memcached` 1.3.x.

- `-R num`

  Sets the maximum number of requests per event process. The default is 20.

- `-B protocol`

Set the binding protocol, that is, the default `memcached` protocol support for client connections. Options are `ascii`, `binary` or `auto`. Automatic (`auto`) is the default.

This option was added in `memcached` 1.4.0.

14.6.2.1. `memcached` Deployment

When using `memcached` you can use a number of different potential deployment strategies and topologies. The exact strategy to use depends on your application and environment. When developing a system for deploying `memcached` within your system, keep in mind the following points:

- `memcached` is only a caching mechanism. It shouldn't be used to store information that you cannot otherwise afford to lose and then load from a different location.
- There is no security built into the `memcached` protocol. At a minimum, make sure that the servers running `memcached` are only accessible from inside your network, and that the network ports being used are blocked (using a firewall or similar). If the information on the `memcached` servers that is being stored is any sensitive, then encrypt the information before storing it in `memcached`.
- `memcached` does not provide any sort of failover. Because there is no communication between different `memcached` instances. If an instance fails, your application must capable of removing it from the list, reloading the data and then writing data to another `memcached` instance.
- Latency between the clients and the `memcached` can be a problem if you are using different physical machines for these tasks. If you find that the latency is a problem, move the `memcached` instances to be on the clients.
- Key length is determined by the `memcached` server. The default maximum key size is 250 bytes.
- Using a single `memcached` instance, especially for multiple clients, is generally a bad idea as it introduces a single point of failure. Instead provide at least two `memcached` instances so that a failure can be handled appropriately. If possible, you should create as many `memcached` nodes as possible. When adding and removing `memcached` instances from a pool, the hashing and distribution of key/value pairs may be affected. For information on how to avoid problems, see Section 14.6.2.4, “`memcached` Hashing/Distribution Types”.

14.6.2.2. Using namespaces

The `memcached` cache is a very simple massive key/value storage system, and as such there is no way of compartmentalizing data automatically into different sections. For example, if you are storing information by the unique ID returned from a MySQL database, then storing the data from two different tables could run into issues because the same ID might be valid in both tables.

Some interfaces provide an automated mechanism for creating *namespaces* when storing information into the cache. In practice, these namespaces are merely a prefix before a given ID that is applied every time a value is stored or retrieve from the cache.

You can implement the same basic principle by using keys that describe the object and the unique identifier within the key that you supply when the object is stored. For example, when storing user data, prefix the ID of the user with `user:` or `user-`.

> **Note**
>
> Using namespaces or prefixes only controls the keys stored/retrieved. There is no security within `memcached`, and therefore no way to enforce that a particular client only accesses keys with a particular namespace. Namespaces are only useful as a method of identifying data and preventing corruption of key/value pairs.

14.6.2.3. Data Expiry

There are two types of data expiry within a `memcached` instance. The first type is applied at the point when you store a new key/value pair into the `memcached` instance. If there is not enough space within a suitable slab to store the value, then an existing least recently used (LRU) object is removed (evicted) from the cache to make room for the new item.

The LRU algorithm ensures that the object that is removed is one that is either no longer in active use or that was used so long ago that its data is potentially out of date or of little value. However, in a system where the memory allocated to `memcached` is smaller than the number of regularly used objects required in the cache, a lot of expired items could be removed from the cache even though they are in active use. You use the statistics mechanism to get a better idea of the level of evictions (expired objects). For more information, see Section 14.6.4, “Getting `memcached` Statistics”.

You can change this eviction behavior by setting the `-M` command-line option when starting `memcached`. This option forces an error to be returned when the memory has been exhausted, instead of automatically evicting older data.

The second type of expiry system is an explicit mechanism that you can set when a key/value pair is inserted into the cache, or when deleting an item from the cache. Using an expiration time can be a useful way of ensuring that the data in the cache is up to date and in line with your application needs and requirements.

A typical scenario for explicitly setting the expiry time might include caching session data for a user when accessing a Web site. `memcached` uses a lazy expiry mechanism where the explicit expiry time that has been set is compared with the current time when the object is requested. Only objects that have not expired are returned.

You can also set the expiry time when explicitly deleting an object from the cache. In this case, the expiry time is really a timeout and indicates the period when any attempts to set the value for a given key are rejected.

14.6.2.4. `memcached` Hashing/Distribution Types

The `memcached` client interface supports a number of different distribution algorithms that are used in multi-server configurations to determine which host should be used when setting or getting data from a given `memcached` instance. When you get or set a value, a hash is constructed from the supplied key and then used to select a host from the list of configured servers. Because the hashing mechanism uses the supplied key as the basis for the hash, the same server is selected during both set and get operations.

You can think of this process as follows. Given an array of servers (a, b, and c), the client uses a hashing algorithm that returns an integer based on the key being stored or retrieved. The resulting value is then used to select a server from the list of servers configured in the client. Most standard client hashing within `memcache` clients uses a simple modulus calculation on the value against the number of configured `memcached` servers. You can summarize the process in pseudocode as:

```
@memcservers = ['a.memc','b.memc','c.memc'];
$value = hash($key);
$chosen = $value % length(@memcservers);
```

Replacing the above with values:

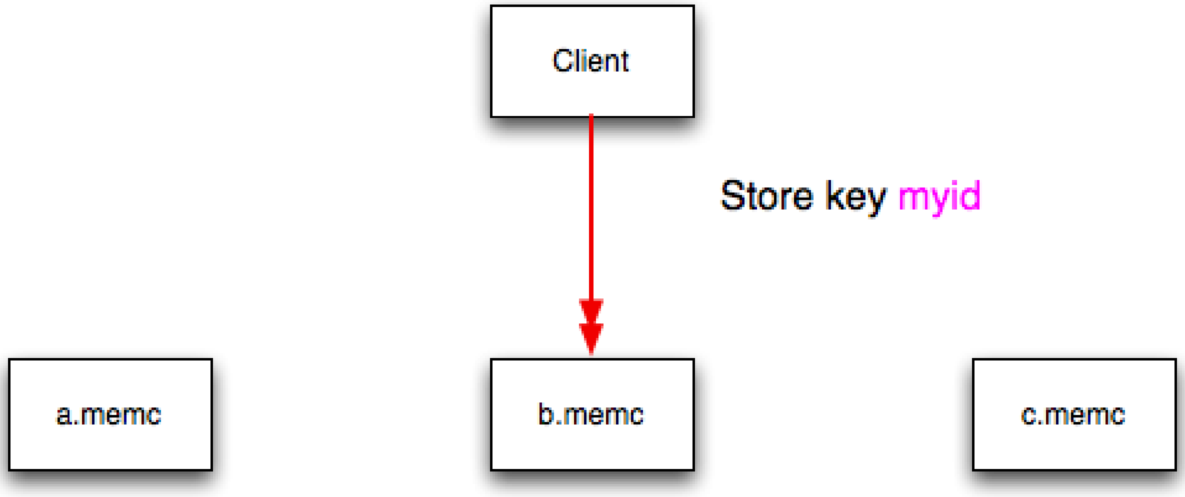
```
@memcservers = ['a.memc','b.memc','c.memc'];
$value = hash('myid');
$chosen = 7009 % 3;
```

In the above example, the client hashing algorithm chooses the server at index 1 (`7009 % 3 = 1`), and store or retrieve the key and value with that server.

> **Note**
>
> This selection and hashing process is handled automatically by the `memcached` client you are using; you need only provide the list of `memcached` servers that you want to use.

You can see a graphical representation of this below in Figure 14.7, “`memcached` Hash Selection”.

Figure 14.7. `memcached` Hash Selection



The same hashing and selection process takes place during any operation on the specified key within the `memcached` client.

Using this method provides a number of advantages:

- The hashing and selection of the server to contact is handled entirely within the client. This eliminates the need to perform network communication to determine the right machine to contact.
- Because the determination of the `memcached` server occurs entirely within the client, the server can be selected automatically regardless of the operation being executed (set, get, increment, etc.).
- Because the determination is handled within the client, the hashing algorithm returns the same value for a given key; values are not affected or reset by differences in the server environment.
- Selection is very fast. The hashing algorithm on the key value is quick and the resulting selection of the server is from a simple array of available machines.
- Using client-side hashing simplifies the distribution of data over each `memcached` server. Natural distribution of the values returned by the hashing algorithm means that keys are automatically spread over the available servers.

Providing that the list of servers configured within the client remains the same, the same stored key returns the same value, and therefore selects the same server.

However, if you do not use the same hashing mechanism then the same data may be recorded on different servers by different interfaces, both wasting space on your `memcached` and leading to potential differences in the information.

> **Note**
>
> One way to use a multi-interface compatible hashing mechanism is to use the `libmemcached` library and the associated interfaces. Because the interfaces for the different languages (including C, Ruby, Perl and Python) use the same client library interface, they always generate the same hash code from the ID.

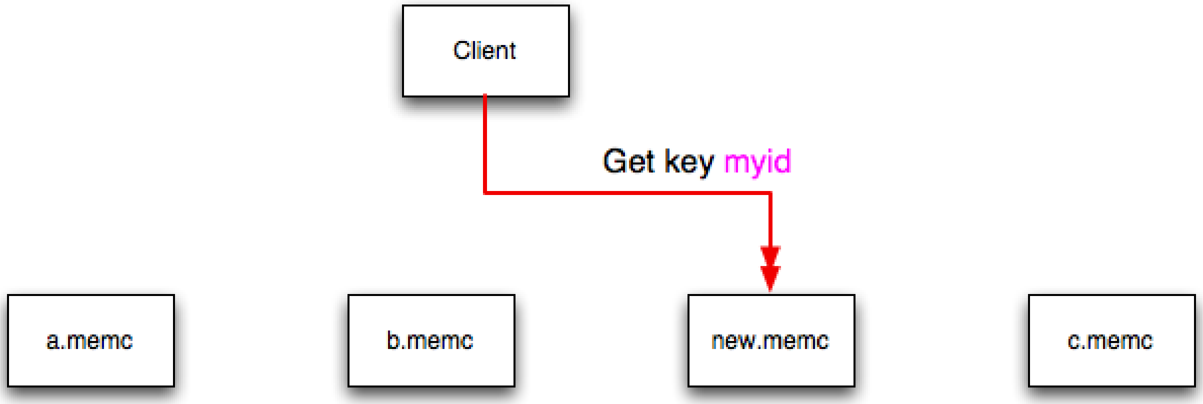
The problem with client-side selection of the server is that the list of the servers (including their sequential order) *must* remain consistent on each client using the `memcached` servers, and the servers must be available. If you try to perform an operation on a key when:

- A new `memcached` instance has been added to the list of available instances
- A `memcached` instance has been removed from the list of available instances
- The order of the `memcached` instances has changed

When the hashing algorithm is used on the given key, but with a different list of servers, the hash calculation may choose a different server from the list.

If a new `memcached` instance is added into the list of servers, as `new.memc` is in the example below, then a GET operation using the same key, `myid`, can result in a cache-miss. This is because the same value is computed from the key, which selects the same index from the array of servers, but index 2 now points to the new server, not the server `c.memc` where the data was originally stored. This would result in a cache miss, even though the key exists within the cache on another `memcached` instance.

Figure 14.8. `memcached` Hash Selection with New `memcached` instance



This means that servers `c.memc` and `new.memc` both contain the information for key `myid`, but the information stored against the key in eachs server may be different in each instance. A more significant problem is a much higher number of cache-misses when retrieving data, as the addition of a new server changes the distribution of keys, and this in turn requires rebuilding the cached data on the `memcached` instances, causing an increase in database reads.

The same effect can occur if you actively manage the list of servers configured in your clients, adding and removing the configured `memcached` instances as each instance is identified as being available. For example, removing a `memcached` instance when the client notices that the instance can no longer be contacted can cause the server selection to fail as described here.

To prevent this causing significant problems and invalidating your cache, you can select the hashing algorithm used to select the server. There are two common types of hashing algorithm, *consistent* and *modula*.

With *consistent* hashing algorithms, the same key when applied to a list of servers always uses the same server to store or retrieve the keys, even if the list of configured servers changes. This means that you can add and remove servers from the configure list and always use the same server for a given key. There are two types of consistent hashing algorithms available, Ketama and Wheel. Both types are supported by `libmemcached`, and implementations are available for PHP and Java.

Any consistent hashing algorithm has some limitations. When you add servers to an existing list of configured servers, keys are distributed to the new servers as part of the normal distribution. When you remove servers from the list, the keys are re-allocated to another server within the list, meaning that the cache needs to be re-populated with the information. Also, a consistent hashing algorithm does not resolve the issue where you want consistent selection of a server across multiple clients, but where each client contains a different list of servers. The consistency is enforced only within a single client.

With a *modula* hashing algorithm, the client selects a server by first computing the hash and then choosing a server from the list of configured servers. As the list of servers changes, so the server selected when using a modula hashing algorithm also changes. The result is the behavior described above; changes to the list of servers mean that different servers are selected when retrieving data, leading to cache misses and increase in database load as the cache is re-seeded with information.

If you use only a single `memcached` instance for each client, or your list of `memcached` servers configured for a client never changes, then the selection of a hashing algorithm is irrelevant, as it has no noticeable effect.

If you change your servers regularly, or you use a common set of servers that are shared among a large number of clients, then using a consistent hashing algorithm should help to ensure that your cache data is not duplicated and the data is evenly distributed.

14.6.2.5. Using `memcached` and DTrace

`memcached` includes a number of different DTrace probes that can be used to monitor the operation of the server. The probes included can monitor individual connections, slab allocations, and modifications to the hash table when a key/value pair is added, updated, or removed.

For more information on DTrace and writing DTrace scripts, read the DTrace User Guide.

Support for DTrace probes was added to `memcached` 1.2.6 includes a number of DTrace probes that can be used to help monitor your application. DTrace is supported on Solaris 10, OpenSolaris, Mac OS X 10.5 and FreeBSD. To enable the DTrace probes in `memcached`, build from source and use the `--enable-dtrace` option. For more information, see Section 14.6.1, “Installing `memcached`”.

The probes supported by `memcached` are:

- `conn-allocate(connid)`

  Fired when a connection object is allocated from the connection pool.

  - `connid`: The connection ID
- `conn-release(connid)`

  Fired when a connection object is released back to the connection pool.

  Arguments:

  - `connid`: The connection ID
- `conn-create(ptr)`

  Fired when a new connection object is being created (that is, there are no free connection objects in the connection pool).

  Arguments:

  - `ptr`: A pointer to the connection object

- `conn-destroy(ptr)`

  Fired when a connection object is being destroyed.

  Arguments:

  - `ptr`: A pointer to the connection object
- `conn-dispatch(connid, threadid)`

  Fired when a connection is dispatched from the main or connection-management thread to a worker thread.

  Arguments:

  - `connid`: The connection ID
  - `threadid`: The thread ID
- `slabs-allocate(size, slabclass, slabsize, ptr)`

  Allocate memory from the slab allocator

  Arguments:

  - `size`: The requested size
  - `slabclass`: The allocation is fulfilled in this class
  - `slabsize`: The size of each item in this class
  - `ptr`: A pointer to allocated memory
- `slabs-allocate-failed(size, slabclass)`

  Failed to allocate memory (out of memory)

  Arguments:

  - `size`: The requested size
  - `slabclass`: The class that failed to fulfill the request
- `slabs-slabclass-allocate(slabclass)`

  Fired when a slab class needs more space

  Arguments:

  - `slabclass`: The class that needs more memory
- `slabs-slabclass-allocate-failed(slabclass)`

  Failed to allocate memory (out of memory)

  Arguments:

  - `slabclass`: The class that failed to grab more memory
- `slabs-free(size, slabclass, ptr)`

  Release memory

  Arguments:

  - `size`: The size of the memory
  - `slabclass`: The class the memory belongs to
  - `ptr`: A pointer to the memory to release
- `assoc-find(key, depth)`

  Fired when the when we have searched the hash table for a named key. These two elements provide an insight in how well the hash function operates. Traversals are a sign of a less optimal function, wasting cpu capacity.

  Arguments:

  - `key`: The key searched for
  - `depth`: The depth in the list of hash table

- `assoc-insert(key, nokeys)`

  Fired when a new item has been inserted.

  Arguments:

  - `key`: The key just inserted
  - `nokeys`: The total number of keys currently being stored, including the key for which insert was called.

- `assoc-delete(key, nokeys)`

  Fired when a new item has been removed.

  Arguments:

  - `key`: The key just deleted
  - `nokeys`: The total number of keys currently being stored, excluding the key for which delete was called.

- `item-link(key, size)`

  Fired when an item is being linked in the cache

  Arguments:

  - `key`: The items key
  - `size`: The size of the data

- `item-unlink(key, size)`

  Fired when an item is being deleted

  Arguments:

  - `key`: The items key
  - `size`: The size of the data

- `item-remove(key, size)`

  Fired when the refcount for an item is reduced

  Arguments:

  - `key`: The items key
  - `size`: The size of the data

- `item-update(key, size)`

  Fired when the "last referenced" time is updated

  Arguments:

  - `key`: The items key
  - `size`: The size of the data

- `item-replace(oldkey, oldsize, newkey, newsize)`

Fired when an item is being replaced with another item

Arguments:

- `oldkey`: The key of the item to replace
- `oldsize`: The size of the old item
- `newkey`: The key of the new item
- `newsize`: The size of the new item

- `process-command-start(connid, request, size)`

  Fired when the processing of a command starts

  Arguments:

  - `connid`: The connection ID
  - `request`: The incoming request
  - `size`: The size of the request

- `process-command-end(connid, response, size)`

  Fired when the processing of a command is done

  Arguments:

  - `connid`: The connection ID
  - `response`: The response to send back to the client
  - `size`: The size of the response

- `command-get(connid, key, size)`

  Fired for a get-command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `size`: The size of the key's data (or -1 if not found)

- `command-gets(connid, key, size, casid)`

  Fired for a gets command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `size`: The size of the key's data (or -1 if not found)
  - `casid`: The casid for the item

- `command-add(connid, key, size)`

  Fired for a add-command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key

  - `size`: The new size of the key's data (or -1 if not found)
- `command-set(connid, key, size)`

  Fired for a set-command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `size`: The new size of the key's data (or -1 if not found)
- `command-replace(connid, key, size)`

  Fired for a replace-command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `size`: The new size of the key's data (or -1 if not found)
- `command-prepend(connid, key, size)`

  Fired for a prepend-command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `size`: The new size of the key's data (or -1 if not found)
- `command-append(connid, key, size)`

  Fired for a append-command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `size`: The new size of the key's data (or -1 if not found)
- `command-cas(connid, key, size, casid)`

  Fired for a cas-command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `size`: The size of the key's data (or -1 if not found)
  - `casid`: The cas ID requested
- `command-incr(connid, key, val)`

  Fired for incr command

  Arguments:

  - `connid`: The connection ID

  - `key`: The requested key
  - `val`: The new value
- `command-decr(connid, key, val)`

  Fired for decr command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `val`: The new value
- `command-delete(connid, key, exptime)`

  Fired for a delete command

  Arguments:

  - `connid`: The connection ID
  - `key`: The requested key
  - `exptime`: The expiry time

14.6.2.6. Memory allocation within `memcached`

When you first start `memcached`, the memory that you have configured is not automatically allocated. Instead, `memcached` only starts allocating and reserving physical memory once you start saving information into the cache.

When you start to store data into the cache, `memcached` does not allocate the memory for the data on an item by item basis. Instead, a slab allocation is used to optimize memory usage and prevent memory fragmentation when information expires from the cache.

With slab allocation, memory is reserved in blocks of 1MB. The slab is divided up into a number of blocks of equal size. When you try to store a value into the cache, `memcached` checks the size of the value that you are adding to the cache and determines which slab contains the right size allocation for the item. If a slab with the item size already exists, the item is written to the block within the slab.

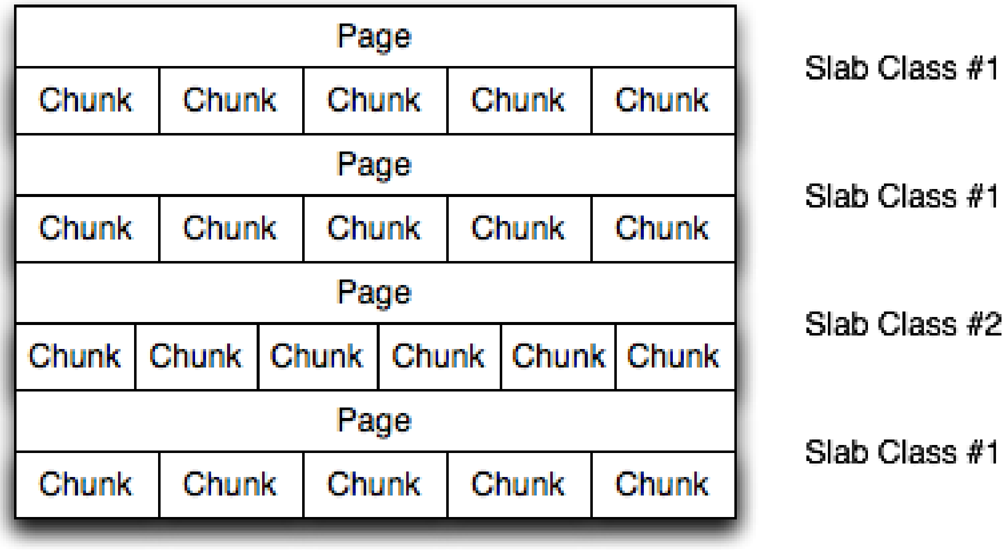
If the new item is bigger than the size of any existing blocks, then a new slab is created, divided up into blocks of a suitable size. If an existing slab with the right block size already exists, but there are no free blocks, a new slab is created. If you update an existing item with data that is larger than the existing block allocation for that key, then the key is re-allocated into a suitable slab.

For example, the default size for the smallest block is 88 bytes (40 bytes of value, and the default 48 bytes for the key and flag data). If the size of the first item you store into the cache is less than 40 bytes, then a slab with a block size of 88 bytes is created and the value stored.

If the size of the data that you want to store is larger than this value, then the block size is increased by the chunk size factor until a block size large enough to hold the value is determined. The block size is always a function of the scale factor, rounded up to a block size which is exactly divisible into the chunk size.

For a sample of the structure, see Figure 14.9, “Memory Allocation in `memcached`”.

Figure 14.9. Memory Allocation in `memcached`



The result is that you have multiple pages allocated within the range of memory allocated to `memcached`. Each page is 1MB in size (by default), and is split into a different number of chunks, according to the chunk size required to store the key/value pairs. Each instance has multiple pages allocated, and a page is always created when a new item needs to be created requiring a chunk of a particular size. A slab may consist of multiple pages, and each page within a slab contains an equal number of chunks.

The chunk size of a new slab is determined by the base chunk size combined with the chunk size growth factor. For example, if the initial chunks are 104 bytes in size, and the default chunk size growth factor is used (1.25), then the next chunk size allocated would be the best power of 2 fit for 104*1.25, or 136 bytes.

Allocating the pages in this way ensures that memory does not get fragmented. However, depending on the distribution of the objects that you want to store, it may lead to an inefficient distribution of the slabs and chunks if you have significantly different sized items. For example, having a relatively small number of items within each chunk size may waste a lot of memory with just few chunks in each allocated page.

You can tune the growth factor to reduce this effect by using the `-f` command line option, which adapts the growth factor applied to make more effective use of the chunks and slabs allocated. For information on how to determine the current slab allocation statistics, see Section 14.6.4.2, “`memcached` Slabs Statistics”.

If your operating system supports it, you can also start `memcached` with the `-L` command line option. This option preallocates all the memory during startup using large memory pages. This can improve performance by reducing the number of misses in the CPU memory cache.

14.6.2.7. `memcached` thread Support

If you enable the thread implementation within when building `memcached` from source, then `memcached` uses multiple threads in addition to the `libevent` system to handle requests.

When enabled, the threading implementation operates as follows:

- Threading is handled by wrapping functions within the code to provide basic protection from updating the same global structures at the same time.
- Each thread uses its own instance of the `libevent` to help improve performance.
- TCP/IP connections are handled with a single thread listening on the TCP/IP socket. Each connection is then distribution to one of the active threads on a simple round-robin basis. Each connection then operates solely within this thread while the connection remains open.
- For UDP connections, all the threads listen to a single UDP socket for incoming requests. Threads that are not currently dealing with another request ignore the incoming packet. One of the remaining, nonbusy, threads reads the request and sends the response. This implementation can lead to increased CPU load as threads wake from sleep to potentially process the request.

Using threads can increase the performance on servers that have multiple CPU cores available, as the requests to update the hash table can be spread between the individual threads. However, because of the locking mechanism employed you may want to experiment with different thread values to achieve the best performance based on the number and type of requests within your given workload.

14.6.2.8. `memcached` Logs

If you enable verbose mode, using the `-v`, `-vv`, or `-vvv` options, then the information output by `memcached` includes details of the operations being performed.

Without the verbose options, `memcached` normally produces no output during normal operating.

- **Output when using `-v`**

  The lowest verbosity level shows you:

  - Errors and warnings
  - Transient errors
  - Protocol and socket errors, including exhausting available connections
  - Each registered client connection, including the socket descriptor number and the protocol used.

    For example:

    ```
    32: Client using the ascii protocol
    33: Client using the ascii protocol
    ```

    Note that the socket descriptor is only valid while the client remains connected. Non-persistant connections may not be effectively represented.

  Examples of the error messages output at this level include:

  ```
  <%d send buffer was %d, now %d
  Can't listen for events on fd %d
  Can't read from libevent pipe
  Catastrophic: event fd doesn't match conn fd!
  Couldn't build response
  Couldn't realloc input buffer
  Couldn't update event
  Failed to build UDP headers
  Failed to read, and not due to blocking
  Too many open connections
  Unexpected state %d
  ```

- **Output when using `-vv`**

  When using the second level of verbosity, you get more detailed information about protocol operations, keys updated, chunk and network operatings and details.

  During the initial start-up of `memcached` with this level of verbosity, you are shown the sizes of the individual slab classes, the chunk sizes, and the number of entries per slab. These do not show the allocation of the slabs, just the slabs that would be created when data is added. You are also given information about the listen queues and buffers used to send information. A sample of the output generated for a TCP/IP based system with the default memory and growth factors is given below:

  ```
  shell> memcached -vv
  slab class   1: chunk size     80 perslab 13107
  slab class   2: chunk size    104 perslab 10082
  slab class   3: chunk size    136 perslab  7710
  slab class   4: chunk size    176 perslab  5957
  slab class   5: chunk size    224 perslab  4681
  slab class   6: chunk size    280 perslab  3744
  slab class   7: chunk size    352 perslab  2978
  slab class   8: chunk size    440 perslab  2383
  slab class   9: chunk size    552 perslab  1899
  slab class  10: chunk size    696 perslab  1506
  slab class  11: chunk size    872 perslab  1202
  slab class  12: chunk size   1096 perslab   956
  slab class  13: chunk size   1376 perslab   762
  slab class  14: chunk size   1720 perslab   609
  slab class  15: chunk size   2152 perslab   487
  slab class  16: chunk size   2696 perslab   388
  slab class  17: chunk size   3376 perslab   310
  slab class  18: chunk size   4224 perslab   248
  slab class  19: chunk size   5280 perslab   198
  slab class  20: chunk size   6600 perslab   158
  slab class  21: chunk size   8256 perslab   127
  slab class  22: chunk size  10320 perslab   101
  ```

```
slab class  23: chunk size  12904 perslab    81
slab class  24: chunk size  16136 perslab    64
slab class  25: chunk size  20176 perslab    51
slab class  26: chunk size  25224 perslab    41
slab class  27: chunk size  31536 perslab    33
slab class  28: chunk size  39424 perslab    26
slab class  29: chunk size  49280 perslab    21
slab class  30: chunk size  61600 perslab    17
slab class  31: chunk size  77000 perslab    13
slab class  32: chunk size  96256 perslab    10
slab class  33: chunk size 120320 perslab     8
slab class  34: chunk size 150400 perslab     6
slab class  35: chunk size 188000 perslab     5
slab class  36: chunk size 235000 perslab     4
slab class  37: chunk size 293752 perslab     3
slab class  38: chunk size 367192 perslab     2
slab class  39: chunk size 458992 perslab     2
<26 server listening (auto-negotiate)
<29 server listening (auto-negotiate)
<30 send buffer was 57344, now 2097152
<31 send buffer was 57344, now 2097152
<30 server listening (udp)
<30 server listening (udp)
<31 server listening (udp)
<30 server listening (udp)
<30 server listening (udp)
<31 server listening (udp)
<31 server listening (udp)
<31 server listening (udp)
```

Using this verbosity level can be a useful way to check the effects of the growth factor used on slabs with different memory allocations, which in turn can be used to better tune the growth factor to suit the data you are storing in the cache. For example, if you set the growth factor to 4 (quadrupling the size of each slab):

```
shell> memcached -f 4 -m 1g -vv
slab class   1: chunk size     80 perslab 13107
slab class   2: chunk size    320 perslab  3276
slab class   3: chunk size   1280 perslab   819
slab class   4: chunk size   5120 perslab   204
slab class   5: chunk size  20480 perslab    51
slab class   6: chunk size  81920 perslab    12
slab class   7: chunk size 327680 perslab     3
...
```

During use of the cache, this verbosity level also prints out detailed information on the storage and recovery of keys and other information. An example of the output during a typical set/get and increment/decrement operation is shown below.

```
32: Client using the ascii protocol
<32 set my_key 0 0 10
>32 STORED
<32 set object_key 1 0 36
>32 STORED
<32 get my_key
>32 sending key my_key
>32 END
<32 get object_key
>32 sending key object_key
>32 END
<32 set key 0 0 6
>32 STORED
<32 incr key 1
>32 789544
<32 decr key 1
>32 789543
<32 incr key 2
>32 789545
<32 set my_key 0 0 10
>32 STORED
<32 set object_key 1 0 36
>32 STORED
<32 get my_key
>32 sending key my_key
>32 END
<32 get object_key
>32 sending key object_key1 1 36

>32 END
<32 set key 0 0 6
>32 STORED
<32 incr key 1
>32 789544
<32 decr key 1
>32 789543
<32 incr key 2
>32 789545
```

During client communication, for each line, the initial character shows the direction of flow of the information. The < for communication from the client to the `memcached` server and > for communication back to the client. The number is the numeric socket descriptor for the connection.

- **Output when using `-vvv`**

  This level of verbosity includes the transitions of connections between different states in the event library while reading and writing content to/from the clients. It should be used to diagnose and identify issues in client communication. For example, you can use this information to determine if `memcached` is taking a long time to return information to the client, during the read of the client operation or before returning and completing the operation. An example of the typical sequence for a set operation is provided below:

```
<32 new auto-negotiating client connection
32: going from conn_new_cmd to conn_waiting
32: going from conn_waiting to conn_read
32: going from conn_read to conn_parse_cmd
32: Client using the ascii protocol
<32 set my_key 0 0 10
32: going from conn_parse_cmd to conn_nread
> NOT FOUND my_key
>32 STORED
32: going from conn_nread to conn_write
32: going from conn_write to conn_new_cmd
32: going from conn_new_cmd to conn_waiting
32: going from conn_waiting to conn_read
32: going from conn_read to conn_closing
<32 connection closed.
```

All of the verbosity levels in `memcached` are designed to be used during debugging or examination of issues. The quantity of information generated, particularly when using `-vvv`, is significant, particularly on a busy server. Also be aware that writing the error information out, especially to disk, may negate some of the performance gains you achieve by using `memcached`. Therefore, use in production or deployment environments is not recommended.

14.6.3. `memcached` Interfaces

A number of interfaces from different languages exist for interacting with `memcached` servers and storing and retrieving information. Interfaces for the most common language platforms including Perl, PHP, Python, Ruby, C and Java.

Data stored into a `memcached` server is referred to by a single string (the key), with storage into the cache and retrieval from the cache using the key as the reference. The cache therefore operates like a large associative array or hash. It is not possible to structure or otherwise organize the information stored in the cache. If you want to store information in a structured way, you must use 'formatted' keys.

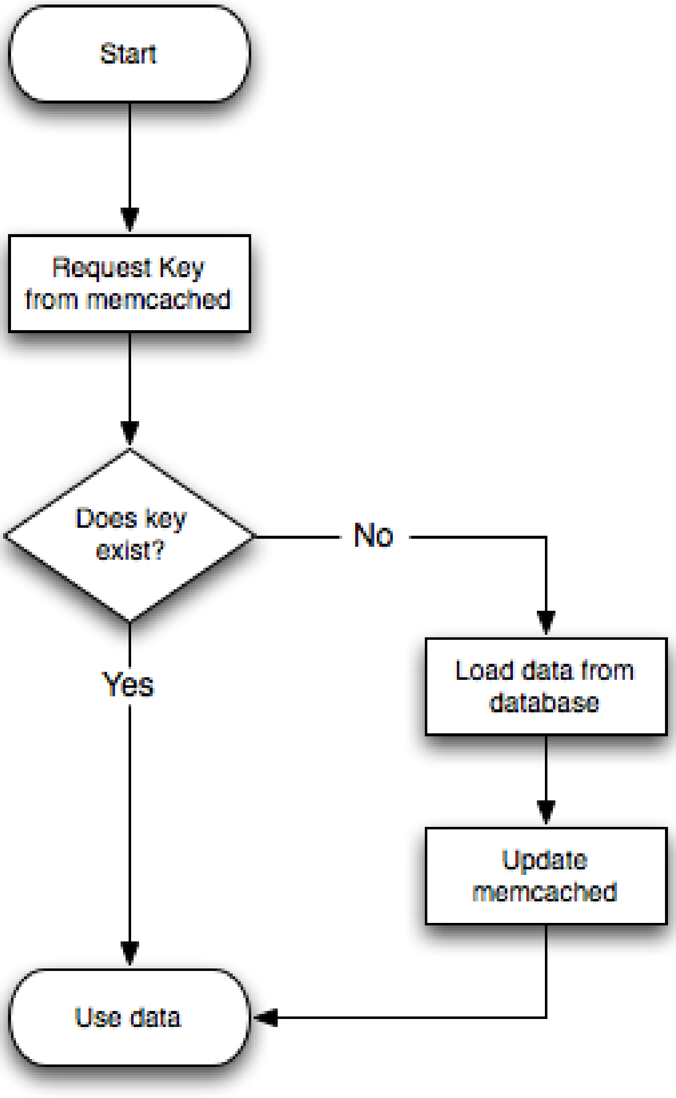
The following tips may be useful to you when using `memcached`:

The general sequence for using `memcached` in any language as a caching solution is as follows:

1. Request the item from the cache.
2. If the item exists, use the item data.
3. If the item does not exist, load the data from MySQL, and store the value into the cache. This means the value is available to the next client that requests it from the cache.

For a flow diagram of this sequence, see Figure 14.10, “Typical `memcached` Application Flowchart”.

Figure 14.10. Typical `memcached` Application Flowchart



The interface to `memcached` supports the following methods for storing and retrieving information in the cache, and these are consistent across all the different APIs, even though the language specific mechanics may be different:

- `get(key)`: Retrieves information from the cache. Returns the value if it exists, or `NULL`, `nil`, or `undefined` or the closest equivalent in the corresponding language, if the specified key does not exist.
- `set(key, value [, expiry])`: Sets the key in the cache to the specified value. Note that this either updates an existing key if it already exists, or adds a new key/value pair if the key doesn't exist. If the expiry time is specified, then the key expires (and is deleted) when the expiry time is reached. The time is specified in seconds, and is taken as a relative time if the value is less than 30 days (30*24*60*60), or an absolute time (epoch) if larger than this value.
- `add(key, value [, expiry])`: Adds the key to the cache, if the specified key doesn't already exist.
- `replace(key, value [, expiry])`: Replaces the `value` of the specified `key`, only if the key already exists.
- `delete(key [, time])`: Deletes the `key` from the cache. If you supply a `time`, then adding a value with the specified `key` is blocked for the specified period.
- `incr(key [, value])`: Increments the specified `key` by one or the specified `value`.
- `decr(key [, value])`: Decrements the specified `key` by one or the specified `value`.
- `flush_all`: Invalidates (or expires) all the current items in the cache. Technically they still exist (they are not deleted), but they are silently destroyed the next time you try to access them.

In all implementations, most or all of these functions are duplicated through the corresponding native language interface.

For all languages and interfaces, use `memcached` to store full items, rather than simply caching single rows of information from the database. For example, when displaying a record about an object (invoice, user history, or blog post), load all the data for the associated entry from the database, and compile it into the internal structure that would normally be required by the application. You then save the complete object into the cache.

Complex data structures cannot be stored directly. Most interfaces serialize the data for you, that is, put it in a form that can reconstruct the original pointers and nesting. Perl uses `Storable`, PHP uses `serialize`, Python uses `cPickle` (or `Pickle`) and Java uses the `Serializable` interface. In most cases, the serialization interface used is customizable. To share data stored in `memcached` instances between different language interfaces, consider using a common serialization solution such as JSON (Javascript Object Notation).

14.6.3.1. Using `libmemcached`

The `libmemcached` library provides both C and C++ interfaces to `memcached` and is also the basis for a number of different additional API implementations, including Perl, Python and Ruby. Understanding the core `libmemcached` functions can help when using these other interfaces.

The C library is the most comprehensive interface library for `memcached` and provides a wealth of functions and operational systems not always exposed in the other interfaces not based on the `libmemcached` library.

The different functions can be divided up according to their basic operation. In addition to functions that interface to the core API, there are a number of utility functions that provide extended functionality, such as appending and prepending data.

To build and install `libmemcached`, download the `libmemcached` package, run configure, and then build and install:

```
shell> tar xjf libmemcached-0.21.tar.gz
shell> cd libmemcached-0.21
shell> ./configure
shell> make
shell> make install
```

On many Linux operating systems, you can install the corresponding `libmemcached` package through the usual `yum`, `apt-get` or similar commands.

To build an application that uses the library, you need to first set the list of servers. You can do this either by directly manipulating the servers configured within the main `memcached_st` structure, or by separately populating a list of servers, and then adding this list to the `memcached_st` structure. The latter method is used in the following example. Once the server list has been set, you can call the functions to store or retrieve data. A simple application for setting a preset value to localhost is provided here:

```
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <libmemcached/memcached.h>

int main(int argc, char *argv[])
{
  memcached_server_st *servers = NULL;
  memcached_st *memc;
  memcached_return rc;
  char *key= "keystring";
  char *value= "keyvalue";

  memcached_server_st *memcached_servers_parse (char *server_strings);
  memc= memcached_create(NULL);

  servers= memcached_server_list_append(servers, "localhost", 11211, &rc);
  rc= memcached_server_push(memc, servers);

  if (rc == MEMCACHED_SUCCESS)
    fprintf(stderr,"Added server successfully\n");
  else
    fprintf(stderr,"Couldn't add server: %s\n",memcached_strerror(memc, rc));

  rc= memcached_set(memc, key, strlen(key), value, strlen(value), (time_t)0, (uint32_t)0);

  if (rc == MEMCACHED_SUCCESS)
    fprintf(stderr,"Key stored successfully\n");
  else
    fprintf(stderr,"Couldn't store key: %s\n",memcached_strerror(memc, rc));

  return 0;
}
```

You can test the success of an operation by using the return value, or populated result code, for a given function. The value is always set to `MEMCACHED_SUCCESS` if the operation succeeded. In the event of a failure, use the `memcached_strerror()` function to translate the result code into a printable string.

To build the application, you must specify the `memcached` library:

```
shell> gcc -o memc_basic memc_basic.c -lmemcached
```

Running the above sample application, after starting a `memcached` server, should return a success message:

```
shell> memc_basic
Added server successfully
Key stored successfully
```

14.6.3.1.1. `libmemcached` Base Functions

The base `libmemcached` functions enable you to create, destroy and clone the main `memcached_st` structure that is used to interface to the `memcached` servers. The main functions are defined below:

```
memcached_st *memcached_create (memcached_st *ptr);
```

Creates a new `memcached_st` structure for use with the other `libmemcached` API functions. You can supply an existing, static, `memcached_st` structure, or `NULL` to have a new structured allocated. Returns a pointer to the created structure, or `NULL` on failure.

```
void memcached_free (memcached_st *ptr);
```

Free the structure and memory allocated to a previously created `memcached_st` structure.

```
memcached_st *memcached_clone(memcached_st *clone, memcached_st *source);
```

Clone an existing `memcached` structure from the specified `source`, copying the defaults and list of servers defined in the structure.

14.6.3.1.2. `libmemcached` Server Functions

The `libmemcached` API uses a list of servers, stored within the `memcached_server_st` structure, to act as the list of servers used by the rest of the functions. To use `memcached`, you first create the server list, and then apply the list of servers to a valid `libmemcached` object.

Because the list of servers, and the list of servers within an active `libmemcached` object can be manipulated separately, you can update and manage server lists while an active `libmemcached` interface is running.

The functions for manipulating the list of servers within a `memcached_st` structure are given below:

```
memcached_return
           memcached_server_add (memcached_st *ptr,
                                 char *hostname,
                                 unsigned int port);
```

Add a server, using the given `hostname` and `port` into the `memcached_st` structure given in `ptr`.

```
memcached_return
           memcached_server_add_unix_socket (memcached_st *ptr,
                                             char *socket);
```

Add a Unix socket to the list of servers configured in the `memcached_st` structure.

```
unsigned int memcached_server_count (memcached_st *ptr);
```

Return a count of the number of configured servers within the `memcached_st` structure.

```
memcached_server_st *
           memcached_server_list (memcached_st *ptr);
```

Returns an array of all the defined hosts within a `memcached_st` structure.

```
memcached_return
           memcached_server_push (memcached_st *ptr,
                                  memcached_server_st *list);
```

Pushes an existing list of servers onto list of servers configured for a current `memcached_st` structure. This adds servers to the end of the existing list, and duplicates are not checked.

The `memcached_server_st` structure can be used to create a list of `memcached` servers which can then be applied individually to `memcached_st` structures.

```
memcached_server_st *
          memcached_server_list_append (memcached_server_st *ptr,
                                        char *hostname,
                                        unsigned int port,
                                        memcached_return *error);
```

Add a server, with `hostname` and `port`, to the server list in `ptr`. The result code is handled by the `error` argument, which should point to an existing `memcached_return` variable. The function returns a pointer to the returned list.

```
 unsigned int memcached_server_list_count (memcached_server_st *ptr);
```

Return the number of the servers in the server list.

```
void memcached_server_list_free (memcached_server_st *ptr);
```

Free up the memory associated with a server list.

```
memcached_server_st *memcached_servers_parse (char *server_strings);
```

Parses a string containing a list of servers, where individual servers are separated by a comma, space, or both, and where individual servers are of the form `server[:port]`. The return value is a server list structure.

14.6.3.1.3. `libmemcached` Set Functions

The set related functions within `libmemcached` provide the same functionality as the core functions supported by the `memcached` protocol. The full definition for the different functions is the same for all the base functions (add, replace, prepend, append). For example, the function definition for `memcached_set()` is:

```
memcached_return
          memcached_set (memcached_st *ptr,
                         const char *key,
                         size_t key_length,
                         const char *value,
                         size_t value_length,
                         time_t expiration,
                         uint32_t flags);
```

The `ptr` is the `memcached_st` structure. The `key` and `key_length` define the key name and length, and `value` and `value_length` the corresponding value and length. You can also set the expiration and optional flags. For more information, see Section 14.6.3.1.5, “`libmemcached` Behaviors”.

The following table outlines the remainder of the set-related functions.

`libmemcached` Function	**Equivalent to**
`memcached_set(memc, key, key_length, value, value_length, expiration, flags)`	Generic `set()` operation.
`memcached_add(memc, key, key_length, value, value_length, expiration, flags)`	Generic `add()` function.
`memcached_replace(memc, key, key_length, value, value_length, expiration, flags)`	Generic `replace()`.
`memcached_prepend(memc, key, key_length, value, value_length, expiration, flags)`	Prepends the specified `value` before the current value of the specified `key`.
`memcached_append(memc, key, key_length, value, value_length, expiration, flags)`	Appends the specified `value` after the current value of the specified `key`.
`memcached_cas(memc, key, key_length, value, value_length, expiration, flags, cas)`	Overwrites the data for a given key as long as the corresponding `cas` value is still the same within the server.
`memcached_set_by_key(memc, master_key, master_key_length, key, key_length, value, value_length, expiration, flags)`	Similar to the generic `set()`, but has the option of an additional master key that can be used to identify an individual server.
`memcached_add_by_key(memc, master_key, master_key_length, key, key_length, value, value_length, expiration, flags)`	Similar to the generic `add()`, but has the option of an additional master key that can be used to identify an individual server.
`memcached_replace_by_key(memc, master_key, master_key_length, key, key_length, value,`	Similar to the generic `replace()`, but has the option of an additional master key that can be used to identify an individual

`libmemcached` Function	Equivalent to
`value_length, expiration, flags)`	server.
`memcached_prepend_by_key(memc, master_key, master_key_length, key, key_length, value, value_length, expiration, flags)`	Similar to the `memcached_prepend()`, but has the option of an additional master key that can be used to identify an individual server.
`memcached_append_by_key(memc, master_key, master_key_length, key, key_length, value, value_length, expiration, flags)`	Similar to the `memcached_append()`, but has the option of an additional master key that can be used to identify an individual server.
`memcached_cas_by_key(memc, master_key, master_key_length, key, key_length, value, value_length, expiration, flags)`	Similar to the `memcached_cas()`, but has the option of an additional master key that can be used to identify an individual server.

The `by_key` methods add two further arguments, the master key, to be used and applied during the hashing stage for selecting the servers. You can see this in the following definition:

```
memcached_return
           memcached_set_by_key(memcached_st *ptr,
                                const char *master_key,
                                size_t master_key_length,
                                const char *key,
                                size_t key_length,
                                const char *value,
                                size_t value_length,
                                time_t expiration,
                                uint32_t flags);
```

All the functions return a value of type `memcached_return`, which you can compare against the `MEMCACHED_SUCCESS` constant.

14.6.3.1.4. `libmemcached` Get Functions

The `libmemcached` functions provide both direct access to a single item, and a multiple-key request mechanism that provides much faster responses when fetching a large number of keys simultaneously.

The main get-style function, which is equivalent to the generic `get()` is `memcached_get()`. The functions a string pointer to the returned value for a corresponding key.

```
char *memcached_get (memcached_st *ptr,
                     const char *key, size_t key_length,
                     size_t *value_length,
                     uint32_t *flags,
                     memcached_return *error);
```

A multi-key get, `memcached_mget()`, is also available. Using a multiple key get operation is much quicker to do in one block than retrieving the key values with individual calls to `memcached_get()`. To start the multi-key get, you need to call `memcached_mget()`:

```
memcached_return
         memcached_mget (memcached_st *ptr,
                         char **keys, size_t *key_length,
                         unsigned int number_of_keys);
```

The return value is the success of the operation. The `keys` parameter should be an array of strings containing the keys, and `key_length` an array containing the length of each corresponding key. `number_of_keys` is the number of keys supplied in the array.

To fetch the individual values, you need to use `memcached_fetch()` to get each corresponding value.

```
char *memcached_fetch (memcached_st *ptr,
                         const char *key, size_t *key_length,
                         size_t *value_length,
                         uint32_t *flags,
                         memcached_return *error);
```

The function returns the key value, with the `key`, `key_length` and `value_length` parameters being populated with the corresponding key and length information. The function returns `NULL` when there are no more values to be returned. A full example, including the populating of the key data and the return of the information is provided here.

```
#include <stdio.h>
#include <sstring.h>
#include <unistd.h>
#include <libmemcached/memcached.h>
```

```
int main(int argc, char *argv[])
{
  memcached_server_st *servers = NULL;
  memcached_st *memc;
  memcached_return rc;
  char *keys[]= {"huey", "dewey", "louie"};
  size_t key_length[3];
  char *values[]= {"red", "blue", "green"};
  size_t value_length[3];
  unsigned int x;
  uint32_t flags;

  char return_key[MEMCACHED_MAX_KEY];
  size_t return_key_length;
  char *return_value;
  size_t return_value_length;

  memc= memcached_create(NULL);

  servers= memcached_server_list_append(servers, "localhost", 11211, &rc);
  rc= memcached_server_push(memc, servers);

  if (rc == MEMCACHED_SUCCESS)
    fprintf(stderr,"Added server successfully\n");
  else
    fprintf(stderr,"Couldn't add server: %s\n",memcached_strerror(memc, rc));

  for(x= 0; x < 3; x++)
    {
      key_length[x] = strlen(keys[x]);
      value_length[x] = strlen(values[x]);

      rc= memcached_set(memc, keys[x], key_length[x], values[x],
                        value_length[x], (time_t)0, (uint32_t)0);
      if (rc == MEMCACHED_SUCCESS)
        fprintf(stderr,"Key %s stored successfully\n",keys[x]);
      else
        fprintf(stderr,"Couldn't store key: %s\n",memcached_strerror(memc, rc));
    }

  rc= memcached_mget(memc, keys, key_length, 3);

  if (rc == MEMCACHED_SUCCESS)
    {
      while ((return_value= memcached_fetch(memc, return_key, &return_key_length,
                                            &return_value_length, &flags, &rc)) != NULL)
        {
          if (rc == MEMCACHED_SUCCESS)
            {
              fprintf(stderr,"Key %s returned %s\n",return_key, return_value);
            }
        }
    }

  return 0;
}
```

Running the above application:

```
shell> memc_multi_fetch
Added server successfully
Key huey stored successfully
Key dewey stored successfully
Key louie stored successfully
Key huey returned red
Key dewey returned blue
Key louie returned green
```

14.6.3.1.5. `libmemcached` Behaviors

The behavior of `libmemcached` can be modified by setting one or more behavior flags. These can either be set globally, or they can be applied during the call to individual functions. Some behaviors also accept an additional setting, such as the hashing mechanism used when selecting servers.

To set global behaviors:

```
memcached_return
           memcached_behavior_set (memcached_st *ptr,
                                   memcached_behavior flag,
                                   uint64_t data);
```

To get the current behavior setting:

```
uint64_t
           memcached_behavior_get (memcached_st *ptr,
                                   memcached_behavior flag);
```

Behavior	Description
`MEMCACHED_BEHAVIOR_NO_BLOCK`	Caused `libmemcached` to use asynchronous I/O.
`MEMCACHED_BEHAVIOR_TCP_NODELAY`	Turns on no-delay for network sockets.
`MEMCACHED_BEHAVIOR_HASH`	Without a value, sets the default hashing algorithm for keys to use MD5. Other valid values include `MEMCACHED_HASH_DEFAULT`, `MEMCACHED_HASH_MD5`, `MEMCACHED_HASH_CRC`, `MEMCACHED_HASH_FNV1_64`, `MEMCACHED_HASH_FNV1A_64`, `MEMCACHED_HASH_FNV1_32`, and `MEMCACHED_HASH_FNV1A_32`.
`MEMCACHED_BEHAVIOR_DISTRIBUTION`	Changes the method of selecting the server used to store a given value. The default method is `MEMCACHED_DISTRIBUTION_MODULA`. You can enable consistent hashing by setting `MEMCACHED_DISTRIBUTION_CONSISTENT`. `MEMCACHED_DISTRIBUTION_CONSISTENT` is an alias for the value `MEMCACHED_DISTRIBUTION_CONSISTENT_KETAMA`.
`MEMCACHED_BEHAVIOR_CACHE_LOOKUPS`	Cache the lookups made to the DNS service. This can improve the performance if you are using names instead of IP addresses for individual hosts.
`MEMCACHED_BEHAVIOR_SUPPORT_CAS`	Support CAS operations. By default, this is disabled because it imposes a performance penalty.
`MEMCACHED_BEHAVIOR_KETAMA`	Sets the default distribution to `MEMCACHED_DISTRIBUTION_CONSISTENT_KETAMA` and the hash to `MEMCACHED_HASH_MD5`.
`MEMCACHED_BEHAVIOR_POLL_TIMEOUT`	Modify the timeout value used by `poll()`. Supply a `signed int` pointer for the timeout value.
`MEMCACHED_BEHAVIOR_BUFFER_REQUESTS`	Buffers IO requests instead of them being sent. A get operation, or closing the connection causes the data to be flushed.
`MEMCACHED_BEHAVIOR_VERIFY_KEY`	Forces `libmemcached` to verify that a specified key is valid.
`MEMCACHED_BEHAVIOR_SORT_HOSTS`	If set, hosts added to the list of configured hosts for a `memcached_st` structure are placed into the host list in sorted order. This breaks consistent hashing if that behavior has been enabled.
`MEMCACHED_BEHAVIOR_CONNECT_TIMEOUT`	In nonblocking mode this changes the value of the timeout during socket connection.

14.6.3.1.6. `libmemcached` Command-line Utilities

In addition to the main C library interface, `libmemcached` also includes a number of command line utilities that can be useful when working with and debugging `memcached` applications.

All of the command line tools accept a number of arguments, the most critical of which is `servers`, which specifies the list of servers to connect to when returning information.

The main tools are:

- `memcat`: Display the value for each ID given on the command line:

  ```
  shell> memcat --servers=localhost hwkey
  Hello world
  ```

- `memcp`: Copy the contents of a file into the cache, using the file names as the key:

  ```
  shell> echo "Hello World" > hwkey
  shell> memcp --servers=localhost hwkey
  shell> memcat --servers=localhost hwkey
  Hello world
  ```

- `memrm`: Remove an item from the cache:

  ```
  shell> memcat --servers=localhost hwkey
  Hello world
  shell> memrm --servers=localhost hwkey
  shell> memcat --servers=localhost hwkey
  ```

- `memslap`: Test the load on one or more `memcached` servers, simulating get/set and multiple client operations. For example, you can simulate the load of 100 clients performing get operations:

```
shell> memslap --servers=localhost --concurrency=100 --flush --test=get
memslap --servers=localhost --concurrency=100 --flush --test=get Threads connecting to servers 100
        Took 13.571 seconds to read data
```

- `memflush`: Flush (empty) the contents of the `memcached` cache.

  ```
  shell> memflush --servers=localhost
  ```

14.6.3.2. Using MySQL and `memcached` with Perl

The `Cache::Memcached` module provides a native interface to the Memcache protocol, and provides support for the core functions offered by `memcached`. You should install the module using your hosts native package management system. Alternatively, you can install the module using `CPAN`:

```
root-shell> perl -MCPAN -e 'install Cache::Memcached'
```

To use `memcached` from Perl through `Cache::Memcached` module, you first need to create a new `Cache::Memcached` object that defines the list of servers and other parameters for the connection. The only argument is a hash containing the options for the cache interface. For example, to create a new instance that uses three `memcached` servers:

```
use Cache::Memcached;

my $cache = new Cache::Memcached {
    'servers' => [
        '192.168.0.100:11211',
        '192.168.0.101:11211',
        '192.168.0.102:11211',
        ],
};
```

> **Note**
>
> When using the `Cache::Memcached` interface with multiple servers, the API automatically performs certain operations across all the servers in the group. For example, getting statistical information through `Cache::Memcached` returns a hash that contains data on a host by host basis, as well as generalized statistics for all the servers in the group.

You can set additional properties on the cache object instance when it is created by specifying the option as part of the option hash. Alternatively, you can use a corresponding method on the instance:

- `servers` or method `set_servers()`: Specifies the list of the servers to be used. The servers list should be a reference to an array of servers, with each element as the address and port number combination (separated by a colon). You can also specify a local connection through a UNIX socket (for example `/tmp/sock/memcached`). You can also specify the server with a weight (indicating how much more frequently the server should be used during hashing) by specifying an array reference with the `memcached` server instance and a weight number. Higher numbers give higher priority.
- `compress_threshold` or method `set_compress_threshold()`: Specifies the threshold when values are compressed. Values larger than the specified number are automatically compressed (using `zlib`) during storage and retrieval.
- `no_rehash` or method `set_norehash()`: Disables finding a new server if the original choice is unavailable.
- `readonly` or method `set_readonly()`: Disables writes to the `memcached` servers.

Once the `Cache::Memcached` object instance has been configured you can use the `set()` and `get()` methods to store and retrieve information from the `memcached` servers. Objects stored in the cache are automatically serialized and deserialized using the `Storable` module.

The `Cache::Memcached` interface supports the following methods for storing/retrieving data, and relate to the generic methods as shown in the table.

`Cache::Memcached` Function	**Equivalent to**
`get()`	Generic `get()`
`get_multi(keys)`	Gets multiple `keys` from memcache using just one query. Returns a hash reference of key/value pairs.
`set()`	Generic `set()`
`add()`	Generic `add()`

`Cache::Memcached` **Function**	**Equivalent to**
`replace()`	Generic `replace()`
`delete()`	Generic `delete()`
`incr()`	Generic `incr()`
`decr()`	Generic `decr()`

Below is a complete example for using `memcached` with Perl and the `Cache::Memcached` module:

```
#!/usr/bin/perl

use Cache::Memcached;
use DBI;
use Data::Dumper;

# Configure the memcached server

my $cache = new Cache::Memcached {
    'servers' => [
                   'localhost:11211',
                   ],
    };

# Get the film name from the command line
# memcached keys must not contain spaces, so create
# a key name by replacing spaces with underscores

my $filmname = shift or die "Must specify the film name\n";
my $filmkey = $filmname;
$filmkey =~ s/ /_/;

# Load the data from the cache

my $filmdata = $cache->get($filmkey);

# If the data wasn't in the cache, then we load it from the database

if (!defined($filmdata))
{
    $filmdata = load_filmdata($filmname);

    if (defined($filmdata))
    {

# Set the data into the cache, using the key

        if ($cache->set($filmkey,$filmdata))
        {
            print STDERR "Film data loaded from database and cached\n";
        }
        else
        {
            print STDERR "Couldn't store to cache\n";
        }
    }
    else
    {
             die "Couldn't find $filmname\n";
    }
}
else
{
    print STDERR "Film data loaded from Memcached\n";
}

sub load_filmdata
{
    my ($filmname) = @_;

    my $dsn = "DBI:mysql:database=sakila;host=localhost;port=3306";

    $dbh = DBI->connect($dsn, 'sakila','password');

    my ($filmbase) = $dbh->selectrow_hashref(sprintf('select * from film where title = %s',
                                                     $dbh->quote($filmname)));

    if (!defined($filmname))
    {
             return (undef);
    }

    $filmbase->{stars} =
        $dbh->selectall_arrayref(sprintf('select concat(first_name," ",last_name) ' .
                                         'from film_actor left join (actor) ' .
                                         'on (film_actor.actor_id = actor.actor_id) ' .
                                         ' where film_id=%s',
                                         $dbh->quote($filmbase->{film_id})));

    return($filmbase);
}
```

The example uses the Sakila database, obtaining film data from the database and writing a composite record of the film and actors to memcache. When calling it for a film does not exist, you get this result:

```
shell> memcached-sakila.pl "ROCK INSTINCT"
Film data loaded from database and cached
```

When accessing a film that has already been added to the cache:

```
shell> memcached-sakila.pl "ROCK INSTINCT"
Film data loaded from Memcached
```

14.6.3.3. Using MySQL and `memcached` with Python

The Python `memcache` module interfaces to `memcached` servers, and is written in pure python (that is, without using one of the C APIs). You can download and install a copy from Python Memcached.

To install, download the package and then run the Python installer:

```
python setup.py install
running install
running bdist_egg
running egg_info
creating python_memcached.egg-info
...
removing 'build/bdist.linux-x86_64/egg' (and everything under it)
Processing python_memcached-1.43-py2.4.egg
creating /usr/lib64/python2.4/site-packages/python_memcached-1.43-py2.4.egg
Extracting python_memcached-1.43-py2.4.egg to /usr/lib64/python2.4/site-packages
Adding python-memcached 1.43 to easy-install.pth file

Installed /usr/lib64/python2.4/site-packages/python_memcached-1.43-py2.4.egg
Processing dependencies for python-memcached==1.43
Finished processing dependencies for python-memcached==1.43
```

Once installed, the `memcache` module provides a class-based interface to your `memcached` servers. Serialization of Python structures is handled by using the Python `cPickle` or `pickle` modules.

To create a new `memcache` interface, import the `memcache` module and create a new instance of the `memcache.Client` class:

```
import memcache
memc = memcache.Client(['127.0.0.1:11211'])
```

The first argument should be an array of strings containing the server and port number for each `memcached` instance you want to use. You can enable debugging by setting the optional `debug` parameter to 1.

By default, the hashing mechanism used is `crc32`. This provides a basic module hashing algorithm for selecting among multiple servers. You can change the function used by setting the value of `memcache.serverHashFunction` to the alternate function you want to use. For example:

```
from zlib import adler32
memcache.serverHashFunction = adler32
```

Once you have defined the servers to use within the `memcache` instance, the core functions provide the same functionality as in the generic interface specification. A summary of the supported functions is provided in the following table.

Python `memcache` Function	**Equivalent to**
`get()`	Generic `get()`
`get_multi(keys)`	Gets multiple values from the supplied array of `keys`. Returns a hash reference of key/value pairs.
`set()`	Generic `set()`
`set_multi(dict [, expiry [, key_prefix]])`	Sets multiple key/value pairs from the supplied `dict`.
`add()`	Generic `add()`
`replace()`	Generic `replace()`
`prepend(key, value [, expiry])`	Prepends the supplied `value` to the value of the existing `key`.
`append(key, value [, expiry[)`	Appends the supplied `value` to the value of the existing `key`.
`delete()`	Generic `delete()`

Python `memcache` Function	**Equivalent to**
`delete_multi(keys [, expiry [, key_prefix]])`	Deletes all the keys from the hash matching each string in the array `keys`.
`incr()`	Generic `incr()`
`decr()`	Generic `decr()`

> **Note**
>
> Within the Python `memcache` module, all the `*_multi()`functions support an optional `key_prefix` parameter. If supplied, then the string is used as a prefix to all key lookups. For example, if you call:
>
> ```
> memc.get_multi(['a','b'], key_prefix='users:')
> ```
>
> The function retrieves the keys `users:a` and `users:b` from the servers.

An example showing the storage and retrieval of information to a `memcache` instance, loading the raw data from MySQL, is shown below:

```
import sys
import MySQLdb
import memcache

memc = memcache.Client(['127.0.0.1:11211'], debug=1);

try:
    conn = MySQLdb.connect (host = "localhost",
                            user = "sakila",
                            passwd = "password",
                            db = "sakila")
except MySQLdb.Error, e:
     print "Error %d: %s" % (e.args[0], e.args[1])
     sys.exit (1)

popularfilms = memc.get('top5films')

if not popularfilms:
    cursor = conn.cursor()
    cursor.execute('select film_id,title from film order by rental_rate desc limit 5')
    rows = cursor.fetchall()
    memc.set('top5films',rows,60)
    print "Updated memcached with MySQL data"
else:
    print "Loaded data from memcached"
    for row in popularfilms:
        print "%s, %s" % (row[0], row[1])
```

When executed for the first time, the data is loaded from the MySQL database and stored to the `memcached` server.

```
shell> python memc_python.py
Updated memcached with MySQL data
```

The data is automatically serialized using `cPickle`/`pickle`. This means when you load the data back from `memcached`, you can use the object directly. In the example above, the information stored to `memcached` is in the form of rows from a Python DB cursor. When accessing the information (within the 60 second expiry time), the data is loaded from `memcached` and dumped:

```
shell> python memc_python.py
Loaded data from memcached
2, ACE GOLDFINGER
7, AIRPLANE SIERRA
8, AIRPORT POLLOCK
10, ALADDIN CALENDAR
13, ALI FOREVER
```

The serialization and deserialization happens automatically, but be aware that serialization of Python data may be incompatible with other interfaces and languages. You can change the serialization module used during initialization, for example to use JSON, which is more easily exchanged.

14.6.3.4. Using MySQL and `memcached` with PHP

PHP provides support for the Memcache functions through a PECL extension. To enable the PHP `memcache` extensions, you must build PHP using the `--enable-memcache` option to `configure` when building from source.

If you are installing on a Red Hat based server, you can install the `php-pecl-memcache` RPM:

```
root-shell> yum --install php-pecl-memcache
```

On Debian based distributions, use the `php-memcache` package.

You can set global runtime configuration options by specifying the values in the following table within your `php.ini` file.

Configuration option	**Default**	**Description**
`memcache.allow_failover`	1	Specifies whether another server in the list should be queried if the first server selected fails.
`memcache.max_failover_attempts`	20	Specifies the number of servers to try before returning a failure.
`memcache.chunk_size`	8192	Defines the size of network chunks used to exchange data with the `memcached` server.
`memcache.default_port`	11211	Defines the default port to use when communicating with the `memcached` servers.
`memcache.hash_strategy`	standard	Specifies which hash strategy to use. Set to `consistent` to enable servers to be added or removed from the pool without causing the keys to be remapped to other servers. When set to `standard`, an older (modula) strategy is used that potentially uses different servers for storage.
`memcache.hash_function`	crc32	Specifies which function to use when mapping keys to servers. `crc32` uses the standard CRC32 hash. `fnv` uses the FNV-1a hashing algorithm.

To create a connection to a `memcached` server, you need to create a new `Memcache` object and then specifying the connection options. For example:

```
<?php

$cache = new Memcache;
$cache->connect('localhost',11211);
?>
```

This opens an immediate connection to the specified server.

To use multiple `memcached` servers, you need to add servers to the memcache object using `addServer()`:

```
bool Memcache::addServer ( string $host [, int $port [, bool $persistent
                 [, int $weight [, int $timeout [, int $retry_interval
                 [, bool $status [, callback $failure_callback
                 ]]]]]]] )
```

The server management mechanism within the `php-memcache` module is a critical part of the interface as it controls the main interface to the `memcached` instances and how the different instances are selected through the hashing mechanism.

To create a simple connection to two `memcached` instances:

```
<?php

$cache = new Memcache;
$cache->addServer('192.168.0.100',11211);
$cache->addServer('192.168.0.101',11211);
?>
```

In this scenario the instance connection is not explicitly opened, but only opened when you try to store or retrieve a value. You can enable persistent connections to `memcached` instances by setting the `$persistent` argument to true. This is the default setting, and causes the connections to remain open.

To help control the distribution of keys to different instances, use the global `memcache.hash_strategy` setting. This sets the hashing mechanism used to select. You can also add another weight to each server, which effectively increases the number of times the instance entry appears in the instance list, therefore increasing the likelihood of the instance being chosen over other instances. To set the weight, set the value of the `$weight` argument to more than one.

The functions for setting and retrieving information are identical to the generic functional interface offered by `memcached`, as shown in this table.

PECL `memcache` Function	**Equivalent to**
`get()`	Generic `get()`

PECL `memcache` Function	**Equivalent to**
`set()`	Generic `set()`
`add()`	Generic `add()`
`replace()`	Generic `replace()`
`delete()`	Generic `delete()`
`increment()`	Generic `incr()`
`decrement()`	Generic `decr()`

A full example of the PECL `memcache` interface is provided below. The code loads film data from the Sakila database when the user provides a film name. The data stored into the `memcached` instance is recorded as a `mysqli` result row, and the API automatically serializes the information for you.

```
<?php

$memc = new Memcache;
$memc->addServer('localhost','11211');
?>

<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en">
<head>
 <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
 <title>Simple Memcache Lookup</title>
</head>
<body>
<form method="post">
   <p><b>Film</b>: <input type="text" size="20" name="film"></p>
<input type="submit">
</form>
<hr/>

<?php

  echo "Loading data...\n";

$value = $memc->get($_REQUEST['film']);

if ($value)
  {
    printf("<p>Film data for %s loaded from memcache</p>",$value['title']);

    foreach (array_keys($value) as $key)
      {
        printf("<p><b>%s</b>: %s</p>",$key, $value[$key]);
      }
  }
 else
   {
     $con = new mysqli('localhost','sakila','password','sakila') or
       die ("<h1>Database problem</h1>" . mysqli_connect_error());

     $result = $con->query(sprintf('select * from film where title ="%s"',$_REQUEST['film']));

     $row = $result->fetch_array(MYSQLI_ASSOC);

     $memc->set($row['title'],$row);

     printf("<p>Loaded %s from MySQL</p>",$row['title']);
   }

?>
```

With PHP, the connections to the `memcached` instances are kept open as long as the PHP and associated Apache instance remain running. When adding a removing servers from the list in a running instance (for example, when starting another script that mentions additional servers), the connections are shared, but the script only selects among the instances explicitly configured within the script.

To ensure that changes to the server list within a script do not cause problems, make sure to use the consistent hashing mechanism.

14.6.3.5. Using MySQL and `memcached` with Ruby

There are a number of different modules for interfacing to `memcached` within Ruby. The `Ruby-MemCache` client library provides a native interface to `memcached` that does not require any external libraries, such as `libmemcached`. You can obtain the installer package from http://www.deveiate.org/projects/RMemCache.

To install, extract the package and then run `install.rb`:

```
shell> install.rb
```

If you have RubyGems, you can install the `Ruby-MemCache` gem:

```
shell> gem install Ruby-MemCache
Bulk updating Gem source index for: http://gems.rubyforge.org
Install required dependency io-reactor? [Yn]  y
Successfully installed Ruby-MemCache-0.0.1
Successfully installed io-reactor-0.05
Installing ri documentation for io-reactor-0.05...
Installing RDoc documentation for io-reactor-0.05...
```

To use a `memcached` instance from within Ruby, create a new instance of the `MemCache` object.

```
require 'memcache'
memc = MemCache::new '192.168.0.100:11211'
```

You can add a weight to each server to increase the likelihood of the server being selected during hashing by appending the weight count to the server host name/port string:

```
require 'memcache'
memc = MemCache::new '192.168.0.100:11211:3'
```

To add servers to an existing list, you can append them directly to the `MemCache` object:

```
memc += ["192.168.0.101:11211"]
```

To set data into the cache, you can just assign a value to a key within the new cache object, which works just like a standard Ruby hash object:

```
memc["key"] = "value"
```

Or to retrieve the value:

```
print memc["key"]
```

For more explicit actions, you can use the method interface, which mimics the main `memcached` API functions, as summarized in the following table.

Ruby `MemCache` Method	**Equivalent to**
`get()`	Generic `get()`
`get_hash(keys)`	Get the values of multiple `keys`, returning the information as a hash of the keys and their values.
`set()`	Generic `set()`
`set_many(pairs)`	Set the values of the keys and values in the hash `pairs`.
`add()`	Generic `add()`
`replace()`	Generic `replace()`
`delete()`	Generic `delete()`
`incr()`	Generic `incr()`
`decr()`	Generic `decr()`

14.6.3.6. Using MySQL and `memcached` with Java

The `com.danga.MemCached` class within Java provides a native interface to `memcached` instances. You can obtain the client from http://whalin.com/memcached/. The Java class uses hashes that are compatible with `libmemcached`, so you can mix and match Java and `libmemcached` applications accessing the same `memcached` instances. The serialization between Java and other interfaces are not compatible. If this is a problem, use JSON or a similar nonbinary serialization format.

On most systems you can download the package and use the `jar` directly.

To use the `com.danga.MemCached` interface, you create a `MemCachedClient` instance and then configure the list of servers by configuring the `SockIOPool`. Through the pool specification you set up the server list, weighting, and the connection parameters to optimized the connections between your client and the `memcached` instances that you configure.

Generally you can configure the `memcached` interface once within a single class and then use this interface throughout the rest of your application.

For example, to create a basic interface, first configure the `MemCachedClient` and base `SockIOPool` settings:

```
public class MyClass {

    protected static MemCachedClient mcc = new MemCachedClient();

    static {

        String[] servers =
            {
                "localhost:11211",
            };

        Integer[] weights = { 1 };

        SockIOPool pool = SockIOPool.getInstance();

        pool.setServers( servers );
        pool.setWeights( weights );
```

In the above sample, the list of servers is configured by creating an array of the `memcached` instances that you want to use. You can then configure individual weights for each server.

The remainder of the properties for the connection are optional, but you can set the connection numbers (initial connections, minimum connections, maximum connections, and the idle timeout) by setting the pool parameters:

```
pool.setInitConn( 5 );
pool.setMinConn( 5 );
pool.setMaxConn( 250 );
pool.setMaxIdle( 1000 * 60 * 60 * 6
```

Once the parameters have been configured, initialize the connection pool:

```
pool.initialize();
```

The pool, and the connection to your `memcached` instances should now be ready to use.

To set the hashing algorithm used to select the server used when storing a given key you can use `pool.setHashingAlg()`:

```
pool.setHashingAlg( SockIOPool.NEW_COMPAT_HASH );
```

Valid values are `NEW_COMPAT_HASH`, `OLD_COMPAT_HASH` and `NATIVE_HASH` are also basic modula hashing algorithms. For a consistent hashing algorithm, use `CONSISTENT_HASH`. These constants are equivalent to the corresponding hash settings within `libmemcached`.

Java `com.danga.MemCached` Method	**Equivalent to**
`get()`	Generic `get()`
`getMulti(keys)`	Get the values of multiple `keys`, returning the information as Hash map using `java.lang.String` for the keys and `java.lang.Object` for the corresponding values.
`set()`	Generic `set()`
`add()`	Generic `add()`
`replace()`	Generic `replace()`
`delete()`	Generic `delete()`
`incr()`	Generic `incr()`
`decr()`	Generic `decr()`

14.6.3.7. Using the MySQL `memcached` UDFs

The `memcached` MySQL User Defined Functions (UDFs) enable you to set and retrieve objects from within MySQL 5.0 or greater.

To install the MySQL `memcached` UDFs, download the UDF package from http://libmemcached.org/. Unpack the package and run `configure` to configure the build process. When running `configure`, use the `--with-mysql` option and specify the location of the `mysql_config` command.

```
shell> tar zxf memcached_functions_mysql-0.5.tar.gz
shell> cd memcached_functions_mysql-0.5
shell> ./configure --with-mysql-config=/usr/local/mysql/bin/mysql_config
```

Now build and install the functions:

```
shell> make
shell> make install
```

Copy the MySQL `memcached` UDFs into your MySQL plugins directory:

```
shell> cp /usr/local/lib/libmemcached_functions_mysql* /usr/local/mysql/lib/mysql/plugins/
```

The plugin directory is given by the value of the `plugin_dir` system variable. For more information, see Section 21.3.2.5, “Compiling and Installing User-Defined Functions”.

Once installed, you must initialize the function within MySQL using `CREATE` and specifying the return value and library. For example, to add the `memc_get()` function:

```
mysql> CREATE FUNCTION memc_get RETURNS STRING SONAME "libmemcached_functions_mysql.so";
```

You must repeat this process for each function that you want to provide access to within MySQL. Once you have created the association, the information is retained, even over restarts of the MySQL server. You can simplify the process by using the SQL script provided in the `memcached` UDFs package:

```
shell> mysql <sql/install_functions.sql
```

Alternatively, if you have Perl installed, then you can use the supplied Perl script, which checks for the existence of each function and creates the function/library association if it is not already defined:

```
shell> utils/install.pl --silent
```

The `--silent` option installs everything automatically. Without this option, the script asks whether you want to install each of the available functions.

The interface remains consistent with the other APIs and interfaces. To set up a list of servers, use the `memc_servers_set()` function, which accepts a single string containing and comma-separated list of servers:

```
mysql> SELECT memc_servers_set('192.168.0.1:11211,192.168.0.2:11211');
```

Note

The list of servers used by the `memcached` UDFs is not persistent over restarts of the MySQL server. If the MySQL server fails, then you must re-set the list of `memcached` servers.

To set a value, use `memc_set`:

```
mysql> SELECT memc_set('myid', 'myvalue');
```

To retrieve a stored value:

```
mysql> SELECT memc_get('myid');
```

The list of functions supported by the UDFs, in relation to the standard protocol functions, is shown in the following table.

MySQL `memcached` UDF Function	Equivalent to
`memc_get()`	Generic `get()`
`memc_get_by_key(master_key, key, value)`	Like the generic `get()`, but uses the supplied master key to select the server to use.
`memc_set()`	Generic `set()`
`memc_set_by_key(master_key, key, value)`	Like the generic `set()`, but uses the supplied master key to select the server to use.
`memc_add()`	Generic `add()`
`memc_add_by_key(master_key, key, value)`	Like the generic `add()`, but uses the supplied master key to select the server to use.
`memc_replace()`	Generic `replace()`
`memc_replace_by_key(master_key, key, value)`	Like the generic `replace()`, but uses the supplied master key

MySQL `memcached` UDF Function	**Equivalent to**
	to select the server to use.
`memc_prepend(key, value)`	Prepend the specified `value` to the current value of the specified `key`.
`memc_prepend_by_key(master_key, key, value)`	Prepend the specified `value` to the current value of the specified `key`, but uses the supplied master key to select the server to use.
`memc_append(key, value)`	Append the specified `value` to the current value of the specified `key`.
`memc_append_by_key(master_key, key, value)`	Append the specified `value` to the current value of the specified `key`, but uses the supplied master key to select the server to use.
`memc_delete()`	Generic `delete()`
`memc_delete_by_key(master_key, key, value)`	Like the generic `delete()`, but uses the supplied master key to select the server to use.
`memc_increment()`	Generic `incr()`
`memc_decrement()`	Generic `decr()`

The respective `*_by_key()` functions are useful when you want to store a specific value into a specific `memcached` server, possibly based on a differently calculated or constructed key.

The `memcached` UDFs include some additional functions:

- `memc_server_count()`

  Returns a count of the number of servers in the list of registered servers.

- `memc_servers_set_behavior(behavior_type, value)`, `memc_set_behavior(behavior_type, value)`

  Set behaviors for the list of servers. These behaviors are identical to those provided by the `libmemcached` library. For more information on `libmemcached` behaviors, see Section 14.6.3.1, “Using `libmemcached`”.

  You can use the behavior name as the `behavior_type`:

  ```
  mysql> SELECT memc_servers_behavior_set("MEMCACHED_BEHAVIOR_KETAMA",1);
  ```

- `memc_servers_behavior_get(behavior_type)`, `memc_get_behavior(behavior_type, value)`

  Returns the value for a given behavior.

- `memc_list_behaviors()`

  Returns a list of the known behaviors.

- `memc_list_hash_types()`

  Returns a list of the supported key-hashing algorithms.

- `memc_list_distribution_types()`

  Returns a list of the supported distribution types to be used when selecting a server to use when storing a particular key.

- `memc_libmemcached_version()`

  Returns the version of the `libmemcached` library.

- `memc_stats()`

  Returns the general statistics information from the server.

14.6.3.8. `memcached` Protocol

Communicating with a `memcached` server can be achieved through either the TCP or UDP protocols. When using the TCP protocol you can use a simple text based interface for the exchange of information.

14.6.3.8.1. Using the TCP text protocol

When communicating with `memcached` you can connect to the server using the port configured for the server. You can open a connection with the server without requiring authorization or login. As soon as you have connected, you can start to send commands to the server. When you have finished, you can terminate the connection without sending any specific disconnection command. Clients are encouraged to keep their connections open to decrease latency and improve performance.

Data is sent to the `memcached` server in two forms:

- Text lines, which are used to send commands to the server, and receive responses from the server.
- Unstructured data, which is used to receive or send the value information for a given key. Data is returned to the client in exactly the format it was provided.

Both text lines (commands and responses) and unstructured data are always terminated with the string `\r\n`. Because the data being stored may contain this sequence, the length of the data (returned by the client before the unstructured data is transmitted should be used to determine the end of the data.

Commands to the server are structured according to their operation:

- **Storage commands**: `set`, `add`, `replace`, `append`, `prepend`, `cas`

  Storage commands to the server take the form:

  ```
  command key [flags] [exptime] length [noreply]
  ```

  Or when using compare and swap (cas):

  ```
  cas key [flags] [exptime] length [casunique] [noreply]
  ```

  Where:

  - `command`: The command name.
    - `set`: Store value against key
    - `add`: Store this value against key if the key does not already exist
    - `replace`: Store this value against key if the key already exists
    - `append`: Append the supplied value to the end of the value for the specified key. The `flags` and `exptime` arguments should not be used.
    - `prepend`: Append value currently in the cache to the end of the supplied value for the specified key. The `flags` and `exptime` arguments should not be used.
    - `cas`: Set the specified key to the supplied value, only if the supplied `casunique` matches. This is effectively the equivalent of change the information if nobody has updated it since I last fetched it.
  - `key`: The key. All data is stored using a the specific key. The key cannot contain control characters or whitespace, and can be up to 250 characters in size.
  - `flags`: The flags for the operation (as an integer). Flags in `memcached` are transparent. The `memcached` server ignores the contents of the flags. They can be used by the client to indicate any type of information. In `memcached` 1.2.0 and lower the value is a 16-bit integer value. In `memcached` 1.2.1 and higher the value is a 32-bit integer.
  - `exptime`: The expiry time, or zero for no expiry.
  - `length`: The length of the supplied value block in bytes, excluding the terminating `\r\n` characters.
  - `casunique`: A unique 64-bit value of an existing entry. This is used to compare against the existing value. Use the value returned by the `gets` command when issuing `cas` updates.
  - `noreply`: Tells the server not to reply to the command.

For example, to store the value `abcdef` into the key `xyzkey`, you would use:

```
set xyzkey 0 0 6\r\nabcdef\r\n
```

The return value from the server is one line, specifying the status or error information. For more information, see Table 14.2, “`memcached` Protocol Responses”.

- **Retrieval commands**: `get`, `gets`

  Retrieval commands take the form:

  ```
  get key1 [key2 .... keyn]
  gets key1 [key2 ... keyn]
  ```

  You can supply multiple keys to the commands, with each requested key separated by whitespace.

  The server responds with an information line of the form:

  ```
  VALUE key flags bytes [casunique]
  ```

  Where:

  - `key`: The key name.
  - `flags`: The value of the flag integer supplied to the `memcached` server when the value was stored.
  - `bytes`: The size (excluding the terminating `\r\n` character sequence) of the stored value.
  - `casunique`: The unique 64-bit integer that identifies the item.

  The information line is immediately followed by the value data block. For example:

  ```
  get xyzkey\r\n
  VALUE xyzkey 0 6\r\n
  abcdef\r\n
  ```

  If you have requested multiple keys, an information line and data block is returned for each key found. If a requested key does not exist in the cache, no information is returned.

- **Delete commands**: `delete`

  Deletion commands take the form:

  ```
  delete key [time] [noreply]
  ```

  Where:

  - `key`: The key name.
  - `time`: The time in seconds (or a specific Unix time) for which the client wishes the server to refuse `add` or `replace` commands on this key. All `add`, `replace`, `get`, and `gets` commands fail during this period. `set` operations succeed. After this period, the key is deleted permanently and all commands are accepted.

    If not supplied, the value is assumed to be zero (delete immediately).
  - `noreply`: Tells the server not to reply to the command.

  Responses to the command are either `DELETED` to indicate that the key was successfully removed, or `NOT_FOUND` to indicate that the specified key could not be found.

- **Increment/Decrement**: `incr`, `decr`

  The increment and decrement commands change the value of a key within the server without performing a separate get/set sequence. The operations assume that the currently stored value is a 64-bit integer. If the stored value is not a 64-bit integer, then the value is assumed to be zero before the increment or decrement operation is applied.

  Increment and decrement commands take the form:

  ```
  incr key value [noreply]
  decr key value [noreply]
  ```

Where:

- `key`: The key name.
- `value`: An integer to be used as the increment or decrement value.
- `noreply`: Tells the server not to reply to the command.

The response is:

- `NOT_FOUND`: The specified key could not be located.
- `value`: The new value of the specified key.

Values are assumed to be unsigned. For `decr` operations the value is never decremented below 0. For `incr` operations, the value wraps around the 64-bit maximum.

- **Statistics commands**: `stats`

  The `stats` command provides detailed statistical information about the current status of the `memcached` instance and the data it is storing.

  Statistics commands take the form:

  ```
  STAT [name] [value]
  ```

  Where:

  - `name`: The optional name of the statistics to return. If not specified, the general statistics are returned.
  - `value`: A specific value to be used when performing certain statistics operations.

  The return value is a list of statistics data, formatted as follows:

  ```
  STAT name value
  ```

  The statistics are terminated with a single line, `END`.

  For more information, see Section 14.6.4, “Getting `memcached` Statistics”.

For reference, a list of the different commands supported and their formats is provided below.

Table 14.1. `memcached` Command Reference

Command	Command Formats
`set`	`set key flags exptime length`, `set key flags exptime length noreply`
`add`	`add key flags exptime length`, `add key flags exptime length noreply`
`replace`	`replace key flags exptime length`, `replace key flags exptime length noreply`
`append`	`append key length`, `append key length noreply`
`prepend`	`prepend key length`, `prepend key length noreply`
`cas`	`cas key flags exptime length casunique`, `cas key flags exptime length casunique noreply`
`get`	`get key1 [key2 ... keyn]`
`gets`	
`delete`	`delete key`, `delete key noreply`, `delete key expiry`, `delete key expiry noreply`
`incr`	`incr key`, `incr key noreply`, `incr key value`, `incr key value noreply`
`decr`	`decr key`, `decr key noreply`, `decr key value`, `decr key value noreply`
`stat`	`stat`, `stat name`, `stat name value`

When sending a command to the server, the response from the server is one of the settings in the following table. All response values from the server are terminated by `\r\n`:

Table 14.2. `memcached` Protocol Responses

String	Description
`STORED`	Value has successfully been stored.
`NOT_STORED`	The value was not stored, but not because of an error. For commands where you are adding a or updating a value if it exists (such as `add` and `replace`), or where the item has already been set to be deleted.
`EXISTS`	When using a `cas` command, the item you are trying to store already exists and has been modified since you last checked it.
`NOT_FOUND`	The item you are trying to store, update or delete does not exist or has already been deleted.
`ERROR`	You submitted a nonexistent command name.
`CLIENT_ERROR error-string`	There was an error in the input line, the detail is contained in `errorstring`.
`SERVER_ERROR error-string`	There was an error in the server that prevents it from returning the information. In extreme conditions, the server may disconnect the client after this error occurs.
`VALUE keys flags length`	The requested key has been found, and the stored `key`, `flags` and data block are returned, of the specified `length`.
`DELETED`	The requested key was deleted from the server.
`STAT name value`	A line of statistics data.
`END`	The end of the statistics data.

14.6.4. Getting `memcached` Statistics

The `memcached` system has a built in statistics system that collects information about the data being stored into the cache, cache hit ratios, and detailed information on the memory usage and distribution of information through the slab allocation used to store individual items. Statistics are provided at both a basic level that provide the core statistics, and more specific statistics for specific areas of the `memcached` server.

This information can prove be very useful to ensure that you are getting the correct level of cache and memory usage, and that your slab allocation and configuration properties are set at an optimal level.

The stats interface is available through the standard `memcached` protocol, so the reports can be accessed by using `telnet` to connect to the `memcached`. The supplied `memcached-tool` includes support for obtaining the Section 14.6.4.2, “`memcached` Slabs Statistics” and Section 14.6.4.1, “`memcached` General Statistics” information. For more information, see Section 14.6.4.6, “Using `memcached-tool`”.

Alternatively, most of the language API interfaces provide a function for obtaining the statistics from the server.

For example, to get the basic stats using `telnet`:

```
shell> telnet localhost 11211
Trying ::1...
Connected to localhost.
Escape character is '^]'.
stats
STAT pid 23599
STAT uptime 675
STAT time 1211439587
STAT version 1.2.5
STAT pointer_size 32
STAT rusage_user 1.404992
STAT rusage_system 4.694685
STAT curr_items 32
STAT total_items 56361
STAT bytes 2642
STAT curr_connections 53
STAT total_connections 438
STAT connection_structures 55
STAT cmd_get 113482
STAT cmd_set 80519
STAT get_hits 78926
STAT get_misses 34556
STAT evictions 0
STAT bytes_read 6379783
STAT bytes_written 4860179
STAT limit_maxbytes 67108864
STAT threads 1
END
```

When using Perl and the `Cache::Memcached` module, the `stats()` function returns information about all the servers currently configured in the connection object, and total statistics for all the `memcached` servers as a whole.

For example, the following Perl script obtains the stats and dumps the hash reference that is returned:

```
use Cache::Memcached;
use Data::Dumper;

my $memc = new Cache::Memcached;
$memc->set_servers(\@ARGV);

print Dumper($memc->stats());
```

When executed on the same `memcached` as used in the `Telnet` example above we get a hash reference with the host by host and total statistics:

```
$VAR1 = {
    'hosts' => {
           'localhost:11211' => {
                      'misc' => {
                            'bytes' => '2421',
                            'curr_connections' => '3',
                            'connection_structures' => '56',
                            'pointer_size' => '32',
                            'time' => '1211440166',
                            'total_items' => '410956',
                            'cmd_set' => '588167',
                            'bytes_written' => '35715151',
                            'evictions' => '0',
                            'curr_items' => '31',
                            'pid' => '23599',
                            'limit_maxbytes' => '67108864',
                            'uptime' => '1254',
                            'rusage_user' => '9.857805',
                            'cmd_get' => '838451',
                            'rusage_system' => '34.096988',
                            'version' => '1.2.5',
                            'get_hits' => '581511',
                            'bytes_read' => '46665716',
                            'threads' => '1',
                            'total_connections' => '3104',
                            'get_misses' => '256940'
                          },
                      'sizes' => {
                             '128' => '16',
                             '64' => '15'
                           }
                    }
         },
    'self' => {},
    'total' => {
           'cmd_get' => 838451,
           'bytes' => 2421,
           'get_hits' => 581511,
           'connection_structures' => 56,
           'bytes_read' => 46665716,
           'total_items' => 410956,
           'total_connections' => 3104,
           'cmd_set' => 588167,
           'bytes_written' => 35715151,
           'curr_items' => 31,
           'get_misses' => 256940
         }
        };
```

The statistics are divided up into a number of distinct sections, and then can be requested by adding the type to the `stats` command. Each statistics output is covered in more detail in the following sections.

- General statistics, see Section 14.6.4.1, "`memcached` General Statistics".
- Slab statistics (`slabs`), see Section 14.6.4.2, "`memcached` Slabs Statistics".
- Item statistics (`items`), see Section 14.6.4.3, "`memcached` Item Statistics".
- Size statistics (`sizes`), see Section 14.6.4.4, "`memcached` Size Statistics".
- Detailed status (`detail`), see Section 14.6.4.5, "`memcached` Detail Statistics".

14.6.4.1. `memcached` General Statistics

The output of the general statistics provides an overview of the performance and use of the `memcached` instance. The statistics returned by the command and their meaning is shown in the following table.

The following terms are used to define the value type for each statistics value:

- `32u`: 32-bit unsigned integer
- `64u`: 64-bit unsigned integer
- `32u32u`: Two 32-bit unsigned integers separated by a colon
- `String`: Character string

Statistic	**Data type**	**Description**	**Version**
pid	32u	Process ID of the `memcached` instance.	
uptime	32u	Uptime (in seconds) for this `memcached` instance.	
time	32u	Current time (as epoch).	
version	string	Version string of this instance.	
pointer_size	string	Size of pointers for this host specified in bits (32 or 64).	
rusage_user	32u:32u	Total user time for this instance (seconds:microseconds).	
rusage_system	32u:32u	Total system time for this instance (seconds:microseconds).	
curr_items	32u	Current number of items stored by this instance.	
total_items	32u	Total number of items stored during the life of this instance.	
bytes	64u	Current number of bytes used by this server to store items.	
curr_connections	32u	Current number of open connections.	
total_connections	32u	Total number of connections opened since the server started running.	
connection_structures	32u	Number of connection structures allocated by the server.	
cmd_get	64u	Total number of retrieval requests (`get` operations).	
cmd_set	64u	Total number of storage requests (`set` operations).	
get_hits	64u	Number of keys that have been requested and found present.	
get_misses	64u	Number of items that have been requested and not found.	
delete_hits	64u	Number of keys that have been deleted and found present.	1.3.x
delete_misses	64u	Number of items that have been delete and not found.	1.3.x
incr_hits	64u	Number of keys that have been incremented and found present.	1.3.x
incr_misses	64u	Number of items that have been incremented and not found.	1.3.x
decr_hits	64u	Number of keys that have been decremented and found present.	1.3.x
decr_misses	64u	Number of items that have been decremented and not found.	1.3.x
cas_hits	64u	Number of keys that have been compared and swapped and found present.	1.3.x
cas_misses	64u	Number of items that have been compared and swapped and not found.	1.3.x
cas_badvalue	64u	Number of keys that have been compared and swapped, but the comparison (original) value did not match the supplied value.	1.3.x
evictions	64u	Number of valid items removed from cache to free memory for new items.	
bytes_read	64u	Total number of bytes read by this server from network.	
bytes_written	64u	Total number of bytes sent by this server to network.	
limit_maxbytes	32u	Number of bytes this server is permitted to use for storage.	
threads	32u	Number of worker threads requested.	
conn_yields	64u	Number of yields for connections (related to the `-R` option).	1.4.0

The most useful statistics from those given here are the number of cache hits, misses, and evictions.

A large number of `get_misses` may just be an indication that the cache is still being populated with information. The number should, over time, decrease in comparison to the number of cache `get_hits`. If, however, you have a large number of cache misses compared to cache hits after an extended period of execution, it may be an indication that the size of the cache is too small and you either need to increase the total memory size, or increase the number of the `memcached` instances to improve the hit ratio.

A large number of `evictions` from the cache, particularly in comparison to the number of items stored is a sign that your cache is too small to hold the amount of information that you regularly want to keep cached. Instead of items being retained in the cache, items are being evicted to make way for new items keeping the turnover of items in the cache high, reducing the efficiency of the cache.

14.6.4.2. `memcached` Slabs Statistics

To get the `slabs` statistics, use the `stats slabs` command, or the API equivalent.

The slab statistics provide you with information about the slabs that have created and allocated for storing information within the cache. You get information both on each individual slab-class and total statistics for the whole slab.

```
STAT 1:chunk_size 104
STAT 1:chunks_per_page 10082
STAT 1:total_pages 1
STAT 1:total_chunks 10082
STAT 1:used_chunks 10081
STAT 1:free_chunks 1
STAT 1:free_chunks_end 10079
STAT 9:chunk_size 696
STAT 9:chunks_per_page 1506
STAT 9:total_pages 63
STAT 9:total_chunks 94878
STAT 9:used_chunks 94878
STAT 9:free_chunks 0
STAT 9:free_chunks_end 0
STAT active_slabs 2
STAT total_malloced 67083616
END
```

Individual stats for each slab class are prefixed with the slab ID. A unique ID is given to each allocated slab from the smallest size up to the largest. The prefix number indicates the slab class number in relation to the calculated chunk from the specified growth factor. Hence in the example, 1 is the first chunk size and 9 is the 9th chunk allocated size.

The different parameters returned for each chunk size and the totals are shown in the following table.

Statistic	**Description**	**Version**
chunk_size	Space allocated to each chunk within this slab class.	
chunks_per_page	Number of chunks within a single page for this slab class.	
total_pages	Number of pages allocated to this slab class.	
total_chunks	Number of chunks allocated to the slab class.	
used_chunks	Number of chunks allocated to an item..	
free_chunks	Number of chunks not yet allocated to items.	
free_chunks_end	Number of free chunks at the end of the last allocated page.	
get_hits	Number of get hits to this chunk	1.3.x
cmd_set	Number of set commands on this chunk	1.3.x
delete_hits	Number of delete hits to this chunk	1.3.x
incr_hits	Number of increment hits to this chunk	1.3.x
decr_hits	Number of decrement hits to this chunk	1.3.x
cas_hits	Number of CAS hits to this chunk	1.3.x
cas_badval	Number of CAS hits on this chunk where the existing value did not match	1.3.x
mem_requested	The true amount of memory of memory requested within this chunk	1.4.1

The following additional statistics cover the information for the entire server, rather than on a chunk by chunk basis:

Statistic	Description	Version
active_slabs	Total number of slab classes allocated.	
total_malloced	Total amount of memory allocated to slab pages.	

The key values in the slab statistics are the `chunk_size`, and the corresponding `total_chunks` and `used_chunks` parameters. These given an indication of the size usage of the chunks within the system. Remember that one key/value pair is placed into a chunk of a suitable size.

From these stats, you can get an idea of your size and chunk allocation and distribution. If you store many items with a number of largely different sizes, then you may want to adjust the chunk size growth factor to increase in larger steps to prevent chunk and memory wastage. A good indication of a bad growth factor is a high number of different slab classes, but with relatively few chunks actually in use within each slab. Increasing the growth factor creates fewer slab classes and therefore makes better use of the allocated pages.

14.6.4.3. `memcached` Item Statistics

To get the `items` statistics, use the `stats items` command, or the API equivalent.

The `items` statistics give information about the individual items allocated within a given slab class.

```
STAT items:2:number 1
STAT items:2:age 452
STAT items:2:evicted 0
STAT items:2:evicted_nonzero 0
STAT items:2:evicted_time 2
STAT items:2:outofmemory 0
STAT items:2:tailrepairs 0
...
STAT items:27:number 1
STAT items:27:age 452
STAT items:27:evicted 0
STAT items:27:evicted_nonzero 0
STAT items:27:evicted_time 2
STAT items:27:outofmemory 0
STAT items:27:tailrepairs 0
```

The prefix number against each statistics relates to the corresponding chunk size, as returned by the `stats slabs` statistics. The result is a display of the number of items stored within each chunk within each slab size, and specific statistics about their age, eviction counts, and out of memory counts. A summary of the statistics is given in the following table.

Statistic	Description	
`number`	The number of items currently stored in this slab class.	
`age`	The age of the oldest item within the slab class, in seconds.	
`evicted`	The number of items evicted to make way for new entries.	
`evicted_time`	The time of the last evicted entry	
`evicted_nonzero`	The time of the last evicted non-zero entry	1.4.0
`outofmemory`	The number of items for this slab class that have triggered an out of memory error (only value when the `-M` command line option is in effect).	
tailrepairs	Number of times the entries for a particular ID need repairing	

Item level statistics can be used to determine how many items are stored within a given slab and their freshness and recycle rate. You can use this to help identify whether there are certain slab classes that are triggering a much larger number of evictions that others.

14.6.4.4. `memcached` Size Statistics

To get size statistics, use the `stats sizes` command, or the API equivalent.

The size statistics provide information about the sizes and number of items of each size within the cache. The information is returned as two columns, the first column is the size of the item (rounded up to the nearest 32 byte boundary), and the second column is the count of the number of items of that size within the cache:

```
96 35
128 38
160 807
192 804
224 410
```

```
256 222
288 83
320 39
352 53
384 33
416 64
448 51
480 30
512 54
544 39
576 10065
```

> **Caution**
>
> Running this statistic locks up your cache as each item is read from the cache and its size calculated. On a large cache, this may take some time and prevent any set or get operations until the process completes.

The item size statistics are useful only to determine the sizes of the objects you are storing. Since the actual memory allocation is relevant only in terms of the chunk size and page size, the information is only useful during a careful debugging or diagnostic session.

14.6.4.5. `memcached` Detail Statistics

For `memcached` 1.3.x and higher, you can enable and obtain detailed statistics about the get, set, and del operations on theindividual keys stored in the cache, and determine whether the attempts hit (found) a particular key. These operations are only recorded while the detailed stats analysis is turned on.

To enable detailed statistics, you must send the `stats detail on` command to the `memcached` server:

```
$ telnet localhost 11211
Trying 127.0.0.1...
Connected to tiger.
Escape character is '^]'.
stats detail on
OK
```

Individual statistics are recorded for every `get`, `set` and `del` operation on a key, including keys that are not currently stored in the server. For example, if an attempt is made to obtain the value of key `abckey` and it does not exist, the `get` operating on the specified key are recorded while detailed statistics are in effect, even if the key is not currently stored. The `hits`, that is, the number of `get` or `del` operations for a key that exists in the server are also counted.

To turn detailed statistics off, send the `stats detail off` command to the `memcached` server:

```
$ telnet localhost 11211
Trying 127.0.0.1...
Connected to tiger.
Escape character is '^]'.
stats detail on
OK
```

To obtain the detailed statistics recorded during the process, send the `stats detail dump` command to the `memcached` server:

```
stats detail dump
PREFIX hykkey get 0 hit 0 set 1 del 0
PREFIX xyzkey get 0 hit 0 set 1 del 0
PREFIX yukkey get 1 hit 0 set 0 del 0
PREFIX abckey get 3 hit 3 set 1 del 0
END
```

You can use the detailed statistics information to determine whether your `memcached` clients are using a large number of keys that do not exist in the server by comparing the `hit` and `get` or `del` counts. Because the information is recorded by key, you can also determine whether the failures or operations are clustered around specific keys.

14.6.4.6. Using `memcached-tool`

The `memcached-tool`, located within the `scripts` directory within the `memcached` source directory. The tool provides convenient access to some reports and statistics from any `memcached` instance.

The basic format of the command is:

```
shell> ./memcached-tool hostname:port [command]
```

The default output produces a list of the slab allocations and usage. For example:

```
shell> memcached-tool localhost:11211 display
  #  Item_Size  Max_age   Pages   Count   Full?  Evicted Evict_Time OOM
  1      80B        93s       1      20      no        0        0    0
  2     104B        93s       1      16      no        0        0    0
  3     136B      1335s       1      28      no        0        0    0
  4     176B      1335s       1      24      no        0        0    0
  5     224B      1335s       1      32      no        0        0    0
  6     280B      1335s       1      34      no        0        0    0
  7     352B      1335s       1      36      no        0        0    0
  8     440B      1335s       1      46      no        0        0    0
  9     552B      1335s       1      58      no        0        0    0
 10     696B      1335s       1      66      no        0        0    0
 11     872B      1335s       1      89      no        0        0    0
 12     1.1K      1335s       1     112      no        0        0    0
 13     1.3K      1335s       1     145      no        0        0    0
 14     1.7K      1335s       1     123      no        0        0    0
 15     2.1K      1335s       1     198      no        0        0    0
 16     2.6K      1335s       1     199      no        0        0    0
 17     3.3K      1335s       1     229      no        0        0    0
 18     4.1K      1335s       1     248     yes       36        2    0
 19     5.2K      1335s       2     328      no        0        0    0
 20     6.4K      1335s       2     316     yes      387        1    0
 21     8.1K      1335s       3     381     yes      492        1    0
 22    10.1K      1335s       3     303     yes      598        2    0
 23    12.6K      1335s       5     405     yes      605        1    0
 24    15.8K      1335s       6     384     yes      766        2    0
 25    19.7K      1335s       7     357     yes      908      170    0
 26    24.6K      1336s       7     287     yes     1012        1    0
 27    30.8K      1336s       7     231     yes     1193      169    0
 28    38.5K      1336s       4     104     yes     1323      169    0
 29    48.1K      1336s       1      21     yes     1287        1    0
 30    60.2K      1336s       1      17     yes     1093      169    0
 31    75.2K      1337s       1      13     yes      713      168    0
 32    94.0K      1337s       1      10     yes      278      168    0
 33   117.5K      1336s       1       3      no        0        0    0
```

This output is the same if you specify the `command` as `display`:

```
shell> memcached-tool localhost:11211 display
  #  Item_Size  Max_age   Pages   Count   Full?  Evicted Evict_Time OOM
  1      80B        93s       1      20      no        0        0    0
  2     104B        93s       1      16      no        0        0    0
...
```

The output shows a summarized version of the output from the `slabs` statistics. The columns provided in the output are shown below:

- `#`: The slab number
- `Item_Size`: The size of the slab
- `Max_age`: The age of the oldest item in the slab
- `Pages`: The number of pages allocated to the slab
- `Count`: The number of items in this slab
- `Full?`: Whether the slab is fully populated
- `Evicted`: The number of objects evicted from this slab
- `Evict_Time`: The time (in seconds) since the last eviction
- `OOM`: The number of items that have triggered an out of memory error

You can also obtain a dump of the general statistics for the server using the `stats` command:

```
shell> memcached-tool localhost:11211 stats
#localhost:11211   Field       Value
         accepting_conns           1
                   bytes         162
              bytes_read         485
           bytes_written        6820
              cas_badval           0
                cas_hits           0
              cas_misses           0
               cmd_flush           0
                 cmd_get           4
                 cmd_set           2
             conn_yields           0
   connection_structures          11
        curr_connections          10
```

```
              curr_items           2
               decr_hits           0
             decr_misses           1
             delete_hits           0
           delete_misses           0
               evictions           0
                get_hits           4
              get_misses           0
               incr_hits           0
             incr_misses           2
          limit_maxbytes    67108864
     listen_disabled_num           0
                     pid       12981
            pointer_size          32
           rusage_system    0.013911
             rusage_user    0.011876
                 threads           4
                    time  1255518565
       total_connections          20
             total_items           2
                  uptime         880
                 version       1.4.2
```

The `memcached-tool` provides

14.6.5. `memcached` FAQ

Questions

- 15.6.5.1: Can MySQL actually trigger/store the changed data to memcached?
- 15.6.5.2: Can memcached be run on a Windows environment?
- 15.6.5.3: Does the `-L` flag automatically sense how much memory is being used by other memcached?
- 15.6.5.4: What is the max size of an object you can store in memcache and is that configurable?
- 15.6.5.5: Is it true `memcached` will be much more effective with db-read-intensive applications than with db-write-intensive applications?
- 15.6.5.6: `memcached` is fast - is there any overhead in not using persistent connections? If persistent is always recommended, what are the downsides (for example, locking up)?
- 15.6.5.7: How does an event such as a crash of one of the `memcached` servers handled by the `memcached` client?
- 15.6.5.8: What's a recommended hardware config for a memcached server? Linux or Windows?
- 15.6.5.9: Doing a direct telnet to the memcached port, is that just for that one machine, or does it magically apply across all nodes?
- 15.6.5.10: Is memcached more effective for video and audio as opposed to textual read/writes
- 15.6.5.11: If you log a complex class (with methods that do calculation etc) will the get from Memcache re-create the class on the way out?
- 15.6.5.12: If I have an object larger then a MB, do I have to manually split it or can I configure `memcached` to handle larger objects?
- 15.6.5.13: Can `memcached` work with `ASPX`?
- 15.6.5.14: Are there any, or are there any plans to introduce, a framework to hide the interaction of memcached from the application; that is, within hibernate?
- 15.6.5.15: So the responsibility lies with the application to populate and get records from the database as opposed to being a transparent cache layer for the db?
- 15.6.5.16: How does `memcached` compare to nCache?
- 15.6.5.17: We are caching XML by serialising using saveXML(), because PHP cannot serialize DOM objects; Some of the XML is variable and is modified per-request. Do you recommend caching then using XPath, or is it better to rebuild the DOM from separate node-groups?
- 15.6.5.18: How easy is it to introduce `memcached` to an existing enterprise application instead of inclusion at project design?
- 15.6.5.19: Do the memcache UDFs work under 5.1?

- 15.6.5.20: Is the data inside of `memcached` secure?
- 15.6.5.21: Is `memcached` typically a better solution for improving speed than MySQL Cluster and\or MySQL Proxy?
- 15.6.5.22: File socket support for `memcached` from the localhost use to the local memcached server?
- 15.6.5.23: How expensive is it to establish a memcache connection? Should those connections be pooled?
- 15.6.5.24: What are the advantages of using UDFs when the get/sets are manageable from within the client code rather than the db?
- 15.6.5.25: How will the data will be handled when the `memcached` server is down?
- 15.6.5.26: How are auto-increment columns in the MySQL database coordinated across multiple instances of memcached?
- 15.6.5.27: Is compression available?
- 15.6.5.28: What speed trade offs is there between `memcached` vs MySQL Query Cache? Where you check `memcached`, and get data from MySQL and put it in `memcached` or just make a query and results are put into MySQL Query Cache.
- 15.6.5.29: Can we implement different types of `memcached` as different nodes in the same server - so can there be deterministic and non deterministic in the same server?
- 15.6.5.30: What are best practices for testing an implementation, to ensure that it is an improvement over the MySQL query cache, and to measure the impact of `memcached` configuration changes? And would you recommend keeping the configuration very simple to start?

Questions and Answers

15.6.5.1: Can MySQL actually trigger/store the changed data to memcached?

Yes. You can use the MySQL UDFs for `memcached` and either write statements that directly set the values in the `memcached` server, or use triggers or stored procedures to do it for you. For more information, see Section 14.6.3.7, “Using the MySQL `memcached` UDFs”

15.6.5.2: Can memcached be run on a Windows environment?

No. Currently `memcached` is available only on the Unix/Linux platform. There is an unofficial port available, see http://www.codeplex.com/memcachedproviders.

15.6.5.3: Does the `-L` flag automatically sense how much memory is being used by other memcached?

No. There is no communication or sharing of information between `memcached` instances.

15.6.5.4: What is the max size of an object you can store in memcache and is that configurable?

The default maximum object size is 1MB. In `memcached` 1.4.2 and later you can change the maximum size of an object using the `-I` command line option.

For versions before this, to increase this size, you have to re-compile `memcached`. You can modify the value of the `POWER_BLOCK` within the `slabs.c` file within the source.

In `memcached` 1.4.2 and higher you can configure the maximum supported object size by using the `-I` command-line option. For example, to increase the maximum object size to 5MB:

```
$ memcached -I 5m
```

15.6.5.5: Is it true `memcached` will be much more effective with db-read-intensive applications than with db-write-intensive applications?

Yes. `memcached` plays no role in database writes, it is a method of caching data already read from the database in RAM.

15.6.5.6: `memcached` is fast - is there any overhead in not using persistent connections? If persistent is always recommended, what are the downsides (for example, locking up)?

If you don't use persistent connections when communicating with `memcached` then there will be a small increase in the latency of opening the connection each time. The effect is comparable to use nonpersistent connections with MySQL.

In general, the chance of locking or other issues with persistent connections is minimal, because there is very little locking within `memcached`. If there is a problem then eventually your request will timeout and return no result so your application will need to load from MySQL again.

15.6.5.7: How does an event such as a crash of one of the `memcached` servers handled by the `memcached` client?

There is no automatic handling of this. If your client fails to get a response from a server then it should fall back to loading the data from the MySQL database.

The client APIs all provide the ability to add and remove `memcached` instances on the fly. If within your application you notice that `memcached` server is no longer responding, your can remove the server from the list of servers, and keys will automatically be redistributed to another `memcached` server in the list. If retaining the cache content on all your servers is important, make sure you use an API that supports a consistent hashing algorithm. For more information, see Section 14.6.2.4, "`memcached` Hashing/Distribution Types".

15.6.5.8: What's a recommended hardware config for a memcached server? Linux or Windows?

`memcached` is only available on Unix/Linux, so using a Windows machine is not an option. Outside of this, `memcached` has a very low processing overhead. All that is required is spare physical RAM capacity. The point is not that you should necessarily deploy a dedicated `memcached` server. If you have web, application, or database servers that have spare RAM capacity, then use them with `memcached`.

If you want to build and deploy a dedicated `memcached` servers, then you use a relatively low-power CPU, lots of RAM and one or more Gigabit Ethernet interfaces.

15.6.5.9: Doing a direct telnet to the memcached port, is that just for that one machine, or does it magically apply across all nodes?

Just one. There is no communication between different instances of `memcached`, even if each instance is running on the same machine.

15.6.5.10: Is memcached more effective for video and audio as opposed to textual read/writes

`memcached` doesn't care what information you are storing. To `memcached`, any value you store is just a stream of data. Remember, though, that the maximum size of an object you can store in `memcached` is 1MB, but can be configured to be larger by using the `-I` option in `memcached` 1.4.2 and later, or by modifying the source in versions before 1.4.2. If you plan on using `memcached` with audio and video content you will probably want to increase the maximum object size. Also remember that `memcached` is a solution for caching information for reading. It shouldn't be used for writes, except when updating the information in the cache.

15.6.5.11: If you log a complex class (with methods that do calculation etc) will the get from Memcache re-create the class on the way out?

In general, yes. If the serialization method within the API/language that you are using supports it, then methods and other information will be stored and retrieved.

15.6.5.12: If I have an object larger then a MB, do I have to manually split it or can I configure `memcached` to handle larger objects?

You would have to manually split it. `memcached` is very simple, you give it a key and some data, it tries to cache it in RAM. If you try to store more than the default maximum size, the value is just truncated for speed reasons.

15.6.5.13: Can `memcached` work with `ASPX`?

There are ports and interfaces for many languages and environments. ASPX relies on an underlying language such as C# or VisualBasic, and if you are using ASP.NET then there is a C# `memcached` library. For more information, see .

15.6.5.14: Are there any, or are there any plans to introduce, a framework to hide the interaction of memcached from the application; that is, within hibernate?

There are lots of projects working with `memcached`. There is a Google Code implementation of Hibernate and `memcached` working together. See http://code.google.com/p/hibernate-memcached/.

15.6.5.15: So the responsibility lies with the application to populate and get records from the database as opposed to being a transparent cache layer for the db?

Yes. You load the data from the database and write it into the cache provided by `memcached`. Using `memcached` as a simple database row cache, however, is probably inefficient. The best way to use `memcached` is to load all of the information from the database relating to a particular object, and then cache the entire object. For example, in a blogging environment, you might load the blog, associated comments, categories and so on, and then cache all of the information relating to that blog post. The reading of the data from the database will require multiple SQL statements and probably multiple rows of data to complete, which is time consuming. Loading the entire blog post and the associated information from `memcached` is just one operation and doesn't involve using the disk or parsing the SQL statement.

15.6.5.16: How does `memcached` compare to nCache?

The main benefit of `memcached` is that is very easy to deploy and works with a wide range of languages and environments, including .NET, Java, Perl, Python, PHP, even MySQL. `memcached` is also very lightweight in terms of systems and requirements, and you can easily add as many or as few `memcached` servers as you need without changing the individual configuration. `memcached` does require additional modifications to the application to take advantage of functionality such as multiple `memcached` servers.

15.6.5.17: We are caching XML by serialising using saveXML(), because PHP cannot serialize DOM objects; Some of the XML is variable and is modified per-request. Do you recommend caching then using XPath, or is it better to rebuild the DOM from separate node-groups?

You would need to test your application using the different methods to determine this information. You may find that the default serialization within PHP may allow you to store DOM objects directly into the cache.

15.6.5.18: How easy is it to introduce `memcached` to an existing enterprise application instead of inclusion at project design?

In general, it is very easy. In many languages and environments the changes to the application will be just a few lines, first to attempt to read from the cache when loading data and then fall back to the old method, and to update the cache with information once the data has been read.

`memcached` is designed to be deployed very easily, and you shouldn't require significant architectural changes to your application to use `memcached`.

15.6.5.19: Do the memcache UDFs work under 5.1?

Yes.

15.6.5.20: Is the data inside of `memcached` secure?

No, there is no security required to access or update the information within a `memcached` instance, which means that anybody with access to the machine has the ability to read, view and potentially update the information. If you want to keep the data secure, you can encrypt and decrypt the information before storing it. If you want to restrict the users capable of connecting to the server, your only choice is to either disable network access, or use IPTables or similar to restrict access to the `memcached` ports to a select set of hosts.

15.6.5.21: Is `memcached` typically a better solution for improving speed than MySQL Cluster and\or MySQL Proxy?

Both MySQL Cluster and MySQL Proxy still require access to the underlying database to retrieve the information. This implies both a parsing overhead for the statement and, often, disk based access to retrieve the data you have selected.

The advantage of `memcached` is that you can store entire objects or groups of information that may require multiple SQL statements to obtain. Restoring the result of 20 SQL statements formatted into a structure that your application can use directly without requiring any additional processing is always going to be faster than building that structure by loading the rows from a database.

15.6.5.22: File socket support for `memcached` from the localhost use to the local memcached server?

You can use the `-s` option to `memcached` to specify the location of a file socket. This automatically disables network support.

15.6.5.23: How expensive is it to establish a memcache connection? Should those connections be pooled?

Opening the connection is relatively inexpensive, because there is no security, authentication or other handshake taking place before you can start sending requests and getting results. Most APIs support a persistent connection to a `memcached` instance to reduce the latency. Connection pooling would depend on the API you are using, but if you are communicating directly over TCP/IP, then connection pooling would provide some small performance benefit.

15.6.5.24: What are the advantages of using UDFs when the get/sets are manageable from within the client code rather than the db?

Sometimes you want to be able to be able to update the information within `memcached` based on a generic database activity, rather than relying on your client code. For example, you may want to update status or counter information in `memcached` through the use of a trigger or stored procedure. For some situations and applications the existing use of a stored procedure for some operations means that updating the value in `memcached` from the database is easier than separately loading and communicating that data to the client just so the client can talk to `memcached.`

In other situations, when you are using a number of different clients and different APIs, you don't want to have to write (and maintain) the code required to update `memcached` in all the environments. Instead, you do this from within the database and the client never gets involved.

15.6.5.25: How will the data will be handled when the `memcached` server is down?

The behavior is entirely application dependent. Most applications will fall back to loading the data from the database (just as if they were updating the `memcached`) information. If you are using multiple `memcached` servers, you may also want to remove a server from the list to prevent the missing server affecting performance. This is because the client will still attempt to communicate the `memcached` that corresponds to the key you are trying to load.

15.6.5.26: How are auto-increment columns in the MySQL database coordinated across multiple instances of memcached?

They aren't. There is no relationship between MySQL and `memcached` unless your application (or, if you are using the MySQL UDFs for `memcached`, your database definition) creates one.

If you are storing information based on an auto-increment key into multiple instances of `memcached` then the information will only be stored on one of the `memcached` instances anyway. The client uses the key value to determine which `memcached` instance to store the information, it doesn't store the same information across all the instances, as that would be a waste of cache memory.

15.6.5.27: Is compression available?

Yes. Most of the client APIs support some sort of compression, and some even allow you to specify the threshold at which a value is deemed appropriate for compression during storage.

15.6.5.28: What speed trade offs is there between `memcached` vs MySQL Query Cache? Where you check `memcached`, and get data from MySQL and put it in `memcached` or just make a query and results are put into MySQL Query Cache.

In general, the time difference between getting data from the MySQL Query Cache and getting the exact same data from `memcached` is very small.

However, the benefit of `memcached` is that you can store any information, including the formatted and processed results of many queries into a single `memcached` key. Even if all the queries that you executed could be retrieved from the Query Cache without having to go to disk, you would still be running multiple queries (with network and other overhead) compared to just one for the `memcached` equivalent. If your application uses objects, or does any kind of processing on the information, with `memcached` you can store the post-processed version, so the data you load is immediately available to be used. With data loaded from the Query Cache, you would still have to do that processing.

In addition to these considerations, keep in mind that keeping data in the MySQL Query Cache is difficult as you have no control over the queries that are stored. This means that a slightly unusual query can temporarily clear a frequently used (and normally cached) query, reducing the effectiveness of your Query Cache. With `memcached` you can specify which objects are stored, when they are stored, and when they should be deleted giving you much more control over the information stored in the cache.

15.6.5.29: Can we implement different types of `memcached` as different nodes in the same server - so can there be deterministic and non deterministic in the same server?

Yes. You can run multiple instances of `memcached` on a single server, and in your client configuration you choose the list of servers you want to use.

15.6.5.30: What are best practices for testing an implementation, to ensure that it is an improvement over the MySQL query cache, and to measure the impact of `memcached` configuration changes? And would you recommend keeping the configuration very simple to start?

The best way to test the performance is to start up a `memcached` instance. First, modify your application so that it stores the data just before the data is about to be used or displayed into `memcached`.Since the APIs handle the serialization of the data, it should just be a one line modification to your code. Then, modify the start of the process that would normally load that information from MySQL with the code that requests the data from `memcached`. If the data cannot be loaded from `memcached`, default to the MySQL process.

All of the changes required will probably amount to just a few lines of code. To get the best benefit, make sure you cache entire objects (for example, all the components of a web page, blog post, discussion thread, etc.), rather than using `memcached` as a simple cache of individuals rows of MySQL tables. You should see performance benefits almost immediately.

Keeping the configuration very simple at the start, or even over the long term, is very easy with `memcached`. Once you have the basic structure up and running, the only change you may want to make is to add more servers into the list of servers used by your clients. You don't need to manage the `memcached` servers, and there is no complex configuration, just add more servers to the list and let the client API and the `memcached` servers make the decisions.

14.7. MySQL Proxy

The MySQL Proxy is an application that communicates over the network using the MySQL network protocol and provides communication between one or more MySQL servers and one or more MySQL clients. In the most basic configuration, MySQL Proxy simply interposes itself between the server and clients, passing queries from the clients to the MySQL Server and returning the responses from the MySQL Server to the appropriate client.

Because MySQL Proxy uses the MySQL network protocol, it can be used without modification with any MySQL-compatible client that uses the protocol. This includes the `mysql` command-line client, any clients that uses the MySQL client libraries, and any connector that supports the MySQL network protocol.

In addition to the basic pass-through configuration, the MySQL Proxy is also capable of monitoring and altering the communication between the client and the server. Query interception enables you to add profiling, and interception of the exchanges is scriptable using the Lua scripting language.

By intercepting the queries from the client, the proxy can insert additional queries into the list of queries sent to the server, and remove the additional results when they are returned by the server. Using this functionality you can return the results from the original query to the client while adding informational statements to each query, for example, to monitor their execution time or progress, and separately log the results.

The proxy enables you to perform additional monitoring, filtering, or manipulation of queries without requiring you to make any modifications to the client and without the client even being aware that it is communicating with anything but a genuine MySQL server.

This documentation covers MySQL Proxy 0.8.0.

> **Warning**
>
> MySQL Proxy is currently an Alpha release and should not be used within production environments.

> **Important**
>
> MySQL Proxy is compatible with MySQL 5.0 or later. Testing has not been performed with Version 4.1. Please provide feedback on your experiences using the MySQL Proxy Forum.

14.7.1. MySQL Proxy Supported Platforms

MySQL Proxy is currently available as a precompiled binary for the following platforms:

- Linux (including Red Hat, Fedora, Debian, SuSE) and derivatives
- Mac OS X
- FreeBSD
- IBM AIX
- Sun Solaris
- Microsoft Windows (including Microsoft Windows XP, Microsoft Windows Vista, Microsoft Windows Server 2003, Microsoft Windows Server 2008)

  > **Note**
  >
  > You must have the .NET Framework 1.1 or higher installed.

Other Unix/Linux platforms not listed should be compatible by using the source package and building MySQL Proxy locally.

System requirements for the MySQL Proxy application are the same as the main MySQL server. Currently MySQL Proxy is compatible only with MySQL 5.0.1 and later. MySQL Proxy is provided as a standalone, statically linked binary. You need not have MySQL or Lua installed.

14.7.2. Installing MySQL Proxy

You have three choices for installing MySQL Proxy:

- Precompiled binaries are available for a number of different platforms. See Section 14.7.2.1, “Installing MySQL Proxy from a Binary Distribution”.
- You can install from the source code if you want to build on an environment not supported by the binary distributions. See Section 14.7.2.2, “Installing MySQL Proxy from a Source Distribution”.
- The latest version of the MySQL Proxy source code is available through a development repository is the best way to stay up to date with the latest fixes and revisions. See Section 14.7.2.3, “Installing MySQL Proxy from the Bazaar Repository”.

14.7.2.1. Installing MySQL Proxy from a Binary Distribution

If you download a binary package, you must extract and copy the package contents to your desired installation directory. The package contains files required by MySQL Proxy, including additional Lua scripts and other components required for execution.

To install, unpack the archive into the desired directory, then modify your `PATH` environment variable so that you can use the `mysql-proxy` command directly:

```
shell> cd /usr/local
shell> tar zxf mysql-proxy-0.7.2-osx10.5.tar.gz
shell> PATH=$PATH:/usr/local/mysql-proxy-0.7.2-osx10.5-x86/sbin
```

If you want to update the path globally on a system, you may need administrator privileges to modify the appropriate `/etc/profile`, `/etc/bashrc`, or other system configuration file.

On Windows, you can update the `PATH` environment variable using this procedure:

1. On the Windows desktop, right-click the My Computer icon, and select Properties.
2. Next select the Advanced tab from the System Properties menu that appears, and click the Environment Variables button.
3. Under **System Variables**, select Path, then click the Edit button. The Edit System Variable dialogue should appear.

The Microsoft Visual C++ runtime libraries are a requirement for running MySQL Proxy as of version 0.8.2. Users that do not have these libraries must download and install the Microsoft Visual C++ 2008 Service Pack 1 Redistributable Package MFC Security Update. Use the following link to obtain the package:

```
http://www.microsoft.com/download/en/details.aspx?displaylang=en&id=26368
```

14.7.2.2. Installing MySQL Proxy from a Source Distribution

If you download a source package, you must compile the MySQL Proxy before using it. A build from source requires that the following prerequisite components be installed:

- `libevent` 1.x or higher (1.3b or later is preferred)
- `lua` 5.1.x or higher
- `glib2` 2.6.0 or higher
- `pkg-config`
- `libtool` 1.5 or higher
- MySQL 5.0.x or higher developer files

> **Note**
>
> On some operating systems you may need to manually build the required components to get the latest version. If you have trouble compiling MySQL Proxy, consider using a binary distributions instead.

After you have verified that the prerequisite components are installed, configure and build MySQL Proxy:

```
shell> tar zxf mysql-proxy-0.7.2.tar.gz
shell> cd mysql-proxy-0.7.2
shell> ./configure
shell> make
```

If you want to test the build, use the `check` target to `make`:

```
shell> make check
```

The tests try to connect to `localhost` using the `root` user. If you need to provide a password, set the `MYSQL_PASSWORD` environment variable:

```
shell> MYSQL_PASSWORD=root_pwd make check
```

You can install using the `install` target:

```
shell> make install
```

By default, `mysql-proxy` is installed into `/usr/local/sbin/mysql-proxy`. The Lua example scripts are installed into `/usr/local/share`.

14.7.2.3. Installing MySQL Proxy from the Bazaar Repository

The MySQL Proxy source is available through a public Bazaar repository and is the quickest way to get the latest releases and fixes.

A build from the Bazaar repository requires that the following prerequisite components be installed:

- Bazaar 1.10.0 or later
- `libtool` 1.5 or higher
- `autoconf` 2.56 or higher
- `automake` 1.10 or higher
- `libevent` 1.x or higher (1.3b or later is preferred)
- `lua` 5.1.x or higher
- `glib2` 2.4.0 or higher
- `pkg-config`
- MySQL 5.0.x or higher developer files

The `mysql-proxy` source is hosted on Launchpad. To check out a local copy of the Bazaar repository, use `bzr`:

```
shell> bzr branch lp:mysql-proxy
```

The preceding command downloads a complete version of the Bazaar repository for `mysql-proxy`. The main source files are located within the `trunk` subdirectory. The configuration scripts must be generated before you can configure and build `mysql-proxy`. The `autogen.sh` script generates the required configuration scripts for you:

```
shell> sh ./autogen.sh
```

The `autogen.sh` script creates the standard `configure` script, which you then use to configure and build with `make`:

```
shell> ./configure
shell> make
shell> make install
```

If you want to create a standalone source distribution, identical to the source distribution available for download, use this command:

```
shell> make distcheck
```

The preceding command creates the file `mysql-proxy-0.7.2.tar.gz` (with the corresponding current version) within the current directory.

14.7.2.4. Setting Up MySQL Proxy as a Windows Service

The MySQL distribution on Windows includes the `mysql-proxy-svc.exe` command that enables a MySQL Proxy instance to be managed by the Windows service control manager. This enables you to control the service without separately running the MySQL Proxy application, and allows for automatically starting and stopping the MySQL Proxy service during boot, reboot and shutdown.

To set up a MySQL Proxy service, you must use the `sc` command to create a new service using the MySQL Proxy service command. Specify the MySQL Proxy options on the `sc` command line, and identify the service with a unique name. For example, to configure a new MySQL Proxy instance that will automatically start when your system boots, redirecting queries to the local

MySQL server:

```
C:\> sc create "Proxy" DisplayName= "MySQL Proxy" start= "auto" »
  binPath= "C:\Program Files\MySQL\mysql-proxy-0.8.0\bin\mysql-proxy-svc.exe »
  --proxy-backend-addresses=127.0.0.1:3306"
```

> **Note**
>
> The space following the equal sign after each property is required; failure to include it results in an error.

The preceding command creates a new service called `Proxy`. You can start and stop the service using the `net start|stop` command with the service name. The service is not automatically started after it has been created. To start the service:

```
C:\> net start proxy
The MySQL Proxy service is starting.
The MySQL Proxy service was started successfully.
```

You can specify any additional command-line options you need to the `sc` command. You can also set up multiple MySQL Proxy services on the same machine (providing they are configured to listen on different ports and/or IP addresses.

You can delete a service that you have created:

```
C:\> sc delete proxy
```

For more information on creating services using `sc`, see How to create a Windows service by using Sc.exe.

14.7.3. MySQL Proxy Command Options

To start MySQL Proxy, you can run it directly from the command line:

```
shell> mysql-proxy
```

However, for most situations you will want to specify at the very least the host name or address and the port number of the backend MySQL server to which the MySQL Proxy should pass queries.

You can specify options to `mysql-proxy` either on the command line, or by using a configuration file and the `--defaults-file` command-line option to specify the file location.

If you use a configuration file, it should be formatted as follows:

- Options must be specified within a `[mysql-proxy]` configuration group. For example:

  ```
  [mysql-proxy]
  admin-address = host:port
  ```

- All configuration options should be specified in the form of a configuration name and the value you want to set.
- For options that are a simple toggle on the command line (for example, `--proxy-skip-profiling`), you must use `true` or `false`. For example, the following is invalid:

  ```
  [mysql-proxy]
  proxy-skip-profiling
  ```

  But this is valid:

  ```
  [mysql-proxy]
  proxy-skip-profiling = true
  ```

- The configuration file should have permissions of `0660` (readable and writable by user and group, no access for others).

Failure to adhere to any of these requirements causes `mysql-proxy` to generate an error during startup.

The following tables list the supported configuration file and command-line options.

Table 14.3. `mysql-proxy` Help Options

Format	Option File	Description	Introduction	Deprecated	Removed
--help	help	Show help options			
--help-admin	help-admin	Show admin module options			
--help-all	help-all	Show all help options			
--help-proxy	help-proxy	Show proxy module options			

Table 14.4. `mysql-proxy` Admin Options

Format	Option File	Description	Introduction	Deprecated	Removed
--admin-address=host:port	admin-address=host:port	The admin module listening host and port			
--admin-lua-script=file_name	admin-lua-script=file_name	Script to execute by the admin module			
--admin-password=password	admin-password=password	Authentication password for admin module			
--admin-username=user_name	admin-username=user_name	Authentication user name for admin module			
--proxy-address=host:port	proxy-address=host:port	The listening proxy server host and port			

Table 14.5. `mysql-proxy` Proxy Options

Format	Option File	Description	Introduction	Deprecated	Removed
--no-proxy	no-proxy	Do not start the proxy module			
--proxy-backend-addresses=host:port	proxy-backend-addresses=host:port	The MySQL server host and port			
--proxy-fix-bug-25371	proxy-fix-bug-25371	Enable the fix for Bug #25371 for older libmysql versions			0.8.1
--proxy-lua-script=file_name	proxy-lua-script=file_name	Filename for Lua script for proxy operations			
--proxy-pool-no-change-user	proxy-pool-no-change-user	Do not use the protocol CHANGE_USER command to reset the connection when coming from the connection pool			
--proxy-	proxy-read-only-	The MySQL server host and port (read only)			

Format	Option File	Description	Introduction	Deprecated	Removed
read-only-backend-addresses=host:port	backend-addresses=host:port				
--proxy-skip-profiling	proxy-skip-profiling	Disable query profiling			

Table 14.6. `mysql-proxy` Applications Options

Format	Option File	Description	Introduction	Deprecated	Removed
--basedir=dir_name	basedir=dir_name	The base directory prefix for paths in the configuration			
--daemon	daemon	Start in daemon mode			
--defaults-file=file_name		The configuration file to use			
--event-threads=count	event-threads=count	The number of event-handling threads			
--keepalive	keepalive	Try to restart the proxy if a crash occurs			
--log-backtrace-on-crash	log-backtrace-on-crash	Try to invoke the debugger and generate a backtrace on crash			
--log-file=file_name	log-file=file_name	The file where error messages are logged			
--log-level=level	log-level=level	The logging level			
--log-use-syslog	log-use-syslog	Log errors to syslog			
--lua-cpath=dir_name	lua-cpath=dir_name	Set the LUA_CPATH			
--lua-path=dir_name	lua-path=dir_name	Set the LUA_PATH			
--max-open-files=count	max-open-files=count	The maximum number of open files to support			
--pid-file=file_name	pid-file=file_name	File in which to store the process ID			
--plugin-dir=dir_name	plugin-dir=dir_name	Directory containing plugin files			
--plugins=plugin,...	plugins=plugin,...	List of plugins to load			
--user=user_name	user=user_name	The user to use when running mysql-proxy			

Format	Option File	Description	Introduction	Deprecated	Removed
--version	version	Show version information			

Except as noted in the following details, all of the options can be used within the configuration file by supplying the option and the corresponding value. For example:

```
[mysql-proxy]
log-file = /var/log/mysql-proxy.log
log-level = message
```

- `--help`, `-h`

Command-Line Format	`--help`
	`-h`
Option-File Format	`help`

  Show available help options.

- `--help-admin`

Command-Line Format	`--help-admin`
Option-File Format	`help-admin`

  Show options for the admin module.

- `--help-all`

Command-Line Format	`--help-all`
Option-File Format	`help-all`

  Show all help options.

- `--help-proxy`

Command-Line Format	`--help-proxy`
Option-File Format	`help-proxy`

  Show options for the proxy module.

- `--admin-address=`*`host:port`*

Command-Line Format	`--admin-address=host:port`	
Option-File Format	`admin-address=host:port`	
	Permitted Values	
	Type	`string`
	Default	`:4041`

  The host name (or IP address) and port for the administration port. The default is `localhost:4041`.

- `--admin-lua-script=`*`file_name`*

Command-Line Format	`--admin-lua-script=file_name`
Option-File Format	`admin-lua-script=file_name`

	Permitted Values	
	Type	`file name`
	Default	

The script to use for the proxy administration module.

- `--admin-password=`*`password`*

Command-Line Format	`--admin-password=password`	
Option-File Format	`admin-password=password`	
	Permitted Values	
	Type	`string`
	Default	

The password to use to authenticate users wanting to connect to the MySQL Proxy administration module. This module uses the MySQL protocol to request a user name and password for connections.

- `--admin-username=`*`user_name`*

Command-Line Format	`--admin-username=user_name`	
Option-File Format	`admin-username=user_name`	
	Permitted Values	
	Type	`string`
	Default	`root`

The user name to use to authenticate users wanting to connect to the MySQL Proxy administration module. This module uses the MySQL protocol to request a user name and password for connections. The default user name is `root`.

- `--basedir=`*`dir_name`*

Command-Line Format	`--basedir=dir_name`	
Option-File Format	`basedir=dir_name`	
	Permitted Values	
	Type	`directory name`

The base directory to use as a prefix for all other file name configuration options. The base name should be an absolute (not relative) directory. If you specify a relative directory, `mysql-proxy` generates an error during startup.

- `--daemon`

Command-Line Format	`--daemon`
Option-File Format	`daemon`

Starts the proxy in daemon mode.

- `--defaults-file=`*`file_name`*

Command-Line Format	`--defaults-file=file_name`

The file to read for configuration options. If not specified, MySQL Proxy takes options only from the command line.

- `--event-threads=`*`count`*

Command-Line Format	`--event-threads=count`
Option-File Format	`event-threads=count`

	Permitted Values	
	Type	`numeric`
	Default	`1`

The number of event threads to reserve to handle incoming requests.

- `--keepalive`

Command-Line Format	`--keepalive`
Option-File Format	`keepalive`

Create a process surrounding the main `mysql-proxy` process that attempts to restart the main `mysql-proxy` process in the event of a crash or other failure.

> **Note**
>
> The `--keepalive` option is not available on Microsoft Windows. When running as a service, `mysql-proxy` automatically restarts.

- `--log-backtrace-on-crash`

Command-Line Format	`--log-backtrace-on-crash`
Option-File Format	`log-backtrace-on-crash`

Log a backtrace to the error log and try to initialize the debugger in the event of a failure.

- `--log-file=`*`file_name`*

Command-Line Format	`--log-file=file_name`	
Option-File Format	`log-file=file_name`	
	Permitted Values	
	Type	`file name`

The file to use to record log information. If this option is not given, `mysql-proxy` logs to the standard error output.

- `--log-level=`*`level`*

Command-Line Format	`--log-level=level`	
Option-File Format	`log-level=level`	
	Permitted Values	
	Type	`enumeration`

	Valid Values	`error`
		`warning`
		`info`
		`message`
		`debug`

The log level to use when outputting error messages. Messages with that level (or lower) are output. For example, `message` level also outputs message with `info`, `warning`, and `error` levels.

- `--log-use-syslog`

Command-Line Format	`--log-use-syslog`

Option-File Format	`log-use-syslog`

Log errors to the syslog (Unix/Linux only).

- `--lua-cpath=`*`dir_name`*

Command-Line Format	`--lua-cpath=dir_name`	
Option-File Format	`lua-cpath=dir_name`	
	Permitted Values	
	Type	`directory name`

The `LUA_CPATH` to use when loading compiled modules or libraries for Lua scripts.

- `--lua-path=`*`dir_name`*

Command-Line Format	`--lua-path=dir_name`	
Option-File Format	`lua-path=dir_name`	
	Permitted Values	
	Type	`directory name`

The `LUA_CPATH` to use when loading modules for Lua.

- `--max-open-files=`*`count`*

Command-Line Format	`--max-open-files=count`	
Option-File Format	`max-open-files=count`	
	Permitted Values	
	Type	`numeric`

The maximum number of open files and sockets supported by the `mysql-proxy` process. You may need to increase this with certain scripts.

- `--no-proxy`

Command-Line Format	`--no-proxy`
Option-File Format	`no-proxy`

Disable the proxy module.

- `--plugin-dir=`*`dir_name`*

Command-Line Format	`--plugin-dir=dir_name`	
Option-File Format	`plugin-dir=dir_name`	
	Permitted Values	
	Type	`directory name`

The directory to use when loading plugins for `mysql-proxy`.

- `--plugins=`*`plugin,...`*

Command-Line Format	`--plugins=plugin,...`	
Option-File Format	`plugins=plugin,...`	
	Permitted Values	
	Type	`string`

A comma-separated list of plugins to load.

- `--proxy-address=host:port`, `-P host:port`

Command-Line Format	`--proxy-address=host:port`	
	`-P host:port`	
Option-File Format	`proxy-address=host:port`	
	Permitted Values	
	Type	`string`
	Default	`:4040`

The listening host name (or IP address) and port of the proxy server. The default is `:4040` (all IPs on port 4040).

- `--proxy-read-only-backend-addresses=host:port`, `-r host:port`

Command-Line Format	`--proxy-read-only-backend-addresses=host:port`	
	`-r host:port`	
Option-File Format	`proxy-read-only-backend-addresses=host:port`	
	Permitted Values	
	Type	`string`

The listening host name (or IP address) and port of the proxy server for read-only connections. The default is for this information not to be set.

> ### Note
>
> Setting this value only configures the servers within the corresponding internal structure (see `proxy.global.backends`). You can determine the backend type by checking the `type` field for each connection.
>
> You should therefore only use this option in combination with a script designed to make use of the different backend types.

When using this option on the command line, you can specify the option and the server multiple times to specify multiple backends. For example:

```
shell> mysql-proxy --proxy-read-only-backend-addresses 192.168.0.1:3306 --proxy-read-only-backend-addresses 192.168
```

When using the option within the configuration file, you should separate multiple servers by commas. The equivalent of the preceding example would be:

```
...
proxy-read-only-backend-addresses = 192.168.0.1:3306,192.168.0.2:3306
```

- `--proxy-backend-addresses=host:port`, `-b host:port`

Command-Line Format	`--proxy-backend-addresses=host:port`	
	`-b host:port`	
Option-File Format	`proxy-backend-addresses=host:port`	
	Permitted Values	
	Type	`string`
	Default	`127.0.0.1:3306`

The host name (or IP address) and port of the MySQL server to connect to. You can specify multiple backend servers by supplying multiple options. Clients are connected to each backend server in round-robin fashion. For example, if you specify two servers A and B, the first client connection will go to server A; the second client connection to server B and the third client connection to server A.

When using this option on the command line, you can specify the option and the server multiple times to specify multiple backends. For example:

```
shell> mysql-proxy --proxy-backend-addresses 192.168.0.1:3306 --proxy-backend-addresses 192.168.0.2:3306
```

When using the option within the configuration file, you should separate multiple servers by commas. The equivalent of the preceding example would be:

```
...
proxy-backend-addresses = 192.168.0.1:3306,192.168.0.2:3306
```

- `--proxy-pool-no-change-user`

Command-Line Format	`--proxy-pool-no-change-user`
Option-File Format	`proxy-pool-no-change-user`

Disable use of the MySQL protocol `CHANGE_USER` command when reusing a connection from the pool of connections specified by the `proxy-backend-addresses` list.

- `--proxy-skip-profiling`

Command-Line Format	`--proxy-skip-profiling`
Option-File Format	`proxy-skip-profiling`

Disable query profiling (statistics time tracking). The default is for tracking to be enabled.

- `--proxy-fix-bug-25371`

Version Removed	0.8.1
Command-Line Format	`--proxy-fix-bug-25371`
Option-File Format	`proxy-fix-bug-25371`

Enable a workaround for an issue when connecting to a MySQL server later than 5.1.12 when using a MySQL client library of any earlier version.

This option was removed in `mysql-proxy` 0.8.1. Now, `mysql-proxy` returns an error message at the protocol level if it sees a `COM_CHANGE_USER` being sent to a server that has a version from 5.1.14 to 5.1.17.

- `--proxy-lua-script=`*`file_name`*, `-s `*`file_name`*

Command-Line Format	`--proxy-lua-script=file_name`	
	`-s file_name`	
Option-File Format	`proxy-lua-script=file_name`	
	Permitted Values	
	Type	`file name`

The Lua script file to be loaded. Note that the script file is not physically loaded and parsed until a connection is made. Also note that the specified Lua script is reloaded for each connection; if the content of the Lua script changes while `mysql-proxy` is running, the updated content is automatically used when a new connection is made.

- `--pid-file=`*`file_name`*

Command-Line Format	`--pid-file=file_name`	
Option-File Format	`pid-file=file_name`	
	Permitted Values	
	Type	`file name`

The name of the file in which to store the process ID.

- `--user=user_name`

Command-Line Format	`--user=user_name`	
Option-File Format	`user=user_name`	
	Permitted Values	
	Type	`string`

  Run `mysql-proxy` as the specified `user`.

- `--version`, `-V`

Command-Line Format	`--version`
	`-V`
Option-File Format	`version`

  Show the version number.

The most common usage is as a simple proxy service (that is, without additional scripting). For basic proxy operation, you must specify at least one `proxy-backend-addresses` option to specify the MySQL server to connect to by default:

```
shell> mysql-proxy --proxy-backend-addresses=MySQL.example.com:3306
```

The default proxy port is `4040`, so you can connect to your MySQL server through the proxy by specifying the host name and port details:

```
shell> mysql --host=localhost --port=4040
```

If your server requires authentication information, this will be passed through natively without alteration by `mysql-proxy`, so you must also specify the required authentication information:

```
shell> mysql --host=localhost --port=4040 \
   --user=user_name --password=password
```

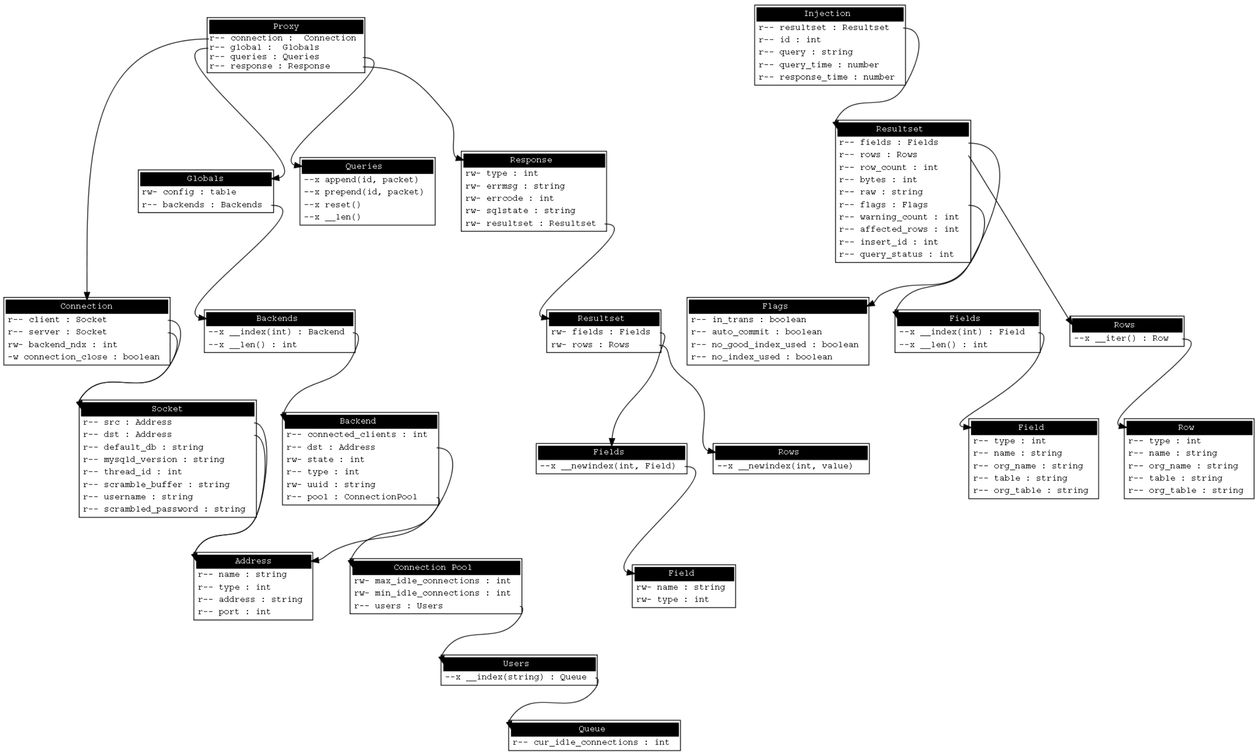
You can also connect to a read-only port (which filters out `UPDATE` and `INSERT` queries) by connecting to the read-only port. By default the host name is the default, and the port is `4042`, but you can alter the host/port information by using the `--proxy-read-only-backend-addresses` command-line option.

For more detailed information on how to use these command-line options, and `mysql-proxy` in general in combination with Lua scripts, see Section 14.7.5, “Using MySQL Proxy”.

14.7.4. MySQL Proxy Scripting

You can control how MySQL Proxy manipulates and works with the queries and results that are passed on to the MySQL server through the use of the embedded Lua scripting language. You can find out more about the Lua programming language from the Lua Web site.

The following diagram shows an overview of the classes exposed by MySQL Proxy.


Proxy
r-- connection : Connection
r-- global : Globals
r-- queries : Queries
r-- response : Response
Injection
r-- resultset : Resultset
r-- id : int
r-- query : string
r-- query_time : number
r-- response_time : number
Resultset
r-- fields : Fields
r-- rows : Rows
r-- row_count : int
r-- bytes : int
r-- raw : string
r-- flags : Flags
r-- warning_count : int
r-- affected_rows : int
r-- insert_id : int
r-- query_status : int
Globals
rw- config : table
r-- backends : Backends
Queries
--x append(id, packet)
--x prepend(id, packet)
--x reset()
--x __len()
Response
rw- type : int
rw- errmsg : string
rw- errcode : int
rw- sqlstate : string
rw- resultset : Resultset
Connection
r-- client : Socket
r-- server : Socket
rw- backend_ndx : int
-w connection_close : boolean
Backends
--x __index(int) : Backend
--x __len() : int
Resultset
rw- fields : Fields
rw- rows : Rows
Flags
r-- in_trans : boolean
r-- auto_commit : boolean
r-- no_good_index_used : boolean
r-- no_index_used : boolean
Fields
--x __index(int) : Field
--x __len() : int
Rows
--x __iter() : Row
Socket
r-- src : Address
r-- dst : Address
r-- default_db : string
r-- mysqld_version : string
r-- thread_id : int
r-- scramble_buffer : string
r-- username : string
r-- scrambled_password : string
Backend
r-- connected_clients : int
r-- dst : Address
rw- state : int
r-- type : int
rw- uuid : string
r-- pool : ConnectionPool
Fields
--x __newindex(int, Field)
Rows
--x __newindex(int, value)
Field
r-- type : int
r-- name : string
r-- org_name : string
r-- table : string
r-- org_table : string
Row
r-- type : int
r-- name : string
r-- org_name : string
r-- table : string
r-- org_table : string
Address
r-- name : string
r-- type : int
r-- address : string
r-- port : int
Connection Pool
rw- max_idle_connections : int
rw- min_idle_connections : int
r-- users : Users
Field
rw- name : string
rw- type : int
Users
--x __index(string) : Queue
Queue
r-- cur_idle_connections : int

The primary interaction between MySQL Proxy and the server is provided by defining one or more functions through an Lua script. A number of functions are supported, according to different events and operations in the communication sequence between a client and one or more backend MySQL servers:

- `connect_server()`: This function is called each time a connection is made to MySQL Proxy from a client. You can use this function during load-balancing to intercept the original connection and decide which server the client should ultimately be attached to. If you do not define a special solution, a simple round-robin style distribution is used by default.
- `read_handshake()`: This function is called when the initial handshake information is returned by the server. You can capture the handshake information returned and provide additional checks before the authorization exchange takes place.
- `read_auth()`: This function is called when the authorization packet (user name, password, default database) are submitted by the client to the server for authentication.
- `read_auth_result()`: This function is called when the server returns an authorization packet to the client indicating whether the authorization succeeded.
- `read_query()`: This function is called each time a query is sent by the client to the server. You can use this to edit and manipulate the original query, including adding new queries before and after the original statement. You can also use this function to return information directly to the client, bypassing the server, which can be useful to filter unwanted queries or queries that exceed known limits.
- `read_query_result()`: This function is called each time a result is returned from the server, providing you have manually injected queries into the query queue. If you have not explicitly injected queries within the `read_query()` function, this function is not triggered. You can use this to edit the result set, or to remove or filter the result sets generated from additional queries you injected into the queue when using `read_query()`.

The following table describes the direction of information flow at the point when the function is triggered.

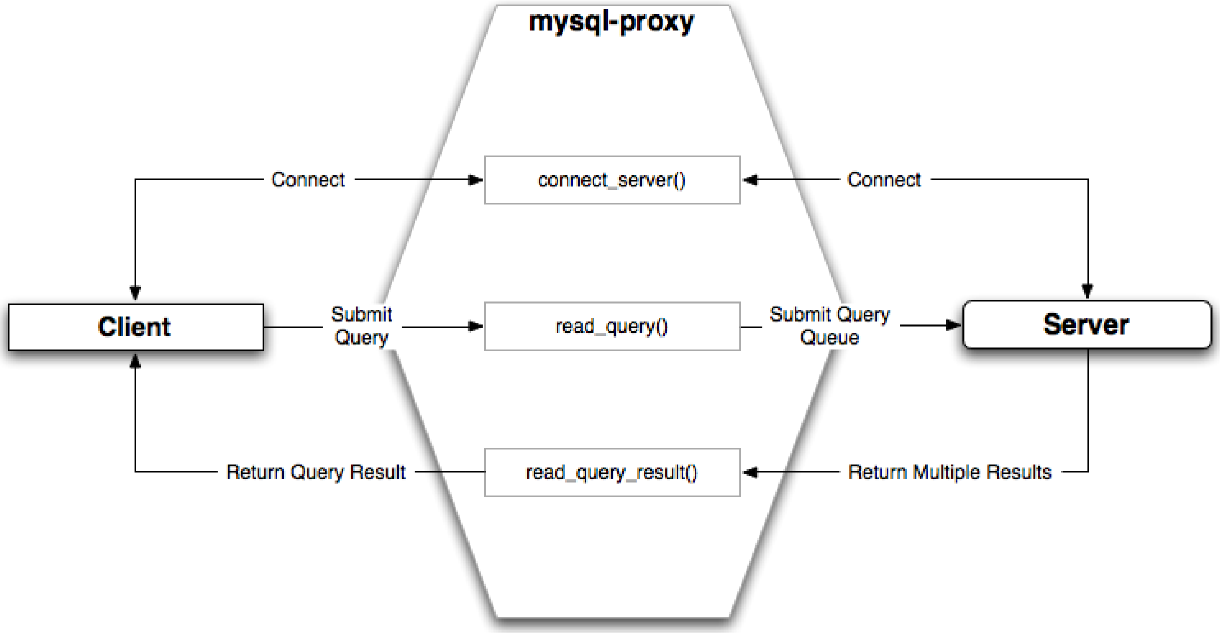
Function	**Supplied Information**	**Direction**
`connect_server()`	None	Client to Server
`read_handshake()`	None	Server to Client
`read_auth()`	None	Client to Server
`read_auth_result()`	None	Server to Client
`read_query()`	Query	Client to Server
`read_query_result()`	Query result	Server to Client

By default, all functions return a result that indicates whether the data should be passed on to the client or server (depending on the direction of the information being transferred). This return value can be overridden by explicitly returning a constant indicating that a particular response should be sent. For example, it is possible to construct result set information by hand within `read_query()` and to return the result set directly to the client without ever sending the original query to the server.

In addition to these functions, a number of built-in structures provide control over how MySQL Proxy forwards queries and returns the results by providing a simplified interface to elements such as the list of queries and the groups of result sets that are returned.

14.7.4.1. Proxy Scripting Sequence During Query Injection

The following figure gives an example of how the proxy might be used when injecting queries into the query queue. Because the proxy sits between the client and MySQL server, what the proxy sends to the server, and the information that the proxy ultimately returns to the client, need not match or correlate. Once the client has connected to the proxy, the sequence shown in the following diagram occurs for each individual query sent by the client.



1. When the client submits one query to the proxy, the `read_query()` function within the proxy is triggered. The function adds the query to the query queue.
2. Once manipulation by `read_query()` has completed, the queries are submitted, sequentially, to the MySQL server.
3. The MySQL server returns the results from each query, one result set for each query submitted. The `read_query_result()` function is triggered for each result set, and each invocation can decide which result set to return to the client

For example, you can queue additional queries into the global query queue to be processed by the server. This can be used to add statistical information by adding queries before and after the original query, changing the original query:

```
SELECT * FROM City;
```

Into a sequence of queries:

```
SELECT NOW();
SELECT * FROM City;
SELECT NOW();
```

You can also modify the original statement; for example, to add `EXPLAIN` to each statement executed to get information on how the statement was processed, again altering our original SQL statement into a number of statements:

```
SELECT * FROM City;
EXPLAIN SELECT * FROM City;
```

In both of these examples, the client would have received more result sets than expected. Regardless of how you manipulate the incoming query and the returned result, the number of queries returned by the proxy must match the number of original queries sent by the client.

You could adjust the client to handle the multiple result sets sent by the proxy, but in most cases you will want the existence of the proxy to remain transparent. To ensure that the number of queries and result sets match, you can use the MySQL Proxy `read_query_result()` to extract the additional result set information and return only the result set the client originally requested back to the client. You can achieve this by giving each query that you add to the query queue a unique ID, then filter out queries that do not match the original query ID when processing them with `read_query_result()`.

14.7.4.2. Internal Structures

There are a number of internal structures within the scripting element of MySQL Proxy. The primary structure is `proxy` and this provides an interface to the many common structures used throughout the script, such as connection lists and configured backend servers. Other structures, such as the incoming packet from the client and result sets are only available within the context of one of the scriptable functions.

Attribute	Description
`connection`	A structure containing the active client connections. For a list of attributes, see `proxy.connection`.
`servers`	A structure containing the list of configured backend servers. For a list of attributes, see `proxy.global.backends`.
`queries`	A structure containing the queue of queries that will be sent to the server during a single client query. For a list of attributes, see `proxy.queries`.
`PROXY_VERSION`	The version number of MySQL Proxy, encoded in hex. You can use this to check that the version number supports a particular option from within the Lua script. Note that the value is encoded as a hex value, so to check the version is at least 0.5.1 you compare against `0x00501`.

`proxy.connection`

The `proxy.connection` object is read only, and provides information about the current connection, and is split into a `client` and `server` tables. This enables you to examine information about both the incoming client connections to the proxy (`client`), and to the backend servers (`server`).

Attribute	Description
`client.default_db`	Default database requested by the client
`client.username`	User name used to authenticate
`client.scrambled_password`	The scrambled version of the password used to authenticate
`client.dst.name`	The combined `address:port` of the Proxy port used by this client (should match the `--proxy-address` configuration parameter)
`client.dst.address`	The IP address of the of the Proxy port used by this client
`client.dst.port`	The port number of the of the Proxy port used by this client
`client.src.name`	The combined `address:port` of the client (originating) TCP/IP endpoint
`client.src.address`	The IP address of the client (originating) TCP/IP port
`client.src.port`	The port of the client (originating) TCP/IP endpoint
`server.scramble_buffer`	The scramble buffer used to scramble the password
`server.mysqld_version`	The MySQL version number of the server
`server.thread_id`	The ID of the thread handling the connection to the current server
`server.dst.name`	The combined `address:port` for the backend server for the current connection (i.e. the connection to the MySQL server)
`server.dst.address`	The address for the backend server
`server.dst.port`	The port for the backend server
`server.src.name`	The combined `address:port` for the TCP/IP endpoint used by the Proxy to connect to the backend server
`server.src.address`	The address of the endpoint for the proxy-side connection to the MySQL server
`server.src.port`	The port of the endpoint for the proxy-side connection to the MySQL server

`proxy.global.backends`

The `proxy.global.backends` table is partially writable and contains an array of all the configured backend servers and the server metadata (IP address, status, etc.). You can determine the array index of the current connection using `proxy.connection["backend_ndx"]` which is the index into this table of the backend server being used by the active connection.

The attributes for each entry within the `proxy.global.backends` table are shown in this table.

Attribute	Description
`dst.name`	The combined `address:port` of the backend server.
`dst.address`	The IP address of the backend server.
`dst.port`	The port of the backend server.
`connected_clients`	The number of clients currently connected.
`state`	The status of the backend server. See Backend State/Type Constants [1351]
`type`	The type of the backend server. You can use this to identify whether the backed was configured as a standard read/write backend, or a read-only backend. You can compare this value to the `proxy.BACKEND_TYPE_RW` and `proxy.BACKEND_TYPE_RO`.

`proxy.queries`

The `proxy.queries` object is a queue representing the list of queries to be sent to the server. The queue is not populated automatically, but if you do not explicitly populate the queue, queries are passed on to the backend server verbatim. Also, if you do not populate the query queue by hand, the `read_query_result()` function is not triggered.

The following methods are supported for populating the `proxy.queries` object.

Function	Description
`append(id,packet,[options])`	Appends a query to the end of the query queue. The `id` is an integer identifier that you can use to recognize the query results when they are returned by the server. The packet should be a properly formatted query packet. The optional `options` should be a table containing the options specific to this packet.
`prepend(id,packet)`	Prepends a query to the query queue. The `id` is an identifier that you can use to recognize the query results when they are returned by the server. The packet should be a properly formatted query packet.
`reset()`	Empties the query queue.
`len()`	Returns the number of query packets in the queue.

For example, you could append a query packet to the `proxy.queries` queue by using the `append()`:

```
proxy.queries:append(1,packet)
```

The optional third argument to `append()` should contain the options for the packet. If you want to have access to the result set through the `read_query_result()` function, you must set the `resultset_is_needed` flag to `true`:

```
proxy.queries:append( 1, packet, { resultset_is_needed = true } )
```

If that flag is `false` (the default), proxy will:

- Send the result set to the client as soon as it is received
- Reduce memory usage (because the result set is not stored internally for processing)
- Reduce latency of returning results to the client
- Pass data from server to client unaltered

The default mode is therefore quicker and useful if you only want to monitor the queries sent, and the basic statistics.

If, however, you want to perform any kind of manipulation on the returned data, you must set the flag to `true`, which will:

- Store the result set so that it can be processed
- Enable modification of the result set before it is returned to the client
- Enable you to discard the result set instead of returning it to the client

`proxy.response`

The `proxy.response` structure is used when you want to return your own MySQL response, instead of forwarding a packet that you have received a backend server. The structure holds the response type information, an optional error message, and the result set (rows/columns) that you want to return.

Attribute	Description
`type`	The type of the response. The type must be either `MYSQLD_PACKET_OK` or `MYSQLD_PACKET_ERR`. If the `MYSQLD_PACKET_ERR`, you should set the value of the `mysql.response.errmsg` with a suitable error message.
`errmsg`	A string containing the error message that will be returned to the client.
`resultset`	A structure containing the result set information (columns and rows), identical to what would be returned when returning a results from a `SELECT` query.

When using `proxy.response` you either set `proxy.response.type` to `proxy.MYSQLD_PACKET_OK` and then build `resultset` to contain the results that you want to return, or set `proxy.response.type` to `proxy.MYSQLD_PACKET_ERR` and set the `proxy.response.errmsg` to a string with the error message. To send the completed result set or error message, you should return the `proxy.PROXY_SEND_RESULT` to trigger the return of the packet information.

An example of this can be seen in the `tutorial-resultset.lua` script within the MySQL Proxy package:

```
if string.lower(command) == "show" and string.lower(option) == "querycounter" then
        ---
        -- proxy.PROXY_SEND_RESULT requires
        --
        -- proxy.response.type to be either
        -- * proxy.MYSQLD_PACKET_OK or
        -- * proxy.MYSQLD_PACKET_ERR
        --
        -- for proxy.MYSQLD_PACKET_OK you need a resultset
        -- * fields
        -- * rows
        --
        -- for proxy.MYSQLD_PACKET_ERR
        -- * errmsg
        proxy.response.type = proxy.MYSQLD_PACKET_OK
        proxy.response.resultset = {
                fields = {
                        { type = proxy.MYSQL_TYPE_LONG, name = "global_query_counter", },
                        { type = proxy.MYSQL_TYPE_LONG, name = "query_counter", },
                },
                rows = {
                        { proxy.global.query_counter, query_counter }
                }
        }

        -- we have our result, send it back
        return proxy.PROXY_SEND_RESULT
elseif string.lower(command) == "show" and string.lower(option) == "myerror" then
        proxy.response.type = proxy.MYSQLD_PACKET_ERR
        proxy.response.errmsg = "my first error"

        return proxy.PROXY_SEND_RESULT
```

`proxy.response.resultset`

The `proxy.response.resultset` structure should be populated with the rows and columns of data that you want to return. The structure contains the information about the entire result set, with the individual elements of the data shown in the following table.

Attribute	Description
`fields`	The definition of the columns being returned. This should be a dictionary structure with the `type` specifying the MySQL data type, and the `name` specifying the column name. Columns should be listed in the order of the column data that will be returned.
`flags`	A number of flags related to the result set. Valid flags include `auto_commit` (whether an automatic commit was triggered), `no_good_index_used` (the query executed without using an appropriate index), and `no_index_used` (the query executed without using any index).

Attribute	**Description**
`rows`	The actual row data. The information should be returned as an array of arrays. Each inner array should contain the column data, with the outer array making up the entire result set.
`warning_count`	The number of warnings for this result set.
`affected_rows`	The number of rows affected by the original statement.
`insert_id`	The last insert ID for an auto-incremented column in a table.
`query_status`	The status of the query operation. You can use the `MYSQLD_PACKET_OK` or `MYSQLD_PACKET_ERR` constants to populate this parameter.

For an example showing how to use this structure, see `proxy.response`.

Proxy Return State Constants

The following constants are used internally by the proxy to specify the response to send to the client or server. All constants are exposed as values within the main `proxy` table.

Constant	**Description**
`PROXY_SEND_QUERY`	Causes the proxy to send the current contents of the queries queue to the server.
`PROXY_SEND_RESULT`	Causes the proxy to send a result set back to the client.
`PROXY_IGNORE_RESULT`	Causes the proxy to drop the result set (nothing is returned to the client).

As constants, these entities are available without qualification in the Lua scripts. For example, at the end of the `read_query_result()` you might return `PROXY_IGNORE_RESULT:`

```
return proxy.PROXY_IGNORE_RESULT
```

Packet State Constants

The following states describe the status of a network packet. These items are entries within the main `proxy` table.

Constant	**Description**
`MYSQLD_PACKET_OK`	The packet is OK
`MYSQLD_PACKET_ERR`	The packet contains error information
`MYSQLD_PACKET_RAW`	The packet contains raw data

Backend State/Type Constants

The following constants are used either to define the status or type of the backend MySQL server to which the proxy is connected. These items are entries within the main `proxy` table.

Constant	**Description**
`BACKEND_STATE_UNKNOWN`	The current status is unknown
`BACKEND_STATE_UP`	The backend is known to be up (available)
`BACKEND_STATE_DOWN`	The backend is known to be down (unavailable)
`BACKEND_TYPE_UNKNOWN`	Backend type is unknown
`BACKEND_TYPE_RW`	Backend is available for read/write
`BACKEND_TYPE_RO`	Backend is available only for read-only use

Server Command Constants

The following values are used in the packets exchanged between the client and server to identify the information in the rest of the packet. These items are entries within the main `proxy` table. The packet type is defined as the first character in the sent packet. For example, when intercepting packets from the client to edit or monitor a query, you would check that the first byte of the packet was of type `proxy.COM_QUERY`.

Constant	**Description**
`COM_SLEEP`	Sleep

Constant	Description
`COM_QUIT`	Quit
`COM_INIT_DB`	Initialize database
`COM_QUERY`	Query
`COM_FIELD_LIST`	Field List
`COM_CREATE_DB`	Create database
`COM_DROP_DB`	Drop database
`COM_REFRESH`	Refresh
`COM_SHUTDOWN`	Shutdown
`COM_STATISTICS`	Statistics
`COM_PROCESS_INFO`	Process List
`COM_CONNECT`	Connect
`COM_PROCESS_KILL`	Kill
`COM_DEBUG`	Debug
`COM_PING`	Ping
`COM_TIME`	Time
`COM_DELAYED_INSERT`	Delayed insert
`COM_CHANGE_USER`	Change user
`COM_BINLOG_DUMP`	Binlog dump
`COM_TABLE_DUMP`	Table dump
`COM_CONNECT_OUT`	Connect out
`COM_REGISTER_SLAVE`	Register slave
`COM_STMT_PREPARE`	Prepare server-side statement
`COM_STMT_EXECUTE`	Execute server-side statement
`COM_STMT_SEND_LONG_DATA`	Long data
`COM_STMT_CLOSE`	Close server-side statement
`COM_STMT_RESET`	Reset statement
`COM_SET_OPTION`	Set option
`COM_STMT_FETCH`	Fetch statement
`COM_DAEMON`	Daemon (MySQL 5.1 only)
`COM_ERROR`	Error

MySQL Type Constants

These constants are used to identify the field types in the query result data returned to clients from the result of a query. These items are entries within the main `proxy` table.

Constant	Field Type
`MYSQL_TYPE_DECIMAL`	Decimal
`MYSQL_TYPE_NEWDECIMAL`	Decimal (MySQL 5.0 or later)
`MYSQL_TYPE_TINY`	Tiny
`MYSQL_TYPE_SHORT`	Short
`MYSQL_TYPE_LONG`	Long
`MYSQL_TYPE_FLOAT`	Float
`MYSQL_TYPE_DOUBLE`	Double
`MYSQL_TYPE_NULL`	Null
`MYSQL_TYPE_TIMESTAMP`	Timestamp
`MYSQL_TYPE_LONGLONG`	Long long
`MYSQL_TYPE_INT24`	Integer
`MYSQL_TYPE_DATE`	Date

Constant	**Field Type**
`MYSQL_TYPE_TIME`	Time
`MYSQL_TYPE_DATETIME`	Datetime
`MYSQL_TYPE_YEAR`	Year
`MYSQL_TYPE_NEWDATE`	Date (MySQL 5.0 or later)
`MYSQL_TYPE_ENUM`	Enumeration
`MYSQL_TYPE_SET`	Set
`MYSQL_TYPE_TINY_BLOB`	Tiny Blob
`MYSQL_TYPE_MEDIUM_BLOB`	Medium Blob
`MYSQL_TYPE_LONG_BLOB`	Long Blob
`MYSQL_TYPE_BLOB`	Blob
`MYSQL_TYPE_VAR_STRING`	Varstring
`MYSQL_TYPE_STRING`	String
`MYSQL_TYPE_TINY`	Tiny (compatible with `MYSQL_TYPE_CHAR)`
`MYSQL_TYPE_ENUM`	Enumeration (compatible with `MYSQL_TYPE_INTERVAL`)
`MYSQL_TYPE_GEOMETRY`	Geometry
`MYSQL_TYPE_BIT`	Bit

14.7.4.3. Capturing a Connection with `connect_server()`

When the proxy accepts a connection from a MySQL client, the `connect_server()` function is called.

There are no arguments to the function, but you can use and if necessary manipulate the information in the `proxy.connection` table, which is unique to each client session.

For example, if you have multiple backend servers, you can specify which server that connection should use by setting the value of `proxy.connection.backend_ndx` to a valid server number. The following code chooses between two servers based on whether the current time in minutes is odd or even:

```
function connect_server()
        print("--> a client really wants to talk to a server")
        if (tonumber(os.date("%M")) % 2 == 0) then
                proxy.connection.backend_ndx = 2
                print("Choosing backend 2")
        else
                proxy.connection.backend_ndx = 1
                print("Choosing backend 1")
        end
        print("Using " .. proxy.global.backends[proxy.connection.backend_ndx].dst.name)
end
```

This example also displays the IP address/port combination by accessing the information from the internal `proxy.global.backends` table.

14.7.4.4. Examining the Handshake with `read_handshake()`

Handshake information is sent by the server to the client after the initial connection (through `connect_server()`) has been made. The handshake information contains details about the MySQL version, the ID of the thread that will handle the connection information, and the IP address of the client and server. This information is exposed through the `proxy.connection` structure.

- `proxy.connection.server.mysqld_version`: The version of the MySQL server.
- `proxy.connection.server.thread_id`: The thread ID.
- `proxy.connection.server.scramble_buffer`: The password scramble buffer.
- `proxy.connection.server.dst.name`: The IP address of the server.
- `proxy.connection.client.src.name`: The IP address of the client.

For example, you can print out the handshake data and refuse clients by IP address with the following function:

```
function read_handshake()
        print("<-- let's send him some information about us")
        print("    mysqld-version: " .. proxy.connection.server.mysqld_version)
        print("    thread-id     : " .. proxy.connection.server.thread_id)
        print("    scramble-buf  : " .. string.format("%q",proxy.connection.server.scramble_buffer))
        print("    server-addr   : " .. proxy.connection.server.dst.name)
        print("    client-addr   : " .. proxy.connection.client.dst.name)

        if not proxy.connection.client.src.name:match("^127.0.0.1:") then
                proxy.response.type = proxy.MYSQLD_PACKET_ERR
                proxy.response.errmsg = "only local connects are allowed"

                print("we don't like this client");

                return proxy.PROXY_SEND_RESULT
        end
end
```

Note that you must return an error packet to the client by using `proxy.PROXY_SEND_RESULT`.

14.7.4.5. Examining the Authentication Credentials with `read_auth()`

The `read_auth()` function is triggered when an authentication handshake is initiated by the client. In the execution sequence, `read_auth()` occurs immediately after `read_handshake()`, so the server selection has already been made, but the connection and authorization information has not yet been provided to the backend server.

You can obtain the authentication information by examining the `proxy.connection.client` structure. For more information, see `proxy.connection`.

For example, you can print the user name and password supplied during authorization using:

```
function read_auth()
        print("    username      : " .. proxy.connection.client.username)
        print("    password      : " .. string.format("%q", proxy.connection.client.scrambled_password))
end
```

You can interrupt the authentication process within this function and return an error packet back to the client by constructing a new packet and returning `proxy.PROXY_SEND_RESULT`:

```
proxy.response.type = proxy.MYSQLD_PACKET_ERR
proxy.response.errmsg = "Logins are not allowed"
return proxy.PROXY_SEND_RESULT
```

14.7.4.6. Accessing Authentication Information with `read_auth_result()`

The return packet from the server during authentication is captured by `read_auth_result()`. The only argument to this function is the authentication packet returned by the server. As the packet is a raw MySQL network protocol packet, you must access the first byte to identify the packet type and contents. The `MYSQLD_PACKET_ERR` and `MYSQLD_PACKET_OK` constants can be used to identify whether the authentication was successful:

```
function read_auth_result(auth)
        local state = auth.packet:byte()

        if state == proxy.MYSQLD_PACKET_OK then
                print("<-- auth ok");
        elseif state == proxy.MYSQLD_PACKET_ERR then
                print("<-- auth failed");
        else
                print("<-- auth ... don't know: " .. string.format("%q", auth.packet));
        end
end
```

If a long-password capable client tries to authenticate to a server that supports long passwords, but the user password provided is actually short, `read_auth_result()` will be called twice. The first time, `auth.packet:byte()` will equal 254, indicating that the client should try again using the old password protocol. The second time time `read_auth_result()/` is called, `auth.packet:byte()` will indicate whether the authentication actually succeeded.

14.7.4.7. Manipulating Queries with `read_query()`

The `read_query()` function is called once for each query submitted by the client and accepts a single argument, the query packet that was provided. To access the content of the packet, you must parse the packet contents manually.

For example, you can intercept a query packet and print out the contents using the following function definition:

```
function read_query( packet )
        if packet:byte() == proxy.COM_QUERY then
                print("we got a normal query: " .. packet:sub(2))
        end
```

```
end
```

This example checks the first byte of the packet to determine the type. If the type is `COM_QUERY` (see Server Command Constants [1351]), we extract the query from the packet and print it. The structure of the packet type supplied is important. In the case of a `COM_QUERY` packet, the remaining contents of the packet are the text of the query string. In this example, no changes have been made to the query or the list of queries that will ultimately be sent to the MySQL server.

To modify a query, or add new queries, you must populate the query queue (`proxy.queries`), then execute the queries that you have placed into the queue. If you do not modify the original query or the queue, the query received from the client is sent to the MySQL server verbatim.

When adding queries to the queue, you should follow these guidelines:

- The packets inserted into the queue must be valid query packets. For each packet, you must set the initial byte to the packet type. If you are appending a query, you can append the query statement to the rest of the packet.
- Once you add a query to the queue, the queue is used as the source for queries sent to the server. If you add a query to the queue to add more information, you must also add the original query to the queue or it will not be executed.
- Once the queue has been populated, you must set the return value from `read_query()` to indicate whether the query queue should be sent to the server.
- When you add queries to the queue, you should add an ID. The ID you specify is returned with the result set so that you identify each query and corresponding result set. The ID has no other purpose than as an identifier for correlating the query and result set. When operating in a passive mode, during profiling for example, you want to identify the original query and the corresponding result set so that the results expect by the client can be returned correctly.
- Unless your client is designed to cope with more result sets than queries, you should ensure that the number of queries from the client match the number of results sets returned to the client. Using the unique ID and removing result sets you inserted will help.

Normally, the `read_query()` and `read_query_result()` function are used in conjunction with each other to inject additional queries and remove the additional result sets. However, `read_query_result()` is only called if you populate the query queue within `read_query()`.

14.7.4.8. Manipulating Results with `read_query_result()`

The `read_query_result()` is called for each result set returned by the server only if you have manually injected queries into the query queue. If you have not manipulated the query queue, this function is not called. The function supports a single argument, the result packet, which provides a number of properties:

- `id`: The ID of the result set, which corresponds to the ID that was set when the query packet was submitted to the server when using `append(id)` on the query queue. You must have set the `resultset_is_needed` flag to `append` to intercept the result set before it is returned to the client. See proxy.queries [1349].
- `query`: The text of the original query.
- `query_time`: The number of microseconds required to receive the first row of a result set since the query was sent to the server.
- `response_time`: The number of microseconds required to receive the last row of the result set since the query was sent to the server.
- `resultset`: The content of the result set data.

By accessing the result information from the MySQL server, you can extract the results that match the queries that you injected, return different result sets (for example, from a modified query), and even create your own result sets.

The following Lua script, for example, will output the query, followed by the query time and response time (that is, the time to execute the query and the time to return the data for the query) for each query sent to the server:

```
function read_query( packet )
        if packet:byte() == proxy.COM_QUERY then
                print("we got a normal query: " .. packet:sub(2))

                proxy.queries:append(1, packet )

                return proxy.PROXY_SEND_QUERY
        end
```

```
end

function read_query_result(inj)
        print("query-time: " .. (inj.query_time / 1000) .. "ms")
        print("response-time: " .. (inj.response_time / 1000) .. "ms")
end
```

You can access the rows of returned results from the result set by accessing the `rows` property of the `resultset` property of the result that is exposed through `read_query_result()`. For example, you can iterate over the results showing the first column from each row using this Lua fragment:

```
for row in inj.resultset.rows do
        print("injected query returned: " .. row[1])
end
```

Just like `read_query()`, `read_query_result()` can return different values for each result according to the result returned. If you have injected additional queries into the query queue, for example, you will want to remove the results returned from those additional queries and return only the results from the query originally submitted by the client.

The following example injects additional `SELECT NOW()` statements into the query queue, giving them a different ID to the ID of the original query. Within `read_query_result()`, if the ID for the injected queries is identified, we display the result row, and return the `proxy.PROXY_IGNORE_RESULT` from the function so that the result is not returned to the client. If the result is from any other query, we print out the query time information for the query and return the default, which passes on the result set unchanged. We could also have explicitly returned `proxy.PROXY_IGNORE_RESULT` to the MySQL client.

```
function read_query( packet )
        if packet:byte() == proxy.COM_QUERY then
                proxy.queries:append(2, string.char(proxy.COM_QUERY) .. "SELECT NOW()", {resultset_is_needed = true} )
                proxy.queries:append(1, packet, {resultset_is_needed = true})
                proxy.queries:append(2, string.char(proxy.COM_QUERY) .. "SELECT NOW()", {resultset_is_needed = true} )

                return proxy.PROXY_SEND_QUERY
        end
end


function read_query_result(inj)
        if inj.id == 2 then
                for row in inj.resultset.rows do
                        print("injected query returned: " .. row[1])
                end
                return proxy.PROXY_IGNORE_RESULT
        else
                print("query-time: " .. (inj.query_time / 1000) .. "ms")
                print("response-time: " .. (inj.response_time / 1000) .. "ms")
        end
end
```

For further examples, see Section 14.7.5, “Using MySQL Proxy”.

14.7.5. Using MySQL Proxy

There are a number of different ways to use MySQL Proxy. At the most basic level, you can allow MySQL Proxy to pass queries from clients to a single server. To use MySQL Proxy in this mode, you just have to specify on the command line the backend server to which the proxy should connect:

```
shell> mysql-proxy --proxy-backend-addresses=sakila:3306
```

If you specify multiple backend MySQL servers, the proxy connects each client to each server in a round-robin fashion. Suppose that you have two MySQL servers, A and B. The first client to connect is connected to server A, the second to server B, the third to server A. For example:

```
shell> mysql-proxy \
     --proxy-backend-addresses=narcissus:3306 \
     --proxy-backend-addresses=nostromo:3306
```

When you specify multiple servers in this way, the proxy automatically identifies when a MySQL server has become unavailable and marks it accordingly. New connections are automatically attached to a server that is available, and a warning is reported to the standard output from `mysql-proxy`:

```
network-mysqld.c.367: connect(nostromo:3306) failed: Connection refused
network-mysqld-proxy.c.2405: connecting to backend (nostromo:3306) failed, marking it as down for ...
```

Lua scripts enable a finer level of control, both over the connections and their distribution and how queries and result sets are processed. When using an Lua script, you must specify the name of the script on the command line using the `--proxy-lua-script` option:

```
shell> mysql-proxy --proxy-lua-script=mc.lua --proxy-backend-addresses=sakila:3306
```

When you specify a script, the script is not executed until a connection is made. This means that faults with the script are not raised until the script is executed. Script faults will not affect the distribution of queries to backend MySQL servers.

> **Note**
>
> Because a script is not read until the connection is made, you can modify the contents of the Lua script file while the proxy is still running and the modified script is automatically used for the next connection. This ensures that MySQL Proxy remains available because it need not be restarted for the changes to take effect.

14.7.5.1. Using the Administration Interface

The `mysql-proxy` administration interface can be accessed using any MySQL client using the standard protocols. You can use the administration interface to gain information about the proxy server as a whole - standard connections to the proxy are isolated to operate as if you were connected directly to the backend MySQL server.

In `mysql-proxy` 0.8.0 and earlier, a rudimentary interface was built into the proxy. In later versions this was replaced so that you must specify an administration script to be used when users connect to the administration interface.

To use the administration interface, you should specify the user name and password required to connect to the admin service (using the `--admin-username` and `--admin-password` options). You must also specify the Lua script to be used as the interface to the administration service by using the `admin-lua-script` script option to point to a Lua script.

For example, you can create a basic interface to the internal components of the `mysql-proxy` system using the following script, written by Diego Medina:

```
--[[

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--]]

-- admin.lua

--[[

    See http://forge.mysql.com/tools/tool.php?id=78
    (Thanks to Jan Kneschke)
    See http://www.chriscalender.com/?p=41
    (Thanks to Chris Calender)
    See http://datacharmer.blogspot.com/2009/01/mysql-proxy-is-back.html
    (Thanks Giuseppe Maxia)

--]]

function set_error(errmsg)
    proxy.response = {
        type = proxy.MYSQLD_PACKET_ERR,
        errmsg = errmsg or "error"
    }
end

function read_query(packet)
    if packet:byte() ~= proxy.COM_QUERY then
        set_error("[admin] we only handle text-based queries (COM_QUERY)")
        return proxy.PROXY_SEND_RESULT
    end

    local query = packet:sub(2)
    local rows = { }
    local fields = { }

    -- try to match the string up to the first non-alphanum
    local f_s, f_e, command = string.find(packet, "^%s*(%w+)", 2)
    local option

    if f_e then
            -- if that match, take the next sub-string as option
            f_s, f_e, option = string.find(packet, "^%s+(%w+)", f_e + 1)
    end

    -- we got our commands, execute it
    if command == "show" and option == "querycounter" then
            ---
            -- proxy.PROXY_SEND_RESULT requires
            --
            -- proxy.response.type to be either
            -- * proxy.MYSQLD_PACKET_OK or
            -- * proxy.MYSQLD_PACKET_ERR
            --
            -- for proxy.MYSQLD_PACKET_OK you need a resultset
            -- * fields
            -- * rows
            --
            -- for proxy.MYSQLD_PACKET_ERR
            -- * errmsg
            proxy.response.type = proxy.MYSQLD_PACKET_OK
            proxy.response.resultset = {
                    fields = {
                            { type = proxy.MYSQL_TYPE_LONG, name = "query_counter", },
                    },
                    rows = {
                            { proxy.global.query_counter }
                    }
            }

            -- we have our result, send it back
            return proxy.PROXY_SEND_RESULT
    elseif command == "show" and option == "myerror" then
            proxy.response.type = proxy.MYSQLD_PACKET_ERR
            proxy.response.errmsg = "my first error"

            return proxy.PROXY_SEND_RESULT

    elseif string.sub(packet, 2):lower() == 'select help' then
            return show_process_help()

    elseif string.sub(packet, 2):lower() == 'show proxy processlist' then
            return show_process_table()

    elseif query == "SELECT * FROM backends" then
        fields = {
            { name = "backend_ndx",
              type = proxy.MYSQL_TYPE_LONG },

            { name = "address",
              type = proxy.MYSQL_TYPE_STRING },
            { name = "state",
              type = proxy.MYSQL_TYPE_STRING },
            { name = "type",
              type = proxy.MYSQL_TYPE_STRING },
        }

        for i = 1, #proxy.global.backends do
            local b = proxy.global.backends[i]

            rows[#rows + 1] = {
                i, b.dst.name, b.state, b.type
            }
        end
    else
        set_error()
        return proxy.PROXY_SEND_RESULT
    end

    proxy.response = {
        type = proxy.MYSQLD_PACKET_OK,
        resultset = {
            fields = fields,
            rows = rows
        }
    }
    return proxy.PROXY_SEND_RESULT
end


function make_dataset (header, dataset)
    proxy.response.type = proxy.MYSQLD_PACKET_OK

    proxy.response.resultset = {
        fields = {},
        rows = {}
    }
    for i,v in pairs (header) do
        table.insert(proxy.response.resultset.fields, {type = proxy.MYSQL_TYPE_STRING, name = v})
    end
    for i,v in pairs (dataset) do
        table.insert(proxy.response.resultset.rows, v )
    end
    return proxy.PROXY_SEND_RESULT
end

function show_process_table()
    local dataset = {}
    local header = { 'Id', 'IP Address', 'Time' }
    local rows = {}
    for t_i, t_v in pairs (proxy.global.process) do
        for s_i, s_v in pairs ( t_v ) do
            table.insert(rows, { t_i, s_v.ip, os.date('%c',s_v.ts) })
        end
    end
    return make_dataset(header,rows)
end

function show_process_help()
    local dataset = {}
    local header = { 'command',  'description' }
    local rows = {
        {'SELECT HELP',                 'This command.'},
        {'SHOW PROXY PROCESSLIST',      'Show all connections and their true IP Address.'},
    }
    return make_dataset(header,rows)
end

function dump_process_table()
    proxy.global.initialize_process_table()
    print('current contents of process table')
    for t_i, t_v in pairs (proxy.global.process) do
        print ('session id: ', t_i)
        for s_i, s_v in pairs ( t_v ) do
            print ( '\t', s_i, s_v.ip, s_v.ts )
        end
    end
    print ('---END PROCESS TABLE---')
end

--[[    Help

we use a simple string-match to split commands are word-boundaries

mysql> show querycounter

is split into
command = "show"
option  = "querycounter"

spaces are ignored, the case has to be as is.

mysql> show myerror

returns a error-packet

--]]
```

The script works in combination with a main proxy script, `reporter.lua`:

```
--[[

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   Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA

--]]

-- reporter.lua

--[[

    See http://forge.mysql.com/tools/tool.php?id=78
    (Thanks to Jan Kneschke)
    See http://www.chriscalender.com/?p=41
    (Thanks to Chris Calender)
    See http://datacharmer.blogspot.com/2009/01/mysql-proxy-is-back.html
    (Thanks Giuseppe Maxia)

--]]

proxy.global.query_counter = proxy.global.query_counter or 0

function proxy.global.initialize_process_table()
    if proxy.global.process == nil then
        proxy.global.process = {}
    end
    if proxy.global.process[proxy.connection.server.thread_id] == nil then
        proxy.global.process[proxy.connection.server.thread_id] = {}
    end
end

function read_auth_result( auth )
    local state = auth.packet:byte()
    if state == proxy.MYSQLD_PACKET_OK then
        proxy.global.initialize_process_table()
        table.insert( proxy.global.process[proxy.connection.server.thread_id],
            { ip = proxy.connection.client.src.name, ts = os.time() } )
    end
end

function disconnect_client()
    local connection_id = proxy.connection.server.thread_id
    if connection_id then
        -- client has disconnected, set this to nil
        proxy.global.process[connection_id] = nil
    end
end


---
-- read_query() can return a resultset
--
-- You can use read_query() to return a result-set.
--
-- @param packet the mysql-packet sent by the client
--
-- @return
--   * nothing to pass on the packet as is,
--   * proxy.PROXY_SEND_QUERY to send the queries from the proxy.queries queue
--   * proxy.PROXY_SEND_RESULT to send your own result-set
--
function read_query( packet )
        -- a new query came in in this connection
        -- using proxy.global.* to make it available to the admin plugin
        proxy.global.query_counter = proxy.global.query_counter + 1

end
```

To use the script, save the first script to a file (`admin.lua` in the following example) and the other to `reporter.lua`, then run `mysql-proxy` specifying the admin script and a backend MySQL server:

```
shell> mysql-proxy --admin-lua-script=admin.lua --admin-password=password \ »
     --admin-username=root --proxy-backend-addresses=127.0.0.1:3306 -proxy-lua-script=reporter.lua
```

In a different window, connect to the MySQL server through the proxy:

```
shell> mysql --user=root --password=password --port=4040
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 1798669
Server version: 5.0.70-log Gentoo Linux mysql-5.0.70-r1

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql>
```

In another different window, connect to the `mysql-proxy` admin service using the specified user name and password:

```
shell> mysql --user=root --password=password --port=4041 --host=localhost
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 1
Server version: 5.0.99-agent-admin

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql>
```

To monitor the status of the proxy, ask for a list of the current active processes:

```
mysql> show proxy processlist;
+---------+---------------------+--------------------------+
| Id      | IP Address          | Time                     |
+---------+---------------------+--------------------------+
| 1798669 | 192.168.0.112:52592 | Wed Jan 20 16:58:00 2010 |
+---------+---------------------+--------------------------+
1 row in set (0.00 sec)

mysql>
```

For more information on the example, see MySQL Proxy Admin Example.

14.7.6. MySQL Proxy FAQ

Questions

- 15.7.6.1: In load balancing, how can I separate reads from writes?
- 15.7.6.2: How do I use a socket with MySQL Proxy? Proxy change logs mention that support for UNIX sockets has been ad-

ded.

- 15.7.6.3: Can I use MySQL Proxy with all versions of MySQL?
- 15.7.6.4: Can I run MySQL Proxy as a daemon?
- 15.7.6.5: Will the proxy road map involve moving popular features from Lua to C? (For example, Read/Write splitting.)
- 15.7.6.6: Do proxy applications run on a separate server? If not, what is the overhead incurred by Proxy on the DB server side?
- 15.7.6.7: With load balancing, what happens to transactions? Are all queries sent to the same server?
- 15.7.6.8: We have looked at using MySQL Proxy but we are concerned about the alpha status. When do you think the proxy will be considered production ready?
- 15.7.6.9: Is it possible to use MySQL Proxy with updating a Lucene index (or Solr) by making TCP calls to that server to update?
- 15.7.6.10: Is the system context switch expensive, how much overhead does the Lua script add?
- 15.7.6.11: How much latency does a proxy add to a connection?
- 15.7.6.12: Do you have to make one large script and call it at proxy startup, can I change scripts without stopping and restarting (interrupting) the proxy?
- 15.7.6.13: If MySQL Proxy has to live on same machine as MySQL, are there any tuning considerations to ensure both perform optimally?
- 15.7.6.14: Can MySQL Proxy be used on slaves and intercept binary log messages?
- 15.7.6.15: I currently use SQL Relay for efficient connection pooling with a number of Apache processes connecting to a MySQL server. Can MySQL Proxy currently accomplish this? My goal is to minimize connection latency while keeping temporary tables available.
- 15.7.6.16: Are these reserved function names (for example, `error_result()`) that get automatically called?
- 15.7.6.17: As the script is re-read by MySQL Proxy, does it cache this or is it looking at the file system with each request?
- 15.7.6.18: Given that there is a `connect_server()` function, can a Lua script link up with multiple servers?
- 15.7.6.19: Is the MySQL Proxy an API?
- 15.7.6.20: The global namespace variable example with quotas does not persist after a reboot, is that correct?
- 15.7.6.21: Can MySQL Proxy handle SSL connections?
- 15.7.6.22: Could MySQL Proxy be used to capture passwords?
- 15.7.6.23: Are there tools for isolating problems? How can someone figure out whether a problem is in the client, the database, or the proxy?
- 15.7.6.24: Can you explain the status of your work with `memcached` and MySQL Proxy?
- 15.7.6.25: Is MySQL Proxy similar to what is provided by Java connection pools?
- 15.7.6.26: So authentication with connection pooling has to be done at every connection? What is the authentication latency?
- 15.7.6.27: If you have multiple databases on the same box, can you use proxy to connect to databases on default port 3306?
- 15.7.6.28: What about caching the authorization information so clients connecting are given back-end connections that were established with identical authorization information, thus saving a few more round trips?
- 15.7.6.29: Is there any big web site using MySQL Proxy? For what purpose and what transaction rate have they achieved?
- 15.7.6.30: How does MySQL Proxy compare to DBSlayer?
- 15.7.6.31: I tried using MySQL Proxy without any Lua script to try a round-robin type load balancing. In this case, if the first database in the list is down, MySQL Proxy would not connect the client to the second database in the list.
- 15.7.6.32: Is it “safe” to use `LuaSocket` with proxy scripts?
- 15.7.6.33: How different is MySQL Proxy from DBCP (Database connection pooling) for Apache in terms of connection pool-

ing?

- 15.7.6.34: MySQL Proxy can handle about 5000 connections, what is the limit on a MySQL server?
- 15.7.6.35: Would the Java-only connection pooling solution work for multiple web servers? With this, I would assume that you can pool across many web servers at once?
- 15.7.6.36: Can you dynamically reconfigure the pool of MySQL servers that MySQL Proxy will use for load balancing?
- 15.7.6.37: In the quick poll, I see "Load Balancer: read-write splitting" as an option, so would it be correct to say that there are no scripts written for Proxy yet to do this?

Questions and Answers

15.7.6.1: In load balancing, how can I separate reads from writes?

There is no automatic separation of queries that perform reads or writes to the different backend servers. However, you can specify to `mysql-proxy` that one or more of the “backend” MySQL servers are read only.

```
shell> mysql-proxy \
--proxy-backend-addresses=10.0.1.2:3306 \
--proxy-read-only-backend-addresses=10.0.1.3:3306 &
```

15.7.6.2: How do I use a socket with MySQL Proxy? Proxy change logs mention that support for UNIX sockets has been added.

Specify the path to the socket:

```
--proxy-backend-addresses=/path/to/socket
```

15.7.6.3: Can I use MySQL Proxy with all versions of MySQL?

MySQL Proxy is designed to work with MySQL 5.0 or higher, and supports the MySQL network protocol for 5.0 and higher.

15.7.6.4: Can I run MySQL Proxy as a daemon?

Use the `--daemon` option. To keep track of the process ID, the daemon can be started with the `--pid-file=file` option to save the PID to a known file name. On version 0.5.x, the Proxy cannot be started natively as a daemon.

15.7.6.5: Will the proxy road map involve moving popular features from Lua to C? (For example, Read/Write splitting.)

We will keep the high-level parts in the Lua layer to be able to adjust to special situations without a rebuild. Read/Write splitting sometimes needs external knowledge that may only be available by the DBA.

15.7.6.6: Do proxy applications run on a separate server? If not, what is the overhead incurred by Proxy on the DB server side?

You can run the proxy on the application server, on its own box, or on the DB-server depending on the use case.

15.7.6.7: With load balancing, what happens to transactions? Are all queries sent to the same server?

Without any special customization the whole connection is sent to the same server. That keeps the whole connection state intact.

15.7.6.8: We have looked at using MySQL Proxy but we are concerned about the alpha status. When do you think the proxy will be considered production ready?

We are on the road to the next feature release: 0.9.0. It will improve the performance quite a bit. After that we may be able to enter the beta phase.

15.7.6.9: Is it possible to use MySQL Proxy with updating a Lucene index (or Solr) by making TCP calls to that server to update?

Yes, but it is not advised for now.

15.7.6.10: Is the system context switch expensive, how much overhead does the Lua script add?

Lua is fast and the overhead should be small enough for most applications. The raw packet overhead is around 400 microseconds.

15.7.6.11: How much latency does a proxy add to a connection?

In the range of 400 microseconds per request.

15.7.6.12: Do you have to make one large script and call it at proxy startup, can I change scripts without stopping and restarting (interrupting) the proxy?

You can just change the script and the proxy will reload it when a client connects.

15.7.6.13: If MySQL Proxy has to live on same machine as MySQL, are there any tuning considerations to ensure both perform optimally?

MySQL Proxy can live on any box: application, database, or its own box. MySQL Proxy uses comparatively little CPU or RAM, with negligible additional requirements or overhead.

15.7.6.14: Can MySQL Proxy be used on slaves and intercept binary log messages?

We are working on that. See http://jan.kneschke.de/2008/5/30/mysql-proxy-rbr-to-sbr-decoding for an example.

15.7.6.15: I currently use SQL Relay for efficient connection pooling with a number of Apache processes connecting to a MySQL server. Can MySQL Proxy currently accomplish this? My goal is to minimize connection latency while keeping temporary tables available.

Yes.

15.7.6.16: Are these reserved function names (for example, `error_result()`) that get automatically called?

Only functions and values starting with `proxy.*` are provided by the proxy. All others are user provided.

15.7.6.17: As the script is re-read by MySQL Proxy, does it cache this or is it looking at the file system with each request?

It looks for the script at client-connect and reads it if it has changed, otherwise it uses the cached version.

15.7.6.18: Given that there is a `connect_server()` function, can a Lua script link up with multiple servers?

MySQL Proxy provides some tutorials in the source package; one is `examples/tutorial-keepalive.lua`.

15.7.6.19: Is the MySQL Proxy an API?

No, MySQL Proxy is an application that forwards packets from a client to a server using the MySQL network protocol. The MySQL Proxy provides a API allowing you to change its behavior.

15.7.6.20: The global namespace variable example with quotas does not persist after a reboot, is that correct?

Yes. If you restart the proxy, you lose the results, unless you save them in a file.

15.7.6.21: Can MySQL Proxy handle SSL connections?

No, being the man-in-the-middle, Proxy cannot handle encrypted sessions because it cannot share the SSL information.

15.7.6.22: Could MySQL Proxy be used to capture passwords?

The MySQL network protocol does not allow passwords to be sent in cleartext, all you could capture is the encrypted version.

15.7.6.23: Are there tools for isolating problems? How can someone figure out whether a problem is in the client, the database, or the proxy?

You can set a debug script in the proxy, which is an exceptionally good tool for this purpose. You can see very clearly which component is causing the problem, if you set the right breakpoints.

15.7.6.24: Can you explain the status of your work with `memcached` and MySQL Proxy?

There are some ideas to integrate proxy and `memcache` a bit, but no code yet.

15.7.6.25: Is MySQL Proxy similar to what is provided by Java connection pools?

Yes and no. Java connection pools are specific to Java applications, MySQL Proxy works with any client API that talks the MySQL network protocol. Also, connection pools do not provide any functionality for intelligently examining the network packets and modifying the contents.

15.7.6.26: So authentication with connection pooling has to be done at every connection? What is the authentication latency?

You can skip the round-trip and use the connection as it was added to the pool. As long as the application cleans up the temporary tables it used. The overhead is (as always) around 400 microseconds.

15.7.6.27: If you have multiple databases on the same box, can you use proxy to connect to databases on default port 3306?

Yes, MySQL Proxy can listen on any port, provided that none of the MySQL servers are listening on the same port.

15.7.6.28: What about caching the authorization information so clients connecting are given back-end connections that were established with identical authorization information, thus saving a few more round trips?

There is an `--proxy-pool-no-change-user` option that provides this functionality.

15.7.6.29: Is there any big web site using MySQL Proxy? For what purpose and what transaction rate have they achieved?

Yes, gaiaonline. They have tested MySQL Proxy and seen it handle 2400 queries per second through the proxy.

15.7.6.30: How does MySQL Proxy compare to DBSlayer?

DBSlayer is a REST->MySQL tool, MySQL Proxy is transparent to your application. No change to the application is needed.

15.7.6.31: I tried using MySQL Proxy without any Lua script to try a round-robin type load balancing. In this case, if the first database in the list is down, MySQL Proxy would not connect the client to the second database in the list.

This issue is fixed in version 0.7.0.

15.7.6.32: Is it “safe” to use `LuaSocket` with proxy scripts?

You can, but it is not advised because it may block.

15.7.6.33: How different is MySQL Proxy from DBCP (Database connection pooling) for Apache in terms of connection pooling?

Connection Pooling is just one use case of the MySQL Proxy. You can use it for a lot more and it works in cases where you cannot use DBCP (for example, if you do not have Java).

15.7.6.34: MySQL Proxy can handle about 5000 connections, what is the limit on a MySQL server?

The server limit is given by the value of the `max_connections` system variable. The default value is version dependent.

15.7.6.35: Would the Java-only connection pooling solution work for multiple web servers? With this, I would assume that you can pool across many web servers at once?

Yes. But you can also start one proxy on each application server to get a similar behavior as you have it already.

15.7.6.36: Can you dynamically reconfigure the pool of MySQL servers that MySQL Proxy will use for load balancing?

Not yet, it is on the list. We are working on a administration interface for that purpose.

15.7.6.37: In the quick poll, I see "Load Balancer: read-write splitting" as an option, so would it be correct to say that there are no scripts written for Proxy yet to do this?

There is a proof of concept script for that included. But its far from perfect and may not work for you yet.

Chapter 15. Replication

Replication enables data from one MySQL database server (the master) to be replicated to one or more MySQL database servers (the slaves). Replication is asynchronous by default - slaves need not to connected permanently to receive updates from the master. This means that updates can occur over long-distance connections and even over temporary or intermittent connections such as a dial-up service. Depending on the configuration, you can replicate all databases, selected databases, or even selected tables within a database.

The target uses for replication in MySQL include:

- Scale-out solutions - spreading the load among multiple slaves to improve performance. In this environment, all writes and updates must take place on the master server. Reads, however, may take place on one or more slaves. This model can improve the performance of writes (since the master is dedicated to updates), while dramatically increasing read speed across an increasing number of slaves.
- Data security - because data is replicated to the slave, and the slave can pause the replication process, it is possible to run backup services on the slave without corrupting the corresponding master data.
- Analytics - live data can be created on the master, while the analysis of the information can take place on the slave without affecting the performance of the master.
- Long-distance data distribution - if a branch office would like to work with a copy of your main data, you can use replication to create a local copy of the data for their use without requiring permanent access to the master.

Replication in MySQL features support for one-way, asynchronous replication, in which one server acts as the master, while one or more other servers act as slaves. This is in contrast to the *synchronous* replication which is a characteristic of MySQL Cluster (see MySQL Cluster NDB 6.X/7.X). In MySQL 5.5, an interface to semisynchronous replication is supported in addition to the built-in asynchronous replication. With semisynchronous replication, a commit performed on the master side blocks before returning to the session that performed the transaction until at least one slave acknowledges that it has received and logged the events for the transaction. See Section 15.3.8, “Semisynchronous Replication”

There are a number of solutions available for setting up replication between two servers, but the best method to use depends on the presence of data and the engine types you are using. For more information on the available options, see Section 15.1.1, “How to Set Up Replication”.

There are two core types of replication format, Statement Based Replication (SBR), which replicates entire SQL statements, and Row Based Replication (RBR), which replicates only the changed rows. You may also use a third variety, Mixed Based Replication (MBR). For more information on the different replication formats, see Section 15.1.2, “Replication Formats”. In MySQL 5.5, statement-based format is the default.

Replication is controlled through a number of different options and variables. These control the core operation of the replication, timeouts, and the databases and filters that can be applied on databases and tables. For more information on the available options, see Section 15.1.3, “Replication and Binary Logging Options and Variables”.

You can use replication to solve a number of different problems, including problems with performance, supporting the backup of different databases, and as part of a larger solution to alleviate system failures. For information on how to address these issues, see Section 15.3, “Replication Solutions”.

For notes and tips on how different data types and statements are treated during replication, including details of replication features, version compatibility, upgrades, and problems and their resolution, including an FAQ, see Section 15.4, “Replication Notes and Tips”.

For detailed information on the implementation of replication, how replication works, the process and contents of the binary log, background threads and the rules used to decide how statements are recorded and replication, see Section 15.2, “Replication Implementation”.

15.1. Replication Configuration

Replication between servers in MySQL is based on the binary logging mechanism. The MySQL instance operating as the master (the source of the database changes) writes updates and changes as “events” to the binary log. The information in the binary log is stored in different logging formats according to the database changes being recorded. Slaves are configured to read the binary log from the master and to execute the events in the binary log on the slave's local database.

The master is “dumb” in this scenario. Once binary logging has been enabled, all statements are recorded in the binary log. Each slave receives a copy of the entire contents of the binary log. It is the responsibility of the slave to decide which statements in the binary log should be executed; you cannot configure the master to log only certain events. If you do not specify otherwise, all events in the master binary log are executed on the slave. If required, you can configure the slave to process only events that apply to particular databases or tables.

Each slave keeps a record of the binary log coordinates: The file name and position within the file that it has read and processed from the master. This means that multiple slaves can be connected to the master and executing different parts of the same binary log. Because the slaves control this process, individual slaves can be connected and disconnected from the server without affecting the master's operation. Also, because each slave remembers the position within the binary log, it is possible for slaves to be disconnected, reconnect and then "catch up" by continuing from the recorded position.

Both the master and each slave must be configured with a unique ID (using the `server-id` option). In addition, each slave must be configured with information about the master host name, log file name, and position within that file. These details can be controlled from within a MySQL session using the `CHANGE MASTER TO` statement on the slave. The details are stored within the slave's `master.info` file.

This section describes the setup and configuration required for a replication environment, including step-by-step instructions for creating a new replication environment. The major components of this section are:

- For a guide to setting up two or more servers for replication, Section 15.1.1, "How to Set Up Replication", deals with the configuration of the systems and provides methods for copying data between the master and slaves.
- Events in the binary log are recorded using a number of formats. These are referred to as statement-based replication (SBR) or row-based replication (RBR). A third type, mixed-format replication (MIXED), uses SBR or RBR replication automatically to take advantage of the benefits of both SBR and RBR formats when appropriate. The different formats are discussed in Section 15.1.2, "Replication Formats".
- Detailed information on the different configuration options and variables that apply to replication is provided in Section 15.1.3, "Replication and Binary Logging Options and Variables".
- Once started, the replication process should require little administration or monitoring. However, for advice on common tasks that you may want to execute, see Section 15.1.4, "Common Replication Administration Tasks".

15.1.1. How to Set Up Replication

This section describes how to set up complete replication of a MySQL server. There are a number of different methods for setting up replication, and the exact method to use depends on how you are setting up replication, and whether you already have data within your master database.

There are some generic tasks that are common to all replication setups:

- On the master, you must enable binary logging and configure a unique server ID. This might require a server restart. See Section 15.1.1.1, "Setting the Replication Master Configuration".
- On each slave that you want to connect to the master, you must configure a unique server ID. This might require a server restart. See Section 15.1.1.2, "Setting the Replication Slave Configuration".
- You may want to create a separate user that will be used by your slaves to authenticate with the master to read the binary log for replication. The step is optional. See Section 15.1.1.3, "Creating a User for Replication".
- Before creating a data snapshot or starting the replication process, you should record the position of the binary log on the master. You will need this information when configuring the slave so that the slave knows where within the binary log to start executing events. See Section 15.1.1.4, "Obtaining the Replication Master Binary Log Coordinates".
- If you already have data on your master and you want to use it to synchronize your slave, you will need to create a data snapshot. You can create a snapshot using `mysqldump` (see Section 15.1.1.5, "Creating a Data Snapshot Using `mysqldump`") or by copying the data files directly (see Section 15.1.1.6, "Creating a Data Snapshot Using Raw Data Files").
- You will need to configure the slave with settings for connecting to the master, such as the host name, login credentials, and binary log file name and position. See Section 15.1.1.10, "Setting the Master Configuration on the Slave".

Once you have configured the basic options, you will need to follow the instructions for your replication setup. A number of alternatives are provided:

- If you are establishing a new MySQL master and one or more slaves, you need only set up the configuration, as you have no data to exchange. For guidance on setting up replication in this situation, see Section 15.1.1.7, "Setting Up Replication with New Master and Slaves".
- If you are already running a MySQL server, and therefore already have data that must be transferred to your slaves before rep-

lication starts, have not previously configured the binary log and are able to shut down your MySQL server for a short period during the process, see Section 15.1.1.8, “Setting Up Replication with Existing Data”.

- If you are adding slaves to an existing replication environment, you can set up the slaves without affecting the master. See Section 15.1.1.9, “Introducing Additional Slaves to an Existing Replication Environment”.

If you will be administering MySQL replication servers, we suggest that you read this entire chapter through and try all statements mentioned in Section 12.5.1, “SQL Statements for Controlling Master Servers”, and Section 12.5.2, “SQL Statements for Controlling Slave Servers”. You should also familiarize yourself with the replication startup options described in Section 15.1.3, “Replication and Binary Logging Options and Variables”.

> **Note**
>
> Note that certain steps within the setup process require the `SUPER` privilege. If you do not have this privilege, it might not be possible to enable replication.

15.1.1.1. Setting the Replication Master Configuration

On a replication master, you must enable binary logging and establish a unique server ID. If this has not already been done, this part of master setup requires a server restart.

Binary logging *must* be enabled on the master because the binary log is the basis for sending data changes from the master to its slaves. If binary logging is not enabled, replication will not be possible.

Each server within a replication group must be configured with a unique server ID. This ID is used to identify individual servers within the group, and must be a positive integer between 1 and (2^{32})–1. How you organize and select the numbers is entirely up to you.

To configure the binary log and server ID options, you will need to shut down your MySQL server and edit the `my.cnf` or `my.ini` file. Add the following options to the configuration file within the `[mysqld]` section. If these options already exist, but are commented out, uncomment the options and alter them according to your needs. For example, to enable binary logging using a log file name prefix of `mysql-bin`, and configure a server ID of 1, use these lines:

```
[mysqld]
log-bin=mysql-bin
server-id=1
```

After making the changes, restart the server.

> **Note**
>
> If you omit `server-id` (or set it explicitly to its default value of 0), a master refuses connections from all slaves.

> **Note**
>
> For the greatest possible durability and consistency in a replication setup using `InnoDB` with transactions, you should use `innodb_flush_log_at_trx_commit=1` and `sync_binlog=1` in the master `my.cnf` file.

> **Note**
>
> Ensure that the `skip-networking` option is not enabled on your replication master. If networking has been disabled, your slave will not able to communicate with the master and replication will fail.

15.1.1.2. Setting the Replication Slave Configuration

On a replication slave, you must establish a unique server ID. If this has not already been done, this part of slave setup requires a server restart.

If the slave server ID is not already set, or the current value conflicts with the value that you have chosen for the master server, you should shut down your slave server and edit the configuration to specify a unique server ID. For example:

```
[mysqld]
server-id=2
```

After making the changes, restart the server.

If you are setting up multiple slaves, each one must have a unique `server-id` value that differs from that of the master and from each of the other slaves. Think of `server-id` values as something similar to IP addresses: These IDs uniquely identify each server instance in the community of replication partners.

> **Note**
>
> If you omit `server-id` (or set it explicitly to its default value of 0), a slave refuses to connect to a master.

You do not have to enable binary logging on the slave for replication to be enabled. However, if you enable binary logging on the slave, you can use the binary log for data backups and crash recovery on the slave, and also use the slave as part of a more complex replication topology (for example, where the slave acts as a master to other slaves).

15.1.1.3. Creating a User for Replication

Each slave must connect to the master using a MySQL user name and password, so there must be a user account on the master that the slave can use to connect. Any account can be used for this operation, providing it has been granted the `REPLICATION SLAVE` privilege. You may wish to create a different account for each slave, or connect to the master using the same account for each slave.

You need not create an account specifically for replication. However, you should be aware that the user name and password will be stored in plain text within the `master.info` file (see Section 15.2.2.2, “Slave Status Logs”). Therefore, you may want to create a separate account that has privileges only for the replication process, to minimize the possibility of compromise to other accounts.

To create a new acccount, use `CREATE USER`. To grant this account the privileges required for replication, use the `GRANT` statement. If you create an account solely for the purposes of replication, that account needs only the `REPLICATION SLAVE` privilege. For example, to set up a new user, `repl`, that can connect for replication from any host within the `mydomain.com` domain, issue these statements on the master:

```
mysql> CREATE USER 'repl'@'%.mydomain.com' IDENTIFIED BY 'slavepass';
mysql> GRANT REPLICATION SLAVE ON *.* TO 'repl'@'%.mydomain.com';
```

See Section 12.4.1, “Account Management Statements”, for more information on statements for manipulation of user accounts.

15.1.1.4. Obtaining the Replication Master Binary Log Coordinates

To configure replication on the slave you must determine the master's current coordinates within its binary log. You will need this information so that when the slave starts the replication process, it is able to start processing events from the binary log at the correct point.

If you have existing data on your master that you want to synchronize on your slaves before starting the replication process, you must stop processing statements on the master, and then obtain its current binary log coordinates and dump its data, before permitting the master to continue executing statements. If you do not stop the execution of statements, the data dump and the master status information that you use will not match and you will end up with inconsistent or corrupted databases on the slaves.

To obtain the master binary log coordinates, follow these steps:

1. Start a session on the master by connecting to it with the command-line client, and flush all tables and block write statements by executing the `FLUSH TABLES WITH READ LOCK` statement:

   ```
   mysql> FLUSH TABLES WITH READ LOCK;
   ```

   For `InnoDB` tables, note that `FLUSH TABLES WITH READ LOCK` also blocks `COMMIT` operations.

   > **Warning**
   >
   > Leave the client from which you issued the `FLUSH TABLES` statement running so that the read lock remains in effect. If you exit the client, the lock is released.

2. In a different session on the master, use the `SHOW MASTER STATUS` statement to determine the current binary log file name and position:

   ```
   mysql > SHOW MASTER STATUS;
   +------------------+----------+--------------+------------------+
   | File             | Position | Binlog_Do_DB | Binlog_Ignore_DB |
   +------------------+----------+--------------+------------------+
   | mysql-bin.000003 | 73       | test         | manual,mysql     |
   +------------------+----------+--------------+------------------+
   ```

   The `File` column shows the name of the log file and `Position` shows the position within the file. In this example, the binary log file is `mysql-bin.000003` and the position is 73. Record these values. You need them later when you are setting up the slave. They represent the replication coordinates at which the slave should begin processing new updates from the master.

If the master has been running previously without binary logging enabled, the log file name and position values displayed by `SHOW MASTER STATUS` or `mysqldump --master-data` will be empty. In that case, the values that you need to use later when specifying the slave's log file and position are the empty string (`''`) and `4`.

You now have the information you need to enable the slave to start reading from the binary log in the correct place to start replication.

If you have existing data that needs be to synchronized with the slave before you start replication, leave the client running so that the lock remains in place and then proceed to Section 15.1.1.5, "Creating a Data Snapshot Using `mysqldump`", or Section 15.1.1.6, "Creating a Data Snapshot Using Raw Data Files". The idea here is to prevent any further changes so that the data copied to the slaves is in synchrony with the master.

If you are setting up a brand new master and slave replication group, you can exit the first session to release the read lock.

15.1.1.5. Creating a Data Snapshot Using `mysqldump`

One way to create a snapshot of the data in an existing master database is to use the `mysqldump` tool. Once the data dump has been completed, you then import this data into the slave before starting the replication process.

To obtain a snapshot of the data using `mysqldump`:

1. If you have not already locked the tables on the server to prevent statements that update data from executing:

   Start a session on the server by connecting to it with the command-line client, and flush all tables and block write statements by executing the `FLUSH TABLES WITH READ LOCK` statement:

   ```
   mysql> FLUSH TABLES WITH READ LOCK;
   ```

   Remember to use `SHOW MASTER STATUS` and record the binary log details for use when starting up the slave. The point in time of your snapshot and the binary log position must match. See Section 15.1.1.4, "Obtaining the Replication Master Binary Log Coordinates".

2. In another session, use `mysqldump` to create a dump either of all the databases you want to replicate, or of selected individual databases. For example:

   ```
   shell> mysqldump --all-databases --lock-all-tables >dbdump.db
   ```

   An alternative to using a bare dump, is to use the `--master-data` option, which automatically appends the `CHANGE MASTER TO` statement required on the slave to start the replication process.

   ```
   shell> mysqldump --all-databases --master-data >dbdump.db
   ```

3. In the client where you acquired the read lock, release the lock:

   ```
   mysql> UNLOCK TABLES;
   ```

   Alternatively, exit the first session to release the read lock.

When choosing databases to include in the dump, remember that you will need to filter out databases on each slave that you do not want to include in the replication process.

You will need either to copy the dump file to the slave, or to use the file from the master when connecting remotely to the slave to import the data.

15.1.1.6. Creating a Data Snapshot Using Raw Data Files

If your database is particularly large, copying the raw data files may be more efficient than using `mysqldump` and importing the file on each slave.

However, using this method with tables in storage engines with complex caching or logging algorithms may not give you a perfect "in time" snapshot as cache information and logging updates may not have been applied, even if you have acquired a global read lock. How the storage engine responds to this depends on its crash recovery abilities.

In addition, this method does not work reliably if the master and slave have different values for `ft_stopword_file`, `ft_min_word_len`, or `ft_max_word_len` and you are copying tables having full-text indexes.

If you are using `InnoDB` tables, you can use the `InnoDB Hot Backup` tool to obtain a consistent snapshot. This tool records the log name and offset corresponding to the snapshot to be later used on the slave. `Hot Backup` is a nonfree (commercial) tool that is not included in the standard MySQL distribution. See the `InnoDB Hot Backup` home page at http://www.innodb.com/wp/products/hot-backup/ for detailed information.

Otherwise, you can obtain a reliable binary snapshot of `InnoDB` tables only after shutting down the MySQL Server.

To create a raw data snapshot of `MyISAM` tables you can use standard copy tools such as `cp` or `copy`, a remote copy tool such as `scp` or `rsync`, an archiving tool such as `zip` or `tar`, or a file system snapshot tool such as `dump`, providing that your MySQL data files exist on a single file system. If you are replicating only certain databases then make sure you copy only those files that related to those tables. (For `InnoDB`, all tables in all databases are stored in the shared tablespace files, unless you have the `innodb_file_per_table` option enabled.)

You may want to specifically exclude the following files from your archive:

- Files relating to the `mysql` database.
- The `master.info` file.
- The master's binary log files.
- Any relay log files.

To get the most consistent results with a raw data snapshot you should shut down the master server during the process, as follows:

1. Acquire a read lock and get the master's status. See Section 15.1.1.4, “Obtaining the Replication Master Binary Log Coordinates”.
2. In a separate session, shut down the master server:

   ```
   shell> mysqladmin shutdown
   ```

3. Make a copy of the MySQL data files. The following examples show common ways to do this. You need to choose only one of them:

   ```
   shell> tar cf /tmp/db.tar ./data
   shell> zip -r /tmp/db.zip ./data
   shell> rsync --recursive ./data /tmp/dbdata
   ```

4. Restart the master server.

If you are not using `InnoDB` tables, you can get a snapshot of the system from a master without shutting down the server as described in the following steps:

1. Acquire a read lock and get the master's status. See Section 15.1.1.4, “Obtaining the Replication Master Binary Log Coordinates”.
2. Make a copy of the MySQL data files. The following examples show common ways to do this. You need to choose only one of them:

   ```
   shell> tar cf /tmp/db.tar ./data
   shell> zip -r /tmp/db.zip ./data
   shell> rsync --recursive ./data /tmp/dbdata
   ```

3. In the client where you acquired the read lock, release the lock:

   ```
   mysql> UNLOCK TABLES;
   ```

Once you have created the archive or copy of the database, you will need to copy the files to each slave before starting the slave replication process.

15.1.1.7. Setting Up Replication with New Master and Slaves

The easiest and most straightforward method for setting up replication is to use new master and slave servers.

You can also use this method if you are setting up new servers but have an existing dump of the databases from a different server that you want to load into your replication configuration. By loading the data into a new master, the data will be automatically replicated to the slaves.

To set up replication between a new master and slave:

1. Configure the MySQL master with the necessary configuration properties. See Section 15.1.1.1, “Setting the Replication Master Configuration”.
2. Start up the MySQL master.
3. Set up a user. See Section 15.1.1.3, “Creating a User for Replication”.
4. Obtain the master status information. See Section 15.1.1.4, “Obtaining the Replication Master Binary Log Coordinates”.
5. On the master, release the read lock:

   ```
   mysql> UNLOCK TABLES;
   ```

6. On the slave, edit the MySQL configuration. See Section 15.1.1.2, “Setting the Replication Slave Configuration”.
7. Start up the MySQL slave.
8. Execute a `CHANGE MASTER TO` statement to set the master replication server configuration. See Section 15.1.1.10, “Setting the Master Configuration on the Slave”.

Perform the slave setup steps on each slave.

Because there is no data to load or exchange on a new server configuration you do not need to copy or import any information.

If you are setting up a new replication environment using the data from a different existing database server, you will now need to run the dump file generated from that server on the new master. The database updates will automatically be propagated to the slaves:

```
shell> mysql -h master < fulldb.dump
```

15.1.1.8. Setting Up Replication with Existing Data

When setting up replication with existing data, you will need to decide how best to get the data from the master to the slave before starting the replication service.

The basic process for setting up replication with existing data is as follows:

1. With the MySQL master running, create a user to be used by the slave when connecting to the master during replication. See Section 15.1.1.3, “Creating a User for Replication”.
2. If you have not already configured the `server-id` and enabled binary logging on the master server, you will need to shut it down to configure these options. See Section 15.1.1.1, “Setting the Replication Master Configuration”.

   If you have to shut down your master server, this is a good opportunity to take a snapshot of its databases. You should obtain the master status (see Section 15.1.1.4, “Obtaining the Replication Master Binary Log Coordinates”) before taking down the master, updating the configuration and taking a snapshot. For information on how to create a snapshot using raw data files, see Section 15.1.1.6, “Creating a Data Snapshot Using Raw Data Files”.

3. If your master server is already correctly configured, obtain its status (see Section 15.1.1.4, “Obtaining the Replication Master Binary Log Coordinates”) and then use `mysqldump` to take a snapshot (see Section 15.1.1.5, “Creating a Data Snapshot Using `mysqldump`”) or take a raw snapshot of the live server using the guide in Section 15.1.1.6, “Creating a Data Snapshot Using Raw Data Files”.
4. Update the configuration of the slave. See Section 15.1.1.2, “Setting the Replication Slave Configuration”.
5. The next step depends on how you created the snapshot of data on the master.

   If you used `mysqldump`:

   a. Start the slave, using the `--skip-slave-start` option so that replication does not start.

   b. Import the dump file:

   ```
   shell> mysql < fulldb.dump
   ```

   If you created a snapshot using the raw data files:

   a. Extract the data files into your slave data directory. For example:

   ```
   shell> tar xvf dbdump.tar
   ```

   You may need to set permissions and ownership on the files so that the slave server can access and modify them.

   b. Start the slave, using the `--skip-slave-start` option so that replication does not start.

6. Configure the slave with the replication coordinates from the master. This tells the slave the binary log file and position within the file where replication needs to start. Also, configure the slave with the login credentials and host name of the master. For more information on the `CHANGE MASTER TO` statement required, see Section 15.1.1.10, “Setting the Master Configuration on the Slave”.

7. Start the slave threads:

   ```
   mysql> START SLAVE;
   ```

After you have performed this procedure, the slave should connect to the master and catch up on any updates that have occurred since the snapshot was taken.

If you have forgotten to set the `server-id` option for the master, slaves cannot connect to it.

If you have forgotten to set the `server-id` option for the slave, you get the following error in the slave's error log:

```
Warning: You should set server-id to a non-0 value if master_host
is set; we will force server id to 2, but this MySQL server will
not act as a slave.
```

You also find error messages in the slave's error log if it is not able to replicate for any other reason.

Once a slave is replicating, you can find in its data directory one file named `master.info` and another named `relay-log.info`. The slave uses these two files to keep track of how much of the master's binary log it has processed. Do *not* remove or edit these files unless you know exactly what you are doing and fully understand the implications. Even in that case, it is preferred that you use the `CHANGE MASTER TO` statement to change replication parameters. The slave will use the values specified in the statement to update the status files automatically.

> **Note**
>
> The content of `master.info` overrides some of the server options specified on the command line or in `my.cnf`. See Section 15.1.3, “Replication and Binary Logging Options and Variables”, for more details.

A single snapshot of the master suffices for multiple slaves. To set up additional slaves, use the same master snapshot and follow the slave portion of the procedure just described.

15.1.1.9. Introducing Additional Slaves to an Existing Replication Environment

To add another slave to an existing replication configuration, you can do so without stopping the master. Instead, set up the new slave by making a copy of an existing slave, except that you configure the new slave with a different `server-id` value.

To duplicate an existing slave:

1. Shut down the existing slave:

   ```
   shell> mysqladmin shutdown
   ```

2. Copy the data directory from the existing slave to the new slave. You can do this by creating an archive using `tar` or `WinZip`, or by performing a direct copy using a tool such as `cp` or `rsync`. Ensure that you also copy the log files and relay log files.

   A common problem that is encountered when adding new replication slaves is that the new slave fails with a series of warning and error messages like these:

```
071118 16:44:10 [Warning] Neither --relay-log nor --relay-log-index were used; so
replication may break when this MySQL server acts as a slave and has his hostname
changed!! Please use '--relay-log=new_slave_hostname-relay-bin' to avoid this problem.
071118 16:44:10 [ERROR] Failed to open the relay log './old_slave_hostname-relay-bin.003525'
(relay_log_pos 22940879)
071118 16:44:10 [ERROR] Could not find target log during relay log initialization
071118 16:44:10 [ERROR] Failed to initialize the master info structure
```

This is due to the fact that, if the `--relay-log` option is not specified, the relay log files contain the host name as part of their file names. (This is also true of the relay log index file if the `--relay-log-index` option is not used. See Section 15.1.3, “Replication and Binary Logging Options and Variables”, for more information about these options.)

To avoid this problem, use the same value for `--relay-log` on the new slave that was used on the existing slave. (If this option was not set explicitly on the existing slave, use `existing_slave_hostname-relay-bin`.) If this is not feasible, copy the existing slave's relay log index file to the new slave and set the `--relay-log-index` option on the new slave to match what was used on the existing slave. (If this option was not set explicitly on the existing slave, use `existing_slave_hostname-relay-bin.index`.) Alternatively—if you have already tried to start the new slave (after following the remaining steps in this section) and have encountered errors like those described previously—then perform the following steps:

a. If you have not already done so, issue a `STOP SLAVE` on the new slave.

   If you have already started the existing slave again, issue a `STOP SLAVE` on the existing slave as well.

b. Copy the contents of the existing slave's relay log index file into the new slave's relay log index file, making sure to overwrite any content already in the file.

c. Proceed with the remaining steps in this section.

3. Copy the `master.info` and `relay-log.info` files from the existing slave to the new slave if they were not located in the data directory. These files hold the current log coordinates for the master's binary log and the slave's relay log.

4. Start the existing slave.

5. On the new slave, edit the configuration and give the new slave a unique `server-id` not used by the master or any of the existing slaves.

6. Start the new slave. The slave will use the information in its `master.info` file to start the replication process.

15.1.1.10. Setting the Master Configuration on the Slave

To set up the slave to communicate with the master for replication, you must tell the slave the necessary connection information. To do this, execute the following statement on the slave, replacing the option values with the actual values relevant to your system:

```
mysql> CHANGE MASTER TO
    ->     MASTER_HOST='master_host_name',
    ->     MASTER_USER='replication_user_name',
    ->     MASTER_PASSWORD='replication_password',
    ->     MASTER_LOG_FILE='recorded_log_file_name',
    ->     MASTER_LOG_POS=recorded_log_position;
```

> **Note**
>
> Replication cannot use Unix socket files. You must be able to connect to the master MySQL server using TCP/IP.

The `CHANGE MASTER TO` statement has other options as well. For example, it is possible to set up secure replication using SSL. For a full list of options, and information about the maximum permissible length for the string-valued options, see Section 12.5.2.1, “`CHANGE MASTER TO` Syntax”.

15.1.2. Replication Formats

Replication works because events written to the binary log are read from the master and then processed on the slave. The events are recorded within the binary log in different formats according to the type of event. The different replication formats used correspond to the binary logging format used when the events were recorded in the master's binary log. The correlation between binary logging formats and the terms used during replication are:

- Replication capabilities in MySQL originally were based on propagation of SQL statements from master to slave. This is called *statement-based replication* (often abbreviated as *SBR*), which corresponds to the standard statement-based binary logging format. In older versions of MySQL (5.1.4 and earlier), binary logging and replication used this format exclusively.

- Row-based binary logging logs changes in individual table rows. When used with MySQL replication, this is known as *row-based replication* (often abbreviated as *RBR*). In row-based replication, the master writes *events* to the binary log that indicate how individual table rows are changed.
- The server can change the binary logging format in real time according to the type of event using *mixed-format logging*.

  When the mixed format is in effect, statement-based logging is used by default, but automatically switches to row-based logging in particular cases as described later. Replication using the mixed format is often referred to as *mixed-based replication* or *mixed-format replication*. For more information, see Section 5.2.4.3, “Mixed Binary Logging Format”.

In MySQL 5.5, statement-based format is the default.

> **Note**
>
> **MySQL Cluster.** The default binary logging format in all MySQL Cluster NDB 6.1, 6.2, 6.3, and later 6.x releases is `ROW`. MySQL Cluster Replication always uses row-based replication, and the `NDBCLUSTER` storage engine is incompatible with statement-based replication. Using `NDBCLUSTER` sets row-based logging format automatically.
>
> See General Requirements for MySQL Cluster Replication, for more information.

When using `MIXED` format, the binary logging format is determined in part by the storage engine being used and the statement being executed. For more information on mixed-format logging and the rules governing the support of different logging formats, see Section 5.2.4.3, “Mixed Binary Logging Format”.

The logging format in a running MySQL server is controlled by setting the `binlog_format` server system variable. This variable can be set with session or global scope. The rules governing when and how the new setting takes effect are the same as for other MySQL server system variables—setting the variable for the current session lasts only until the end of that session, and the change is not visible to other sessions; setting the variable globally requires a restart of the server to take effect. For more information, see Section 12.4.4, “`SET` Syntax”.

You must have the `SUPER` privilege to set either the global or session `binlog_format` value.

The statement-based and row-based replication formats have different issues and limitations. For a comparison of their relative advantages and disadvantages, see Section 15.1.2.1, “Comparison of Statement-Based and Row-Based Replication”.

With statement-based replication, you may encounter issues with replicating stored routines or triggers. You can avoid these issues by using row-based replication instead. For more information, see Section 17.7, “Binary Logging of Stored Programs”.

15.1.2.1. Comparison of Statement-Based and Row-Based Replication

Each binary logging format has advantages and disadvantages. For most users, the mixed replication format should provide the best combination of data integrity and performance. If, however, you want to take advantage of the features specific to the statement-based or row-based replication format when performing certain tasks, you can use the information in this section, which provides a summary of their relative advantages and disadvantages, to determine which is best for your needs.

Advantages of statement-based replication:

- Proven technology that has existed in MySQL since 3.23.
- Less data written to log files. When updates or deletes affect many rows, this results in *much* less storage space required for log files. This also means that taking and restoring from backups can be accomplished more quickly.
- Log files contain all statements that made any changes, so they can be used to audit the database.

Disadvantages of statement-based replication:

- **Statements that are unsafe for SBR.** Not all statements which modify data (such as `INSERT` `DELETE`, `UPDATE`, and `REPLACE` statements) can be replicated using statement-based replication. Any nondeterministic behavior is difficult to replicate when using statement-based replication. Examples of such DML (Data Modification Language) statements include the following:
  - A statement that depends on a UDF or stored program that is nondeterministic, since the value returned by such a UDF or stored program or depends on factors other than the parameters supplied to it. (Row-based replication, however, simply replicates the value returned by the UDF or stored program, so its effect on table rows and data is the same on both the master

and slave.) See Section 15.4.1.8, “Replication of Invoked Features”, for more information.

- `DELETE` and `UPDATE` statements that use a `LIMIT` clause without an `ORDER BY` are nondeterministic. See Section 15.4.1.12, “Replication and `LIMIT`”.
- Statements using any of the following functions cannot be replicated properly using statement-based replication:
  - `LOAD_FILE()`
  - `UUID()`, `UUID_SHORT()`
  - `USER()`
  - `FOUND_ROWS()`
  - `SYSDATE()` (unless both the master and the slave are started with the `--sysdate-is-now` option)
  - `GET_LOCK()`
  - `IS_FREE_LOCK()`
  - `IS_USED_LOCK()`
  - `MASTER_POS_WAIT()`
  - `RELEASE_LOCK()`
  - `SLEEP()`
  - `VERSION()`

  However, all other functions are replicated correctly using statement-based replication, including `RAND()`, `NOW()`, and so forth.

  For more information, see Section 15.4.1.11, “Replication and System Functions”.

  Statements that cannot be replicated correctly using statement-based replication are logged with a warning like the one shown here:

  ```
  090213 16:58:54 [Warning] Statement is not safe to log in statement format.
  ```

  A similar warning is also issued to the client in such cases. The client can display it using `SHOW WARNINGS`.

- `INSERT ... SELECT` requires a greater number of row-level locks than with row-based replication.
- `UPDATE` statements that require a table scan (because no index is used in the `WHERE` clause) must lock a greater number of rows than with row-based replication.
- For `InnoDB`: An `INSERT` statement that uses `AUTO_INCREMENT` blocks other nonconflicting `INSERT` statements.
- For complex statements, the statement must be evaluated and executed on the slave before the rows are updated or inserted. With row-based replication, the slave only has to modify the affected rows, not execute the full statement.
- If there is an error in evaluation on the slave, particularly when executing complex statements, statement-based replication may slowly increase the margin of error across the affected rows over time. See Section 15.4.1.24, “Slave Errors During Replication”.
- Stored functions execute with the same `NOW()` value as the calling statement. However, this is not true of stored procedures.
- Deterministic UDFs must be applied on the slaves.
- Table definitions must be (nearly) identical on master and slave. See Section 15.4.1.6, “Replication with Differing Table Definitions on Master and Slave”, for more information.

Advantages of row-based replication:

- All changes can be replicated. This is the safest form of replication.

  The `mysql` database is not replicated. The `mysql` database is instead seen as a node-specific database. Row-based replication is not supported on tables in this database. Instead, statements that would normally update this information—such as `GRANT`, `REVOKE` and the manipulation of triggers, stored routines (including stored procedures), and views—are all replicated to slaves using statement-based replication.

For statements such as `CREATE TABLE ... SELECT`, a `CREATE` statement is generated from the table definition and replicated using statement-based format, while the row insertions are replicated using row-based format.

- The technology is the same as in most other database management systems; knowledge about other systems transfers to MySQL.
- Fewer row locks are required on the master, which thus achieves higher concurrency, for the following types of statements:
  - `INSERT ... SELECT`
  - `INSERT` statements with `AUTO_INCREMENT`
  - `UPDATE` or `DELETE` statements with `WHERE` clauses that do not use keys or do not change most of the examined rows.
- Fewer row locks are required on the slave for any `INSERT`, `UPDATE`, or `DELETE` statement.

Disadvantages of row-based replication:

- RBR tends to generate more data that must be logged. To replicate a DML statement (such as an `UPDATE` or `DELETE` statement), statement-based replication writes only the statement to the binary log. By contrast, row-based replication writes each changed row to the binary log. If the statement changes many rows, row-based replication may write significantly more data to the binary log; this is true even for statements that are rolled back. This also means that taking and restoring from backup can require more time. In addition, the binary log is locked for a longer time to write the data, which may cause concurrency problems.
- Deterministic UDFs that generate large `BLOB` values take longer to replicate with row-based replication than with statement-based replication. This is because the `BLOB` column value is logged, rather than the statement generating the data.
- You cannot examine the logs to see what statements were executed, nor can you see on the slave what statements were received from the master and executed.

  However, you can see what data was changed using `mysqlbinlog` with the options `--base64-output=DECODE-ROWS` and `--verbose`.
- For tables using the `MyISAM` storage engine, a stronger lock is required on the slave for `INSERT` statements when applying them as row-based events to the binary log than when applying them as statements. This means that concurrent inserts on `MyISAM` tables are not supported when using row-based replication.

15.1.2.2. Safe and Unsafe Statements in Logging and Replication

Major changes in the replication environment and in the behavior of applications can result from using row-based logging (RBL) or row-based replication (RBR) rather than statement-based logging or replication. This section describes a number of issues known to exist when using row-based logging or replication, and discusses some best practices for taking advantage of row-based logging and replication.

For additional information, see Section 15.1.2, “Replication Formats”, and Section 15.1.2.1, “Comparison of Statement-Based and Row-Based Replication”.

- **RBL, RBR, and temporary tables.** As noted in Section 15.4.1.19, “Replication and Temporary Tables”, temporary tables are not replicated when using row-based format. When mixed format is in effect, “safe” statements involving temporary tables are logged using statement-based format. For more information, see Section 15.1.2.1, “Comparison of Statement-Based and Row-Based Replication”.

  > **Note**
  >
  > Temporary tables are not replicated when using row-based format because there is no need. In addition, because temporary tables can be read only from the thread which created them, there is seldom if ever any benefit obtained from replicating them, even when using statement-based format.

- **RBL and synchronization of nontransactional tables.** When many rows are affected, the set of changes is split into several events; when the statement commits, all of these events are written to the binary log. When executing on the slave, a table lock is taken on all tables involved, and then the rows are applied in batch mode. (This may or may not be effective, depending on the engine used for the slave's copy of the table.)

- **Latency and binary log size.** Because RBL writes changes for each row to the binary log, its size can increase quite rapidly. In a replication environment, this can significantly increase the time required to make changes on the slave that match those on the master. You should be aware of the potential for this delay in your applications.

- **Reading the binary log.** `mysqlbinlog` displays row-based events in the binary log using the `BINLOG` statement (see Section 12.4.6.1, “`BINLOG` Syntax”). This statement displays an event in printable form, but as a base 64-encoded string the meaning of which is not evident. When invoked with the `--base64-output=DECODE-ROWS` and `--verbose` options, `mysqlbinlog` formats the contents of the binary log in a manner that is easily human readable. This is helpful when binary log events were written in row-based format if you want to read or recover from a replication or database failure using the contents of the binary log. For more information, see Section 4.6.7.2, “`mysqlbinlog` Row Event Display”.

- **Binary log execution errors and `slave_exec_mode`.** If `slave_exec_mode` is `IDEMPOTENT`, a failure to apply changes from RBL because the original row cannot be found does not trigger an error or cause replication to fail. This means that it is possible that updates are not applied on the slave, so that the master and slave are no longer synchronized. Latency issues and use of nontransactional tables with RBR when `slave_exec_mode` is `IDEMPOTENT` can cause the master and slave to diverge even further. For more information about `slave_exec_mode`, see Section 5.1.3, “Server System Variables”.

  > **Note**
  >
  > `slave_exec_mode=IDEMPOTENT` is generally useful only for circular replication or multi-master replication with MySQL Cluster, for which `IDEMPOTENT` is the default value.
  >
  > For other scenarios, setting `slave_exec_mode` to `STRICT` is normally sufficient; this is the default value for storage engines other than `NDB`.
  >
  > The `NDBCLUSTER` storage engine is currently not supported in MySQL 5.5. MySQL Cluster users wishing to upgrade from MySQL 5.0 should instead migrate to MySQL Cluster NDB 7.0 or later; these are based on MySQL 5.1 but contain the latest improvements and fixes for `NDBCLUSTER`. For more information, see MySQL Cluster NDB 6.X/7.X.

- **Lack of binary log checksums.** RBL uses no checksums. This means that network, disk, and other errors may not be identified when processing the binary log. To ensure that data is transmitted without network corruption, you may want to consider using SSL, which adds another layer of checksumming, for replication connections. The `CHANGE MASTER TO` statement has options to enable replication over SSL. See also Section 12.5.2.1, “`CHANGE MASTER TO` Syntax”, for general information about setting up MySQL with SSL.

- **Filtering based on server ID not supported.** A common practice is to filter out changes on some slaves by using a `WHERE` clause that includes the relation `@@server_id <> id_value` clause with `UPDATE` and `DELETE` statements, a simple example of such a clause being `WHERE @@server_id <> 1`. However, this does not work correctly with row-based logging. If you must use the `server_id` system variable for statement filtering, you must also use `--binlog_format=STATEMENT`.

  In MySQL 5.5, you can do filtering based on server ID by using the `IGNORE_SERVER_IDS` option for the `CHANGE MASTER TO` statement. This option works with the statement-based and row-based logging formats.

- **Database-level replication options.** The effects of the `--replicate-do-db`, `--replicate-ignore-db`, and `--replicate-rewrite-db` options differ considerably depending on whether row-based or statement-based logging is used. Because of this, it is recommended to avoid database-level options and instead use table-level options such as `--replicate-do-table` and `--replicate-ignore-table`. For more information about these options and the impact that your choice of replication format has on how they operate, see Section 15.1.3, “Replication and Binary Logging Options and Variables”.

15.1.2.3. Safe and Unsafe Statements for Row-Based Logging and Replication

When speaking of the “safeness” of a statement in MySQL Replication, we are referring to whether a statement and its effects can be replicated correctly using statement-based format. If this is true of the statement, we refer to the statement as *safe*; otherwise, we refer to it as *unsafe*.

In general, a statement is safe if it deterministic, and unsafe if it is not. However, certain nondeterministic functions are *not* considered unsafe (see Nondeterministic functions not considered unsafe, later in this section). In addition, statements using results from floating-point math functions—which are hardware-dependent—are always considered safe (see Section 15.4.1.9, “Replication and Floating-Point Values”).

Handling of safe and unsafe statements. A statement is treated differently depending on whether the statement is considered safe, and with respect to the binary logging format (that is, the current value of `binlog_format`).

- No distinction is made in the treatment of safe and unsafe statements when the binary logging mode is `ROW`.

- If the binary logging format is `MIXED`, statements flagged as unsafe are logged using the row-based format; statements regarded as safe are logged using the statement-based format.
- If the binary logging format is `STATEMENT`, statements flagged as being unsafe generate a warning to this effect. (Safe statements are logged normally.)

For more information, see Section 15.1.2, "Replication Formats".

Statements considered unsafe. Statements having the following characteristics are considered unsafe:

- **Statements containing system functions that may return a different value on slave.** These functions include `FOUND_ROWS()`, `GET_LOCK()`, `IS_FREE_LOCK()`, `IS_USED_LOCK()`, `LOAD_FILE()`, `MASTER_POS_WAIT()`, `RELEASE_LOCK()`, `ROW_COUNT()`, `SESSION_USER()`, `SLEEP()`, `SYSDATE()`, `SYSTEM_USER()`, `USER()`, `UUID()`, and `UUID_SHORT()`.

  Nondeterministic functions not considered unsafe. Although these functions are not deterministic, they are treated as safe for purposes of logging and replication: `CONNECTION_ID()`, `CURDATE()`, `CURRENT_DATE()`, `CURRENT_TIME()`, `CURRENT_TIMESTAMP()`, `CURTIME()`, `LOCALTIME()`, `LOCALTIMESTAMP()`, `NOW()`, `UNIX_TIMESTAMP()`, `UTC_DATE()`, `UTC_TIME()`, `UTC_TIMESTAMP()`, and `LAST_INSERT_ID()`

  For more information, see Section 15.4.1.11, "Replication and System Functions".

- **References to system variables.** Most system variables are not replicated correctly using the statement-based format. For exceptions, see Section 5.2.4.3, "Mixed Binary Logging Format".

  See Section 15.4.1.33, "Replication and Variables".

- **UDFs.** Since we have no control over what a UDF does, we must assume that it is executing unsafe statements.
- **Updates a table having an `AUTO_INCREMENT` column.** This is unsafe because the order in which the rows are updated may differ on the master and the slave.

  For more information, see Section 15.4.1.1, "Replication and `AUTO_INCREMENT`".

- **`INSERT DELAYED` statement.** This statement is considered unsafe because the insertion of the rows may interleave with concurrently executing statements.
- **Updates using `LIMIT`.** The order in which rows are retrieved is not specified.

  See Section 15.4.1.12, "Replication and `LIMIT`".

- **Accesses or references log tables.** The contents of the system log table may differ between master and slave.
- **Nontransactional operations after transactional operations.** Within a transaction, allowing any nontransactional reads or writes to execute after any transactional reads or writes is considered unsafe.

  For more information, see Section 15.4.1.29, "Replication and Transactions".

- **Accesses or references self-logging tables.** All reads and writes to self-logging tables are considered unsafe. Within a transaction, any statement following a read or write to self-logging tables is also considered unsafe.
- **`LOAD DATA INFILE` statements.** Beginning with MySQL 5.5.6, `LOAD DATA INFILE` is considered unsafe, it causes a warning in statement-based mode, and a switch to row-based format when using mixed-format logging. See Section 15.4.1.13, "Replication and `LOAD DATA INFILE`".

For additional information, see Section 15.4.1, "Replication Features and Issues".

15.1.3. Replication and Binary Logging Options and Variables

The next few sections contain information about `mysqld` options and server variables that are used in replication and for controlling the binary log. Options and variables for use on replication masters and replication slaves are covered separately, as are options and variables relating to binary logging. A set of quick-reference tables providing basic information about these options and variables is also included (in the next section following this one).

Of particular importance is the `--server-id` option.

Command-Line Format	`--server-id=#`

Option-File Format	`server-id`	
Option Sets Variable	Yes, `server_id`	
Variable Name	`server_id`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`

This option is common to both master and slave replication servers, and is used in replication to enable master and slave servers to identify themselves uniquely. For additional information, see Section 15.1.3.2, “Replication Master Options and Variables”, and Section 15.1.3.3, “Replication Slave Options and Variables”.

On the master and each slave, you *must* use the `--server-id` option to establish a unique replication ID in the range from 1 to 2^{32} – 1. “Unique”, means that each ID must be different from every other ID in use by any other replication master or slave. Example: `server-id=3`.

If you omit `--server-id`, the default ID is 0, in which case a master refuses connections from all slaves, and a slave refuses to connect to a master. For more information, see Section 15.1.1.2, “Setting the Replication Slave Configuration”.

15.1.3.1. Replication and Binary Logging Option and Variable Reference

The following tables list basic information about the MySQL command-line options and system variables applicable to replication and the binary log.

Table 15.1. Replication Option/Variable Summary

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
abort-slave-event-count	Yes	Yes				
Com_change_master				Yes	Both	No
Com_show_master_status				Yes	Both	No
Com_show_new_master				Yes	Both	No
Com_show_slave_hosts				Yes	Both	No
Com_show_slave_status				Yes	Both	No
Com_slave_start				Yes	Both	No
Com_slave_stop				Yes	Both	No
disconnect-slave-event-count	Yes	Yes				
init_slave	Yes	Yes	Yes		Global	Yes
log-slave-updates	Yes	Yes			Global	No
- *Variable*: log_slave_updates			Yes		Global	No
master-connect-retry	Yes	Yes				
master-host	Yes	Yes				
master-info-file	Yes	Yes				
master-password	Yes	Yes				
master-port	Yes	Yes				
master-retry-count	Yes	Yes				
master-ssl	Yes	Yes				

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
master-ssl-ca	Yes	Yes				
master-ssl-capath	Yes	Yes				
master-ssl-cert	Yes	Yes				
master-ssl-cipher	Yes	Yes				
master-ssl-key	Yes	Yes				
master-user	Yes	Yes				
relay-log	Yes	Yes				
relay-log-index	Yes	Yes			Both	No
- *Variable*: relay_log_index			Yes		Both	No
relay_log_index	Yes	Yes	Yes		Global	No
relay-log-info-file	Yes	Yes				
- *Variable*: relay_log_info_file						
relay_log_info_file	Yes	Yes	Yes		Global	No
relay_log_purge	Yes	Yes	Yes		Global	Yes
relay_log_recovery	Yes	Yes	Yes		Global	Yes
relay_log_space_limit	Yes	Yes	Yes		Global	No
replicate-do-db	Yes	Yes				
replicate-do-table	Yes	Yes				
replicate-ignore-db	Yes	Yes				
replicate-ignore-table	Yes	Yes				
replicate-rewrite-db	Yes	Yes				
replicate-same-server-id	Yes	Yes				
replicate-wild-do-table	Yes	Yes				
replicate-wild-ignore-table	Yes	Yes				
report-host	Yes	Yes			Global	No
- *Variable*: report_host			Yes		Global	No
report-password	Yes	Yes			Global	No
- *Variable*: report_password			Yes		Global	No
report-port	Yes	Yes			Global	No
- *Variable*: report_port			Yes		Global	No
report-user	Yes	Yes			Global	No
- *Variable*: report_user			Yes		Global	No
rpl_recovery_rank			Yes		Global	Yes
Rpl_semi_sync_master_clients				Yes	Global	No
rpl_semi_sync_master_enabled			Yes		Global	Yes
Rpl_semi_sync_master_net_avg_wait_time				Yes	Global	No
Rpl_semi_sync_master_net_wait_time				Yes	Global	No
Rpl_semi_sync_master_net_waits				Yes	Global	No
Rpl_semi_sync_maste				Yes	Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
r_no_times						
Rpl_semi_sync_master_no_tx				Yes	Global	No
Rpl_semi_sync_master_status				Yes	Global	No
Rpl_semi_sync_master_timefunc_failures				Yes	Global	No
rpl_semi_sync_master_timeout			Yes		Global	Yes
rpl_semi_sync_master_trace_level			Yes		Global	Yes
Rpl_semi_sync_master_tx_avg_wait_time				Yes	Global	No
Rpl_semi_sync_master_tx_wait_time				Yes	Global	No
Rpl_semi_sync_master_tx_waits				Yes	Global	No
rpl_semi_sync_master_wait_no_slave			Yes		Global	Yes
Rpl_semi_sync_master_wait_pos_backtraverse				Yes	Global	No
Rpl_semi_sync_master_wait_sessions				Yes	Global	No
Rpl_semi_sync_master_yes_tx				Yes	Global	No
rpl_semi_sync_slave_enabled			Yes		Global	Yes
Rpl_semi_sync_slave_status				Yes	Global	No
rpl_semi_sync_slave_trace_level			Yes		Global	Yes
Rpl_status				Yes	Global	No
show-slave-auth-info	Yes	Yes				
skip-slave-start	Yes	Yes				
slave_compressed_protocol	Yes	Yes	Yes		Global	Yes
slave_exec_mode			Yes		Global	Yes
Slave_heartbeat_period				Yes	Global	No
slave-load-tmpdir	Yes	Yes			Global	No
- *Variable*: slave_load_tmpdir			Yes		Global	No
slave-net-timeout	Yes	Yes			Global	Yes
- *Variable*: slave_net_timeout			Yes		Global	Yes
Slave_open_temp_tables				Yes	Global	No
Slave_received_heartbeats				Yes	Global	No
Slave_retried_transactions				Yes	Global	No
Slave_running				Yes	Global	No
slave-skip-errors	Yes	Yes			Global	No
- *Variable*:			Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
slave_skip_errors						
slave_transaction_retries	Yes	Yes	Yes		Global	Yes
slave_type_conversions	Yes	Yes	Yes		Global	No
sql_slave_skip_counter			Yes		Global	Yes
sync_master_info	Yes	Yes	Yes		Global	Yes
sync_relay_log	Yes	Yes	Yes		Global	Yes
sync_relay_log_info	Yes	Yes	Yes		Global	Yes

Section 15.1.3.2, “Replication Master Options and Variables”, provides more detailed information about options and variables relating to replication master servers. For more information about options and variables relating to replication slaves, see Section 15.1.3.3, “Replication Slave Options and Variables”.

Table 15.2. Binary Logging Option/Variable Summary

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
Binlog_cache_disk_use				Yes	Global	No
binlog_cache_size	Yes	Yes	Yes		Global	Yes
Binlog_cache_use				Yes	Global	No
binlog_direct_non_transactional_updates	Yes	Yes	Yes		Both	Yes
binlog-do-db	Yes	Yes				
binlog-format	Yes	Yes			Both	Yes
- *Variable*: binlog_format			Yes		Both	Yes
binlog-ignore-db	Yes	Yes				
binlog-row-event-max-size	Yes	Yes				
Binlog_stmt_cache_disk_use				Yes	Global	No
binlog_stmt_cache_size	Yes	Yes	Yes		Global	Yes
Binlog_stmt_cache_use				Yes	Global	No
Com_show_binlog_events				Yes	Both	No
Com_show_binlogs				Yes	Both	No
max_binlog_cache_size	Yes	Yes	Yes		Global	Yes
max-binlog-dump-events	Yes	Yes				
max_binlog_size	Yes	Yes	Yes		Global	Yes
max_binlog_stmt_cache_size	Yes	Yes	Yes		Global	Yes
sporadic-binlog-dump-fail	Yes	Yes				

Section 15.1.3.4, “Binary Log Options and Variables”, provides more detailed information about options and variables relating to binary logging. For additional general information about the binary log, see Section 5.2.4, “The Binary Log”.

For a table showing *all* command-line options, system and status variables used with `mysqld`, see Section 5.1.1, “Server Option and Variable Reference”.

15.1.3.2. Replication Master Options and Variables

This section describes the server options and system variables that you can use on replication master servers. You can specify the options either on the command line or in an option file. You can specify system variable values using `SET`.

On the master and each slave, you must use the `server-id` option to establish a unique replication ID. For each server, you should pick a unique positive integer in the range from 1 to $2^{32} – 1$, and each ID must be different from every other ID in use by any other replication master or slave. Example: `server-id=3`.

For options used on the master for controlling binary logging, see Section 15.1.3.4, “Binary Log Options and Variables”.

- `auto_increment_increment`

Command-Line Format	`--auto_increment_increment[=#]`	
Option-File Format	`auto_increment_increment`	
Option Sets Variable	Yes, `auto_increment_increment`	
Variable Name	`auto_increment_increment`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1`
	Range	`1-65535`

`auto_increment_increment` and `auto_increment_offset` are intended for use with master-to-master replication, and can be used to control the operation of `AUTO_INCREMENT` columns. Both variables have global and session values, and each can assume an integer value between 1 and 65,535 inclusive. Setting the value of either of these two variables to 0 causes its value to be set to 1 instead. Attempting to set the value of either of these two variables to an integer greater than 65,535 or less than 0 causes its value to be set to 65,535 instead. Attempting to set the value of `auto_increment_increment` or `auto_increment_offset` to a noninteger value gives rise to an error, and the actual value of the variable remains unchanged.

These two variables affect `AUTO_INCREMENT` column behavior as follows:

- `auto_increment_increment` controls the interval between successive column values. For example:

```
mysql> SHOW VARIABLES LIKE 'auto_inc%';
+--------------------------+-------+
| Variable_name            | Value |
+--------------------------+-------+
| auto_increment_increment | 1     |
| auto_increment_offset    | 1     |
+--------------------------+-------+
2 rows in set (0.00 sec)

mysql> CREATE TABLE autoinc1
    -> (col INT NOT NULL AUTO_INCREMENT PRIMARY KEY);
  Query OK, 0 rows affected (0.04 sec)

mysql> SET @@auto_increment_increment=10;
Query OK, 0 rows affected (0.00 sec)

mysql> SHOW VARIABLES LIKE 'auto_inc%';
+--------------------------+-------+
| Variable_name            | Value |
+--------------------------+-------+
| auto_increment_increment | 10    |
| auto_increment_offset    | 1     |
+--------------------------+-------+
2 rows in set (0.01 sec)

mysql> INSERT INTO autoinc1 VALUES (NULL), (NULL), (NULL), (NULL);
Query OK, 4 rows affected (0.00 sec)
Records: 4  Duplicates: 0  Warnings: 0

mysql> SELECT col FROM autoinc1;
+-----+
| col |
+-----+
|   1 |
|  11 |
|  21 |
|  31 |
+-----+
4 rows in set (0.00 sec)
```

- `auto_increment_offset` determines the starting point for the `AUTO_INCREMENT` column value. Consider the following, assuming that these statements are executed during the same session as the example given in the description for `auto_increment_increment`:

  ```
  mysql> SET @@auto_increment_offset=5;
  Query OK, 0 rows affected (0.00 sec)

  mysql> SHOW VARIABLES LIKE 'auto_inc%';
  +--------------------------+-------+
  | Variable_name            | Value |
  +--------------------------+-------+
  | auto_increment_increment | 10    |
  | auto_increment_offset    | 5     |
  +--------------------------+-------+
  2 rows in set (0.00 sec)

  mysql> CREATE TABLE autoinc2
      -> (col INT NOT NULL AUTO_INCREMENT PRIMARY KEY);
  Query OK, 0 rows affected (0.06 sec)

  mysql> INSERT INTO autoinc2 VALUES (NULL), (NULL), (NULL), (NULL);
  Query OK, 4 rows affected (0.00 sec)
  Records: 4  Duplicates: 0  Warnings: 0

  mysql> SELECT col FROM autoinc2;
  +-----+
  | col |
  +-----+
  |   5 |
  |  15 |
  |  25 |
  |  35 |
  +-----+
  4 rows in set (0.02 sec)
  ```

  If the value of `auto_increment_offset` is greater than that of `auto_increment_increment`, the value of `auto_increment_offset` is ignored.

Should one or both of these variables be changed and then new rows inserted into a table containing an `AUTO_INCREMENT` column, the results may seem counterintuitive because the series of `AUTO_INCREMENT` values is calculated without regard to any values already present in the column, and the next value inserted is the least value in the series that is greater than the maximum existing value in the `AUTO_INCREMENT` column. In other words, the series is calculated like so:

`auto_increment_offset` + *N* × `auto_increment_increment`

where *N* is a positive integer value in the series [1, 2, 3, ...]. For example:

```
mysql> SHOW VARIABLES LIKE 'auto_inc%';
+--------------------------+-------+
| Variable_name            | Value |
+--------------------------+-------+
| auto_increment_increment | 10    |
| auto_increment_offset    | 5     |
+--------------------------+-------+
2 rows in set (0.00 sec)

mysql> SELECT col FROM autoinc1;
+-----+
| col |
+-----+
|   1 |
|  11 |
|  21 |
|  31 |
+-----+
4 rows in set (0.00 sec)

mysql> INSERT INTO autoinc1 VALUES (NULL), (NULL), (NULL), (NULL);
Query OK, 4 rows affected (0.00 sec)
Records: 4  Duplicates: 0  Warnings: 0

mysql> SELECT col FROM autoinc1;
+-----+
| col |
+-----+
|   1 |
|  11 |
|  21 |
|  31 |
|  35 |
|  45 |
```

```
|  55 |
|  65 |
+-----+
8 rows in set (0.00 sec)
```

The values shown for `auto_increment_increment` and `auto_increment_offset` generate the series 5 + *N* × 10, that is, [5, 15, 25, 35, 45, ...]. The greatest value present in the `col` column prior to the `INSERT` is 31, and the next available value in the `AUTO_INCREMENT` series is 35, so the inserted values for `col` begin at that point and the results are as shown for the `SELECT` query.

It is not possible to confine the effects of these two variables to a single table, and thus they do not take the place of the sequences offered by some other database management systems; these variables control the behavior of all `AUTO_INCREMENT` columns in *all* tables on the MySQL server. If the global value of either variable is set, its effects persist until the global value is changed or overridden by setting the session value, or until `mysqld` is restarted. If the local value is set, the new value affects `AUTO_INCREMENT` columns for all tables into which new rows are inserted by the current user for the duration of the session, unless the values are changed during that session.

The default value of `auto_increment_increment` is 1. See Section 15.4.1.1, "Replication and `AUTO_INCREMENT`".

- `auto_increment_offset`

Command-Line Format	`--auto_increment_offset[=#]`	
Option-File Format	`auto_increment_offset`	
Option Sets Variable	Yes, `auto_increment_offset`	
Variable Name	`auto_increment_offset`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1`
	Range	`1-65535`

This variable has a default value of 1. For particulars, see the description for `auto_increment_increment`.

15.1.3.3. Replication Slave Options and Variables

This section describes the server options and system variables that apply to slave replication servers. You can specify the options either on the command line or in an option file. Many of the options can be set while the server is running by using the `CHANGE MASTER TO` statement. You can specify system variable values using `SET`.

Server ID. On the master and each slave, you must use the `server-id` option to establish a unique replication ID in the range from 1 to $2^{32} – 1$. "Unique" means that each ID must be different from every other ID in use by any other replication master or slave. Example `my.cnf` file:

```
[mysqld]
server-id=3
```

Startup options for replication slaves. The following list describes startup options for controlling replication slave servers. Many of these options can be set while the server is running by using the `CHANGE MASTER TO` statement. Others, such as the `--replicate-*` options, can be set only when the slave server starts. Replication-related system variables are discussed later in this section.

- `--abort-slave-event-count`

Command-Line Format	`--abort-slave-event-count=#`	
Option-File Format	`abort-slave-event-count`	
	Permitted Values	
	Type	`numeric`
	Default	`0`
	Min Value	`0`

When this option is set to some positive integer *`value`* other than 0 (the default) it affects replication behavior as follows: After the slave SQL thread has started, *`value`* log events are permitted to be executed; after that, the slave SQL thread does not receive any more events, just as if the network connection from the master were cut. The slave thread continues to run, and the output from `SHOW SLAVE STATUS` displays `Yes` in both the `Slave_IO_Running` and the `Slave_SQL_Running` columns, but no further events are read from the relay log.

This option is used internally by the MySQL test suite for replication testing and debugging. It is not intended for use in a production setting.

- `--disconnect-slave-event-count`

Command-Line Format	`--disconnect-slave-event-count=#`	
Option-File Format	`disconnect-slave-event-count`	
	Permitted Values	
	Type	`numeric`
	Default	`0`

This option is used internally by the MySQL test suite for replication testing and debugging.

- `--log-slave-updates`

Command-Line Format	`--log-slave-updates`	
Option-File Format	`log-slave-updates`	
Option Sets Variable	Yes, `log_slave_updates`	
Variable Name	`log_slave_updates`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Normally, a slave does not log to its own binary log any updates that are received from a master server. This option tells the slave to log the updates performed by its SQL thread to its own binary log. For this option to have any effect, the slave must also be started with the `--log-bin` option to enable binary logging. Prior to MySQL 5.5, the server would not start when using the `--log-slave-updates` option without also starting the server with the `--log-bin` option, and would fail with an error; in MySQL 5.5, only a warning is generated. (Bug #44663) `--log-slave-updates` is used when you want to chain replication servers. For example, you might want to set up replication servers using this arrangement:

```
A -> B -> C
```

Here, `A` serves as the master for the slave `B`, and `B` serves as the master for the slave `C`. For this to work, `B` must be both a master *and* a slave. You must start both `A` and `B` with `--log-bin` to enable binary logging, and `B` with the `--log-slave-updates` option so that updates received from `A` are logged by `B` to its binary log.

- `--log-slow-slave-statements`

Command-Line Format	`--log-slow-slave-statements`	
Option-File Format	`log-slow-slave-statements`	
	Permitted Values	
	Type	`boolean`
	Default	`off`

When the slow query log is enabled, this option enables logging for queries that have taken more than `long_query_time` seconds to execute on the slave.

- `--log-warnings[=`*`level`*`]`

Command-Line Format	`--log-warnings[=#]`

	`-W [#]`	
Option-File Format	`log-warnings`	
Option Sets Variable	Yes, `log_warnings`	
Variable Name	`log_warnings`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
Disabled by	`skip-log-warnings`	
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1`
	Range	`0-18446744073709547520`

This option causes a server to print more messages to the error log about what it is doing. With respect to replication, the server generates warnings that it succeeded in reconnecting after a network/connection failure, and informs you as to how each slave thread started. This option is enabled by default; to disable it, use `--skip-log-warnings`. If the value is greater than 1, aborted connections are written to the error log, and access-denied errors for new connection attempts are written. See Section C.5.2.11, “Communication Errors and Aborted Connections”.

Note that the effects of this option are not limited to replication. It produces warnings across a spectrum of server activities.

- `--master-info-file=`*`file_name`*

Command-Line Format	`--master-info-file=file_name`	
Option-File Format	`master-info-file=file_name`	
	Permitted Values	
	Type	`file name`
	Default	`master.info`

The name to use for the file in which the slave records information about the master. The default name is `master.info` in the data directory. For information about the format of this file, see Section 15.2.2.2, “Slave Status Logs”.

- `--master-retry-count=`*`count`*

Command-Line Format	`--master-retry-count=#`	
Option-File Format	`master-retry-count`	
Deprecated	5.6.1	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`86400`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`86400`
	Range	`0-18446744073709551615`

The number of times that the slave tries to connect to the master before giving up. Reconnects are attempted at intervals set by the `MASTER_CONNECT_RETRY` option of the `CHANGE MASTER TO` statement (default 60). Reconnects are triggered when data reads by the slave time out according to the `--slave-net-timeout` option. The default value is 86400. A value of 0 means “infinite”; the slave attempts to connect forever.

- `--max-relay-log-size=size`

  The size at which the server rotates relay log files automatically. For more information, see Section 15.2.2, “Replication Relay and Status Logs”. The default size is 1GB.

- `--read-only`

  Cause the slave to permit no updates except from slave threads or from users having the `SUPER` privilege. On a slave server, this can be useful to ensure that the slave accepts updates only from its master server and not from clients. This variable does not apply to `TEMPORARY` tables.

- `--relay-log=file_name`

Command-Line Format	`--relay-log=name`	
Option-File Format	`relay-log`	
	Permitted Values	
	Type	`file name`

  The basename for the relay log. The default basename is `host_name-relay-bin`. The server writes the file in the data directory unless the basename is given with a leading absolute path name to specify a different directory. The server creates relay log files in sequence by adding a numeric suffix to the basename.

  Due to the manner in which MySQL parses server options, if you specify this option, you must supply a value; *the default basename is used only if the option is not actually specified*. If you use the `--relay-log` option without specifying a value, unexpected behavior is likely to result; this behavior depends on the other options used, the order in which they are specified, and whether they are specified on the command line or in an option file. For more information about how MySQL handles server options, see Section 4.2.3, “Specifying Program Options”.

  If you specify this option, the value specified is also used as the basename for the relay log index file. You can override this behavior by specifying a different relay log index file basename using the `--relay-log-index` option.

  You may find the `--relay-log` option useful in performing the following tasks:

  - Creating relay logs whose names are independent of host names.
  - If you need to put the relay logs in some area other than the data directory because your relay logs tend to be very large and you do not want to decrease `max_relay_log_size`.
  - To increase speed by using load-balancing between disks.

- `--relay-log-index=file_name`

Command-Line Format	`--relay-log-index=name`	
Option-File Format	`relay-log-index`	
Option Sets Variable	Yes, `relay_log_index`	
Variable Name	`relay-log-index`	
Variable Scope	Global, Session	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`

  The name to use for the relay log index file. The default name is `host_name-relay-bin.index` in the data directory, where `host_name` is the name of the slave server.

  Due to the manner in which MySQL parses server options, if you specify this option, you must supply a value; *the default basename is used only if the option is not actually specified*. If you use the `--relay-log-index` option without specifying a value, unexpected behavior is likely to result; this behavior depends on the other options used, the order in which they are specified, and whether they are specified on the command line or in an option file. For more information about how MySQL handles server options, see Section 4.2.3, “Specifying Program Options”.

  If you specify this option, the value specified is also used as the basename for the relay logs. You can override this behavior by specifying a different relay log file basename using the `--relay-log` option.

- `--relay-log-info-file=`*`file_name`*

Command-Line Format	`--relay-log-info-file=file_name`	
Option-File Format	`relay-log-info-file`	
Option Sets Variable	Yes, `relay_log_info_file`	
	Permitted Values	
	Type	`file name`
	Default	`relay-log.info`

The name to use for the file in which the slave records information about the relay logs. The default name is `relay-log.info` in the data directory. For information about the format of this file, see Section 15.2.2.2, “Slave Status Logs”.

- `--relay-log-purge={0|1}`

Disable or enable automatic purging of relay logs as soon as they are no longer needed. The default value is 1 (enabled). This is a global variable that can be changed dynamically with `SET GLOBAL relay_log_purge =` *`N`*.

- `--relay-log-recovery={0|1}`

Enables automatic relay log recovery immediately following server startup, which means that the replication slave discards all unprocessed relay logs and retrieves them from the replication master. This should be used following a crash on the replication slave to ensure that no possibly corrupted relay logs are processed. The default value is 0 (disabled).

- `--relay-log-space-limit=`*`size`*

This option places an upper limit on the total size in bytes of all relay logs on the slave. A value of 0 means “no limit.” This is useful for a slave server host that has limited disk space. When the limit is reached, the I/O thread stops reading binary log events from the master server until the SQL thread has caught up and deleted some unused relay logs. Note that this limit is not absolute: There are cases where the SQL thread needs more events before it can delete relay logs. In that case, the I/O thread exceeds the limit until it becomes possible for the SQL thread to delete some relay logs because not doing so would cause a deadlock. You should not set `--relay-log-space-limit` to less than twice the value of `--max-relay-log-size` (or `--max-binlog-size` if `--max-relay-log-size` is 0). In that case, there is a chance that the I/O thread waits for free space because `--relay-log-space-limit` is exceeded, but the SQL thread has no relay log to purge and is unable to satisfy the I/O thread. This forces the I/O thread to ignore `--relay-log-space-limit` temporarily.

- `--replicate-do-db=`*`db_name`*

Command-Line Format	`--replicate-do-db=name`	
Option-File Format	`replicate-do-db`	
	Permitted Values	
	Type	`string`

The effects of this option depend on whether statement-based or row-based replication is in use.

Statement-based replication. Tell the slave SQL thread to restrict replication to statements where the default database (that is, the one selected by `USE`) is *`db_name`*. To specify more than one database, use this option multiple times, once for each database; however, doing so does *not* replicate cross-database statements such as `UPDATE` *`some_db.some_table`* `SET foo='bar'` while a different database (or no database) is selected.

> **Warning**
>
> To specify multiple databases you *must* use multiple instances of this option. Because database names can contain commas, if you supply a comma separated list then the list will be treated as the name of a single database.

An example of what does not work as you might expect when using statement-based replication: If the slave is started with `--replicate-do-db=sales` and you issue the following statements on the master, the `UPDATE` statement is *not* replicated:

```
USE prices;
UPDATE sales.january SET amount=amount+1000;
```

The main reason for this “check just the default database” behavior is that it is difficult from the statement alone to know whether it should be replicated (for example, if you are using multiple-table `DELETE` statements or multiple-table `UPDATE` statements that act across multiple databases). It is also faster to check only the default database rather than all databases if there is no need.

Row-based replication. Tells the slave SQL thread to restrict replication to database *`db_name`*. Only tables belonging to *`db_name`* are changed; the current database has no effect on this. Suppose that the slave is started with `--replicate-do-db=sales` and row-based replication is in effect, and then the following statements are run on the master:

```
USE prices;
UPDATE sales.february SET amount=amount+100;
```

The `february` table in the `sales` database on the slave is changed in accordance with the `UPDATE` statement; this occurs whether or not the `USE` statement was issued. However, issuing the following statements on the master has no effect on the slave when using row-based replication and `--replicate-do-db=sales`:

```
USE prices;
UPDATE prices.march SET amount=amount-25;
```

Even if the statement `USE prices` were changed to `USE sales`, the `UPDATE` statement's effects would still not be replicated.

Another important difference in how `--replicate-do-db` is handled in statement-based replication as opposed to row-based replication occurs with regard to statements that refer to multiple databases. Suppose that the slave is started with `--replicate-do-db=db1`, and the following statements are executed on the master:

```
USE db1;
UPDATE db1.table1 SET col1 = 10, db2.table2 SET col2 = 20;
```

If you are using statement-based replication, then both tables are updated on the slave. However, when using row-based replication, only `table1` is affected on the slave; since `table2` is in a different database, `table2` on the slave is not changed by the `UPDATE`. Now suppose that, instead of the `USE db1` statement, a `USE db4` statement had been used:

```
USE db4;
UPDATE db1.table1 SET col1 = 10, db2.table2 SET col2 = 20;
```

In this case, the `UPDATE` statement would have no effect on the slave when using statement-based replication. However, if you are using row-based replication, the `UPDATE` would change `table1` on the slave, but not `table2`—in other words, only tables in the database named by `--replicate-do-db` are changed, and the choice of default database has no effect on this behavior.

If you need cross-database updates to work, use `--replicate-wild-do-table=`*`db_name`*`.%` instead. See Section 15.2.3, "How Servers Evaluate Replication Filtering Rules".

> **Note**
>
> This option affects replication in the same manner that `--binlog-do-db` affects binary logging, and the effects of the replication format on how `--replicate-do-db` affects replication behavior are the same as those of the logging format on the behavior of `--binlog-do-db`.
>
> This option has no effect on `BEGIN`, `COMMIT`, or `ROLLBACK` statements.

- `--replicate-ignore-db=`*`db_name`*

Command-Line Format	`--replicate-ignore-db=name`	
Option-File Format	`replicate-ignore-db`	
	Permitted Values	
	Type	`string`

As with `--replicate-do-db`, the effects of this option depend on whether statement-based or row-based replication is in use.

Statement-based replication. Tells the slave SQL thread not to replicate any statement where the default database (that is, the one selected by `USE`) is *`db_name`*.

Row-based replication. Tells the slave SQL thread not to update any tables in the database *`db_name`*. The default database has no effect.

When using statement-based replication, the following example does not work as you might expect. Suppose that the slave is started with `--replicate-ignore-db=sales` and you issue the following statements on the master:

```
USE prices;
UPDATE sales.january SET amount=amount+1000;
```

The `UPDATE` statement *is* replicated in such a case because `--replicate-ignore-db` applies only to the default database (determined by the `USE` statement). Because the `sales` database was specified explicitly in the statement, the statement has not been filtered. However, when using row-based replication, the `UPDATE` statement's effects are *not* propagated to the slave, and the slave's copy of the `sales.january` table is unchanged; in this instance, `--replicate-ignore-db=sales` causes *all* changes made to tables in the master's copy of the `sales` database to be ignored by the slave.

To specify more than one database to ignore, use this option multiple times, once for each database. Because database names can contain commas, if you supply a comma separated list then the list will be treated as the name of a single database.

You should not use this option if you are using cross-database updates and you do not want these updates to be replicated. See Section 15.2.3, "How Servers Evaluate Replication Filtering Rules".

If you need cross-database updates to work, use `--replicate-wild-ignore-table=`*`db_name`*`.%` instead. See Section 15.2.3, "How Servers Evaluate Replication Filtering Rules".

> **Note**
>
> This option affects replication in the same manner that `--binlog-ignore-db` affects binary logging, and the effects of the replication format on how `--replicate-ignore-db` affects replication behavior are the same as those of the logging format on the behavior of `--binlog-ignore-db`.
>
> This option has no effect on `BEGIN`, `COMMIT`, or `ROLLBACK` statements.

- `--replicate-do-table=`*`db_name.tbl_name`*

Command-Line Format	`--replicate-do-table=name`	
Option-File Format	`replicate-do-table`	
	Permitted Values	
	Type	`string`

Tells the slave SQL thread to restrict replication to the specified table. To specify more than one table, use this option multiple times, once for each table. This works for both cross-database updates and default database updates, in contrast to `--replicate-do-db`. See Section 15.2.3, "How Servers Evaluate Replication Filtering Rules".

This option affects only statements that apply to tables. It does not affect statements that apply only to other database objects, such as stored routines. To filter statements operating on stored routines, use one or more of the `--replicate-*-db` options.

- `--replicate-ignore-table=`*`db_name.tbl_name`*

Command-Line Format	`--replicate-ignore-table=name`	
Option-File Format	`replicate-ignore-table`	
	Permitted Values	
	Type	`string`

Tells the slave SQL thread not to replicate any statement that updates the specified table, even if any other tables might be updated by the same statement. To specify more than one table to ignore, use this option multiple times, once for each table. This works for cross-database updates, in contrast to `--replicate-ignore-db`. See Section 15.2.3, "How Servers Evaluate Replication Filtering Rules".

This option affects only statements that apply to tables. It does not affect statements that apply only to other database objects, such as stored routines. To filter statements operating on stored routines, use one or more of the `--replicate-*-db` options.

- `--replicate-rewrite-db=`*`from_name`*`->`*`to_name`*

Command-Line Format	`--replicate-rewrite-db=old_name->new_name`
Option-File Format	`replicate-rewrite-db`

	Permitted Values	
	Type	`string`

Tells the slave to translate the default database (that is, the one selected by `USE`) to *`to_name`* if it was *`from_name`* on the master. Only statements involving tables are affected (not statements such as `CREATE DATABASE`, `DROP DATABASE`, and `ALTER DATABASE`), and only if *`from_name`* is the default database on the master. This does not work for cross-database updates. To specify multiple rewrites, use this option multiple times. The server uses the first one with a *`from_name`* value that matches. The database name translation is done *before* the `--replicate-*` rules are tested.

If you use this option on the command line and the "`>`" character is special to your command interpreter, quote the option value. For example:

```
shell> mysqld --replicate-rewrite-db="olddb->newdb"
```

- `--replicate-same-server-id`

Command-Line Format	`--replicate-same-server-id`	
Option-File Format	`replicate-same-server-id`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

To be used on slave servers. Usually you should use the default setting of 0, to prevent infinite loops caused by circular replication. If set to 1, the slave does not skip events having its own server ID. Normally, this is useful only in rare configurations. Cannot be set to 1 if `--log-slave-updates` is used. By default, the slave I/O thread does not write binary log events to the relay log if they have the slave's server ID (this optimization helps save disk usage). If you want to use `--replicate-same-server-id`, be sure to start the slave with this option before you make the slave read its own events that you want the slave SQL thread to execute.

- `--replicate-wild-do-table=`*`db_name.tbl_name`*

Command-Line Format	`--replicate-wild-do-table=name`	
Option-File Format	`replicate-wild-do-table`	
	Permitted Values	
	Type	`string`

Tells the slave thread to restrict replication to statements where any of the updated tables match the specified database and table name patterns. Patterns can contain the "`%`" and "`_`" wildcard characters, which have the same meaning as for the `LIKE` pattern-matching operator. To specify more than one table, use this option multiple times, once for each table. This works for cross-database updates. See Section 15.2.3, "How Servers Evaluate Replication Filtering Rules".

This option applies to tables, views, and triggers. It does not apply to stored procedures and functions, or events. To filter statements operating on the latter objects, use one or more of the `--replicate-*-db` options.

Example: `--replicate-wild-do-table=foo%.bar%` replicates only updates that use a table where the database name starts with `foo` and the table name starts with `bar`.

If the table name pattern is `%`, it matches any table name and the option also applies to database-level statements (`CREATE DATABASE`, `DROP DATABASE`, and `ALTER DATABASE`). For example, if you use `--replicate-wild-do-table=foo%.%`, database-level statements are replicated if the database name matches the pattern `foo%`.

To include literal wildcard characters in the database or table name patterns, escape them with a backslash. For example, to replicate all tables of a database that is named `my_own%db`, but not replicate tables from the `my1ownAABCdb` database, you should escape the "`_`" and "`%`" characters like this: `--replicate-wild-do-table=my\_own\%db`. If you use the option on the command line, you might need to double the backslashes or quote the option value, depending on your command interpreter. For example, with the `bash` shell, you would need to type `--replicate-wild-do-table=my\\_own\\%db`.

- `--replicate-wild-ignore-table=`*`db_name.tbl_name`*

Command-Line Format	`--replicate-wild-ignore-table=name`

Option-File Format	`replicate-wild-ignore-table`	
	Permitted Values	
	Type	`string`

Tells the slave thread not to replicate a statement where any table matches the given wildcard pattern. To specify more than one table to ignore, use this option multiple times, once for each table. This works for cross-database updates. See Section 15.2.3, "How Servers Evaluate Replication Filtering Rules".

Example: `--replicate-wild-ignore-table=foo%.bar%` does not replicate updates that use a table where the database name starts with `foo` and the table name starts with `bar`.

For information about how matching works, see the description of the `--replicate-wild-do-table` option. The rules for including literal wildcard characters in the option value are the same as for `--replicate-wild-ignore-table` as well.

- `--report-host=`*`host_name`*

Command-Line Format	`--report-host=host_name`	
Option-File Format	`report-host`	
Option Sets Variable	Yes, `report_host`	
Variable Name	`report-host`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The host name or IP address of the slave to be reported to the master during slave registration. This value appears in the output of `SHOW SLAVE HOSTS` on the master server. Leave the value unset if you do not want the slave to register itself with the master. Note that it is not sufficient for the master to simply read the IP address of the slave from the TCP/IP socket after the slave connects. Due to NAT and other routing issues, that IP may not be valid for connecting to the slave from the master or other hosts.

- `--report-password=`*`password`*

Command-Line Format	`--report-password=name`	
Option-File Format	`report-password`	
Option Sets Variable	Yes, `report_password`	
Variable Name	`report-password`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The account password of the slave to be reported to the master during slave registration. This value appears in the output of `SHOW SLAVE HOSTS` on the master server if the `--show-slave-auth-info` option is given.

Although the name of this option might imply otherwise, `--report-password` is not connected to the MySQL user privilege system and so is not necessarily (or even likely to be) the same as the password for the MySQL replication user account.

- `--report-port=`*`slave_port_num`*

Command-Line Format	`--report-port=#`
Option-File Format	`report-port`
Option Sets Variable	Yes, `report_port`
Variable Name	`report-port`
Variable Scope	Global

Dynamic Variable	No	
	Permitted Values	
	Type	`numeric`
	Default	`3306`

The TCP/IP port number for connecting to the slave, to be reported to the master during slave registration. Set this only if the slave is listening on a nondefault port or if you have a special tunnel from the master or other clients to the slave. If you are not sure, do not use this option.

- `--report-user=user_name`

Command-Line Format	`--report-user=name`	
Option-File Format	`report-user`	
Option Sets Variable	Yes, `report_user`	
Variable Name	`report-user`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`

The account user name of the slave to be reported to the master during slave registration. This value appears in the output of `SHOW SLAVE HOSTS` on the master server if the `--show-slave-auth-info` option is given.

Although the name of this option might imply otherwise, `--report-user` is not connected to the MySQL user privilege system and so is not necessarily (or even likely to be) the same as the name of the MySQL replication user account.

- `--show-slave-auth-info`

Command-Line Format	`--show-slave-auth-info`	
Option-File Format	`show-slave-auth-info`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Display slave user names and passwords in the output of `SHOW SLAVE HOSTS` on the master server for slaves started with the `--report-user` and `--report-password` options.

- `--skip-slave-start`

Command-Line Format	`--skip-slave-start`	
Option-File Format	`skip-slave-start`	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Tells the slave server not to start the slave threads when the server starts. To start the threads later, use a `START SLAVE` statement.

- `--slave_compressed_protocol={0|1}`

Command-Line Format	`--slave_compressed_protocol`
Option-File Format	`slave_compressed_protocol`
Option Sets Variable	Yes, `slave_compressed_protocol`
Variable Name	`slave_compressed_protocol`

Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

If this option is set to 1, use compression for the slave/master protocol if both the slave and the master support it. The default is 0 (no compression).

- `--slave-load-tmpdir=file_name`

Command-Line Format	`--slave-load-tmpdir=path`	
Option-File Format	`slave-load-tmpdir`	
Option Sets Variable	Yes, `slave_load_tmpdir`	
Variable Name	`slave_load_tmpdir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`
	Default	`/tmp`

The name of the directory where the slave creates temporary files. This option is by default equal to the value of the `tmpdir` system variable. When the slave SQL thread replicates a `LOAD DATA INFILE` statement, it extracts the file to be loaded from the relay log into temporary files, and then loads these into the table. If the file loaded on the master is huge, the temporary files on the slave are huge, too. Therefore, it might be advisable to use this option to tell the slave to put temporary files in a directory located in some file system that has a lot of available space. In that case, the relay logs are huge as well, so you might also want to use the `--relay-log` option to place the relay logs in that file system.

The directory specified by this option should be located in a disk-based file system (not a memory-based file system) because the temporary files used to replicate `LOAD DATA INFILE` must survive machine restarts. The directory also should not be one that is cleared by the operating system during the system startup process.

- `--slave-net-timeout=seconds`

Command-Line Format	`--slave-net-timeout=#`	
Option-File Format	`slave-net-timeout`	
Option Sets Variable	Yes, `slave_net_timeout`	
Variable Name	`slave_net_timeout`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`3600`
	Min Value	`1`

The number of seconds to wait for more data from the master before the slave considers the connection broken, aborts the read, and tries to reconnect. The first retry occurs immediately after the timeout. The interval between retries is controlled by the `MASTER_CONNECT_RETRY` option for the `CHANGE MASTER TO` statement, and the number of reconnection attempts is limited by the `--master-retry-count` option. The default is 3600 seconds (one hour).

- `--slave-skip-errors=[err_code1,err_code2,...|all]`

  Normally, replication stops when an error occurs on the slave. This gives you the opportunity to resolve the inconsistency in the data manually. This option tells the slave SQL thread to continue replication when a statement returns any of the errors listed in the option value.

Do not use this option unless you fully understand why you are getting errors. If there are no bugs in your replication setup and client programs, and no bugs in MySQL itself, an error that stops replication should never occur. Indiscriminate use of this option results in slaves becoming hopelessly out of synchrony with the master, with you having no idea why this has occurred.

For error codes, you should use the numbers provided by the error message in your slave error log and in the output of `SHOW SLAVE STATUS`. Appendix C, *Errors, Error Codes, and Common Problems*, lists server error codes.

You can also (but should not) use the very nonrecommended value of `all` to cause the slave to ignore all error messages and keeps going regardless of what happens. Needless to say, if you use `all`, there are no guarantees regarding the integrity of your data. Please do not complain (or file bug reports) in this case if the slave's data is not anywhere close to what it is on the master. *You have been warned*.

Examples:

```
--slave-skip-errors=1062,1053
--slave-skip-errors=all
```

Obsolete options. *The following options are removed in MySQL 5.5. If you attempt to start* `mysqld` *with any of these options in MySQL 5.5, the server aborts with an* `UNKNOWN VARIABLE` *error*. To set the replication parameters formerly associated with these options, you must use the `CHANGE MASTER TO ...` statement (see Section 12.5.2.1, “`CHANGE MASTER TO` Syntax”).

The options affected are shown in this list:

- `--master-host`
- `--master-user`
- `--master-password`
- `--master-port`
- `--master-connect-retry`
- `--master-ssl`
- `--master-ssl-ca`
- `--master-ssl-capath`
- `--master-ssl-cert`
- `--master-ssl-cipher`
- `--master-ssl-key`

System variables used on replication slaves. The following list describes system variables for controlling replication slave servers. They can be set at server startup and some of them can be changed at runtime using `SET`. Server options used with replication slaves are listed earlier in this section.

- `init_slave`

Command-Line Format	`--init-slave=name`	
Option-File Format	`init_slave`	
Option Sets Variable	Yes, `init_slave`	
Variable Name	`init_slave`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`string`

This variable is similar to `init_connect`, but is a string to be executed by a slave server each time the SQL thread starts. The format of the string is the same as for the `init_connect` variable.

> **Note**
>
> The SQL thread sends an acknowledgment to the client before it executes `init_slave`. Therefore, it is not guaranteed that `init_slave` has been executed when `START SLAVE` returns. See Section 12.5.2.5, “`START SLAVE` Syntax”, for more information.

- `relay_log_index`

Command-Line Format	`--relay-log-index`	
Option-File Format	`relay_log_index`	
Option Sets Variable	Yes, `relay_log_index`	
Variable Name	`relay_log_index`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`
	Default	`*host_name*-relay-bin.index`

The name of the relay log index file. The default name is *`host_name`*`-relay-bin.index` in the data directory, where *`host_name`* is the name of the slave server.

- `relay_log_info_file`

Command-Line Format	`--relay-log-info-file=file_name`	
Option-File Format	`relay_log_info_file`	
Option Sets Variable	Yes, `relay_log_info_file`	
Variable Name	`relay_log_info_file`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`string`
	Default	`relay-log.info`

The name of the file in which the slave records information about the relay logs. The default name is `relay-log.info` in the data directory.

- `relay_log_recovery`

Command-Line Format	`--relay-log-recovery`	
Option-File Format	`relay_log_recovery`	
Option Sets Variable	Yes, `relay_log_recovery`	
Variable Name	`relay_log_recovery`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

Enables automatic relay log recovery immediately following server startup, which means that the replication slave discards all unprocessed relay logs and retrieves them from the replication master. This should be used following a crash on the replication slave to ensure that no possibly corrupted relay logs are processed. The default value is 0 (disabled). This global variable can be changed dynamically, or by starting the slave with the `--relay-log-recovery` option.

- `rpl_recovery_rank`

This variable is unused, and is removed in MySQL 5.6.

- `slave_compressed_protocol`

Command-Line Format	`--slave_compressed_protocol`	
Option-File Format	`slave_compressed_protocol`	
Option Sets Variable	Yes, `slave_compressed_protocol`	
Variable Name	`slave_compressed_protocol`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Whether to use compression of the slave/master protocol if both the slave and the master support it.

- `slave_exec_mode`

Variable Name	`slave_exec_mode`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`STRICT` (ALL)
	Default	`IDEMPOTENT` (NDB)
	Valid Values	`IDEMPOTENT` `STRICT`

Controls whether `IDEMPOTENT` or `STRICT` mode is used in replication conflict resolution and error checking. `IDEMPOTENT` mode causes suppression of duplicate-key and no-key-found errors. This mode should be employed in multi-master replication, circular replication, and some other special replication scenarios. `STRICT` mode is the default, and is suitable for most other cases.

- `slave_load_tmpdir`

Command-Line Format	`--slave-load-tmpdir=path`	
Option-File Format	`slave-load-tmpdir`	
Option Sets Variable	Yes, `slave_load_tmpdir`	
Variable Name	`slave_load_tmpdir`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`
	Default	`/tmp`

The name of the directory where the slave creates temporary files for replicating `LOAD DATA INFILE` statements.

- `slave_net_timeout`

Command-Line Format	`--slave-net-timeout=#`
Option-File Format	`slave-net-timeout`
Option Sets Variable	Yes, `slave_net_timeout`

Variable Name	`slave_net_timeout`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`3600`
	Min Value	`1`

The number of seconds to wait for more data from a master/slave connection before aborting the read. This timeout applies only to TCP/IP connections, not to connections made using Unix socket files, named pipes, or shared memory.

- `slave_skip_errors`

Command-Line Format	`--slave-skip-errors=name`
Option-File Format	`slave-skip-errors`
Option Sets Variable	Yes, `slave_skip_errors`
Variable Name	`slave_skip_errors`
Variable Scope	Global
Dynamic Variable	No

Normally, replication stops when an error occurs on the slave. This gives you the opportunity to resolve the inconsistency in the data manually. This variable tells the slave SQL thread to continue replication when a statement returns any of the errors listed in the variable value.

- `slave_transaction_retries`

Command-Line Format	`--slave_transaction_retries=#`	
Option-File Format	`slave_transaction_retries`	
Option Sets Variable	Yes, `slave_transaction_retries`	
Variable Name	`slave_transaction_retries`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`10`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`10`
	Range	`0-18446744073709547520`

If a replication slave SQL thread fails to execute a transaction because of an `InnoDB` deadlock or because the transaction's execution time exceeded `InnoDB`'s `innodb_lock_wait_timeout`, it automatically retries `slave_transaction_retries` times before stopping with an error. The default value is 10.

- `slave_type_conversions`

Version Introduced	5.5.3

Command-Line Format	`--slave_type_conversions=set`	
Option-File Format	`slave_type_conversions`	
Option Sets Variable	Yes, `slave_type_conversions`	
Variable Name	`slave_type_conversions`	
Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`set`
	Default	

	Valid Values	`ALL_LOSSY`
		`ALL_NON_LOSSY`
		`ALL_LOSSY,ALL_NON_LOSSY`

Controls the type conversion mode in effect on the slave when using row-based replication. Its value is a comma-delimited set of zero or more elements from the list: `ALL_LOSSY`, `ALL_NON_LOSSY`. Set this variable to an empty string to disallow type conversions between the master and the slave. Changes require a restart of the slave to take effect.

For additional information on type conversion modes applicable to attribute promotion and demotion in row-based replication, see Row-based replication: attribute promotion and demotion.

This variable was added in MySQL 5.5.3.

- `sql_slave_skip_counter`

Variable Name	`sql_slave_skip_counter`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`

The number of events from the master that a slave server should skip.

> ### Important
>
> If skipping the number of events specified by setting this variable would cause the slave to begin in the middle of an event group, the slave continues to skip until it finds the beginning of the next event group and begins from that point. For more information, see Section 12.5.2.4, “`SET GLOBAL sql_slave_skip_counter` Syntax”.

- `sync_master_info`

Command-Line Format	`--sync-master-info=#`	
Option-File Format	`sync_master_info`	
Option Sets Variable	Yes, `sync_master_info`	
Variable Name	`sync_master_info`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

If the value of this variable is greater than 0, a replication slave synchronizes its `master.info` file to disk (using `fdatasync()`) after every `sync_master_info` events. The default value of `sync_relay_log_info` is 0 (recommended in most situations), which does not force any synchronization to disk by the MySQL server; in this case, the server relies on the operating system to flush the `master.info` file's contents from time to time as for any other file.

- `sync_relay_log`

Command-Line Format	`--sync-relay-log=#`	
Option-File Format	`sync_relay_log`	
Option Sets Variable	Yes, `sync_relay_log`	
Variable Name	`sync_relay_log`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

If the value of this variable is greater than 0, the MySQL server synchronizes its relay log to disk (using `fdatasync()`) after every `sync_relay_log` writes to the relay log. There is one write to the relay log per statement if autocommit is enabled, and one write per transaction otherwise. The default value of `sync_relay_log` is 0, which does no synchronizing to disk—in this case, the server relies on the operating system to flush the relay log's contents from time to time as for any other file. A value of 1 is the safest choice because in the event of a crash you lose at most one statement or transaction from the relay log. However, it is also the slowest choice (unless the disk has a battery-backed cache, which makes synchronization very fast).

- `sync_relay_log_info`

Command-Line Format	`--sync-relay-log-info=#`
Option-File Format	`sync_relay_log_info`
Option Sets Variable	Yes, `sync_relay_log_info`
Variable Name	`sync_relay_log_info`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

If the value of this variable is greater than 0, a replication slave synchronizes its `relay-log.info` file to disk (using `fdatasync()`) after every `sync_relay_log_info` transactions. A value of 1 is the generally the best choice. The default value of `sync_relay_log_info` is 0, which does not force any synchronization to disk by the MySQL server—in this case, the server relies on the operating system to flush the `relay-log.info` file's contents from time to time as for any other file.

15.1.3.4. Binary Log Options and Variables

You can use the `mysqld` options and system variables that are described in this section to affect the operation of the binary log as well as to control which statements are written to the binary log. For additional information about the binary log, see Section 5.2.4, “The Binary Log”. For additional information about using MySQL server options and system variables, see Section 5.1.2, “Server Command Options”, and Section 5.1.3, “Server System Variables”.

Startup options used with binary logging. The following list describes startup options for enabling and configuring the binary log. System variables used with binary logging are discussed later in this section.

- `--binlog-row-event-max-size=N`

Command-Line Format	`--binlog-row-event-max-size=#`	
Option-File Format	`binlog-row-event-max-size`	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`1024`
	Range	`256-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`1024`
	Range	`256-18446744073709547520`

Specify the maximum size of a row-based binary log event, in bytes. Rows are grouped into events smaller than this size if possible. The value should be a multiple of 256. The default is 1024. See Section 15.1.2, “Replication Formats”.

- `--log-bin[=base_name]`

Command-Line Format	`--log-bin`
Option-File Format	`log-bin`
Variable Name	`log_bin`

Variable Scope	Global	
Dynamic Variable	No	
	Permitted Values	
	Type	`file name`
	Default	`OFF`

Enable binary logging. The server logs all statements that change data to the binary log, which is used for backup and replication. See Section 5.2.4, “The Binary Log”.

The option value, if given, is the basename for the log sequence. The server creates binary log files in sequence by adding a numeric suffix to the basename. It is recommended that you specify a basename (see Section C.5.8, “Known Issues in MySQL”, for the reason). Otherwise, MySQL uses `*host_name*-bin` as the basename.

Setting this option causes the `log_bin` system variable to be set to `ON` (or `1`), and not to the basename. This is a known issue; see Bug #19614 for more information.

- `--log-bin-index[=*file_name*]`

Command-Line Format	`--log-bin-index=name`	
Option-File Format	`log-bin-index`	
	Permitted Values	
	Type	`file name`
	Default	`OFF`

The index file for binary log file names. See Section 5.2.4, “The Binary Log”. If you omit the file name, and if you did not specify one with `--log-bin`, MySQL uses `*host_name*-bin.index` as the file name.

- `--log-bin-trust-function-creators[={0|1}]`

Command-Line Format	`--log-bin-trust-function-creators`	
Option-File Format	`log-bin-trust-function-creators`	
Option Sets Variable	Yes, `log_bin_trust_function_creators`	
Variable Name	`log_bin_trust_function_creators`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

This option sets the corresponding `log_bin_trust_function_creators` system variable. If no argument is given, the option sets the variable to 1. `log_bin_trust_function_creators` affects how MySQL enforces restrictions on stored function and trigger creation. See Section 17.7, “Binary Logging of Stored Programs”.

Statement selection options. The options in the following list affect which statements are written to the binary log, and thus sent by a replication master server to its slaves. There are also options for slave servers that control which statements received from the master should be executed or ignored. For details, see Section 15.1.3.3, “Replication Slave Options and Variables”.

- `--binlog-do-db=*db_name*`

Command-Line Format	`--binlog-do-db=name`	
Option-File Format	`binlog-do-db`	
	Permitted Values	
	Type	`string`

This option affects binary logging in a manner similar to the way that `--replicate-do-db` affects replication.

The effects of this option depend on whether the statement-based or row-based logging format is in use, in the same way that the effects of `--replicate-do-db` depend on whether statement-based or row-based replication is in use. You should keep in mind that the format used to log a given statement may not necessarily be the same as that indicated by the value of `binlog_format`. For example, DDL statements such as `CREATE TABLE` and `ALTER TABLE` are always logged as statements, without regard to the logging format in effect, so the following statement-based rules for `--binlog-do-db` always apply in determining whether or not the statement is logged.

Statement-based logging. Only those statements are written to the binary log where the default database (that is, the one selected by `USE`) is *`db_name`*. To specify more than one database, use this option multiple times, once for each database; however, doing so does *not* cause cross-database statements such as `UPDATE some_db.some_table SET foo='bar'` to be logged while a different database (or no database) is selected.

> **Warning**
>
> To specify multiple databases you *must* use multiple instances of this option. Because database names can contain commas, the list will be treated as the name of a single database if you supply a comma-separated list.

An example of what does not work as you might expect when using statement-based logging: If the server is started with `--binlog-do-db=sales` and you issue the following statements, the `UPDATE` statement is *not* logged:

```
USE prices;
UPDATE sales.january SET amount=amount+1000;
```

The main reason for this “just check the default database” behavior is that it is difficult from the statement alone to know whether it should be replicated (for example, if you are using multiple-table `DELETE` statements or multiple-table `UPDATE` statements that act across multiple databases). It is also faster to check only the default database rather than all databases if there is no need.

Another case which may not be self-evident occurs when a given database is replicated even though it was not specified when setting the option. If the server is started with `--binlog-do-db=sales`, the following `UPDATE` statement is logged even though `prices` was not included when setting `--binlog-do-db`:

```

USE sales;
UPDATE prices.discounts SET percentage = percentage + 10;
```

Because `sales` is the default database when the `UPDATE` statement is issued, the `UPDATE` is logged.

Row-based logging. Logging is restricted to database *`db_name`*. Only changes to tables belonging to *`db_name`* are logged; the default database has no effect on this. Suppose that the server is started with `--binlog-do-db=sales` and row-based logging is in effect, and then the following statements are executed:

```
USE prices;
UPDATE sales.february SET amount=amount+100;
```

The changes to the `february` table in the `sales` database are logged in accordance with the `UPDATE` statement; this occurs whether or not the `USE` statement was issued. However, when using the row-based logging format and `--binlog-do-db=sales`, changes made by the following `UPDATE` are not logged:

```
USE prices;
UPDATE prices.march SET amount=amount-25;
```

Even if the `USE prices` statement were changed to `USE sales`, the `UPDATE` statement's effects would still not be written to the binary log.

Another important difference in `--binlog-do-db` handling for statement-based logging as opposed to the row-based logging occurs with regard to statements that refer to multiple databases. Suppose that the server is started with `--binlog-do-db=db1`, and the following statements are executed:

```
USE db1;
UPDATE db1.table1 SET col1 = 10, db2.table2 SET col2 = 20;
```

If you are using statement-based logging, the updates to both tables are written to the binary log. However, when using the row-based format, only the changes to `table1` are logged; `table2` is in a different database, so it is not changed by the `UPDATE`. Now suppose that, instead of the `USE db1` statement, a `USE db4` statement had been used:

```
USE db4;
UPDATE db1.table1 SET col1 = 10, db2.table2 SET col2 = 20;
```

In this case, the `UPDATE` statement is not written to the binary log when using statement-based logging. However, when using row-based logging, the change to `table1` is logged, but not that to `table2`—in other words, only changes to tables in the database named by `--binlog-do-db` are logged, and the choice of default database has no effect on this behavior.

- `--binlog-ignore-db=`*`db_name`*

Command-Line Format	`--binlog-ignore-db=name`	
Option-File Format	`binlog-ignore-db`	
	Permitted Values	
	Type	`string`

This option affects binary logging in a manner similar to the way that `--replicate-ignore-db` affects replication.

The effects of this option depend on whether the statement-based or row-based logging format is in use, in the same way that the effects of `--replicate-ignore-db` depend on whether statement-based or row-based replication is in use. You should keep in mind that the format used to log a given statement may not necessarily be the same as that indicated by the value of `binlog_format`. For example, DDL statements such as `CREATE TABLE` and `ALTER TABLE` are always logged as statements, without regard to the logging format in effect, so the following statement-based rules for `--binlog-ignore-db` always apply in determining whether or not the statement is logged.

Statement-based logging. Tells the server to not log any statement where the default database (that is, the one selected by `USE`) is *`db_name`*.

Row-based format. Tells the server not to log updates to any tables in the database *`db_name`*. The current database has no effect.

When using statement-based logging, the following example does not work as you might expect. Suppose that the server is started with `--binlog-ignore-db=sales` and you issue the following statements:

```
USE prices;
UPDATE sales.january SET amount=amount+1000;
```

The `UPDATE` statement *is* logged in such a case because `--binlog-ignore-db` applies only to the default database (determined by the `USE` statement). Because the `sales` database was specified explicitly in the statement, the statement has not been filtered. However, when using row-based logging, the `UPDATE` statement's effects are *not* written to the binary log, which means that no changes to the `sales.january` table are logged; in this instance, `--binlog-ignore-db=sales` causes *all* changes made to tables in the master's copy of the `sales` database to be ignored for purposes of binary logging.

To specify more than one database to ignore, use this option multiple times, once for each database. Because database names can contain commas, the list will be treated as the name of a single database if you supply a comma-separated list.

You should not use this option if you are using cross-database updates and you do not want these updates to be logged.

Testing and debugging options. The following binary log options are used in replication testing and debugging. They are not intended for use in normal operations.

- `--max-binlog-dump-events=`*`N`*

Command-Line Format	`--max-binlog-dump-events=#`	
Option-File Format	`max-binlog-dump-events`	
	Permitted Values	
	Type	`numeric`
	Default	`0`

This option is used internally by the MySQL test suite for replication testing and debugging.

- `--sporadic-binlog-dump-fail`

Command-Line Format	`--sporadic-binlog-dump-fail`
Option-File Format	`sporadic-binlog-dump-fail`

	Permitted Values	
	Type	`boolean`
	Default	`FALSE`

This option is used internally by the MySQL test suite for replication testing and debugging.

System variables used with the binary log. The following list describes system variables for controlling binary logging. They can be set at server startup and some of them can be changed at runtime using `SET`. Server options used to control binary logging are listed earlier in this section.

- `binlog_cache_size`

Command-Line Format	`--binlog_cache_size=#`	
Option-File Format	`binlog_cache_size`	
Option Sets Variable	Yes, `binlog_cache_size`	
Variable Name	`binlog_cache_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`32768`
	Range	`4096-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`32768`
	Range	`4096-18446744073709547520`

The size of the cache to hold changes to the binary log during a transaction. A binary log cache is allocated for each client if the server supports any transactional storage engines and if the server has the binary log enabled (`--log-bin` option). If you often use large transactions, you can increase this cache size to get better performance. The `Binlog_cache_use` and `Binlog_cache_disk_use` status variables can be useful for tuning the size of this variable. See Section 5.2.4, “The Binary Log”.

In MySQL 5.5.3, a separate binary log cache (the binary log statement cache) was introduced for nontransactional statements and in MySQL 5.5.3 through 5.5.8, this variable sets.the size for both caches. This means that, in these MySQL versions, the total memory used for these caches is double the value set for `binlog_cache_size`.

Begining with MySQL 5.5.9, `binlog_cache_size` sets the size for the transaction cache only, and the size of the statement cache is governed by the `binlog_stmt_cache_size` system variable.

- `binlog_direct_non_transactional_updates`

Version Introduced	5.5.2
Command-Line Format	`--binlog_direct_non_transactional_updates[=value]`
Option-File Format	`binlog_direct_non_transactional_updates`
Option Sets Variable	Yes, `binlog_direct_non_transactional_updates`
Variable Name	`binlog_direct_non_transactional_updates`
Variable Scope	Global, Session
Dynamic Variable	Yes

	Permitted Values	
	Type	`boolean`
	Default	`OFF`

Due to concurrency issues, a slave can become inconsistent when a transaction contains updates to both transactional and nontransactional tables. MySQL tries to preserve causality among these statements by writing non-transactional statements to the transaction cache, which is flushed upon commit. However, problems arise when modifications done to nontransactional tables on behalf of a transaction become immediately visible to other connections because these changes may not be written immediately into the binary log.

Beginning with MySQL 5.5.2, the `binlog_direct_non_transactional_updates` variable offers one possible workaround to this issue. By default, this variable is disabled. Enabling `binlog_direct_non_transactional_updates` causes updates to nontransactional tables to be written directly to the binary log, rather than to the transaction cache.

`binlog_direct_non_transactional_updates` works only for statements that are replicated using the statement-based binary logging format; that is, it works only when the value of `binlog_format` is `STATEMENT`, or when `binlog_format` is `MIXED` and a given statement is being replicated using the statement-based format. This variable has no effect when the binary log format is `ROW`, or when `binlog_format` is set to `MIXED` and a given statement is replicated using the row-based format.

> ### Important
>
> Before enabling this variable, you must make certain that there are no dependencies between transactional and nontransactional tables; an example of such a dependency would be the statement `INSERT INTO myisam_table SELECT * FROM innodb_table`. Otherwise, such statements are likely to cause the slave to diverge from the master.

Beginning with MySQL 5.5.5, this variable has no effect when the binary log format is `ROW` or `MIXED`. (Bug #51291)

- `binlog_format`

Command-Line Format	`--binlog-format=format`	
Option-File Format	`binlog-format=format`	
Option Sets Variable	Yes, `binlog_format`	
Variable Name	`binlog_format`	
Variable Scope	Global, Session	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`enumeration`
	Default	`STATEMENT`

	Valid Values	`ROW`
		`STATEMENT`
		`MIXED`

This variable sets the binary logging format, and can be any one of `STATEMENT`, `ROW`, or `MIXED`. See Section 15.1.2, “Replication Formats”. `binlog_format` is set by the `--binlog-format` option at startup, or by the `binlog_format` variable at runtime.

In MySQL 5.5, the default format is `STATEMENT`.

You must have the `SUPER` privilege to set either the global or session `binlog_format` value.

The rules governing when changes to this variable take effect and how long the effect lasts are the same as for other MySQL server system variables. See Section 12.4.4, “`SET` Syntax”, for more information.

When `MIXED` is specified, statement-based replication is used, except for cases where only row-based replication is guaranteed to lead to proper results. For example, this happens when statements contain user-defined functions (UDF) or the `UUID()` function. An exception to this rule is that `MIXED` always uses statement-based replication for stored functions and triggers.

There are exceptions when you cannot switch the replication format at runtime:

- From within a stored function or a trigger.
- If the session is currently in row-based replication mode and has open temporary tables.
- Beginning with MySQL 5.5.3, within a transaction. (Bug #47863)

Trying to switch the format in those cases results in an error.

The binary log format affects the behavior of the following server options:

- `--replicate-do-db`
- `--replicate-ignore-db`
- `--binlog-do-db`
- `--binlog-ignore-db`

These effects are discussed in detail in the descriptions of the individual options.

- `max_binlog_cache_size`

Command-Line Format	`--max_binlog_cache_size=#`	
Option-File Format	`max_binlog_cache_size`	
Option Sets Variable	Yes, `max_binlog_cache_size`	
Variable Name	`max_binlog_cache_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`18446744073709547520`
	Range	`4096-18446744073709547520`

If a transaction requires more than this many bytes of memory, the server generates a `MULTI-STATEMENT TRANSACTION REQUIRED MORE THAN 'MAX_BINLOG_CACHE_SIZE' BYTES OF STORAGE` error. The minimum value is 4096. The maximum and default values are 4GB on 32-bit platforms and 16PB (petabytes) on 64-bit platforms.

In MySQL 5.5.3, a separate binary log cache (the binary log statement cache) was introduced for nontransactional statements and in MySQL 5.5.3 through 5.5.8, this variable sets.the upper limit for both caches. This means that, in these MySQL versions, the effective maximum for these caches is double the value set for `max_binlog_cache_size`.

Begining with MySQL 5.5.9, `max_binlog_cache_size` sets the size for the transaction cache only, and the upper limit for the statement cache is governed by the `max_binlog_stmt_cache_size` system variable.

Also beginning with MySQL 5.5.9, the session visibility of the `max_binlog_cache_size` system variable matches that of the `binlog_cache_size` system variable: In MySQL 5.5.8 and earlier releases, a change in `max_binlog_cache_size` took immediate effect; in MySQL 5.5.9 and later, a change in `max_binlog_cache_size` takes effect only for new sessions that started after the value is changed.

- `max_binlog_stmt_cache_size`

Version Introduced	5.5.9
Command-Line Format	`--max_binlog_stmt_cache_size=#`
Option-File Format	`max_binlog_stmt_cache_size`
Option Sets Variable	Yes, `max_binlog_stmt_cache_size`
Variable Name	`max_binlog_stmt_cache_size`
Variable Scope	Global
Dynamic Variable	Yes

	Permitted Values	
	Type	`numeric`
	Default	`18446744073709547520`
	Range	`4096-18446744073709547520`

If nontransaction statements within a transaction require more than this many bytes of memory, the server generates an error. The minimum value is 4096. The maximum and default values are 4GB on 32-bit platforms and 16PB (petabytes) on 64-bit platforms.

In MySQL 5.5.3, a separate binary log cache (the binary log statement cache) was introduced for nontransactional statements and in MySQL 5.5.3 through 5.5.8, this variable sets.the upper limit for both caches. This means that, in these MySQL versions, the effective maximum for these caches is double the value set for `max_binlog_cache_size`.

Begining with MySQL 5.5.9, `max_binlog_stmt_cache_size` sets the size for the transaction cache only, and the upper limit for the transaction cache is governed exclusively by the `max_binlog_cache_size` system variable.

- `max_binlog_size`

Command-Line Format	`--max_binlog_size=#`	
Option-File Format	`max_binlog_size`	
Option Sets Variable	Yes, `max_binlog_size`	
Variable Name	`max_binlog_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Type	`numeric`
	Default	`1073741824`
	Range	`4096-1073741824`

If a write to the binary log causes the current log file size to exceed the value of this variable, the server rotates the binary logs (closes the current file and opens the next one). The minimum value is 4096 bytes. The maximum and default value is 1GB.

A transaction is written in one chunk to the binary log, so it is never split between several binary logs. Therefore, if you have big transactions, you might see binary log files larger than `max_binlog_size`.

If `max_relay_log_size` is 0, the value of `max_binlog_size` applies to relay logs as well.

- `binlog_stmt_cache_size`

Version Introduced	5.5.9	
Command-Line Format	`--binlog_stmt_cache_size=#`	
Option-File Format	`binlog_stmt_cache_size`	
Option Sets Variable	Yes, `binlog_stmt_cache_size`	
Variable Name	`binlog_stmt_cache_size`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`32768`
	Range	`4096-4294967295`

	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`32768`
	Range	`4096-18446744073709547520`

Beginning with MySQL 5.5.9, this variable determines the size of the cache for the binary log to hold nontransactional statements issued during a transaction. In MySQL 5.5.3 and later, separate binary log transaction and statement caches are allocated for each client if the server supports any transactional storage engines and if the server has the binary log enabled (`--log-bin` option). If you often use large nontransactional statements during transactions, you can increase this cache size to get more performance. The `Binlog_stmt_cache_use` and `Binlog_stmt_cache_disk_use` status variables can be useful for tuning the size of this variable. See Section 5.2.4, “The Binary Log”.

In MySQL 5.5.3 through 5.5.8, the size for both caches is set using `binlog_cache_size`. This means that, in these MySQL versions, the total memory used for these caches is double the value set for `binlog_cache_size`. Begining with MySQL 5.5.9, `binlog_cache_size` sets the size for the transaction cache only.

- `sync_binlog`

Command-Line Format	`--sync-binlog=#`	
Option-File Format	`sync_binlog`	
Option Sets Variable	Yes, `sync_binlog`	
Variable Name	`sync_binlog`	
Variable Scope	Global	
Dynamic Variable	Yes	
	Permitted Values	
	Platform Bit Size	`32`
	Type	`numeric`
	Default	`0`
	Range	`0-4294967295`
	Permitted Values	
	Platform Bit Size	`64`
	Type	`numeric`
	Default	`0`
	Range	`0-18446744073709547520`

If the value of this variable is greater than 0, the MySQL server synchronizes its binary log to disk (using `fdatasync()`) after every `sync_binlog` writes to the binary log. There is one write to the binary log per statement if autocommit is enabled, and one write per transaction otherwise. The default value of `sync_binlog` is 0, which does no synchronizing to disk—in this case, the server relies on the operating system to flush the binary log's contents from to time as for any other file. A value of 1 is the safest choice because in the event of a crash you lose at most one statement or transaction from the binary log. However, it is also the slowest choice (unless the disk has a battery-backed cache, which makes synchronization very fast).

15.1.4. Common Replication Administration Tasks

Once replication has been started it should execute without requiring much regular administration. Depending on your replication environment, you will want to check the replication status of each slave periodically, daily, or even more frequently.

15.1.4.1. Checking Replication Status

The most common task when managing a replication process is to ensure that replication is taking place and that there have been no errors between the slave and the master. The primary statement for this is `SHOW SLAVE STATUS`, which you must execute on each slave:

```
mysql> SHOW SLAVE STATUS\G
*************************** 1. row ***************************
               Slave_IO_State: Waiting for master to send event
                  Master_Host: master1
                  Master_User: root
                  Master_Port: 3306
                Connect_Retry: 60
              Master_Log_File: mysql-bin.000004
          Read_Master_Log_Pos: 931
               Relay_Log_File: slave1-relay-bin.000056
                Relay_Log_Pos: 950
        Relay_Master_Log_File: mysql-bin.000004
             Slave_IO_Running: Yes
            Slave_SQL_Running: Yes
              Replicate_Do_DB:
          Replicate_Ignore_DB:
           Replicate_Do_Table:
       Replicate_Ignore_Table:
      Replicate_Wild_Do_Table:
  Replicate_Wild_Ignore_Table:
                   Last_Errno: 0
                   Last_Error:
                 Skip_Counter: 0
          Exec_Master_Log_Pos: 931
              Relay_Log_Space: 1365
              Until_Condition: None
               Until_Log_File:
                Until_Log_Pos: 0
           Master_SSL_Allowed: No
           Master_SSL_CA_File:
           Master_SSL_CA_Path:
              Master_SSL_Cert:
            Master_SSL_Cipher:
               Master_SSL_Key:
        Seconds_Behind_Master: 0
Master_SSL_Verify_Server_Cert: No
                Last_IO_Errno: 0
                Last_IO_Error:
               Last_SQL_Errno: 0
               Last_SQL_Error:
  Replicate_Ignore_Server_Ids: 0
```

The key fields from the status report to examine are:

- `Slave_IO_State`: The current status of the slave. See Section 7.12.5.6, “Replication Slave I/O Thread States”, and Section 7.12.5.7, “Replication Slave SQL Thread States”, for more information.
- `Slave_IO_Running`: Whether the I/O thread for reading the master's binary log is running. Normally, you want this to be `Yes` unless you have not yet started replication or have explicitly stopped it with `STOP SLAVE`.
- `Slave_SQL_Running`: Whether the SQL thread for executing events in the relay log is running. As with the I/O thread, this should normally be `Yes`.
- `Last_IO_Error`, `Last_SQL_Error`: The last errors registered by the I/O and SQL threads when processing the relay log. Ideally these should be blank, indicating no errors.
- `Seconds_Behind_Master`: The number of seconds that the slave SQL thread is behind processing the master binary log. A high number (or an increasing one) can indicate that the slave is unable to handle events from the master in a timely fashion.

  A value of 0 for `Seconds_Behind_Master` can usually be interpreted as meaning that the slave has caught up with the master, but there are some cases where this is not strictly true. For example, this can occur if the network connection between master and slave is broken but the slave I/O thread has not yet noticed this—that is, `slave_net_timeout` has not yet elapsed.

  It is also possible that transient values for `Seconds_Behind_Master` may not reflect the situation accurately. When the slave SQL thread has caught up on I/O, `Seconds_Behind_Master` displays 0; but when the slave I/O thread is still queuing up a new event, `Seconds_Behind_Master` may show a large value until the SQL thread finishes executing the new event. This is especially likely when the events have old timestamps; in such cases, if you execute `SHOW SLAVE STATUS` several times in a relatively short period, you may see this value change back and forth repeatedly between 0 and a relatively large value.

Several pairs of fields provide information about the progress of the slave in reading events from the master binary log and processing them in the relay log:

- (`Master_Log_file`, `Read_Master_Log_Pos`): Coordinates in the master binary log indicating how far the slave I/O thread has read events from that log.
- (`Relay_Master_Log_File`, `Exec_Master_Log_Pos`): Coordinates in the master binary log indicating how far the

slave SQL thread has executed events received from that log.

- (`Relay_Log_File`, `Relay_Log_Pos`): Coordinates in the slave relay log indicating how far the slave SQL thread has executed the relay log. These correspond to the preceding coordinates, but are expressed in slave relay log coordinates rather than master binary log coordinates.

On the master, you can check the status of connected slaves using `SHOW PROCESSLIST` to examine the list of running processes. Slave connections have `Binlog Dump` in the `Command` field:

```
mysql> SHOW PROCESSLIST \G;
*************************** 4. row ***************************
     Id: 10
   User: root
   Host: slave1:58371
     db: NULL
Command: Binlog Dump
   Time: 777
  State: Has sent all binlog to slave; waiting for binlog to be updated
   Info: NULL
```

Because it is the slave that drives the replication process, very little information is available in this report.

For slaves that were started with the `--report-host` option and are connected to the master, the `SHOW SLAVE HOSTS` statement on the master shows basic information about the slaves. The output includes the ID of the slave server, the value of the `--report-host` option, the connecting port, and master ID:

```
mysql> SHOW SLAVE HOSTS;
+-----------+--------+------+-------------------+-----------+
| Server_id | Host   | Port | Rpl_recovery_rank | Master_id |
+-----------+--------+------+-------------------+-----------+
|        10 | slave1 | 3306 |                 0 |         1 |
+-----------+--------+------+-------------------+-----------+
1 row in set (0.00 sec)
```

15.1.4.2. Pausing Replication on the Slave

You can stop and start the replication of statements on the slave using the `STOP SLAVE` and `START SLAVE` statements.

To stop processing of the binary log from the master, use `STOP SLAVE`:

```
mysql> STOP SLAVE;
```

When replication is stopped, the slave I/O thread stops reading events from the master binary log and writing them to the relay log, and the SQL thread stops reading events from the relay log and executing them. You can pause the I/O or SQL thread individually by specifying the thread type:

```
mysql> STOP SLAVE IO_THREAD;
mysql> STOP SLAVE SQL_THREAD;
```

To start execution again, use the `START SLAVE` statement:

```
mysql> START SLAVE;
```

To start a particular thread, specify the thread type:

```
mysql> START SLAVE IO_THREAD;
mysql> START SLAVE SQL_THREAD;
```

For a slave that performs updates only by processing events from the master, stopping only the SQL thread can be useful if you want to perform a backup or other task. The I/O thread will continue to read events from the master but they are not executed. This makes it easier for the slave to catch up when you restart the SQL thread.

Stopping only the I/O thread enables the events in the relay log to be executed by the SQL thread up to the point where the relay log ends. This can be useful when you want to pause execution to catch up with events already received from the master, when you want to perform administration on the slave but also ensure that it has processed all updates to a specific point. This method can also be used to pause event receipt on the slave while you conduct administration on the master. Stopping the I/O thread but permitting the SQL thread to run helps ensure that there is not a massive backlog of events to be executed when replication is started again.

15.2. Replication Implementation

Replication is based on the master server keeping track of all changes to its databases (updates, deletes, and so on) in its binary log. The binary log serves as a written record of all events that modify database structure or content (data) from the moment the server was started. Typically, `SELECT` statements are not recorded because they modify neither database structure nor content.

Each slave that connects to the master requests a copy of the binary log. That is, it pulls the data from the master, rather than the master pushing the data to the slave. The slave also executes the events from the binary log that it receives. This has the effect of repeating the original changes just as they were made on the master. Tables are created or their structure modified, and data is inserted, deleted, and updated according to the changes that were originally made on the master.

Because each slave is independent, the replaying of the changes from the master's binary log occurs independently on each slave that is connected to the master. In addition, because each slave receives a copy of the binary log only by requesting it from the master, the slave is able to read and update the copy of the database at its own pace and can start and stop the replication process at will without affecting the ability to update to the latest database status on either the master or slave side.

For more information on the specifics of the replication implementation, see Section 15.2.1, “Replication Implementation Details”.

Masters and slaves report their status in respect of the replication process regularly so that you can monitor them. See Section 7.12.5, “Examining Thread Information”, for descriptions of all replicated-related states.

The master binary log is written to a local relay log on the slave before it is processed. The slave also records information about the current position with the master's binary log and the local relay log. See Section 15.2.2, “Replication Relay and Status Logs”.

Database changes are filtered on the slave according to a set of rules that are applied according to the various configuration options and variables that control event evaluation. For details on how these rules are applied, see Section 15.2.3, “How Servers Evaluate Replication Filtering Rules”.

15.2.1. Replication Implementation Details

MySQL replication capabilities are implemented using three threads, one on the master server and two on the slave:

- **Binlog dump thread.** The master creates a thread to send the binary log contents to a slave when the slave connects. This thread can be identified in the output of `SHOW PROCESSLIST` on the master as the `Binlog Dump` thread.

  The binlog dump thread acquires a lock on the master's binary log for reading each event that is to be sent to the slave. As soon as the event has been read, the lock is released, even before the event is sent to the slave.

- **Slave I/O thread.** When a `START SLAVE` statement is issued on a slave server, the slave creates an I/O thread, which connects to the master and asks it to send the updates recorded in its binary logs.

  The slave I/O thread reads the updates that the master's `Binlog Dump` thread sends (see previous item) and copies them to local files that comprise the slave's relay log.

  The state of this thread is shown as `Slave_IO_running` in the output of `SHOW SLAVE STATUS` or as `Slave_running` in the output of `SHOW STATUS`.

- **Slave SQL thread.** The slave creates an SQL thread to read the relay log that is written by the slave I/O thread and execute the events contained therein.

In the preceding description, there are three threads per master/slave connection. A master that has multiple slaves creates one binlog dump thread for each currently connected slave, and each slave has its own I/O and SQL threads.

A slave uses two threads to separate reading updates from the master and executing them into independent tasks. Thus, the task of reading statements is not slowed down if statement execution is slow. For example, if the slave server has not been running for a while, its I/O thread can quickly fetch all the binary log contents from the master when the slave starts, even if the SQL thread lags far behind. If the slave stops before the SQL thread has executed all the fetched statements, the I/O thread has at least fetched everything so that a safe copy of the statements is stored locally in the slave's relay logs, ready for execution the next time that the slave starts. This enables the master server to purge its binary logs sooner because it no longer needs to wait for the slave to fetch their contents.

The `SHOW PROCESSLIST` statement provides information that tells you what is happening on the master and on the slave regarding replication. For information on master states, see Section 7.12.5.5, “Replication Master Thread States”. For slave states, see Section 7.12.5.6, “Replication Slave I/O Thread States”, and Section 7.12.5.7, “Replication Slave SQL Thread States”.

The following example illustrates how the three threads show up in the output from `SHOW PROCESSLIST`.

On the master server, the output from `SHOW PROCESSLIST` looks like this:

```
mysql> SHOW PROCESSLIST\G
*************************** 1. row ***************************
```

```
     Id: 2
   User: root
   Host: localhost:32931
     db: NULL
Command: Binlog Dump
   Time: 94
  State: Has sent all binlog to slave; waiting for binlog to
         be updated
   Info: NULL
```

Here, thread 2 is a `Binlog Dump` replication thread that services a connected slave. The `State` information indicates that all outstanding updates have been sent to the slave and that the master is waiting for more updates to occur. If you see no `Binlog Dump` threads on a master server, this means that replication is not running; that is, no slaves are currently connected.

On a slave server, the output from `SHOW PROCESSLIST` looks like this:

```
mysql> SHOW PROCESSLIST\G
*************************** 1. row ***************************
     Id: 10
   User: system user
   Host:
     db: NULL
Command: Connect
   Time: 11
  State: Waiting for master to send event
   Info: NULL
*************************** 2. row ***************************
     Id: 11
   User: system user
   Host:
     db: NULL
Command: Connect
   Time: 11
  State: Has read all relay log; waiting for the slave I/O
         thread to update it
   Info: NULL
```

The `State` information indicates that thread 10 is the I/O thread that is communicating with the master server, and thread 11 is the SQL thread that is processing the updates stored in the relay logs. At the time that `SHOW PROCESSLIST` was run, both threads were idle, waiting for further updates.

The value in the `Time` column can show how late the slave is compared to the master. See Section 15.4.4, “Replication FAQ”. If sufficient time elapses on the master side without activity on the `Binlog Dump` thread, the master determines that the slave is no longer connected. As for any other client connection, the timeouts for this depend on the values of `net_write_timeout` and `net_retry_count`; for more information about these, see Section 5.1.3, “Server System Variables”.

The `SHOW SLAVE STATUS` statement provides additional information about replication processing on a slave server. See Section 15.1.4.1, “Checking Replication Status”.

15.2.2. Replication Relay and Status Logs

During replication, a slave server creates several logs that hold the binary log events relayed from the master to the slave, and to record information about the current status and location within the relay log. There are three types of logs used in the process, listed here:

- The *relay log* consists of the events read from the binary log of the master and written by the slave I/O thread. Events in the relay log are executed on the slave as part of the SQL thread.
- The *master info log* contains status and current configuration information for the slave's connection to the master. This log holds information on the master host name, login credentials, and coordinates indicating how far the slave has read from the master's binary log.
- The *relay log info log* holds status information about the execution point within the slave's relay log.

15.2.2.1. The Slave Relay Log

The relay log, like the binary log, consists of a set of numbered files containing events that describe database changes, and an index file that contains the names of all used relay log files.

The term “relay log file” generally denotes an individual numbered file containing database events. The term “relay log” collectively denotes the set of numbered relay log files plus the index file.

Relay log files have the same format as binary log files and can be read using `mysqlbinlog` (see Section 4.6.7, “`mysqlbinlog` — Utility for Processing Binary Log Files”).

By default, relay log file names have the form `host_name-relay-bin.nnnnnn` in the data directory, where `host_name` is the name of the slave server host and `nnnnnn` is a sequence number. Successive relay log files are created using successive sequence numbers, beginning with `000001`. The slave uses an index file to track the relay log files currently in use. The default relay log index file name is `host_name-relay-bin.index` in the data directory.

The default relay log file and relay log index file names can be overridden with, respectively, the `--relay-log` and `--relay-log-index` server options (see Section 15.1.3, “Replication and Binary Logging Options and Variables”).

If a slave uses the default host-based relay log file names, changing a slave's host name after replication has been set up can cause replication to fail with the errors `FAILED TO OPEN THE RELAY LOG` and `COULD NOT FIND TARGET LOG DURING RELAY LOG INITIALIZATION`. This is a known issue (see Bug #2122). If you anticipate that a slave's host name might change in the future (for example, if networking is set up on the slave such that its host name can be modified using DHCP), you can avoid this issue entirely by using the `--relay-log` and `--relay-log-index` options to specify relay log file names explicitly when you initially set up the slave. This will make the names independent of server host name changes.

If you encounter the issue after replication has already begun, one way to work around it is to stop the slave server, prepend the contents of the old relay log index file to the new one, and then restart the slave. On a Unix system, this can be done as shown here:

```
shell> cat new_relay_log_name.index >> old_relay_log_name.index
shell> mv old_relay_log_name.index new_relay_log_name.index
```

A slave server creates a new relay log file under the following conditions:

- Each time the I/O thread starts.
- When the logs are flushed; for example, with `FLUSH LOGS` or `mysqladmin flush-logs`.
- When the size of the current relay log file becomes “too large,” determined as follows:
  - If the value of `max_relay_log_size` is greater than 0, that is the maximum relay log file size.
  - If the value of `max_relay_log_size` is 0, `max_binlog_size` determines the maximum relay log file size.

The SQL thread automatically deletes each relay log file as soon as it has executed all events in the file and no longer needs it. There is no explicit mechanism for deleting relay logs because the SQL thread takes care of doing so. However, `FLUSH LOGS` rotates relay logs, which influences when the SQL thread deletes them.

15.2.2.2. Slave Status Logs

A replication slave server creates two logs. By default, these logs are files named `master.info` and `relay-log.info` and created in the data directory. The names and locations of these files can be changed by using the `--master-info-file` and `--relay-log-info-file` options, respectively. See Section 15.1.3, “Replication and Binary Logging Options and Variables”.

The two status logs contain information like that shown in the output of the `SHOW SLAVE STATUS` statement, which is discussed in Section 12.5.2, “SQL Statements for Controlling Slave Servers”. Because the status logs are stored on disk, they survive a slave server's shutdown. The next time the slave starts up, it reads the two logs to determine how far it has proceeded in reading binary logs from the master and in processing its own relay logs.

The master info log should be protected because it contains the password for connecting to the master. See Section 5.3.2.1, “Administrator Guidelines for Password Security”.

The slave I/O thread updates the master info log. The following table shows the correspondence between the lines in the `master.info` file and the columns displayed by `SHOW SLAVE STATUS`.

Line in `master.info`	`SHOW SLAVE STATUS` Column	Description
1		Number of lines in the file
2	`Master_Log_File`	The name of the master binary log currently being read from the master
3	`Read_Master_Log_Pos`	The current position within the master binary log that have been read from the master
4	`Master_Host`	The host name of the master
5	`Master_User`	The user name used to connect to the master
6	Password (not shown by `SHOW SLAVE STATUS`)	The password used to connect to the master

Line in `master.info`	**`SHOW SLAVE STATUS` Column**	**Description**
7	`Master_Port`	The network port used to connect to the master
8	`Connect_Retry`	The period (in seconds) that the slave will wait before trying to reconnect to the master
9	`Master_SSL_Allowed`	Indicates whether the server supports SSL connections
10	`Master_SSL_CA_File`	The file used for the Certificate Authority (CA) certificate
11	`Master_SSL_CA_Path`	The path to the Certificate Authority (CA) certificates
12	`Master_SSL_Cert`	The name of the SSL certificate file
13	`Master_SSL_Cipher`	The list of possible ciphers used in the handshake for the SSL connection
14	`Master_SSL_Key`	The name of the SSL key file
15	`Master_SSL_Verify_Server_Cert`	Whether to verify the server certificate
17	`Replicate_Ignore_Server_Ids`	The number of server IDs to be ignored, followed by the actual server IDs

The slave SQL thread updates the relay log info log. The following table shows the correspondence between the lines in the `relay-log.info` file and the columns displayed by `SHOW SLAVE STATUS`.

Line in `relay-log.info`	**`SHOW SLAVE STATUS` Column**	**Description**
1	`Relay_Log_File`	The name of the current relay log file
2	`Relay_Log_Pos`	The current position within the relay log file; events up to this position have been executed on the slave database
3	`Relay_Master_Log_File`	The name of the master binary log file from which the events in the relay log file were read
4	`Exec_Master_Log_Pos`	The equivalent position within the master's binary log file of events that have already been executed

The contents of the `relay-log.info` file and the states shown by the `SHOW SLAVE STATUS` statement might not match if the `relay-log.info` file has not been flushed to disk. Ideally, you should only view `relay-log.info` on a slave that is offline (that is, `mysqld` is not running). For a running system, `SHOW SLAVE STATUS` should be used.

When you back up the slave's data, you should back up these two status logs, along with the relay log files. The status logs are needed to resume replication after you restore the data from the slave. If you lose the relay logs but still have the relay log info log, you can check it to determine how far the SQL thread has executed in the master binary logs. Then you can use `CHANGE MASTER TO` with the `MASTER_LOG_FILE` and `MASTER_LOG_POS` options to tell the slave to re-read the binary logs from that point. Of course, this requires that the binary logs still exist on the master.

15.2.3. How Servers Evaluate Replication Filtering Rules

If a master server does not write a statement to its binary log, the statement is not replicated. If the server does log the statement, the statement is sent to all slaves and each slave determines whether to execute it or ignore it.

On the master, you can control which databases to log changes for by using the `--binlog-do-db` and `--binlog-ignore-db` options to control binary logging. For a description of the rules that servers use in evaluating these options, see Section 15.2.3.1, “Evaluation of Database-Level Replication and Binary Logging Options”. You should not use these options to control which databases and tables are replicated. Instead, use filtering on the slave to control the events that are executed on the slave.

On the slave side, decisions about whether to execute or ignore statements received from the master are made according to the `--replicate-*` options that the slave was started with. (See Section 15.1.3, “Replication and Binary Logging Options and Variables”.)

In the simplest case, when there are no `--replicate-*` options, the slave executes all statements that it receives from the master. Otherwise, the result depends on the particular options given.

Database-level options (`--replicate-do-db`, `--replicate-ignore-db`) are checked first; see Section 15.2.3.1, “Evaluation of Database-Level Replication and Binary Logging Options”, for a description of this process. If no matching database-level options are found, option checking proceeds to any table-level options that may be in use, as discussed in Section 15.2.3.2, “Evaluation of Table-Level Replication Options”.

To make it easier to determine what effect an option set will have, it is recommended that you avoid mixing “do” and “ignore” options, or wildcard and nonwildcard options. An example of the latter that may have unintended effects is the use of `--replicate-do-db` and `--replicate-wild-do-table` together, where `--replicate-wild-do-table` uses a pattern for the database name that matches the name given for `--replicate-do-db`. Suppose a replication slave is started with `--replicate-do-db=dbx` `--replicate-wild-do-table=db%.t1`. Then, suppose that on the master, you issue the statement `CREATE DATABASE dbx`. Although you might expect it, this statement is not replicated because it does not reference a table named `t1`.

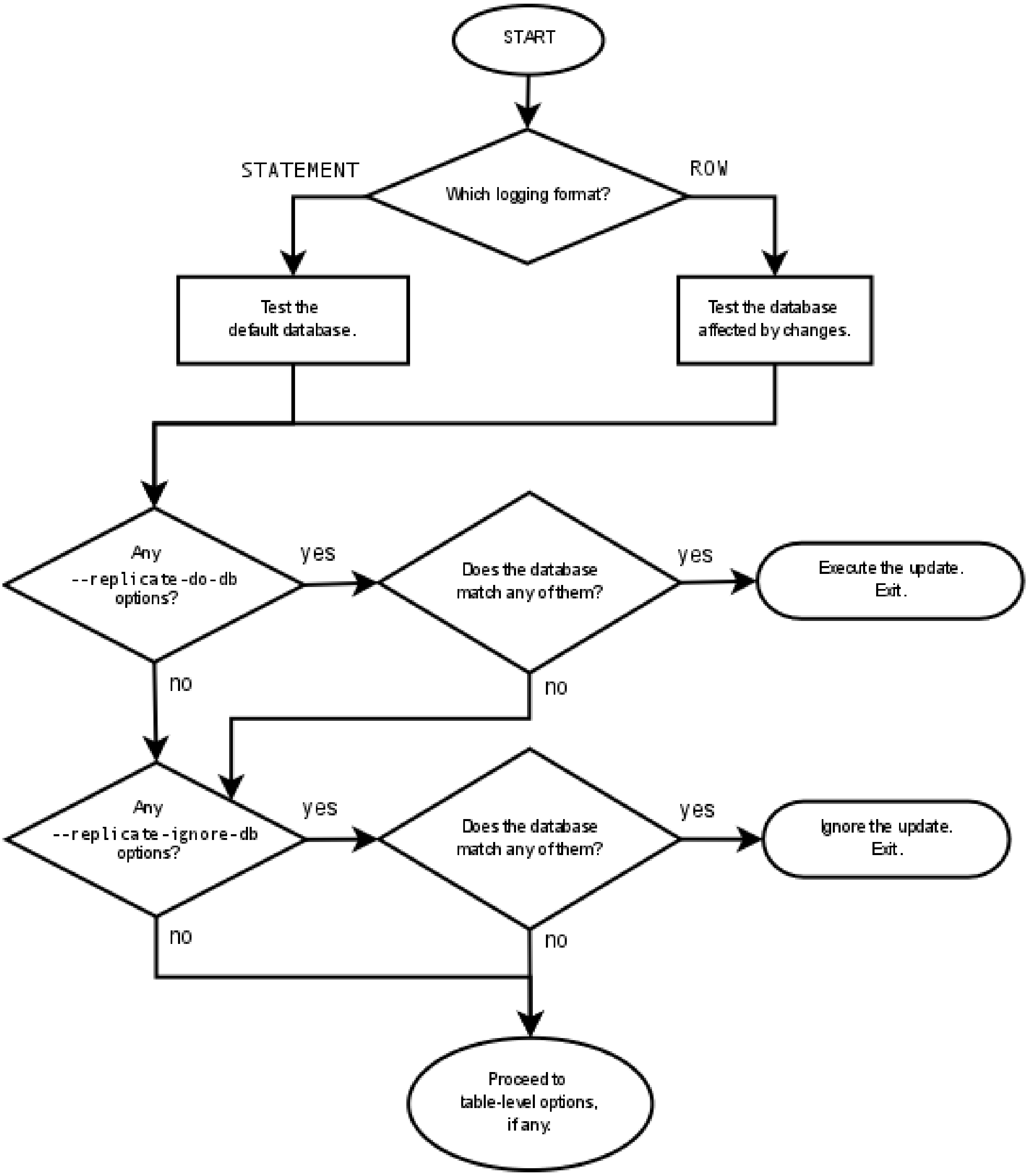
If any `--replicate-rewrite-db` options were specified, they are applied before the `--replicate-*` filtering rules are tested.

> **Note**
>
> In MySQL 5.5, database-level filtering options are case-sensitive on platforms supporting case sensitivity in filenames, whereas table-level filtering options are not (regardless of platform). This is true regardless of the value of the `lower_case_table_names` system variable.

15.2.3.1. Evaluation of Database-Level Replication and Binary Logging Options

When evaluating replication options, the slave begins by checking to see whether there are any `--replicate-do-db` or `--replicate-ignore-db` options that apply. When using `--binlog-do-db` or `--binlog-ignore-db`, the process is similar, but the options are checked on the master.

With statement-based replication, the default database is checked for a match. With row-based replication, the database where data is to be changed is the database that is checked. Regardless of the binary logging format, checking of database-level options proceeds as shown in the following diagram.


START
STATEMENT
Which logging format?
ROW
Test the default database.
Test the database affected by changes.
Any --replicate-do-db options?
yes
Does the database match any of them?
yes
Execute the update. Exit.
no
no
Any --replicate-ignore-db options?
yes
Does the database match any of them?
yes
Ignore the update. Exit.
no
no
Proceed to table-level options, if any.

The steps involved are listed here:

1. Are there any `--replicate-do-db` options?
   - **Yes.** Do any of them match the database?
     - **Yes.** Execute the statement and exit.
     - **No.** Continue to step 2.
   - **No.** Continue to step 2.
2. Are there any `--replicate-ignore-db` options?

  - **Yes.** Do any of them match the database?
    - **Yes.** Ignore the statement and exit.
    - **No.** Continue to step 3.
  - **No.** Continue to step 3.

3. Proceed to checking the table-level replication options, if there are any. For a description of how these options are checked, see Section 15.2.3.2, "Evaluation of Table-Level Replication Options".

   > **Important**
   >
   > A statement that is still permitted at this stage is not yet actually executed. The statement is not executed until all table-level options (if any) have also been checked, and the outcome of that process permits execution of the statement.

For binary logging, the steps involved are listed here:

1. Are there any `--binlog-do-db` or `--binlog-ignore-db` options?
   - **Yes.** Continue to step 2.
   - **No.** Log the statement and exit.
2. Is there a default database (has any database been selected by `USE`)?
   - **Yes.** Continue to step 3.
   - **No.** Ignore the statement and exit.
3. There is a default database. Are there any `--binlog-do-db` options?
   - **Yes.** Do any of them match the database?
     - **Yes.** Log the statement and exit.
     - **No.** Ignore the statement and exit.
   - **No.** Continue to step 4.
4. Do any of the `--binlog-ignore-db` options match the database?
   - **Yes.** Ignore the statement and exit.
   - **No.** Log the statement and exit.

   > **Important**
   >
   > For statement-based logging, an exception is made in the rules just given for the `CREATE DATABASE`, `ALTER DATABASE`, and `DROP DATABASE` statements. In those cases, the database being *created, altered, or dropped* replaces the default database when determining whether to log or ignore updates.

`--binlog-do-db` can sometimes mean "ignore other databases". For example, when using statement-based logging, a server running with only `--binlog-do-db=sales` does not write to the binary log statements for which the default database differs from `sales`. When using row-based logging with the same option, the server logs only those updates that change data in `sales`.

15.2.3.2. Evaluation of Table-Level Replication Options

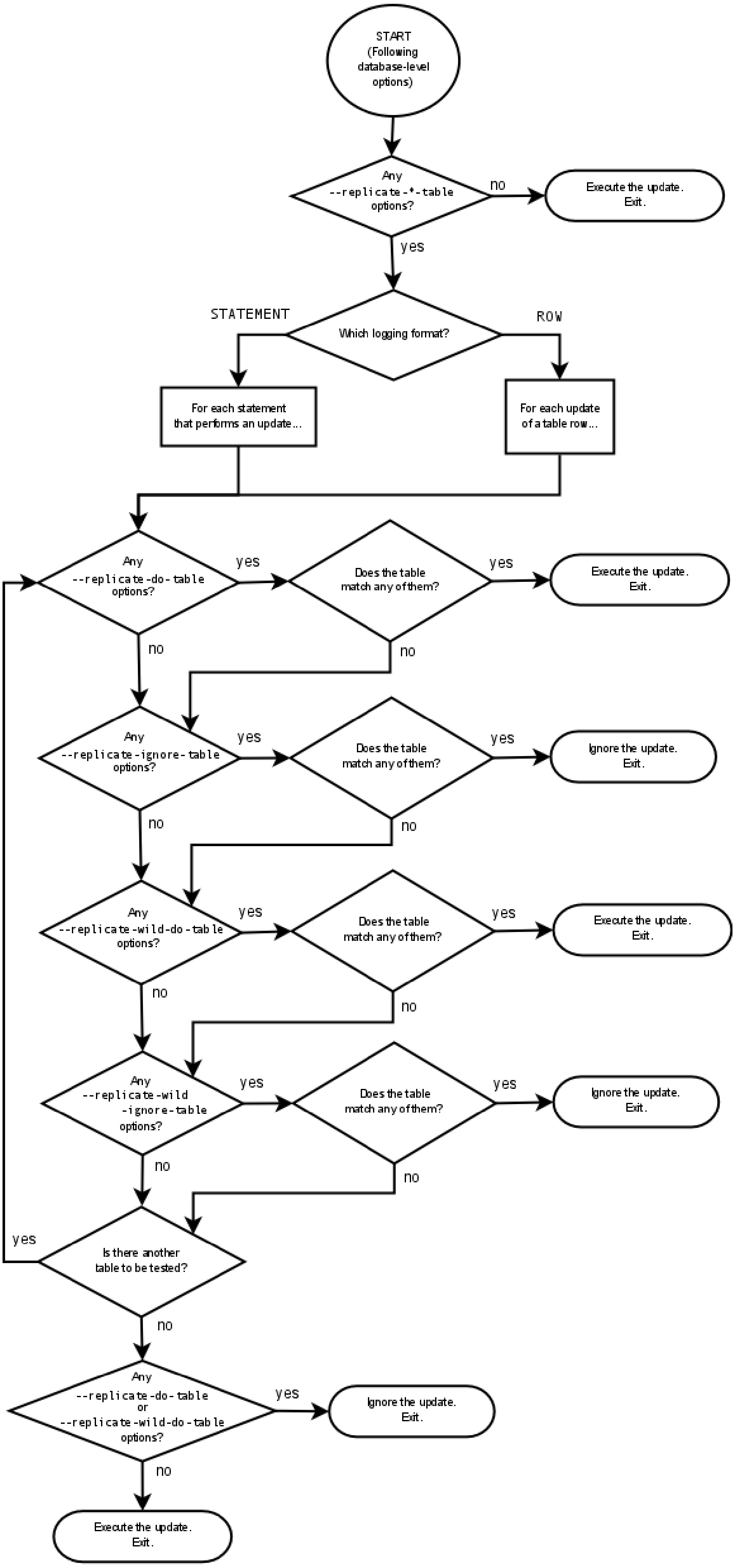
The slave checks for and evaluates table options only if no matching database options were found (see Section 15.2.3.1, "Evaluation of Database-Level Replication and Binary Logging Options").

First, as a preliminary condition, the slave checks whether statement-based replication is enabled. If so, and the statement occurs within a stored function, the slave executes the statement and exits. If row-based replication is enabled, the slave does not know whether a statement occurred within a stored function on the master, so this condition does not apply.

> **Note**

> For statement-based replication, replication events represent statements (all changes making up a given event are associated with a single SQL statement); for row-based replication, each event represents a change in a single table row (thus a single statement such as `UPDATE mytable SET mycol = 1` may yield many row-based events). When viewed in terms of events, the process of checking table options is the same for both row-based and statement-based replication.

Having reached this point, if there are no table options, the slave simply executes all events. If there are any `--replicate-do-table` or `--replicate-wild-do-table` options, the event must match one of these if it is to be executed; otherwise, it is ignored. If there are any `--replicate-ignore-table` or `--replicate-wild-ignore-table` options, all events are executed except those that match any of these options. This process is illustrated in the following diagram.


START
(Following
database-level
options)
Any
--replicate-*-table
options?
no
Execute the update.
Exit.
yes
STATEMENT
Which logging format?
ROW
For each statement
that performs an update...
For each update
of a table row...
Any
--replicate-do-table
options?
yes
Does the table
match any of them?
yes
Execute the update.
Exit.
no
no
Any
--replicate-ignore-table
options?
yes
Does the table
match any of them?
yes
Ignore the update.
Exit.
no
no
Any
--replicate-wild-do-table
options?
yes
Does the table
match any of them?
yes
Execute the update.
Exit.
no
no
Any
--replicate-wild
-ignore-table
options?
yes
Does the table
match any of them?
yes
Ignore the update.
Exit.
no
no
yes
Is there another
table to be tested?
no
Any
--replicate-do-table
or
--replicate-wild-do-table
options?
yes
Ignore the update.
Exit.
no
Execute the update.
Exit.

The following steps describe this evaluation in more detail:

1. Are there any table options?
   - **Yes.** Continue to step 2.
   - **No.** Execute the event and exit.
2. Are there any `--replicate-do-table` options?
   - **Yes.** Does the table match any of them?
     - **Yes.** Execute the event and exit.
     - **No.** Continue to step 3.
   - **No.** Continue to step 3.
3. Are there any `--replicate-ignore-table` options?
   - **Yes.** Does the table match any of them?
     - **Yes.** Ignore the event and exit.
     - **No.** Continue to step 4.
   - **No.** Continue to step 4.
4. Are there any `--replicate-wild-do-table` options?
   - **Yes.** Does the table match any of them?
     - **Yes.** Execute the event and exit.
     - **No.** Continue to step 5.
   - **No.** Continue to step 5.
5. Are there any `--replicate-wild-ignore-table` options?
   - **Yes.** Does the table match any of them?
     - **Yes.** Ignore the event and exit.
     - **No.** Continue to step 6.
   - **No.** Continue to step 6.
6. Are there any `--replicate-do-table` or `--replicate-wild-do-table` options?
   - **Yes.** Ignore the event and exit.
   - **No.** Execute the event and exit.

15.2.3.3. Replication Rule Application

This section provides additional explanation and examples of usage for different combinations of replication filtering options.

Some typical combinations of replication filter rule types are given in the following table:

Condition (Types of Options)	**Outcome**
No `--replicate-*` options at all:	The slave executes all events that it receives from the master.
`--replicate-*-db` options, but no table options:	The slave accepts or ignores events using the database options. It executes all events permitted by those options because there are no table restrictions.
`--replicate-*-table` options, but no database options:	All events are accepted at the database-checking stage because there are no database conditions. The slave executes or ignores events based solely on the table options.
A combination of database and table options:	The slave accepts or ignores events using the database options. Then it evalu-

Condition (Types of Options)	Outcome
	ates all events permitted by those options according to the table options. This can sometimes lead to results that seem counterintuitive, and that may be different depending on whether you are using statement-based or row-based replication; see the text for an example.

A more complex example follows, in which we examine the outcomes for both statement-based and row-based settings.

Suppose that we have two tables `mytbl1` in database `db1` and `mytbl2` in database `db2` on the master, and the slave is running with the following options (and no other replication filtering options):

```
replicate-ignore-db = db1
replicate-do-table  = db2.tbl2
```

Now we execute the following statements on the master:

```
USE db1;
INSERT INTO db2.tbl2 VALUES (1);
```

The results on the slave vary considerably depending on the binary log format, and may not match initial expectations in either case.

Statement-based replication. The `USE` statement causes `db1` to be the default database. Thus the `--replicate-ignore-db` option matches, *and the `INSERT` statement is ignored*. The table options are not checked.

Row-based replication. The default database has no effect on how the slave reads database options when using row-based replication. Thus, the `USE` statement makes no difference in how the `--replicate-ignore-db` option is handled: the database specified by this option does not match the database where the `INSERT` statement changes data, so the slave proceeds to check the table options. The table specified by `--replicate-do-table` matches the table to be updated, *and the row is inserted*.

15.3. Replication Solutions

Replication can be used in many different environments for a range of purposes. This section provides general notes and advice on using replication for specific solution types.

For information on using replication in a backup environment, including notes on the setup, backup procedure, and files to back up, see Section 15.3.1, “Using Replication for Backups”.

For advice and tips on using different storage engines on the master and slaves, see Section 15.3.2, “Using Replication with Different Master and Slave Storage Engines”.

Using replication as a scale-out solution requires some changes in the logic and operation of applications that use the solution. See Section 15.3.3, “Using Replication for Scale-Out”.

For performance or data distribution reasons, you may want to replicate different databases to different replication slaves. See Section 15.3.4, “Replicating Different Databases to Different Slaves”

As the number of replication slaves increases, the load on the master can increase and lead to reduced performance (because of the need to replicate the binary log to each slave). For tips on improving your replication performance, including using a single secondary server as an replication master, see Section 15.3.5, “Improving Replication Performance”.

For guidance on switching masters, or converting slaves into masters as part of an emergency failover solution, see Section 15.3.6, “Switching Masters During Failover”.

To secure your replication communication, you can use SSL to encrypt the communication channel. For step-by-step instructions, see Section 15.3.7, “Setting Up Replication Using SSL”.

15.3.1. Using Replication for Backups

To use replication as a backup solution, replicate data from the master to a slave, and then back up the data slave. The slave can be paused and shut down without affecting the running operation of the master, so you can produce an effective snapshot of “live” data that would otherwise require the master to be shut down.

How you back up a database depends on its size and whether you are backing up only the data, or the data and the replication slave state so that you can rebuild the slave in the event of failure. There are therefore two choices:

- If you are using replication as a solution to enable you to back up the data on the master, and the size of your database is not too large, the `mysqldump` tool may be suitable. See Section 15.3.1.1, “Backing Up a Slave Using `mysqldump`”.
- For larger databases, where `mysqldump` would be impractical or inefficient, you can back up the raw data files instead. Using the raw data files option also means that you can back up the binary and relay logs that will enable you to recreate the slave in the event of a slave failure. For more information, see Section 15.3.1.2, “Backing Up Raw Data from a Slave”.

Another backup strategy, which can be used for either master or slave servers, is to put the server in a read-only state. The backup is performed against the read-only server, which then is changed back to its usual read/write operational status. See Section 15.3.1.3, “Backing Up a Master or Slave by Making It Read Only”.

15.3.1.1. Backing Up a Slave Using `mysqldump`

Using `mysqldump` to create a copy of a database enables you to capture all of the data in the database in a format that enables the information to be imported into another instance of MySQL Server (see Section 4.5.4, “`mysqldump` — A Database Backup Program”). Because the format of the information is SQL statements, the file can easily be distributed and applied to running servers in the event that you need access to the data in an emergency. However, if the size of your data set is very large, `mysqldump` may be impractical.

When using `mysqldump`, you should stop replication on the slave before starting the dump process to ensure that the dump contains a consistent set of data:

1. Stop the slave from processing requests. You can stop replication completely on the slave using `mysqladmin`:

   ```
   shell> mysqladmin stop-slave
   ```

   Alternatively, you can stop only the slave SQL thread to pause event execution:

   ```
   shell> mysql -e 'STOP SLAVE SQL_THREAD;'
   ```

   This enables the slave to continue to receive data change events from the master's binary log and store them in the relay logs using the I/O thread, but prevents the slave from executing these events and changing its data. Within busy replication environments, permitting the I/O thread to run during backup may speed up the catch-up process when you restart the slave SQL thread.

2. Run `mysqldump` to dump your databases. You may either dump all databases or select databases to be dumped. For example, to dump all databases:

   ```
   shell> mysqldump --all-databases > fulldb.dump
   ```

3. Once the dump has completed, start slave operations again:

   ```
   shell> mysqladmin start-slave
   ```

In the preceding example, you may want to add login credentials (user name, password) to the commands, and bundle the process up into a script that you can run automatically each day.

If you use this approach, make sure you monitor the slave replication process to ensure that the time taken to run the backup does not affect the slave's ability to keep up with events from the master. See Section 15.1.4.1, “Checking Replication Status”. If the slave is unable to keep up, you may want to add another slave and distribute the backup process. For an example of how to configure this scenario, see Section 15.3.4, “Replicating Different Databases to Different Slaves”.

15.3.1.2. Backing Up Raw Data from a Slave

To guarantee the integrity of the files that are copied, backing up the raw data files on your MySQL replication slave should take place while your slave server is shut down. If the MySQL server is still running, background tasks may still be updating the database files, particularly those involving storage engines with background processes such as `InnoDB`. With `InnoDB`, these problems should be resolved during crash recovery, but since the slave server can be shut down during the backup process without affecting the execution of the master it makes sense to take advantage of this capability.

To shut down the server and back up the files:

1. Shut down the slave MySQL server:

   ```
   shell> mysqladmin shutdown
   ```

2. Copy the data files. You can use any suitable copying or archive utility, including `cp`, `tar` or `WinZip`. For example, assuming that the data directory is located under the current directory, you can archive the entire directory as follows:

   ```
   shell> tar cf /tmp/dbbackup.tar ./data
   ```

3. Start the MySQL server again. Under Unix:

   ```
   shell> mysqld_safe &
   ```

   Under Windows:

   ```
   C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld"
   ```

Normally you should back up the entire data directory for the slave MySQL server. If you want to be able to restore the data and operate as a slave (for example, in the event of failure of the slave), then in addition to the slave's data, you should also back up the slave status files, `master.info` and `relay-log.info`, along with the relay log files. These files are needed to resume replication after you restore the slave's data.

If you lose the relay logs but still have the `relay-log.info` file, you can check it to determine how far the SQL thread has executed in the master binary logs. Then you can use `CHANGE MASTER TO` with the `MASTER_LOG_FILE` and `MASTER_LOG_POS` options to tell the slave to re-read the binary logs from that point. This requires that the binary logs still exist on the master server.

If your slave is replicating `LOAD DATA INFILE` statements, you should also back up any `SQL_LOAD-*` files that exist in the directory that the slave uses for this purpose. The slave needs these files to resume replication of any interrupted `LOAD DATA INFILE` operations. The location of this directory is the value of the `--slave-load-tmpdir` option. If the server was not started with that option, the directory location is the value of the `tmpdir` system variable.

15.3.1.3. Backing Up a Master or Slave by Making It Read Only

It is possible to back up either master or slave servers in a replication setup by acquiring a global read lock and manipulating the `read_only` system variable to change the read-only state of the server to be backed up:

1. Make the server read-only, so that it processes only retrievals and blocks updates.
2. Perform the backup.
3. Change the server back to its normal read/write state.

> **Note**
>
> The instructions in this section place the server to be backed up in a state that is safe for backup methods that get the data from the server, such as `mysqldump` (see Section 4.5.4, “`mysqldump` — A Database Backup Program”). You should not attempt to use these instructions to make a binary backup by copying files directly because the server may still have modified data cached in memory and not flushed to disk.

The following instructions describe how to do this for a master server and for a slave server. For both scenarios discussed here, suppose that you have the following replication setup:

- A master server M1
- A slave server S1 that has M1 as its master
- A client C1 connected to M1
- A client C2 connected to S1

In either scenario, the statements to acquire the global read lock and manipulate the `read_only` variable are performed on the server to be backed up and do not propagate to any slaves of that server.

Scenario 1: Backup with a Read-Only Master

Put the master M1 in a read-only state by executing these statements on it:

```
mysql> FLUSH TABLES WITH READ LOCK;
```

```
mysql> SET GLOBAL read_only = ON;
```

While M1 is in a read-only state, the following properties are true:

- Requests for updates sent by C1 to M1 will block because the server is in read-only mode.
- Requests for query results sent by C1 to M1 will succeed.
- Making a backup on M1 is safe.
- Making a backup on S1 is not safe. This server is still running, and might be processing the binary log or update requests coming from client C2

While M1 is read only, perform the backup. For example, you can use `mysqldump`.

After the backup operation on M1 completes, restore M1 to its normal operational state by executing these statements:

```
mysql> SET GLOBAL read_only = OFF;
mysql> UNLOCK TABLES;
```

Although performing the backup on M1 is safe (as far as the backup is concerned), it is not optimal for performance because clients of M1 are blocked from executing updates.

This strategy applies to backing up a master server in a replication setup, but can also be used for a single server in a nonreplication setting.

Scenario 2: Backup with a Read-Only Slave

Put the slave S1 in a read-only state by executing these statements on it:

```
mysql> FLUSH TABLES WITH READ LOCK;
mysql> SET GLOBAL read_only = ON;
```

While S1 is in a read-only state, the following properties are true:

- The master M1 will continue to operate, so making a backup on the master is not safe.
- The slave S1 is stopped, so making a backup on the slave S1 is safe.

These properties provide the basis for a popular backup scenario: Having one slave busy performing a backup for a while is not a problem because it does not affect the entire network, and the system is still running during the backup. In particular, clients can still perform updates on the master server, which remains unaffected by backup activity on the slave.

While S1 is read only, perform the backup. For example, you can use `mysqldump`.

After the backup operation on S1 completes, restore S1 to its normal operational state by executing these statements:

```
mysql> SET GLOBAL read_only = OFF;
mysql> UNLOCK TABLES;
```

After the slave is restored to normal operation, it again synchronizes to the master by catching up with any outstanding updates from the binary log of the master.

15.3.2. Using Replication with Different Master and Slave Storage Engines

It does not matter for the replication process whether the source table on the master and the replicated table on the slave use different engine types. In fact, the `default_storage_engine` and `storage_engine` system variables are not replicated.

This provides a number of benefits in the replication process in that you can take advantage of different engine types for different replication scenarios. For example, in a typical scale-out scenario (see Section 15.3.3, "Using Replication for Scale-Out"), you want to use `InnoDB` tables on the master to take advantage of the transactional functionality, but use `MyISAM` on the slaves where transaction support is not required because the data is only read. When using replication in a data-logging environment you may want to use the `Archive` storage engine on the slave.

Configuring different engines on the master and slave depends on how you set up the initial replication process:

- If you used `mysqldump` to create the database snapshot on your master, you could edit the dump file text to change the engine type used on each table.

  Another alternative for `mysqldump` is to disable engine types that you do not want to use on the slave before using the dump to build the data on the slave. For example, you can add the `--skip-innodb` option on your slave to disable the `InnoDB` engine. If a specific engine does not exist for a table to be created, MySQL will use the default engine type, usually `MyISAM`. (This requires that the `NO_ENGINE_SUBSTITUTION` SQL mode is not enabled.) If you want to disable additional engines in this way, you may want to consider building a special binary to be used on the slave that only supports the engines you want.

- If you are using raw data files (a binary backup) to set up the slave, you will be unable to change the initial table format. Instead, use `ALTER TABLE` to change the table types after the slave has been started.

- For new master/slave replication setups where there are currently no tables on the master, avoid specifying the engine type when creating new tables.

If you are already running a replication solution and want to convert your existing tables to another engine type, follow these steps:

1. Stop the slave from running replication updates:

   ```
   mysql> STOP SLAVE;
   ```

   This will enable you to change engine types without interruptions.

2. Execute an `ALTER TABLE ... ENGINE='engine_type'` for each table to be changed.

3. Start the slave replication process again:

   ```
   mysql> START SLAVE;
   ```

Although the `default_storage_engine` variable is not replicated, be aware that `CREATE TABLE` and `ALTER TABLE` statements that include the engine specification will be correctly replicated to the slave. For example, if you have a CSV table and you execute:

```
mysql> ALTER TABLE csvtable Engine='MyISAM';
```

The above statement will be replicated to the slave and the engine type on the slave will be converted to `MyISAM`, even if you have previously changed the table type on the slave to an engine other than CSV. If you want to retain engine differences on the master and slave, you should be careful to use the `default_storage_engine` variable on the master when creating a new table. For example, instead of:

```
mysql> CREATE TABLE tablea (columna int) Engine=MyISAM;
```

Use this format:

```
mysql> SET default_storage_engine=MyISAM;
mysql> CREATE TABLE tablea (columna int);
```

When replicated, the `default_storage_engine` variable will be ignored, and the `CREATE TABLE` statement will execute on the slave using the slave's default engine.

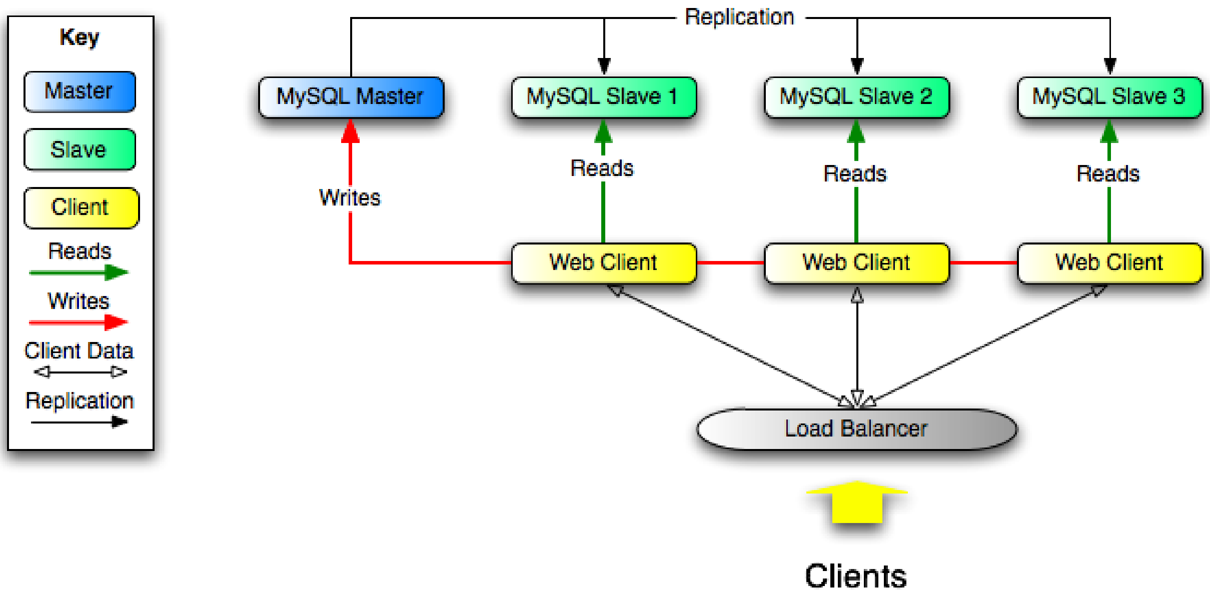
15.3.3. Using Replication for Scale-Out

You can use replication as a scale-out solution; that is, where you want to split up the load of database queries across multiple database servers, within some reasonable limitations.

Because replication works from the distribution of one master to one or more slaves, using replication for scale-out works best in an environment where you have a high number of reads and low number of writes/updates. Most Web sites fit into this category, where users are browsing the Web site, reading articles, posts, or viewing products. Updates only occur during session management, or when making a purchase or adding a comment/message to a forum.

Replication in this situation enables you to distribute the reads over the replication slaves, while still enabling your web servers to communicate with the replication master when a write is required. You can see a sample replication layout for this scenario in Figure 15.1, “Using Replication to Improve Performance During Scale-Out”.

Figure 15.1. Using Replication to Improve Performance During Scale-Out



If the part of your code that is responsible for database access has been properly abstracted/modularized, converting it to run with a replicated setup should be very smooth and easy. Change the implementation of your database access to send all writes to the master, and to send reads to either the master or a slave. If your code does not have this level of abstraction, setting up a replicated system gives you the opportunity and motivation to clean it up. Start by creating a wrapper library or module that implements the following functions:

- `safe_writer_connect()`
- `safe_reader_connect()`
- `safe_reader_statement()`
- `safe_writer_statement()`

`safe_` in each function name means that the function takes care of handling all error conditions. You can use different names for the functions. The important thing is to have a unified interface for connecting for reads, connecting for writes, doing a read, and doing a write.

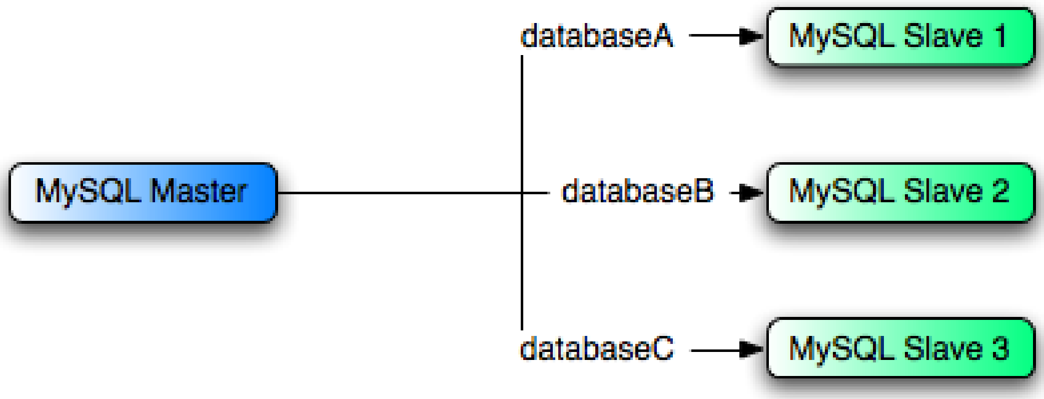
Then convert your client code to use the wrapper library. This may be a painful and scary process at first, but it pays off in the long run. All applications that use the approach just described are able to take advantage of a master/slave configuration, even one involving multiple slaves. The code is much easier to maintain, and adding troubleshooting options is trivial. You need modify only one or two functions; for example, to log how long each statement took, or which statement among those issued gave you an error.

If you have written a lot of code, you may want to automate the conversion task by using the `replace` utility that comes with standard MySQL distributions, or write your own conversion script. Ideally, your code uses consistent programming style conventions. If not, then you are probably better off rewriting it anyway, or at least going through and manually regularizing it to use a consistent style.

15.3.4. Replicating Different Databases to Different Slaves

There may be situations where you have a single master and want to replicate different databases to different slaves. For example, you may want to distribute different sales data to different departments to help spread the load during data analysis. A sample of this layout is shown in Figure 15.2, “Using Replication to Replicate Databases to Separate Replication Slaves”.

Figure 15.2. Using Replication to Replicate Databases to Separate Replication Slaves



You can achieve this separation by configuring the master and slaves as normal, and then limiting the binary log statements that each slave processes by using the `--replicate-wild-do-table` configuration option on each slave.

> **Important**
>
> You should *not* use `--replicate-do-db` for this purpose when using statement-based replication, since statement-based replication causes this option's affects to vary according to the database that is currently selected. This applies to mixed-format replication as well, since this enables some updates to be replicated using the statement-based format.
>
> However, it should be safe to use `--replicate-do-db` for this purpose if you are using row-based replication only, since in this case the currently selected database has no effect on the option's operation.

For example, to support the separation as shown in Figure 15.2, “Using Replication to Replicate Databases to Separate Replication Slaves”, you should configure each replication slave as follows, before executing `START SLAVE`:

- Replication slave 1 should use `--replicate-wild-do-table=databaseA.%`.
- Replication slave 2 should use `--replicate-wild-do-table=databaseB.%`.
- Replication slave 3 should use `--replicate-wild-do-table=databaseC.%`.

Each slave in this configuration receives the entire binary log from the master, but executes only those events from the binary log that apply to the databases and tables included by the `--replicate-wild-do-table` option in effect on that slave.

If you have data that must be synchronized to the slaves before replication starts, you have a number of choices:

- Synchronize all the data to each slave, and delete the databases, tables, or both that you do not want to keep.
- Use `mysqldump` to create a separate dump file for each database and load the appropriate dump file on each slave.
- Use a raw data file dump and include only the specific files and databases that you need for each slave.

> **Note**
>
> This does not work with `InnoDB` databases unless you use `innodb_file_per_table`.

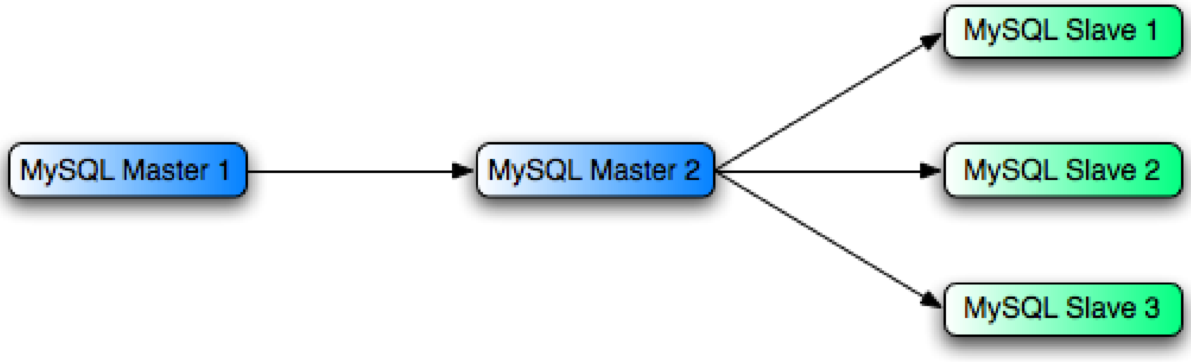
15.3.5. Improving Replication Performance

As the number of slaves connecting to a master increases, the load, although minimal, also increases, as each slave uses a client connection to the master. Also, as each slave must receive a full copy of the master binary log, the network load on the master may also increase and create a bottleneck.

If you are using a large number of slaves connected to one master, and that master is also busy processing requests (for example, as part of a scale-out solution), then you may want to improve the performance of the replication process.

One way to improve the performance of the replication process is to create a deeper replication structure that enables the master to replicate to only one slave, and for the remaining slaves to connect to this primary slave for their individual replication requirements. A sample of this structure is shown in Figure 15.3, “Using an Additional Replication Host to Improve Performance”.

Figure 15.3. Using an Additional Replication Host to Improve Performance



For this to work, you must configure the MySQL instances as follows:

- Master 1 is the primary master where all changes and updates are written to the database. Binary logging should be enabled on this machine.
- Master 2 is the slave to the Master 1 that provides the replication functionality to the remainder of the slaves in the replication structure. Master 2 is the only machine permitted to connect to Master 1. Master 2 also has binary logging enabled, and the `--log-slave-updates` option so that replication instructions from Master 1 are also written to Master 2's binary log so that they can then be replicated to the true slaves.
- Slave 1, Slave 2, and Slave 3 act as slaves to Master 2, and replicate the information from Master 2, which actually consists of the upgrades logged on Master 1.

The above solution reduces the client load and the network interface load on the primary master, which should improve the overall performance of the primary master when used as a direct database solution.

If your slaves are having trouble keeping up with the replication process on the master, there are a number of options available:

- If possible, put the relay logs and the data files on different physical drives. To do this, use the `--relay-log` option to specify the location of the relay log.
- If the slaves are significantly slower than the master, you may want to divide up the responsibility for replicating different databases to different slaves. See Section 15.3.4, “Replicating Different Databases to Different Slaves”.
- If your master makes use of transactions and you are not concerned about transaction support on your slaves, use `MyISAM` or another nontransactional engine on the slaves. See Section 15.3.2, “Using Replication with Different Master and Slave Storage Engines”.
- If your slaves are not acting as masters, and you have a potential solution in place to ensure that you can bring up a master in the event of failure, then you can switch off `--log-slave-updates`. This prevents “dumb” slaves from also logging events they have executed into their own binary log.

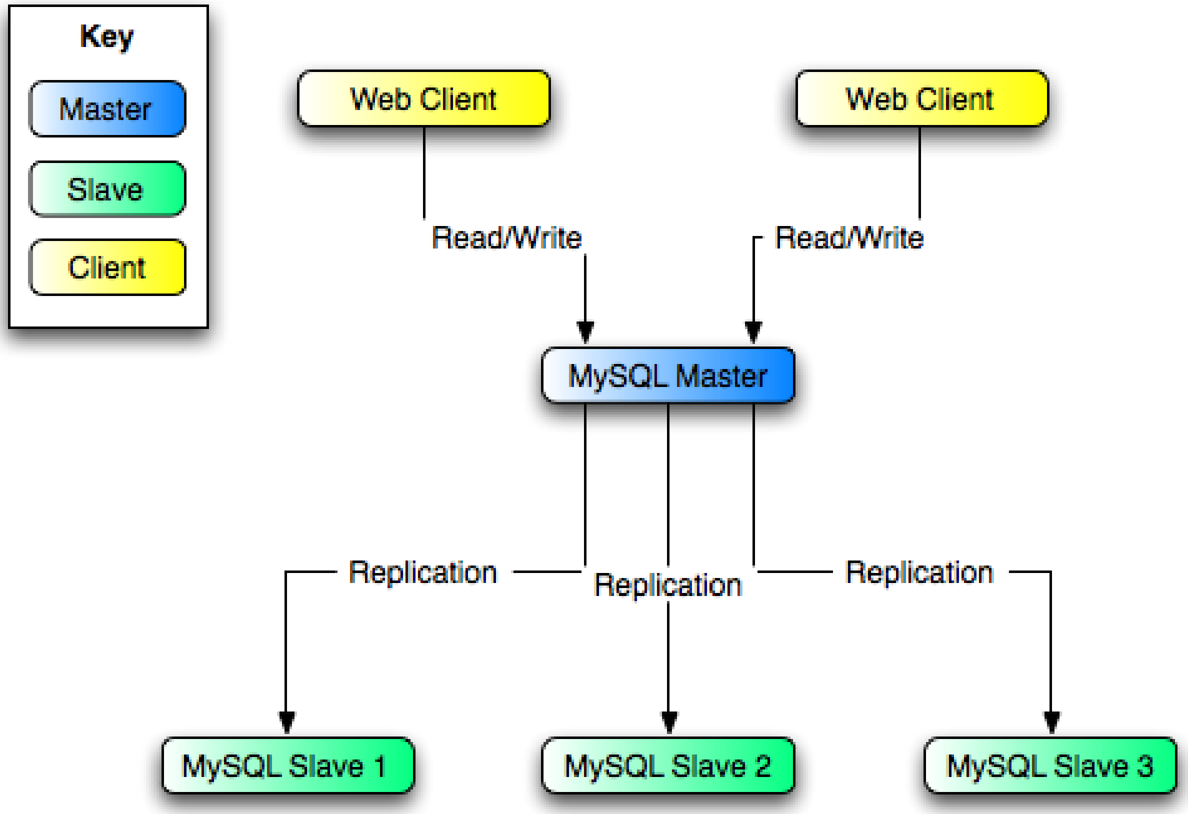
15.3.6. Switching Masters During Failover

There is currently no official solution for providing failover between master and slaves in the event of a failure. With the currently available features, you would have to set up a master and a slave (or several slaves), and to write a script that monitors the master to check whether it is up. Then instruct your applications and the slaves to change master in case of failure.

Remember that you can tell a slave to change its master at any time, using the `CHANGE MASTER TO` statement. The slave will not check whether the databases on the master are compatible with the slave, it will just start reading and executing events from the specified binary log coordinates on the new master. In a failover situation, all the servers in the group are typically executing the same events from the same binary log file, so changing the source of the events should not affect the database structure or integrity providing you are careful.

Run your slaves with the `--log-bin` option and without `--log-slave-updates`. In this way, the slave is ready to become a master as soon as you issue `STOP SLAVE`; `RESET MASTER`, and `CHANGE MASTER TO` statement on the other slaves. For example, assume that you have the structure shown in Figure 15.4, “Redundancy Using Replication, Initial Structure”.

Figure 15.4. Redundancy Using Replication, Initial Structure



In this diagram, the `MySQL Master` holds the master database, the `MySQL Slave` hosts are replication slaves, and the `Web Client` machines are issuing database reads and writes. Web clients that issue only reads (and would normally be connected to the slaves) are not shown, as they do not need to switch to a new server in the event of failure. For a more detailed example of a read/write scale-out replication structure, see Section 15.3.3, “Using Replication for Scale-Out”.

Each MySQL Slave (`Slave 1`, `Slave 2`, and `Slave 3`) is a slave running with `--log-bin` and without `--log-slave-updates`. Because updates received by a slave from the master are not logged in the binary log unless `--log-slave-updates` is specified, the binary log on each slave is empty initially. If for some reason `MySQL Master` becomes unavailable, you can pick one of the slaves to become the new master. For example, if you pick `Slave 1`, all `Web Clients` should be redirected to `Slave 1`, which will log updates to its binary log. `Slave 2` and `Slave 3` should then replicate from `Slave 1`.

The reason for running the slave without `--log-slave-updates` is to prevent slaves from receiving updates twice in case you cause one of the slaves to become the new master. Suppose that `Slave 1` has `--log-slave-updates` enabled. Then it will write updates that it receives from `Master` to its own binary log. When `Slave 2` changes from `Master` to `Slave 1` as its master, it may receive updates from `Slave 1` that it has already received from `Master`

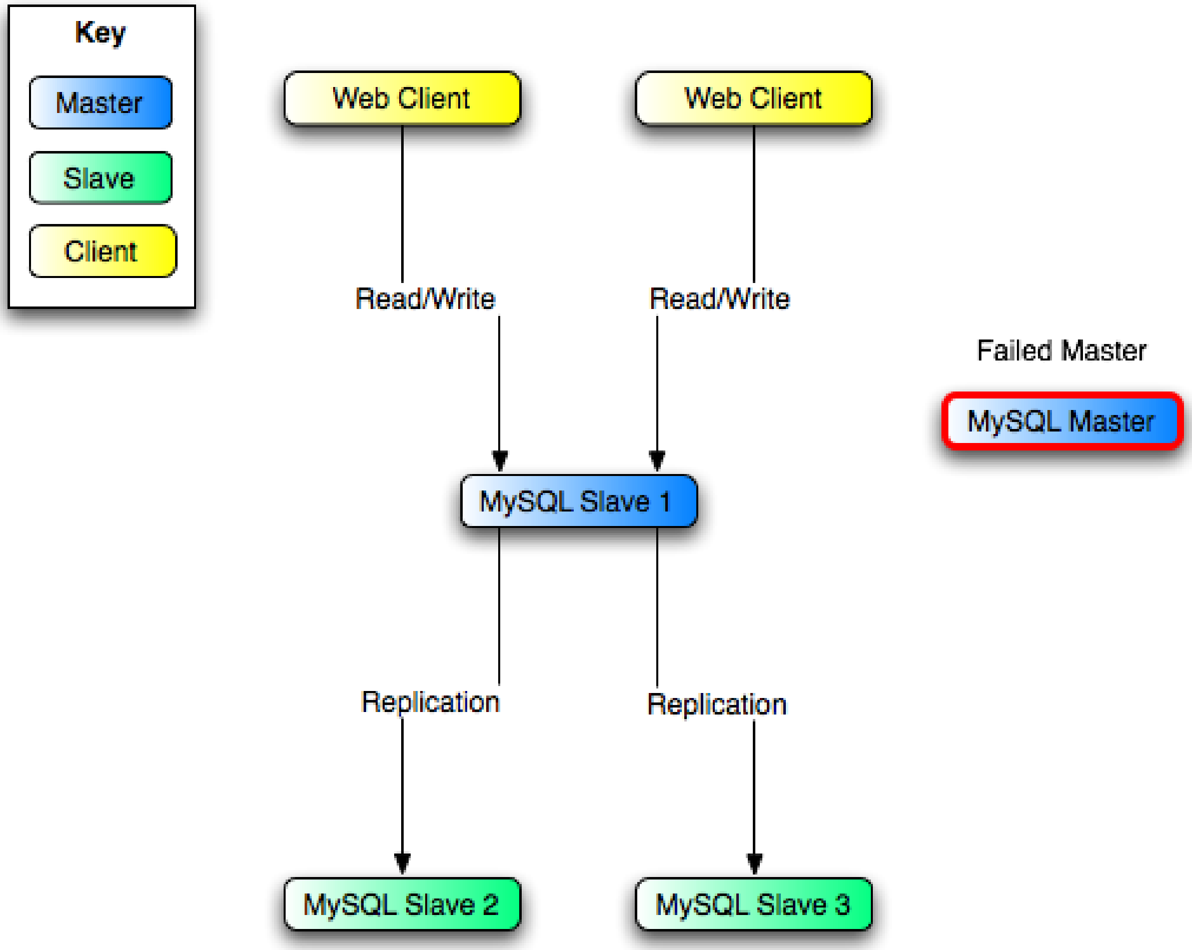
Make sure that all slaves have processed any statements in their relay log. On each slave, issue `STOP SLAVE IO_THREAD`, then check the output of `SHOW PROCESSLIST` until you see `Has read all relay log`. When this is true for all slaves, they can be reconfigured to the new setup. On the slave `Slave 1` being promoted to become the master, issue `STOP SLAVE` and `RESET MASTER`.

On the other slaves `Slave 2` and `Slave 3`, use `STOP SLAVE` and `CHANGE MASTER TO MASTER_HOST='Slave1'` (where `'Slave1'` represents the real host name of `Slave 1`). To use `CHANGE MASTER TO`, add all information about how to connect to `Slave 1` from `Slave 2` or `Slave 3` (*`user`*, *`password`*, *`port`*). In `CHANGE MASTER TO`, there is no need to specify the name of the `Slave 1` binary log file or log position to read from: We know it is the first binary log file and position 4, which are the defaults for `CHANGE MASTER TO`. Finally, use `START SLAVE` on `Slave 2` and `Slave 3`.

Once the new replication is in place, you will then need to instruct each `Web Client` to direct its statements to `Slave 1`. From that point on, all updates statements sent by `Web Client` to `Slave 1` are written to the binary log of `Slave 1`, which then contains every update statement sent to `Slave 1` since `Master` died.

The resulting server structure is shown in Figure 15.5, “Redundancy Using Replication, After Master Failure”.

Figure 15.5. Redundancy Using Replication, After Master Failure



When `Master` is up again, you must issue on it the same `CHANGE MASTER TO` as that issued on `Slave 2` and `Slave 3`, so that `Master` becomes a slave of `S1` and picks up each `Web Client` writes that it missed while it was down.

To make `Master` a master again (for example, because it is the most powerful machine), use the preceding procedure as if `Slave 1` was unavailable and `Master` was to be the new master. During this procedure, do not forget to run `RESET MASTER` on `Master` before making `Slave 1`, `Slave 2`, and `Slave 3` slaves of `Master`. Otherwise, they may pick up old `Web Client` writes from before the point at which `Master` became unavailable.

Note that there is no synchronization between the different slaves to a master. Some slaves might be ahead of others. This means that the concept outlined in the previous example might not work. In practice, however, the relay logs of different slaves will most likely not be far behind the master, so it would work, anyway (but there is no guarantee).

A good way to keep your applications informed as to the location of the master is by having a dynamic DNS entry for the master. With `bind` you can use `nsupdate` to dynamically update your DNS.

15.3.7. Setting Up Replication Using SSL

To use SSL for encrypting the transfer of the binary log required during replication, both the master and the slave must support SSL network connections. If either host does not support SSL connections (because it has not been compiled or configured for SSL), replication through an SSL connection is not possible.

Setting up replication using an SSL connection is similar to setting up a server and client using SSL. You must obtain (or create) a suitable security certificate that you can use on the master, and a similar certificate (from the same certificate authority) on each slave.

For more information on setting up a server and client for SSL connectivity, see Section 5.5.8.2, “Using SSL Connections”.

To enable SSL on the master you must create or obtain suitable certificates, and then add the following configuration options to the master's configuration within the `[mysqld]` section of the master's `my.cnf` file:

```
[mysqld]
ssl-ca=cacert.pem
ssl-cert=server-cert.pem
ssl-key=server-key.pem
```

The paths to the certificates may be relative or absolute; we recommend that you always use complete paths for this purpose.

The options are as follows:

- `ssl-ca` identifies the Certificate Authority (CA) certificate.
- `ssl-cert` identifies the server public key. This can be sent to the client and authenticated against the CA certificate that it has.
- `ssl-key` identifies the server private key.

On the slave, you have two options available for setting the SSL information. You can either add the slave certificates to the `[client]` section of the slave's `my.cnf` file, or you can explicitly specify the SSL information using the `CHANGE MASTER TO` statement:

- To add the slave certificates using an option file, add the following lines to the `[client]` section of the slave's `my.cnf` file:

  ```
  [client]
  ssl-ca=cacert.pem
  ssl-cert=client-cert.pem
  ssl-key=client-key.pem
  ```

  Restart the slave server, using the `--skip-slave-start` option to prevent the slave from connecting to the master. Use `CHANGE MASTER TO` to specify the master configuration, using the `MASTER_SSL` option to enable SSL connectivity:

  ```
  mysql> CHANGE MASTER TO
      -> MASTER_HOST='master_hostname',
      -> MASTER_USER='replicate',
      -> MASTER_PASSWORD='password',
      -> MASTER_SSL=1;
  ```

- To specify the SSL certificate options using the `CHANGE MASTER TO` statement, append the SSL options:

  ```
  mysql> CHANGE MASTER TO
      -> MASTER_HOST='master_hostname',
      -> MASTER_USER='replicate',
      -> MASTER_PASSWORD='password',
      -> MASTER_SSL=1,
      -> MASTER_SSL_CA = 'ca_file_name',
      -> MASTER_SSL_CAPATH = 'ca_directory_name',
      -> MASTER_SSL_CERT = 'cert_file_name',
      -> MASTER_SSL_KEY = 'key_file_name';
  ```

After the master information has been updated, start the slave replication process:

```
mysql> START SLAVE;
```

You can use the `SHOW SLAVE STATUS` statement to confirm that the SSL connection was established successfully.

For more information on the `CHANGE MASTER TO` statement, see Section 12.5.2.1, “`CHANGE MASTER TO` Syntax”.

If you want to enforce the use of SSL connections during replication, then create a user with the `REPLICATION SLAVE` privilege and use the `REQUIRE SSL` option for that user. For example:

```
mysql> CREATE USER 'repl'@'%.mydomain.com' IDENTIFIED BY 'slavepass';
mysql> GRANT REPLICATION SLAVE ON *.*
    -> TO 'repl'@'%.mydomain.com' REQUIRE SSL;
```

If the account already exists, you can add `REQUIRE SSL` to it with this statement:

```
mysql> GRANT USAGE ON *.*
    -> TO 'repl'@'%.mydomain.com' REQUIRE SSL;
```

15.3.8. Semisynchronous Replication

MySQL 5.5 supports an interface to semisynchronous replication in addition to the built-in asynchronous replication. This section discusses what semisynchronous replication is and how it works. The following sections cover the administrative interface to semisynchronous replication and how to install, configure, and monitor it.

MySQL replication by default is asynchronous. The master writes events to its binary log but does not know whether or when a slave has retrieved and processed them. With asynchronous replication, if the master crashes, transactions that it has committed might not have been transmitted to any slave. Consequently, failover from master to slave in this case may result in failover to a server that is missing transactions relative to the master.

Semisynchronous replication can be used as an alternative to asynchronous replication:

- A slave indicates whether it is semisynchronous-capable when it connects to the master.
- If semisynchronous replication is enabled on the master side and there is at least one semisynchronous slave, a thread that performs a transaction commit on the master blocks after the commit is done and waits until at least one semisynchronous slave acknowledges that it has received all events for the transaction, or until a timeout occurs.
- The slave acknowledges receipt of a transaction's events only after the events have been written to its relay log and flushed to disk.
- If a timeout occurs without any slave having acknowledged the transaction, the master reverts to asynchronous replication. When at least one semisynchronous slave catches up, the master returns to semisynchronous replication.
- Semisynchronous replication must be enabled on both the master and slave sides. If semisynchronous replication is disabled on the master, or enabled on the master but on no slaves, the master uses asynchronous replication.

While the master is blocking (waiting for acknowledgment from a slave after having performed a commit), it does not return to the session that performed the transaction. When the block ends, the master returns to the session, which then can proceed to execute other statements. At this point, the transaction has committed on the master side, and receipt of its events has been acknowledged by at least one slave.

Blocking also occurs after rollbacks that are written to the binary log, which occurs when a transaction that modifies nontransactional tables is rolled back. The rolled-back transaction is logged even though it has no effect for transactional tables because the modifications to the nontransactional tables cannot be rolled back and must be sent to slaves.

For statements that do not occur in transactional context (that is, when no transaction has been started with `START TRANSACTION` or `SET autocommit = 0`), autocommit is enabled and each statement commits implicitly. With semisynchronous replication, the master blocks after committing each such statement, just as it does for explicit transaction commits.

To understand what the “semi” in “semisynchronous replication” means, compare it with asynchronous and fully synchronous replication:

- With asynchronous replication, the master writes events to its binary log and slaves request them when they are ready. There is no guarantee that any event will ever reach any slave.
- With fully synchronous replication, when a master commits a transaction, all slaves also will have committed the transaction before the master returns to the session that performed the transaction. The drawback of this is that there might be a lot of delay to complete a transaction.
- Semisynchronous replication falls between asynchronous and fully synchronous replication. The master waits after commit only until at least one slave has received and logged the events. It does not wait for all slaves to acknowledge receipt, and it requires only receipt, not that the events have been fully executed and committed on the slave side.

Compared to asynchronous replication, semisynchronous replication provides improved data integrity. When a commit returns successfully, it is known that the data exists in at least two places (on the master and at least one slave). If the master commits but a crash occurs while the master is waiting for acknowledgment from a slave, it is possible that the transaction may not have reached any slave.

Semisynchronous replication also places a rate limit on busy sessions by constraining the speed at which binary log events can be sent from master to slave. When one user is too busy, this will slow it down, which is useful in some deployment situations.

Semisynchronous replication does have some performance impact because commits are slower due to the need to wait for slaves. This is the tradeoff for increased data integrity. The amount of slowdown is at least the TCP/IP roundtrip time to send the commit to the slave and wait for the acknowledgment of receipt by the slave. This means that semisynchronous replication works best for close servers communicating over fast networks, and worst for distant servers communicating over slow networks.

15.3.8.1. Semisynchronous Replication Administrative Interface

The administrative interface to semisynchronous replication has several components:

- Two plugins implement semisynchronous capability. There is one plugin for the master side and one for the slave side.
- System variables control plugin behavior. Some examples:
  - `rpl_semi_sync_master_enabled`

    Controls whether semisynchronous replication is enabled on the master. To enable or disable the plugin, set this variable to 1 or 0, respectively. The default is 1.
  - `rpl_semi_sync_master_timeout`

    A value in milliseconds that controls how long the master waits on a commit for acknowledgment from a slave before timing out and reverting to asynchronous replication. The default value is 10000 (10 seconds).
  - `rpl_semi_sync_slave_enabled`

    Similar to `rpl_semi_sync_master_enabled`, but controls the slave plugin.

  All `rpl_semi_sync_xxx` system variables are described at Section 5.1.3, “Server System Variables”.
- Status variables enable semisynchronous replication monitoring. Some examples:
  - `Rpl_semi_sync_master_clients`

    The number of semisynchronous slaves.
  - `Rpl_semi_sync_master_status`

    Whether semisynchronous replication currently is operational on the master. The value is 1 if the plugin has been enabled and a commit acknowledgment has occurred. It is 0 if the plugin is not enabled or the master has fallen back to asynchronous replication due to commit acknowledgment timeout.
  - `Rpl_semi_sync_master_no_tx`

    The number of commits that were not acknowledged successfully by a slave.
  - `Rpl_semi_sync_master_yes_tx`

    The number of commits that were acknowledged successfully by a slave.
  - `Rpl_semi_sync_slave_status`

    Whether semisynchronous replication currently is operational on the slave. This is 1 if the plugin has been enabled and the slave I/O thread is running, 0 otherwise.

  All `Rpl_semi_sync_xxx` status variables are described at Section 5.1.5, “Server Status Variables”.

The system and status variables are available only if the appropriate master or slave plugin has been installed with `INSTALL PLUGIN`.

15.3.8.2. Semisynchronous Replication Installation and Configuration

Semisynchronous replication is implemented using plugins, so the plugins must be installed into the server to make them available. After a plugin has been installed, you control it by means of the system variables associated with it. These system variables are unavailable until the associated plugin has been installed.

To use semisynchronous replication, the following requirements must be satisfied:

- MySQL 5.5 or higher must be installed.
- The capability of installing plugins requires a MySQL server that supports dynamic loading. To verify this, check that the value of the `have_dynamic_loading` system variable is `YES`. Binary distributions should support dynamic loading.
- Replication must already be working. For information on creating a master/slave relationship, see Section 15.1.1, "How to Set Up Replication".

To set up semisynchronous replication, use the following instructions. The `INSTALL PLUGIN`, `SET GLOBAL`, `STOP SLAVE`, and `START SLAVE` statements mentioned here require the `SUPER` privilege.

The semisynchronous replication plugins are included with MySQL distributions.

Unpack the component distribution, which contains files for the master side and the slave side.

Install the component files in the plugin directory of the appropriate server. Install the `semisync_master*` files in the plugin directory of the master server. Install the `semisync_slave*` files in the plugin directory of each slave server. The location of the plugin directory is available as the value of the server's `plugin_dir` system variable.

To load the plugins, use the `INSTALL PLUGIN` statement on the master and on each slave that is to be semisynchronous.

On the master:

```
mysql> INSTALL PLUGIN rpl_semi_sync_master SONAME 'semisync_master.so';
```

On each slave:

```
mysql> INSTALL PLUGIN rpl_semi_sync_slave SONAME 'semisync_slave.so';
```

The preceding commands use a plugin file name suffix of `.so`. A different suffix might apply on your system. If you are not sure about the plugin file name, look for the plugins in the server's plugin directory.

If an attempt to install a plugin results in an error on Linux similar to that shown here, you will need to install `libimf`:

```
mysql> INSTALL PLUGIN rpl_semi_sync_master SONAME 'semisync_master.so';
ERROR 1126 (HY000): Can't open shared library
'/usr/local/mysql/lib/plugin/semisync_master.so' (errno: 22 libimf.so: cannot open
shared object file: No such file or directory)
```

You can obtain `libimf` from http://dev.mysql.com/downloads/os-linux.html.

To see which plugins are installed, use the `SHOW PLUGINS` statement, or query the `INFORMATION_SCHEMA.PLUGINS` table.

After a semisynchronous replication plugin has been installed, it is disabled by default. The plugins must be enabled both on the master side and the slave side to enable semisynchronous replication. If only one side is enabled, replication will be asynchronous.

To control whether an installed plugin is enabled, set the appropriate system variables. You can set these variables at runtime using `SET GLOBAL`, or at server startup on the command line or in an option file.

At runtime, these master-side system variables are available:

```
mysql> SET GLOBAL rpl_semi_sync_master_enabled = {0|1};
mysql> SET GLOBAL rpl_semi_sync_master_timeout = N;
```

On the slave side, this system variable is available:

```
mysql> SET GLOBAL rpl_semi_sync_slave_enabled = {0|1};
```

For `rpl_semi_sync_master_enabled` or `rpl_semi_sync_slave_enabled`, the value should be 1 to enable semisynchronous replication or 0 to disable it. By default, these variables are set to 1.

For `rpl_semi_sync_master_timeout`, the value *N* is given in milliseconds. The default value is 10000 (10 seconds).

If you enable semisynchronous replication on a slave at runtime, you must also start the slave I/O thread (stopping it first if it is already running) to cause the slave to connect to the master and register as a semisynchronous slave:

```
mysql> STOP SLAVE IO_THREAD; START SLAVE IO_THREAD;
```

If the I/O thread is already running and you do not restart it, the slave continues to use asynchronous replication.

At server startup, the variables that control semisynchronous replication can be set as command-line options or in an option file. A setting listed in an option file takes effect each time the server starts. For example, you can set the variables in `my.cnf` files on the master and slave sides as follows.

On the master:

```
[mysqld]
rpl_semi_sync_master_enabled=1
rpl_semi_sync_master_timeout=1000 # 1 second
```

On each slave:

```
[mysqld]
rpl_semi_sync_slave_enabled=1
```

15.3.8.3. Semisynchronous Replication Monitoring

The plugins for the semisynchronous replication capability expose several system and status variables that you can examine to determine its configuration and operational state.

The system variable reflect how semisynchronous replication is configured. To check their values, use `SHOW VARIABLES`:

```
mysql> SHOW VARIABLES LIKE 'rpl_semi_sync%';
```

The status variables enable you to monitor the operation of semisynchronous replication. To check their values, use `SHOW STATUS`:

```
mysql> SHOW STATUS LIKE 'Rpl_semi_sync%';
```

When the master switches between asynchronous or semisynchronous replication due to commit-blocking timeout or a slave catching up, it sets the value of the `Rpl_semi_sync_master_status` status variable appropriately. Automatic fallback from semisynchronous to asynchronous replication on the master means that it is possible for the `rpl_semi_sync_master_enabled` system variable to have a value of 1 on the master side even when semisynchronous replication is in fact not operational at the moment. You can monitor the `Rpl_semi_sync_master_status` status variable to determine whether the master currently is using asynchronous or semisynchronous replication.

To see how many semisynchronous slaves are connected, check `Rpl_semi_sync_master_clients`.

The number of commits that have been acknowledged successfully or unsuccessfully by slaves are indicated by the `Rpl_semi_sync_master_yes_tx` and `Rpl_semi_sync_master_no_tx` variables.

On the slave side, `Rpl_semi_sync_slave_status` indicates whether semisynchronous replication currently is operational.

15.4. Replication Notes and Tips

15.4.1. Replication Features and Issues

The following sections provide information about what is supported and what is not in MySQL replication, and about specific issues and situations that may occur when replicating certain statements.

Statement-based replication depends on compatibility at the SQL level between the master and slave. In others, successful SBR requires that any SQL features used be supported by both the master and the slave servers. For example, if you use a feature on the master server that is available only in MySQL 5.5 (or later), you cannot replicate to a slave that uses MySQL 5.1 (or earlier).

Such incompatibilities also can occur within a release series when using pre-production releases of MySQL. For example, the `SLEEP()` function is available beginning with MySQL 5.0.12. If you use this function on the master, you cannot replicate to a slave that uses MySQL 5.0.11 or earlier.

For this reason, use Generally Available (GA) releases of MySQL for statement-based replication in a production setting, since we do not introduce new SQL statements or change their behavior within a given release series once that series reaches GA release status.

If you are planning to use statement-based replication between MySQL 5.5 and a previous MySQL release series, it is also a good idea to consult the edition of the *MySQL Reference Manual* corresponding to the earlier release series for information regarding the replication characteristics of that series.

With MySQL's statement-based replication, there may be issues with replicating stored routines or triggers. You can avoid these issues by using MySQL's row-based replication instead. For a detailed list of issues, see Section 17.7, “Binary Logging of Stored

Programs”. For more information about row-based logging and row-based replication, see Section 5.2.4.1, “Binary Logging Formats”, and Section 15.1.2, “Replication Formats”.

For additional information specific to replication and `InnoDB`, see Section 13.3.5.5, “`InnoDB` and MySQL Replication”. For information relating to replication with MySQL Cluster, see MySQL Cluster Replication.

15.4.1.1. Replication and `AUTO_INCREMENT`

Statement-based replication of `AUTO_INCREMENT`, `LAST_INSERT_ID()`, and `TIMESTAMP` values is done correctly, subject to the following exceptions:

- A statement invoking a trigger or function that causes an update to an `AUTO_INCREMENT` column is not replicated correctly using statement-based replication. In MySQL 5.5, such statements are marked as unsafe. (Bug #45677)
- Adding an `AUTO_INCREMENT` column to a table with `ALTER TABLE` might not produce the same ordering of the rows on the slave and the master. This occurs because the order in which the rows are numbered depends on the specific storage engine used for the table and the order in which the rows were inserted. If it is important to have the same order on the master and slave, the rows must be ordered before assigning an `AUTO_INCREMENT` number. Assuming that you want to add an `AUTO_INCREMENT` column to a table `t1` that has columns `col1` and `col2`, the following statements produce a new table `t2` identical to `t1` but with an `AUTO_INCREMENT` column:

  ```
  CREATE TABLE t2 LIKE t1;
  ALTER TABLE t2 ADD id INT AUTO_INCREMENT PRIMARY KEY;
  INSERT INTO t2 SELECT * FROM t1 ORDER BY col1, col2;
  ```

  Important

  To guarantee the same ordering on both master and slave, the `ORDER BY` clause must name *all* columns of `t1`.

  The instructions just given are subject to the limitations of `CREATE TABLE ... LIKE`: Foreign key definitions are ignored, as are the `DATA DIRECTORY` and `INDEX DIRECTORY` table options. If a table definition includes any of those characteristics, create `t2` using a `CREATE TABLE` statement that is identical to the one used to create `t1`, but with the addition of the `AUTO_INCREMENT` column.

  Regardless of the method used to create and populate the copy having the `AUTO_INCREMENT` column, the final step is to drop the original table and then rename the copy:

  ```
  DROP t1;
  ALTER TABLE t2 RENAME t1;
  ```

  See also Section C.5.7.1, “Problems with `ALTER TABLE`”.

15.4.1.2. Replication and Character Sets

The following applies to replication between MySQL servers that use different character sets:

- If the master uses MySQL 4.1, you must *always* use the same *global* character set and collation on the master and the slave, regardless of the slave MySQL version. (These are controlled by the `--character-set-server` and `--collation-server` options.) Otherwise, you may get duplicate-key errors on the slave, because a key that is unique in the master character set might not be unique in the slave character set. Note that this is not a cause for concern when master and slave are both MySQL 5.0 or later.
- If the master is older than MySQL 4.1.3, the character set of any client should never be made different from its global value because this character set change is not known to the slave. In other words, clients should not use `SET NAMES`, `SET CHARACTER SET`, and so forth. If both the master and the slave are 4.1.3 or newer, clients can freely set session values for character set variables because these settings are written to the binary log and so are known to the slave. That is, clients can use `SET NAMES` or `SET CHARACTER SET` or can set variables such as `collation_client` or `collation_server`. However, clients are prevented from changing the *global* value of these variables; as stated previously, the master and slave must always have identical global character set values. This is true whether you are using statement-based or row-based replication.
- If the master has databases with a character set different from the global `character_set_server` value, you should design your `CREATE TABLE` statements so that they do not implicitly rely on the database default character set. A good workaround is to state the character set and collation explicitly in `CREATE TABLE` statements.

15.4.1.3. Replication of `CREATE ... IF NOT EXISTS` Statements

MySQL applies these rules when various `CREATE ... IF NOT EXISTS` statements are replicated:

- Every `CREATE DATABASE IF NOT EXISTS` statement is replicated, whether or not the database already exists on the master.
- Similarly, every `CREATE TABLE IF NOT EXISTS` statement without a `SELECT` is replicated, whether or not the table already exists on the master. This includes `CREATE TABLE IF NOT EXISTS ... LIKE`. Replication of `CREATE TABLE IF NOT EXISTS ... SELECT` follows somewhat different rules; see Section 15.4.1.4, "Replication of `CREATE TABLE ... SELECT` Statements", for more information.
- `CREATE EVENT IF NOT EXISTS` is always replicated in MySQL 5.5, whether or not the event named in the statement already exists on the master.

See also Bug #45574.

15.4.1.4. Replication of `CREATE TABLE ... SELECT` Statements

This section discusses how MySQL replicates `CREATE TABLE ... SELECT` statements.

These behaviors are not dependent on MySQL version:

- `CREATE TABLE ... SELECT` always performs an implicit commit (Section 12.3.3, "Statements That Cause an Implicit Commit").
- If destination table does not exist, logging occurs as follows. It does not matter whether `IF NOT EXISTS` is present.
  - `STATEMENT` or `MIXED` format: The statement is logged as written.
  - `ROW` format: The statement is logged as a `CREATE TABLE` statement followed by a series of insert-row events.
- If the statement fails, nothing is logged. This includes the case that the destination table exists and `IF NOT EXISTS` is not given.

When the destination table exists and `IF NOT EXISTS` is given, MySQL handles the statement in a version-dependent way.

In MySQL 5.1 before 5.1.51 and in MySQL 5.5 before 5.5.6 (this is the original behavior):

- `STATEMENT` or `MIXED` format: The statement is logged as written.
- `ROW` format: The statement is logged as a `CREATE TABLE` statement followed by a series of insert-row events.

In MySQL 5.1 as of 5.1.51:

- `STATEMENT` or `MIXED` format: The statement is logged as the equivalent pair of `CREATE TABLE` and `INSERT INTO ... SELECT` statements.
- `ROW` format: The statement is logged as a `CREATE TABLE` statement followed by a series of insert-row events.

In MySQL 5.5 as of 5.5.6:

- Nothing is inserted or logged.

These version dependencies arise due to a change in MySQL 5.5.6 in handling of `CREATE TABLE ... SELECT` not to insert rows if the destination table already exists, and a change made in MySQL 5.1.51 to preserve forward compatibility in replication of such statements from a 5.1 master to a 5.5 slave. For details, see Section 12.1.14.1, "`CREATE TABLE ... SELECT` Syntax".

When using statement-based replication between a MySQL 5.6 or later slave and a master running a previous version of MySQL, a `CREATE TABLE ... SELECT` statement causing changes in other tables on the master fails on the slave, causing replication to stop. This is due to the fact that MySQL 5.6 does not allow a `CREATE TABLE ... SELECT` statement to make any changes in tables other than the table that is created by the statement—a change in behavior from previous versions of MySQL, which permitted these statements to do so. To keep this from happening, you should use row-based replication, rewrite the offending statement before running it on the master, or upgrade the master to MySQL 5.6 (or later). (If you choose to upgrade the master, keep in mind that such a `CREATE TABLE ... SELECT` statement will fail there as well, following the upgrade, unless the statement is rewritten to remove any side effects on other tables.) This is not an issue when using row-based replication, because the statement is logged as a `CREATE TABLE` statement with any changes to table data logged as row-insert events (or possibly row-update events), rather than as the entire `CREATE TABLE ... SELECT` statement.

15.4.1.5. Replication of `DROP ... IF EXISTS` Statements

The `DROP DATABASE IF EXISTS`, `DROP TABLE IF EXISTS`, and `DROP VIEW IF EXISTS` statements are always replicated, even if the database, table, or view to be dropped does not exist on the master. This is to ensure that the object to be dropped no longer exists on either the master or the slave, once the slave has caught up with the master.

`DROP ... IF EXISTS` statements for stored programs (stored procedures and functions, triggers, and events) are also replicated, even if the stored program to be dropped does not exist on the master. (Bug #13684)

15.4.1.6. Replication with Differing Table Definitions on Master and Slave

Source and target tables for replication do not have to be identical. A table on the master can have more or fewer columns than the slave's copy of the table. In addition, corresponding table columns on the master and the slave can use different data types, subject to certain conditions.

In all cases where the source and target tables do not have identical definitions, the following must be true for replication to work:

- You must be using row-based replication. (Using `MIXED` for the binary logging format does not work.)
- The database and table names must be the same on both the master and the slave.

Additional conditions are discussed, with examples, in the following two sections.

15.4.1.6.1. Replication with More Columns on Master or Slave

You can replicate a table from the master to the slave such that the master and slave copies of the table have differing numbers of columns, subject to the following conditions:

- Columns common to both versions of the table must be defined in the same order on the master and the slave.

  (This is true even if both tables have the same number of columns.)

- Columns common to both versions of the table must be defined before any additional columns.

  This means that executing an `ALTER TABLE` statement on the slave where a new column is inserted into the table within the range of columns common to both tables causes replication to fail, as shown in the following example:

  Suppose that a table `t`, existing on the master and the slave, is defined by the following `CREATE TABLE` statement:

  ```
  CREATE TABLE t (
      c1 INT,
      c2 INT,
      c3 INT
  );
  ```

  Suppose that the `ALTER TABLE` statement shown here is executed on the slave:

  ```
  ALTER TABLE t ADD COLUMN cnew1 INT AFTER c3;
  ```

  The previous `ALTER TABLE` is permitted on the slave because the columns `c1`, `c2`, and `c3` that are common to both versions of table `t` remain grouped together in both versions of the table, before any columns that differ.

  However, the following `ALTER TABLE` statement cannot be executed on the slave without causing replication to break:

  ```
  ALTER TABLE t ADD COLUMN cnew2 INT AFTER c3;
  ```

  Replication fails after execution on the slave of the `ALTER TABLE` statement just shown, because the new column `cnew2` comes between columns common to both versions of `t`.

- Each “extra” column in the version of the table having more columns must have a default value.

  > **Note**
  >
  > A column's default value is determined by a number of factors, including its type, whether it is defined with a `DEFAULT` option, whether it is declared as `NULL`, and the server SQL mode in effect at the time of its creation; for more

information, see Section 10.1.4, “Data Type Default Values”).

In addition, when the slave's copy of the table has more columns than the master's copy, each column common to the tables must use the same data type in both tables.

Examples. The following examples illustrate some valid and invalid table definitions:

More columns on the master. The following table definitions are valid and replicate correctly:

```
master> CREATE TABLE t1 (c1 INT, c2 INT, c3 INT);
slave>  CREATE TABLE t1 (c1 INT, c2 INT);
```

The following table definitions would raise Error 1532 (`ER_BINLOG_ROW_RBR_TO_SBR`) because the definitions of the columns common to both versions of the table are in a different order on the slave than they are on the master:

```
master> CREATE TABLE t1 (c1 INT, c2 INT, c3 INT);
slave>  CREATE TABLE t1 (c2 INT, c1 INT);
```

The following table definitions would also raise Error 1532 because the definition of the extra column on the master appears before the definitions of the columns common to both versions of the table:

```
master> CREATE TABLE t1 (c3 INT, c1 INT, c2 INT);
slave>  CREATE TABLE t1 (c1 INT, c2 INT);
```

More columns on the slave. The following table definitions are valid and replicate correctly:

```
master> CREATE TABLE t1 (c1 INT, c2 INT);
slave>  CREATE TABLE t1 (c1 INT, c2 INT, c3 INT);
```

The following definitions raise Error 1532 because the columns common to both versions of the table are not defined in the same order on both the master and the slave:

```
master> CREATE TABLE t1 (c1 INT, c2 INT);
slave>  CREATE TABLE t1 (c2 INT, c1 INT, c3 INT);
```

The following table definitions also raise Error 1532 because the definition for the extra column in the slave's version of the table appears before the definitions for the columns which are common to both versions of the table:

```
master> CREATE TABLE t1 (c1 INT, c2 INT);
slave>  CREATE TABLE t1 (c3 INT, c1 INT, c2 INT);
```

The following table definitions fail because the slave's version of the table has additional columns compared to the master's version, and the two versions of the table use different data types for the common column `c2`:

```
master> CREATE TABLE t1 (c1 INT, c2 BIGINT);
slave>  CREATE TABLE t1 (c1 INT, c2 INT, c3 INT);
```

15.4.1.6.2. Replication of Columns Having Different Data Types

Corresponding columns on the master's and the slave's copies of the same table ideally should have the same data type. However, beginning with MySQL 5.1.21, this is not always strictly enforced, as long as certain conditions are met.

All other things being equal, it is always possible to replicate from a column of a given data type to another column of the same type and same size or width, where applicable, or larger. For example, you can replicate from a `CHAR(10)` column to another `CHAR(10)`, or from a `CHAR(10)` column to a `CHAR(25)` column without any problems. In certain cases, it also possible to replicate from a column having one data type (on the master) to a column having a different data type (on the slave); when the data type of the master's version of the column is promoted to a type that is the same size or larger on the slave, this is known as *attribute promotion*.

Attribute promotion can be used with both statement-based and row-based replication, and is not dependent on the storage engine used by either the master or the slave. However, the choice of logging format does have an effect on the type conversions that are permitted; the particulars are discussed later in this section.

> **Important**
>
> Whether you use statement-based or row-based replication, the slave's copy of the table cannot contain more columns than the master's copy if you wish to employ attribute promotion.

Statement-based replication. When using statement-based replication, a simple rule of thumb to follow is, “If the statement run on the master would also execute successfully on the slave, it should also replicate successfully”. In other words, if the statement uses a value that is compatible with the type of a given column on the slave, the statement can be replicated. For example, you can insert any value that fits in a `TINYINT` column into a `BIGINT` column as well; it follows that, even if you change the type of a `TINYINT` column in the slave's copy of a table to `BIGINT`, any insert into that column on the master that succeeds should also succeed on the slave, since it is impossible to have a legal `TINYINT` value that is large enough to exceed a `BIGINT` column.

Row-based replication: attribute promotion and demotion. Formerly, due to the fact that in row-based replication changes rather than statements are replicated, and that these changes are transmitted using formats that do not always map directly to MySQL server column data types, you could not replicate between different subtypes of the same general type (for example, from `TINYINT` to `BIGINT`, both `INT` subtypes). However, beginning with MySQL 5.5.3, MySQL Replication supports attribute promotion and demotion between smaller data types and larger types. It is also possible to specify whether or not to permit lossy (truncated) or non-lossy conversions of demoted column values, as explained later in this section.

Lossy and non-lossy conversions. In the event that the target type cannot represent the value being inserted, a decision must be made on how to handle the conversion. If we permit the conversion but truncate (or otherwise modify) the source value to achieve a “fit” in the target column, we make what is known as a *lossy conversion*. A conversion which does not require truncation or similar modifications to fit the source column value in the target column is a *non-lossy* conversion.

Type conversion modes (`slave_type_conversions` variable). The setting of the `slave_type_conversions` global server variable controls the type conversion mode used on the slave. This variable takes a set of values from the following table, which shows the effects of each mode on the slave's type-conversion behavior:

Mode	**Effect**
`ALL_LOSSY`	In this mode, type conversions that would mean loss of information are permitted. This does not imply that non-lossy conversions are permitted, merely that only cases requiring either lossy conversions or no conversion at all are permitted; for example, enabling *only* this mode permits an `INT` column to be converted to `TINYINT` (a lossy conversion), but not a `TINYINT` column to an `INT` column (non-lossy). Attempting the latter conversion in this case would cause replication to stop with an error on the slave.
`ALL_NON_LOSSY`	This mode permits conversions that do not require truncation or other special handling of the source value; that is, it permits conversions where the source type has a wider range than the target type. Setting this mode has no bearing on whether lossy conversions are permitted; this is controlled with the `ALL_LOSSY` mode. If only `ALL_NON_LOSSY` is set, but not `ALL_LOSSY`, then attempting a conversion that would result in the loss of data (such as `INT` to `TINYINT`, or `CHAR(25)` to `VARCHAR(20)`) causes the slave to stop with an error.
`ALL_LOSSY,ALL_NON_LOSSY`	When this mode is set, all supported type conversions are permitted, whether or not they are lossy conversions.
[*empty*]	When `slave_type_conversions` is not set, no attribute promotion or demotion is permitted; this means that all columns in the source and target tables must be of the same types. This mode is the default.

Changing the type conversion mode requires restarting the slave with the new `slave_type_conversions` setting.

Supported conversions. Supported conversions between different but similar data types are shown in the following list:

- Between any of the integer types `TINYINT`, `SMALLINT`, `MEDIUMINT`, `INT`, and `BIGINT`.

  This includes conversions between the signed and unsigned versions of these types.

  Lossy conversions are made by truncating the source value to the maximum (or minimum) permitted by the target column. For insuring non-lossy conversions when going from unsigned to signed types, the target column must be large enough to accommodate the range of values in the source column. For example, you can demote `TINYINT UNSIGNED` non-lossily to `SMALLINT`, but not to `TINYINT`.

- Between any of the decimal types `DECIMAL`, `FLOAT`, `DOUBLE`, and `NUMERIC`.

  `FLOAT` to `DOUBLE` is a non-lossy conversion; `DOUBLE` to `FLOAT` can only be handled lossily. A conversion from `DECIMAL(M,D)` to `DECIMAL(M',D')` where `M' => M` and `D' => D` is non-lossy; for any case where `M' < M`, `D' <`

, or both, only a lossy conversion can be made.

For any of the decimal types, if a value to be stored cannot be fit in the target type, the value is rounded down according to the rounding rules defined for the server elsewhere in the documentation. See Section 11.18.4, “Rounding Behavior”, for information about how this is done for decimal types.

- Between any of the string types `CHAR`, `VARCHAR`, and `TEXT`, including conversions between different widths.

  Conversion of a `CHAR`, `VARCHAR`, or `TEXT` to a `CHAR`, `VARCHAR`, or `TEXT` column the same size or larger is never lossy. Lossy conversion is handled by inserting only the first *`N`* characters of the string on the slave, where *`N`* is the width of the target column.

  > **Important**
  >
  > Replication between columns using different character sets is not supported.

- Between any of the binary data types `BINARY`, `VARBINARY`, and `BLOB`, including conversions between different widths.

  Conversion of a `BINARY`, `VARBINARY`, or `BLOB` to a `BINARY`, `VARBINARY`, or `BLOB` column the same size or larger is never lossy. Lossy conversion is handled by inserting only the first *`N`* bytes of the string on the slave, where *`N`* is the width of the target column.

- Between any 2 `BIT` columns of any 2 sizes.

  When inserting a value from a `BIT(M)` column into a `BIT(M')` column, where `M' > M`, the most significant bits of the `BIT(M')` columns are cleared (set to zero) and the *`M`* bits of the `BIT(M)` value are set as the least significant bits of the `BIT(M')` column.

  When inserting a value from a source `BIT(M)` column into a target `BIT(M')` column, where `M' < M`, the maximum possible value for the `BIT(M')` column is assigned; in other words, an “all-set” value is assigned to the target column.

Conversions between types not in the previous list are not permitted.

Replication type conversions in MySQL 5.5.3 and earlier. Prior to MySQL 5.5.3, with row-based binary logging, you could not replicate between different `INT` subtypes, such as from `TINYINT` to `BIGINT`, because changes to columns of these types were represented differently from one another in the binary log when using row-based logging. (However, you could replicate from `BLOB` to `TEXT` using row-based replication because changes to `BLOB` and `TEXT` columns were represented using the same format in the binary log.)

Supported conversions for attribute promotion when using row-based replication prior to MySQL 5.5.3 are shown in the following table:

From (Master)	**To (Slave)**
`BINARY`	`CHAR`
`BLOB`	`TEXT`
`CHAR`	`BINARY`
`DECIMAL`	`NUMERIC`
`NUMERIC`	`DECIMAL`
`TEXT`	`BLOB`
`VARBINARY`	`VARCHAR`
`VARCHAR`	`VARBINARY`

> **Note**
>
> In all cases, the size or width of the column on the slave must be equal to or greater than that of the column on the master. For example, you could replicate from a `CHAR(10)` column on the master to a column that used `BINARY(10)` or `BINARY(25)` on the slave, but you could not replicate from a `CHAR(10)` column on the master to `BINARY(5)` column on the slave.
>
> For `DECIMAL` and `NUMERIC` columns, both the mantissa (*M*) and the number of decimals (*D*) must be the same size or larger on the slave as compared with the master. For example, replication from a `NUMERIC(5,4)` to a `DECIMAL(6,4)` worked, but not from a `NUMERIC(5,4)` to a `DECIMAL(5,3)`.

Prior to MySQL 5.5.3, MySQL replication did not support attribute promotion of any of the following data types to or from any other data type when using row-based replication:

- `INT` (including `TINYINT`, `SMALLINT`, `MEDIUMINT`, `BIGINT`).

  Promotion between `INT` subtypes—for example, from `SMALLINT` to `BIGINT`—was also not supported prior to MySQL 5.5.3.
- `SET` or `ENUM`.
- `FLOAT` or `DOUBLE`.
- All of the data types relating to dates, times, or both: `DATE`, `TIME`, `DATETIME`, `TIMESTAMP`, and `YEAR`.

15.4.1.7. Replication and `DIRECTORY` Table Options

If a `DATA DIRECTORY` or `INDEX DIRECTORY` table option is used in a `CREATE TABLE` statement on the master server, the table option is also used on the slave. This can cause problems if no corresponding directory exists in the slave host file system or if it exists but is not accessible to the slave server. This can be overridden by using the `NO_DIR_IN_CREATE` server SQL mode on the slave, which causes the slave to ignore the `DATA DIRECTORY` and `INDEX DIRECTORY` table options when replicating `CREATE TABLE` statements. The result is that `MyISAM` data and index files are created in the table's database directory.

For more information, see Section 5.1.6, “Server SQL Modes”.

15.4.1.8. Replication of Invoked Features

Replication of invoked features such as user-defined functions (UDFs) and stored programs (stored procedures and functions, triggers, and events) provides the following characteristics:

- The effects of the feature are always replicated.
- The following statements are replicated using statement-based replication:
  - `CREATE EVENT`
  - `ALTER EVENT`
  - `DROP EVENT`
  - `CREATE PROCEDURE`
  - `DROP PROCEDURE`
  - `CREATE FUNCTION`
  - `DROP FUNCTION`
  - `CREATE TRIGGER`
  - `DROP TRIGGER`

  However, the *effects* of features created, modified, or dropped using these statements are replicated using row-based replication.

  > **Note**
  >
  > Attempting to replicate invoked features using statement-based replication produces the warning `STATEMENT IS NOT SAFE TO LOG IN STATEMENT FORMAT`. For example, trying to replicate a UDF with statement-based replication generates this warning because it currently cannot be determined by the MySQL server whether the UDF is deterministic. If you are absolutely certain that the invoked feature's effects are deterministic, you can safely disregard such warnings.
- In the case of `CREATE EVENT` and `ALTER EVENT`:
  - The status of the event is set to `SLAVESIDE_DISABLED` on the slave regardless of the state specified (this does not apply to `DROP EVENT`).
  - The master on which the event was created is identified on the slave by its server ID. The `ORIGINATOR` column in `INFORMATION_SCHEMA.EVENTS` and the `originator` column in `mysql.event` store this information. See Section 18.20, “The `INFORMATION_SCHEMA EVENTS` Table”, and Section 12.4.5.19, “`SHOW EVENTS` Syntax”, for more information.
- The feature implementation resides on the slave in a renewable state so that if the master fails, the slave can be used as the master without loss of event processing.

To determine whether there are any scheduled events on a MySQL server that were created on a different server (that was acting as a replication master), query the `INFORMATION_SCHEMA.EVENTS` table in a manner similar to what is shown here:

```
SELECT EVENT_SCHEMA, EVENT_NAME
    FROM INFORMATION_SCHEMA.EVENTS
    WHERE STATUS = 'SLAVESIDE_DISABLED';
```

Alternatively, you can use the `SHOW EVENTS` statement, like this:

```
SHOW EVENTS
    WHERE STATUS = 'SLAVESIDE_DISABLED';
```

When promoting a replication slave having such events to a replication master, you must enable each event using `ALTER EVENT event_name ENABLED`, where *`event_name`* is the name of the event.

If more than one master was involved in creating events on this slave, and you wish to identify events that were created only on a given master having the server ID *`master_id`*, modify the previous query on the `EVENTS` table to include the `ORIGINATOR` column, as shown here:

```
SELECT EVENT_SCHEMA, EVENT_NAME, ORIGINATOR
    FROM INFORMATION_SCHEMA.EVENTS
    WHERE STATUS = 'SLAVESIDE_DISABLED'
    AND   ORIGINATOR = 'master_id'
```

You can employ `ORIGINATOR` with the `SHOW EVENTS` statement in a similar fashion:

```
SHOW EVENTS
    WHERE STATUS = 'SLAVESIDE_DISABLED'
    AND   ORIGINATOR = 'master_id'
```

Before enabling events that were replicated from the master, you should disable the MySQL Event Scheduler on the slave (using a statement such as `SET GLOBAL event_scheduler = OFF;`), run any necessary `ALTER EVENT` statements, restart the server, then re-enable the Event Scheduler on the slave afterward (using a statement such as `SET GLOBAL event_scheduler = ON;`)-

If you later demote the new master back to being a replication slave, you must disable manually all events enabled by the `ALTER EVENT` statements. You can do this by storing in a separate table the event names from the `SELECT` statement shown previously, or using `ALTER EVENT` statements to rename the events with a common prefix such as `replicated_` to identify them.

If you rename the events, then when demoting this server back to being a replication slave, you can identify the events by querying the `EVENTS` table, as shown here:

```
SELECT CONCAT(EVENT_SCHEMA, '.', EVENT_NAME) AS 'Db.Event'
      FROM INFORMATION_SCHEMA.EVENTS
      WHERE INSTR(EVENT_NAME, 'replicated_') = 1;
```

15.4.1.9. Replication and Floating-Point Values

With statement-based replication, values are converted from decimal to binary. Because conversions between decimal and binary representations of them may be approximate, comparisons involving floating-point values are inexact. This is true for operations that use floating-point values explicitly, or that use values that are converted to floating-point implicitly. Comparisons of floating-point values might yield different results on master and slave servers due to differences in computer architecture, the compiler used to build MySQL, and so forth. See Section 11.2, “Type Conversion in Expression Evaluation”, and Section C.5.5.8, “Problems with Floating-Point Values”.

15.4.1.10. Replication and `FLUSH`

Some forms of the `FLUSH` statement are not logged because they could cause problems if replicated to a slave: `FLUSH LOGS`, `FLUSH MASTER`, `FLUSH SLAVE`, and `FLUSH TABLES WITH READ LOCK`. For a syntax example, see Section 12.4.6.3, “`FLUSH` Syntax”. The `FLUSH TABLES`, `ANALYZE TABLE`, `OPTIMIZE TABLE`, and `REPAIR TABLE` statements are written to the binary log and thus replicated to slaves. This is not normally a problem because these statements do not modify table data.

However, this behavior can cause difficulties under certain circumstances. If you replicate the privilege tables in the `mysql` database and update those tables directly without using `GRANT`, you must issue a `FLUSH PRIVILEGES` on the slaves to put the new privileges into effect. In addition, if you use `FLUSH TABLES` when renaming a `MyISAM` table that is part of a `MERGE` table, you must issue `FLUSH TABLES` manually on the slaves. These statements are written to the binary log unless you specify `NO_WRITE_TO_BINLOG` or its alias `LOCAL`.

15.4.1.11. Replication and System Functions

Certain functions do not replicate well under some conditions:

- The `USER()`, `CURRENT_USER()` (or `CURRENT_USER`), `UUID()`, `VERSION()`, and `LOAD_FILE()` functions are replicated without change and thus do not work reliably on the slave unless row-based replication is enabled. (See Section 15.1.2, “Replication Formats”.)

  `USER()` and `CURRENT_USER()` are automatically replicated using row-based replication when using `MIXED` mode, and generate a warning in `STATEMENT` mode. (Bug #28086) Beginning with MySQL 5.5.1, the same is true for `VERSION()`. (Bug #47995)

- For `NOW()`, the binary log includes the timestamp. This means that the value *as returned by the call to this function on the master* is replicated to the slave. This can lead to a possibly unexpected result when replicating between MySQL servers in different time zones. Suppose that the master is located in New York, the slave is located in Stockholm, and both servers are using local time. Suppose further that, on the master, you create a table `mytable`, perform an `INSERT` statement on this table, and then select from the table, as shown here:

  ```
  mysql> CREATE TABLE mytable (mycol TEXT);
  Query OK, 0 rows affected (0.06 sec)

  mysql> INSERT INTO mytable VALUES ( NOW() );
  Query OK, 1 row affected (0.00 sec)

  mysql> SELECT * FROM mytable;
  +---------------------+
  | mycol               |
  +---------------------+
  | 2009-09-01 12:00:00 |
  +---------------------+
  1 row in set (0.00 sec)
  ```

  Local time in Stockholm is 6 hours later than in New York; so, if you issue `SELECT NOW()` on the slave at that exact same instant, the value `2009-09-01 18:00:00` is returned. For this reason, if you select from the slave's copy of `mytable` after the `CREATE TABLE` and `INSERT` statements just shown have been replicated, you might expect `mycol` to contain the value `2009-09-01 18:00:00`. However, this is not the case; when you select from the slave's copy of `mytable`, you obtain exactly the same result as on the master:

  ```
  mysql> SELECT * FROM mytable;
  +---------------------+
  | mycol               |
  +---------------------+
  | 2009-09-01 12:00:00 |
  +---------------------+
  1 row in set (0.00 sec)
  ```

  Unlike `NOW()`, the `SYSDATE()` function is not replication-safe because it is not affected by `SET TIMESTAMP` statements in the binary log and is nondeterministic if statement-based logging is used. This is not a problem if row-based logging is used.

  An alternative is to use the `--sysdate-is-now` option to cause `SYSDATE()` to be an alias for `NOW()`. This must be done on the master and the slave to work correctly. In such cases, a warning is still issued by this function, but can safely be ignored as long as `--sysdate-is-now` is used on both the master and the slave.

  Beginning with MySQL 5.5.1, `SYSDATE()` is automatically replicated using row-based replication when using `MIXED` mode, and generates a warning in `STATEMENT` mode. (Bug #47995)

  See also Section 15.4.1.28, “Replication and Time Zones”.

- *The following restriction applies to statement-based replication only, not to row-based replication.* The `GET_LOCK()`, `RELEASE_LOCK()`, `IS_FREE_LOCK()`, and `IS_USED_LOCK()` functions that handle user-level locks are replicated without the slave knowing the concurrency context on the master. Therefore, these functions should not be used to insert into a master table because the content on the slave would differ. For example, do not issue a statement such as `INSERT INTO mytable VALUES(GET_LOCK(...))`.

  Beginning with MySQL 5.5.1, these functions are automatically replicated using row-based replication when using `MIXED` mode, and generate a warning in `STATEMENT` mode. (Bug #47995)

As a workaround for the preceding limitations when statement-based replication is in effect, you can use the strategy of saving the problematic function result in a user variable and referring to the variable in a later statement. For example, the following single-row `INSERT` is problematic due to the reference to the `UUID()` function:

```
INSERT INTO t VALUES(UUID());
```

To work around the problem, do this instead:

```
SET @my_uuid = UUID();
INSERT INTO t VALUES(@my_uuid);
```

That sequence of statements replicates because the value of `@my_uuid` is stored in the binary log as a user-variable event prior to the `INSERT` statement and is available for use in the `INSERT`.

The same idea applies to multiple-row inserts, but is more cumbersome to use. For a two-row insert, you can do this:

```
SET @my_uuid1 = UUID(); @my_uuid2 = UUID();
INSERT INTO t VALUES(@my_uuid1),(@my_uuid2);
```

However, if the number of rows is large or unknown, the workaround is difficult or impracticable. For example, you cannot convert the following statement to one in which a given individual user variable is associated with each row:

```
INSERT INTO t2 SELECT UUID(), * FROM t1;
```

Within a stored function, `RAND()` replicates correctly as long as it is invoked only once during the execution of the function. (You can consider the function execution timestamp and random number seed as implicit inputs that are identical on the master and slave.)

The `FOUND_ROWS()` and `ROW_COUNT()` functions are not replicated reliably using statement-based replication. A workaround is to store the result of the function call in a user variable, and then use that in the `INSERT` statement. For example, if you wish to store the result in a table named `mytable`, you might normally do so like this:

```
SELECT SQL_CALC_FOUND_ROWS FROM mytable LIMIT 1;
INSERT INTO mytable VALUES( FOUND_ROWS() );
```

However, if you are replicating `mytable`, you should use `SELECT INTO`, and then store the variable in the table, like this:

```
SELECT SQL_CALC_FOUND_ROWS INTO @found_rows FROM mytable LIMIT 1;
INSERT INTO mytable VALUES(@found_rows);
```

In this way, the user variable is replicated as part of the context, and applied on the slave correctly.

These functions are automatically replicated using row-based replication when using `MIXED` mode, and generate a warning in `STATEMENT` mode. (Bug #12092, Bug #30244)

15.4.1.12. Replication and `LIMIT`

Statement-based replication of `LIMIT` clauses in `DELETE`, `UPDATE`, and `INSERT ... SELECT` statements is unsafe since the order of the rows affected is not defined. (Such statements can be replicated correctly with statement-based replication only if they also contain an `ORDER BY` clause.) When such a statement is encountered:

- When using `STATEMENT` mode, a warning that the statement is not safe for statement-based replication is now issued.

  Currently, when using `STATEMENT` mode, warnings are issued for DML statements containing `LIMIT` even when they also have an `ORDER BY` clause (and so are made deterministic). This is a known issue. (Bug #42851)

- When using `MIXED` mode, the statement is now automatically replicated using row-based mode.

15.4.1.13. Replication and `LOAD DATA INFILE`

The `LOAD DATA INFILE` statement was not always replicated correctly to a slave running MySQL 5.5.0 or earlier from a master running MySQL 4.0 or earlier. When using statement-based replication, the `LOAD DATA INFILE` statement `CONCURRENT` option was not replicated. This issue was fixed in MySQL 5.5.0. This issue does not have any impact on `CONCURRENT` option handling when using row-based replication in MySQL 5.1 or later. (Bug #34628)

In MySQL 5.5.6 and later, `LOAD DATA INFILE` is considered unsafe (see Section 15.1.2.3, “Safe and Unsafe Statements for Row-Based Logging and Replication”). It causes a warning when using statement-based logging format, and is logged using row-based format when using mixed-format logging.

15.4.1.14. Replication and the Slow Query Log

Replication slaves do not write replicated queries to the slow query log, even if the same queries were written to the slow query log on the master. This is a known issue. (Bug #23300)

15.4.1.15. Replication and `REPAIR TABLE`

When used on a corrupted or otherwise damaged table, it is possible for the `REPAIR TABLE` statement to delete rows that cannot be recovered. However, any such modifications of table data performed by this statement are not replicated, which can cause master and slave to lose synchronization. For this reason, in the event that a table on the master becomes damaged and you use `REPAIR TABLE` to repair it, you should first stop replication (if it is still running) before using `REPAIR TABLE`, then afterward compare the master's and slave's copies of the table and be prepared to correct any discrepancies manually, before restarting replication.

15.4.1.16. Replication and Master or Slave Shutdowns

It is safe to shut down a master server and restart it later. When a slave loses its connection to the master, the slave tries to reconnect immediately and retries periodically if that fails. The default is to retry every 60 seconds. This may be changed with the `CHANGE MASTER TO` statement. A slave also is able to deal with network connectivity outages. However, the slave notices the network outage only after receiving no data from the master for `slave_net_timeout` seconds. If your outages are short, you may want to decrease `slave_net_timeout`. See Section 5.1.3, “Server System Variables”.

An unclean shutdown (for example, a crash) on the master side can result in the master binary log having a final position less than the most recent position read by the slave, due to the master binary log file not being flushed. This can cause the slave not to be able to replicate when the master comes back up. Setting `sync_binlog=1` in the master `my.cnf` file helps to minimize this problem because it causes the master to flush its binary log more frequently.

Shutting down a slave cleanly is safe because it keeps track of where it left off. However, be careful that the slave does not have temporary tables open; see Section 15.4.1.19, “Replication and Temporary Tables”. Unclean shutdowns might produce problems, especially if the disk cache was not flushed to disk before the problem occurred:

- For transactions, the slave commits and then updates `relay-log.info`. If a crash occurs between these two operations, relay log processing will have proceeded further than the information file indicates and the slave will re-execute the events from the last transaction in the relay log after it has been restarted.
- A similar problem can occur if the slave updates `relay-log.info` but the server host crashes before the write has been flushed to disk. To minimize the chance of this occurring, set `sync_relay_log_info=1` in the slave `my.cnf` file. The default value of `sync_relay_log_info` is 0, which does not cause writes to be forced to disk; the server relies on the operating system to flush the file from time to time.

The fault tolerance of your system for these types of problems is greatly increased if you have a good uninterruptible power supply.

15.4.1.17. Replication and `max_allowed_packet`

`max_allowed_packet` sets an upper limit on the size of any single message between the MySQL server and clients, including replication slaves. If you are replicating large column values (such as might be found in `TEXT` or `BLOB` columns) and `max_allowed_packet` is too small on the master, the master fails with an error, and the slave shuts down the I/O thread. If `max_allowed_packet` is too small on the slave, this also causes the slave to stop the I/O thread.

Row-based replication currently sends all columns and column values for updated rows from the master to the slave, including values of columns that were not actually changed by the update. This means that, when you are replicating large column values using row-based replication, you must take care to set `max_allowed_packet` large enough to accommodate the largest row in any table to be replicated, even if you are replicating updates only, or you are inserting only relatively small values.

15.4.1.18. Replication and `MEMORY` Tables

When a master server shuts down and restarts, its `MEMORY` tables become empty. To replicate this effect to slaves, the first time that the master uses a given `MEMORY` table after startup, it logs an event that notifies slaves that the table must to be emptied by writing a `DELETE` statement for that table to the binary log.

When a slave server shuts down and restarts, its `MEMORY` tables become empty. This causes the slave to be out of synchrony with the master and may lead to other failures or cause the slave to stop:

- Row-format updates and deletes received from the master may fail with `Can't find record in '`*`memory_table`*`'`.
- Statements such as `INSERT INTO ... SELECT FROM` *`memory_table`* may insert a different set of rows on the master and slave.

The safe way to restart a slave that is replicating `MEMORY` tables is to first drop or delete all rows from the `MEMORY` tables on the master and wait until those changes have replicated to the slave. Then it is safe to restart the slave.

An alternative restart method may apply in some cases. When `binlog_format=ROW`, you can prevent the slave from stopping if you set `slave_exec_mode=IDEMPOTENT` before you start the slave again. This allows the slave to continue to replicate, but its

`MEMORY` tables will still be different from those on the master. This can be okay if the application logic is such that the contents of `MEMORY` tables can be safely lost (for example, if the `MEMORY` tables are used for caching). `slave_exec_mode=IDEMPOTENT` applies globally to all tables, so it may hide other replication errors in non-`MEMORY` tables.

See Section 13.6, “The `MEMORY` Storage Engine”, for more information about `MEMORY` tables.

15.4.1.19. Replication and Temporary Tables

This section does not apply when row-based replication is in use because in that case temporary tables are not replicated. It does apply with mixed-format replication for statements involving temporary tables that can be logged safely using statement-based format. See Section 15.1.2.2, “Safe and Unsafe Statements in Logging and Replication”.

Safe slave shutdown when using temporary tables. Temporary tables are replicated except in the case where you stop the slave server (not just the slave threads) and you have replicated temporary tables that are open for use in updates that have not yet been executed on the slave. If you stop the slave server, the temporary tables needed by those updates are no longer available when the slave is restarted. To avoid this problem, do not shut down the slave while it has temporary tables open. Instead, use the following procedure:

1. Issue a `STOP SLAVE SQL_THREAD` statement.
2. Use `SHOW STATUS` to check the value of the `Slave_open_temp_tables` variable.
3. If the value is not 0, restart the slave SQL thread with `START SLAVE SQL_THREAD` and repeat the procedure later.
4. When the value is 0, issue a `mysqladmin shutdown` command to stop the slave.

Temporary tables and replication options. By default, all temporary tables are replicated; this happens whether or not there are any matching `--replicate-do-db`, `--replicate-do-table`, or `--replicate-wild-do-table` options in effect. However, the `--replicate-ignore-table` and `--replicate-wild-ignore-table` options are honored for temporary tables.

A recommended practice when using statement-based or mixed-format replication is to designate a prefix for exclusive use in naming temporary tables that you do not want replicated, then employ a `--replicate-wild-ignore-table` option to match that prefix. For example, you might give all such tables names beginning with `norep` (such as `norepmytable`, `norepyourtable`, and so on), then use `--replicate-wild-ignore-table=norep%` to prevent them from being replicated.

15.4.1.20. Replication of the `mysql` System Database

Data modification statements made to tables in the `mysql` database are replicated according to the value of `binlog_format`; if this value is `MIXED`, these statements are replicated using row-based format. However, statements that would normally update this information indirectly—such `GRANT`, `REVOKE`, and statements manipulating triggers, stored routines, and views—are replicated to slaves using statement-based replication.

15.4.1.21. Replication and the Query Optimizer

It is possible for the data on the master and slave to become different if a statement is written in such a way that the data modification is nondeterministic; that is, left up the query optimizer. (In general, this is not a good practice, even outside of replication.) Examples of nondeterministic statements include `DELETE` or `UPDATE` statements that use `LIMIT` with no `ORDER BY` clause; see Section 15.4.1.12, “Replication and `LIMIT`”, for a detailed discussion of these.

15.4.1.22. Replication and Reserved Words

You can encounter problems when you attempt to replicate from an older master to a newer slave and you make use of identifiers on the master that are reserved words in the newer MySQL version running on the slave. An example of this is using a table column named `current_user` on a 4.0 master that is replicating to a 4.1 or higher slave because `CURRENT_USER` is a reserved word beginning in MySQL 4.1. Replication can fail in such cases with Error 1064 `You have an error in your SQL syntax...`, *even if a database or table named using the reserved word or a table having a column named using the reserved word is excluded from replication*. This is due to the fact that each SQL event must be parsed by the slave prior to execution, so that the slave knows which database object or objects would be affected; only after the event is parsed can the slave apply any filtering rules defined by `--replicate-do-db`, `--replicate-do-table`, `--replicate-ignore-db`, and `--replicate-ignore-table`.

To work around the problem of database, table, or column names on the master which would be regarded as reserved words by the slave, do one of the following:

- Use one or more `ALTER TABLE` statements on the master to change the names of any database objects where these names would be considered reserved words on the slave, and change any SQL statements that use the old names to use the new names instead.

- In any SQL statements using these database object names, write the names as quoted identifiers using backtick characters (`` ` ``).

For listings of reserved words by MySQL version, see Reserved Words, in the *MySQL Server Version Reference*. For identifier quoting rules, see Section 8.2, “Schema Object Names”.

15.4.1.23. `SET PASSWORD` and Row-Based Replication

Row-based replication of `SET PASSWORD` statements from a MySQL 5.1 master to a MySQL 5.5 slave did not work correctly prior to MySQL 5.1.53 on the master and MySQL 5.5.7 on the slave (see Bug #57098, Bug #57357).

15.4.1.24. Slave Errors During Replication

If a statement produces the same error (identical error code) on both the master and the slave, the error is logged, but replication continues.

If a statement produces different errors on the master and the slave, the slave SQL thread terminates, and the slave writes a message to its error log and waits for the database administrator to decide what to do about the error. This includes the case that a statement produces an error on the master or the slave, but not both. To address the issue, connect to the slave manually and determine the cause of the problem. `SHOW SLAVE STATUS` is useful for this. Then fix the problem and run `START SLAVE`. For example, you might need to create a nonexistent table before you can start the slave again.

If this error code validation behavior is not desirable, some or all errors can be masked out (ignored) with the `--slave-skip-errors` option.

For nontransactional storage engines such as `MyISAM`, it is possible to have a statement that only partially updates a table and returns an error code. This can happen, for example, on a multiple-row insert that has one row violating a key constraint, or if a long update statement is killed after updating some of the rows. If that happens on the master, the slave expects execution of the statement to result in the same error code. If it does not, the slave SQL thread stops as described previously.

If you are replicating between tables that use different storage engines on the master and slave, keep in mind that the same statement might produce a different error when run against one version of the table, but not the other, or might cause an error for one version of the table, but not the other. For example, since `MyISAM` ignores foreign key constraints, an `INSERT` or `UPDATE` statement accessing an `InnoDB` table on the master might cause a foreign key violation but the same statement performed on a `MyISAM` version of the same table on the slave would produce no such error, causing replication to stop.

15.4.1.25. Replication and Server SQL Mode

Using different server SQL mode settings on the master and the slave may cause the same `INSERT` statements to be handled differently on the master and the slave, leading the master and slave to diverge. For best results, you should always use the same server SQL mode on the master and on the slave. This advice applies whether you are using statement-based or row-based replication.

If you are replicating partitioned tables, using different SQL modes on the master and the slave is likely to cause issues. At a minimum, this is likely to cause the distribution of data among partitions to be different in the master's and slave's copies of a given table. It may also cause inserts into partitioned tables that succeed on the master to fail on the slave.

For more information, see Section 5.1.6, “Server SQL Modes”.

15.4.1.26. Replication Retries and Timeouts

The global system variable `slave_transaction_retries` affects replication as follows: If the slave SQL thread fails to execute a transaction because of an `InnoDB` deadlock or because it exceeded the `InnoDB` `innodb_lock_wait_timeout` value, or the `NDBCLUSTER` `TransactionDeadlockDetectionTimeout` or `TransactionInactiveTimeout` value, the slave automatically retries the transaction `slave_transaction_retries` times before stopping with an error. The default value is 10. The total retry count can be seen in the output of `SHOW STATUS`; see Section 5.1.5, “Server Status Variables”.

15.4.1.27. Replication and `TIMESTAMP`

Older versions of MySQL (prior to 4.1) differed significantly in several ways in their handling of the `TIMESTAMP` data type from what is supported in MySQL versions 5.5 and newer; these include syntax extensions which are deprecated in MySQL 5.1, and that no longer supported in MySQL 5.5. This this can cause problems (including replication failures) when replicating between MySQL Server versions, if you are using columns that are defined using the old `TIMESTAMP(N)` syntax. See Section 2.11.1.1, “Upgrading from MySQL 5.1 to 5.5”, for more information about the differences, how they can impact MySQL replication, and what you can do if you encounter such problems.

15.4.1.28. Replication and Time Zones

The same system time zone should be set for both master and slave. Otherwise, statements depending on the local time on the master are not replicated properly, such as statements that use the `NOW()` or `FROM_UNIXTIME()` functions. You can set the time zone in which MySQL server runs by using the `--timezone=timezone_name` option of the `mysqld_safe` script or by setting the `TZ` environment variable. See also Section 15.4.1.11, "Replication and System Functions".

If the master is MySQL 4.1 or earlier, both master and slave should also use the same default connection time zone. That is, the `--default-time-zone` parameter should have the same value for both master and slave.

`CONVERT_TZ(...,...,@@session.time_zone)` is properly replicated only if both master and slave are running MySQL 5.0.4 or newer.

15.4.1.29. Replication and Transactions

Mixing transactional and nontransactional statements within the same transaction. In general, you should avoid transactions that update both transactional and nontransactional tables in a replication environment. You should also avoid using any statement that accesses both transactional (or temporary) and nontransactional tables and writes to any of them.

As of MySQL 5.5.2, the server uses these rules for binary logging:

- If the initial statements in a transaction are nontransactional, they are written to the binary log immediately. The remaining statements in the transaction are cached and not written to the binary log until the transaction is committed. (If the transaction is rolled back, the cached statements are written to the binary log only if they make nontransactional changes that cannot be rolled back. Otherwise, they are discarded.)
- For statement-based logging, logging of nontransactional statements is affected by the `binlog_direct_non_transactional_updates` system variable. When this variable is `OFF` (the default), logging is as just described. When this variable is `ON`, logging occurs immediately for nontransactional statements occurring anywhere in the transaction (not just initial nontransactional statements). Other statements are kept in the transaction cache and logged when the transaction commits. `binlog_direct_non_transactional_updates` has no effect for row-format or mixed-format binary logging.

Transactional, nontransactional, and mixed statements. To apply those rules, the server considers a statement nontransactional if it changes only nontransactional tables, and transactional if it changes only transactional tables. Prior to MySQL 5.5.6, a statement that changed both nontransactional and transactional tables was considered "mixed". Beginning with MySQL 5.5.6, a statement that references both nontransactional and transactional tables and updates *any* of the tables involved, is considered a mixed statement. Mixed statements, like transactional statements, are cached and logged when the transaction commits.

Beginning with MySQL 5.5.6, a mixed statement that updates a transactional table is considered unsafe if the statement also performs either of the following actions:

- Updates or reads a transactional table
- Reads a nontransactional table and the transaction isolation level is less than REPEATABLE_READ

Also beginning with MySQL 5.5.6, any mixed statement following the update of a transactional table within a transaction is considered unsafe if it performs either of the following actions:

- Updates any table and reads from any temporary table
- Updates a nontransactional table and binlog_direct_non_trans_update is OFF

For more information, see Section 15.1.2.3, "Safe and Unsafe Statements for Row-Based Logging and Replication".

> **Note**
>
> A mixed statement is unrelated to mixed binary logging format.

Before MySQL 5.5.2, the rules for binary logging are similar to those just described, except that there is no `binlog_direct_non_transactional_updates` system variable to affect logging of transactional statements. Thus, the server immediately logs only the initial nontransactional statements in a transaction and caches the rest until commit time.

In situations where transactions mix updates to transactional and nontransactional tables, the order of statements in the binary log is correct, and all needed statements are written to the binary log even in case of a `ROLLBACK`. However, when a second connection updates the nontransactional table before the first connection transaction is complete, statements can be logged out of order because the second connection update is written immediately after it is performed, regardless of the state of the transaction being performed by the first connection.

Using different storage engines on master and slave. It is possible to replicate transactional tables on the master using nontransactional tables on the slave. For example, you can replicate an `InnoDB` master table as a `MyISAM` slave table. However, if you do this, there are problems if the slave is stopped in the middle of a `BEGIN` ... `COMMIT` block because the slave restarts at the beginning of the `BEGIN` block.

Beginning with MySQL 5.5.0, it is also safe to replicate transactions from `MyISAM` tables on the master to transactional tables—such as tables that use the `InnoDB` storage engine—on the slave. In such cases (beginning with MySQL 5.5.0), an `AUTOCOMMIT=1` statement issued on the master is replicated, thus enforcing `AUTOCOMMIT` mode on the slave.

When the storage engine type of the slave is nontransactional, transactions on the master that mix updates of transactional and nontransactional tables should be avoided because they can cause inconsistency of the data between the master transactional table and the slave nontransactional table. That is, such transactions can lead to master storage engine-specific behavior with the possible effect of replication going out of synchrony. MySQL does not issue a warning about this currently, so extra care should be taken when replicating transactional tables from the master to nontransactional tables on the slaves.

Changing the binary logging format within transactions. Beginning with MySQL 5.5.3, the `binlog_format` system variable is read-only as long as a transaction is in progress. (Bug #47863)

Every transaction (including `autocommit` transactions) is recorded in the binary log as though it starts with a `BEGIN` statement, and ends with either a `COMMIT` or a `ROLLBACK` statement. In MySQL 5.5, this true is even for statements affecting tables that use a nontransactional storage engine (such as `MyISAM`).

15.4.1.30. Replication and Triggers

With statement-based replication, triggers executed on the master also execute on the slave. With row-based replication, triggers executed on the master do not execute on the slave. Instead, the row changes on the master resulting from trigger execution are replicated and applied on the slave.

This behavior is by design. If under row-based replication the slave applied the triggers as well as the row changes caused by them, the changes would in effect be applied twice on the slave, leading to different data on the master and the slave.

If you want triggers to execute on both the master and the slave—perhaps because you have different triggers on the master and slave—you must use statement-based replication. However, to enable slave-side triggers, it is not necessary to use statement-based replication exclusively. It is sufficient to switch to statement-based replication only for those statements where you want this effect, and to use row-based replication the rest of the time.

A statement invoking a trigger (or function) that causes an update to an `AUTO_INCREMENT` column is not replicated correctly using statement-based replication. MySQL 5.5 marks such statements as unsafe. (Bug #45677)

15.4.1.31. Replication and Views

Views are always replicated to slaves. Views are filtered by their own name, not by the tables they refer to. This means that a view can be replicated to the slave even if the view contains a table that would normally be filtered out by `replication-ignore-table` rules. Care should therefore be taken to ensure that views do not replicate table data that would normally be filtered for security reasons.

15.4.1.32. Replication and `TRUNCATE TABLE`

`TRUNCATE TABLE` is normally regarded as a DML statement, and so would be expected to be logged and replicated using row-based format when the binary logging mode is `ROW` or `MIXED`. However this caused issues when logging or replicating, in `STATEMENT` or `MIXED` mode, tables that used transactional storage engines such as `InnoDB` when the transaction isolation level was `READ COMMITTED` or `READ UNCOMMITTED`, which precludes statement-based logging.

`TRUNCATE TABLE` is treated for purposes of logging and replication as DDL rather than DML so that it can be logged and replicated as a statement. However, the effects of the statement as applicable to `InnoDB` and other transactional tables on replication slaves still follow the rules described in Section 12.1.27, "`TRUNCATE TABLE` Syntax" governing such tables. (Bug #36763)

15.4.1.33. Replication and Variables

System variables are not replicated correctly when using `STATEMENT` mode, except for the following variables when they are used with session scope:

- `auto_increment_increment`
- `auto_increment_offset`
- `character_set_client`

- `character_set_connection`
- `character_set_database`
- `character_set_server`
- `collation_connection`
- `collation_database`
- `collation_server`
- `foreign_key_checks`
- `identity`
- `last_insert_id`
- `lc_time_names`
- `pseudo_thread_id`
- `sql_auto_is_null`
- `time_zone`
- `timestamp`
- `unique_checks`

When `MIXED` mode is used, the variables in the preceding list, when used with session scope, cause a switch from statement-based to row-based logging. See Section 5.2.4.3, “Mixed Binary Logging Format”.

`sql_mode` is also replicated except for the `NO_DIR_IN_CREATE` mode; the slave always preserves its own value for `NO_DIR_IN_CREATE`, regardless of changes to it on the master. This is true for all replication formats.

However, when `mysqlbinlog` parses a `SET @@sql_mode = mode` statement, the full *`mode`* value, including `NO_DIR_IN_CREATE`, is passed to the receiving server. For this reason, replication of such a statement may not be safe when `STATEMENT` mode is in use.

The `default_storage_engine` and `storage_engine` system variables are not replicated, regardless of the logging mode; this is intended to facilitate replication between different storage engines.

The `read_only` system variable is not replicated. In addition, the enabling this variable has different effects with regard to temporary tables, table locking, and the `SET PASSWORD` statement in different MySQL versions.

In statement-based replication, session variables are not replicated properly when used in statements that update tables. For example, the following sequence of statements will not insert the same data on the master and the slave:

```
SET max_join_size=1000;
INSERT INTO mytable VALUES(@@max_join_size);
```

This does not apply to the common sequence:

```
SET time_zone=...;
INSERT INTO mytable VALUES(CONVERT_TZ(..., ..., @@time_zone));
```

Replication of session variables is not a problem when row-based replication is being used, in which case, session variables are always replicated safely. See Section 15.1.2, “Replication Formats”.

In MySQL 5.5, the following session variables are written to the binary log and honored by the replication slave when parsing the binary log, regardless of the logging format:

- `sql_mode`
- `foreign_key_checks`
- `unique_checks`

- `character_set_client`
- `collation_connection`
- `collation_database`
- `collation_server`
- `sql_auto_is_null`

> **Important**
>
> Even though session variables relating to character sets and collations are written to the binary log, replication between different character sets is not supported.

It is strongly recommended that you always use the same setting for the `lower_case_table_names` system variable on both master and slave. In particular, when a case-sensitive file system is used, setting this variable to 1 on the slave, but to a different value on the master, can cause two types of problems: Names of databases are not converted to lowercase; in addition, when using row-based replication names of tables are also not converted. Either of these problems can cause replication to fail. This is a known issue, which is fixed in MySQL 5.6.

15.4.2. Replication Compatibility Between MySQL Versions

MySQL supports replication from one major version to the next higher major version. For example, you can replicate from a master running MySQL 4.1 to a slave running MySQL 5.0, from a master running MySQL 5.0 to a slave running MySQL 5.1, and so on.

However, one may encounter difficulties when replicating from an older master to a newer slave if the master uses statements or relies on behavior no longer supported in the version of MySQL used on the slave. For example, in MySQL 5.5, `CREATE TABLE ... SELECT` statements are permitted to change tables other than the one being created, but are no longer allowed to do so in MySQL 5.6 (see Section 15.4.1.4, “Replication of `CREATE TABLE ... SELECT` Statements”).

The use of more than 2 MySQL Server versions is not supported in replication setups involving multiple masters, regardless of the number of master or slave MySQL servers. This restriction applies not only to major versions, but to minor versions within the same major version as well. For example, if you are using a chained or circular replication setup, you cannot use MySQL 5.5.1, MySQL 5.5.2, and MySQL 5.5.4 concurrently, although you could use any 2 of these releases together.

In some cases, it is also possible to replicate between a master and a slave that is more than one major version newer than the master. However, there are known issues with trying to replicate from a master running MySQL 4.1 or earlier to a slave running MySQL 5.1 or later. To work around such problems, you can insert a MySQL server running an intermediate version between the two; for example, rather than replicating directly from a MySQL 4.1 master to a MySQL 5.1 slave, it is possible to replicate from a MySQL 4.1 server to a MySQL 5.0 server, and then from the MySQL 5.0 server to a MySQL 5.1 server.

> **Important**
>
> It is strongly recommended to use the most recent release available within a given MySQL major version because replication (and other) capabilities are continually being improved. It is also recommended to upgrade masters and slaves that use early releases of a major version of MySQL to GA (production) releases when the latter become available for that major version.

Replication from newer masters to older slaves may be possible, but is generally not supported. This is due to a number of factors:

- **Binary log format changes.** The binary log format can change between major releases. While we attempt to maintain backward compatibility, this is not always possible. For example, the binary log format implemented in MySQL 5.0 changed considerably from that used in previous versions, especially with regard to handling of character sets, `LOAD DATA INFILE`, and time zones. This means that replication from a MySQL 5.0 (or later) master to a MySQL 4.1 (or earlier) slave is generally not supported.

  This also has significant implications for upgrading replication servers; see Section 15.4.3, “Upgrading a Replication Setup”, for more information.

- **Use of row-based replication.** Row-based replication was implemented in MySQL 5.1.5, so you cannot replicate using row-based replication from any MySQL 5.5 or later master to a slave older than MySQL 5.1.5.

  For more information about row-based replication, see Section 15.1.2, “Replication Formats”.

- **SQL incompatibilities.** You cannot replicate from a newer master to an older slave using statement-based replication if the statements to be replicated use SQL features available on the master but not on the slave.

> However, if both the master and the slave support row-based replication, and there are no data definition statements to be replicated that depend on SQL features found on the master but not on the slave, you can use row-based replication to replicate the effects of data modification statements even if the DDL run on the master is not supported on the slave.

For more information on potential replication issues, see Section 15.4.1, “Replication Features and Issues”.

15.4.3. Upgrading a Replication Setup

When you upgrade servers that participate in a replication setup, the procedure for upgrading depends on the current server versions and the version to which you are upgrading.

This section applies to upgrading replication from older versions of MySQL to MySQL 5.5. A 4.0 server should be 4.0.3 or newer.

When you upgrade a master to 5.5 from an earlier MySQL release series, you should first ensure that all the slaves of this master are using the same 5.5.x release. If this is not the case, you should first upgrade the slaves. To upgrade each slave, shut it down, upgrade it to the appropriate 5.5.x version, restart it, and restart replication. The 5.5 slave is able to read the old relay logs written prior to the upgrade and to execute the statements they contain. Relay logs created by the slave after the upgrade are in 5.5 format.

After the slaves have been upgraded, shut down the master, upgrade it to the same 5.5.x release as the slaves, and restart it. The 5.5 master is able to read the old binary logs written prior to the upgrade and to send them to the 5.5 slaves. The slaves recognize the old format and handle it properly. Binary logs created by the master subsequent to the upgrade are in 5.5 format. These too are recognized by the 5.5 slaves.

In other words, when upgrading to MySQL 5.5, the slaves must be MySQL 5.5 before you can upgrade the master to 5.5. Note that downgrading from 5.5 to older versions does not work so simply: You must ensure that any 5.5 binary log or relay log has been fully processed, so that you can remove it before proceeding with the downgrade.

Downgrading a replication setup to a previous version cannot be done once you have switched from statement-based to row-based replication, and after the first row-based statement has been written to the binlog. See Section 15.1.2, “Replication Formats”.

Some upgrades may require that you drop and re-create database objects when you move from one MySQL series to the next. For example, collation changes might require that table indexes be rebuilt. Such operations, if necessary, will be detailed at Section 2.11.1.1, “Upgrading from MySQL 5.1 to 5.5”. It is safest to perform these operations separately on the slaves and the master, and to disable replication of these operations from the master to the slave. To achieve this, use the following procedure:

1. Stop all the slaves and upgrade them. Restart them with the `--skip-slave-start` option so that they do not connect to the master. Perform any table repair or rebuilding operations needed to re-create database objects, such as use of `REPAIR TABLE` or `ALTER TABLE`, or dumping and reloading tables or triggers.

2. Disable the binary log on the master. To do this without restarting the master, execute a `SET sql_log_bin = 0` statement. Alternatively, stop the master and restart it without the `--log-bin` option. If you restart the master, you might also want to disallow client connections. For example, if all clients connect using TCP/IP, use the `--skip-networking` option when you restart the master.

3. With the binary log disabled, perform any table repair or rebuilding operations needed to re-create database objects. The binary log must be disabled during this step to prevent these operations from being logged and sent to the slaves later.

4. Re-enable the binary log on the master. If you set `sql_log_bin` to 0 earlier, execute a `SET sql_log_bin = 1` statement. If you restarted the master to disable the binary log, restart it with `--log-bin`, and without `--skip-networking` so that clients and slaves can connect.

5. Restart the slaves, this time without the `--skip-slave-start` option.

15.4.4. Replication FAQ

Questions

- 16.4.4.1: Must the slave be connected to the master all the time?

- 16.4.4.2: Must I enable networking on my master and slave to enable replication?

- 16.4.4.3: How do I know how late a slave is compared to the master? In other words, how do I know the date of the last statement replicated by the slave?

- 16.4.4.4: How do I force the master to block updates until the slave catches up?

- 16.4.4.5: What issues should I be aware of when setting up two-way replication?
- 16.4.4.6: How can I use replication to improve performance of my system?
- 16.4.4.7: What should I do to prepare client code in my own applications to use performance-enhancing replication?
- 16.4.4.8: When and how much can MySQL replication improve the performance of my system?
- 16.4.4.9: How can I use replication to provide redundancy or high availability?
- 16.4.4.10: How do I tell whether a master server is using statement-based or row-based binary logging format?
- 16.4.4.11: How do I tell a slave to use row-based replication?
- 16.4.4.12: How do I prevent `GRANT` and `REVOKE` statements from replicating to slave machines?
- 16.4.4.13: Does replication work on mixed operating systems (for example, the master runs on Linux while slaves run on Mac OS X and Windows)?
- 16.4.4.14: Does replication work on mixed hardware architectures (for example, the master runs on a 64-bit machine while slaves run on 32-bit machines)?

Questions and Answers

16.4.4.1: Must the slave be connected to the master all the time?

No, it does not. The slave can go down or stay disconnected for hours or even days, and then reconnect and catch up on updates. For example, you can set up a master/slave relationship over a dial-up link where the link is up only sporadically and for short periods of time. The implication of this is that, at any given time, the slave is not guaranteed to be in synchrony with the master unless you take some special measures.

To ensure that catchup can occur for a slave that has been disconnected, you must not remove binary log files from the master that contain information that has not yet been replicated to the slaves. Asynchronous replication can work only if the slave is able to continue reading the binary log from the point where it last read events.

16.4.4.2: Must I enable networking on my master and slave to enable replication?

Yes, networking must be enabled on the master and slave. If networking is not enabled, the slave cannot connect to the master and transfer the binary log. Check that the `skip-networking` option has not been enabled in the configuration file for either server.

16.4.4.3: How do I know how late a slave is compared to the master? In other words, how do I know the date of the last statement replicated by the slave?

Check the `Seconds_Behind_Master` column in the output from `SHOW SLAVE STATUS`. See Section 15.1.4.1, "Checking Replication Status".

When the slave SQL thread executes an event read from the master, it modifies its own time to the event timestamp. (This is why `TIMESTAMP` is well replicated.) In the `Time` column in the output of `SHOW PROCESSLIST`, the number of seconds displayed for the slave SQL thread is the number of seconds between the timestamp of the last replicated event and the real time of the slave machine. You can use this to determine the date of the last replicated event. Note that if your slave has been disconnected from the master for one hour, and then reconnects, you may immediately see large `Time` values such as 3600 for the slave SQL thread in `SHOW PROCESSLIST`. This is because the slave is executing statements that are one hour old. See Section 15.2.1, "Replication Implementation Details".

16.4.4.4: How do I force the master to block updates until the slave catches up?

Use the following procedure:

1. On the master, execute these statements:

   ```
   mysql> FLUSH TABLES WITH READ LOCK;
   mysql> SHOW MASTER STATUS;
   ```

   Record the replication coordinates (the current binary log file name and position) from the output of the `SHOW` statement.

2. On the slave, issue the following statement, where the arguments to the `MASTER_POS_WAIT()` function are the replication coordinate values obtained in the previous step:

   ```
   mysql> SELECT MASTER_POS_WAIT('log_name', log_pos);
   ```

The `SELECT` statement blocks until the slave reaches the specified log file and position. At that point, the slave is in synchrony with the master and the statement returns.

3. On the master, issue the following statement to enable the master to begin processing updates again:

```
mysql> UNLOCK TABLES;
```

16.4.4.5: What issues should I be aware of when setting up two-way replication?

MySQL replication currently does not support any locking protocol between master and slave to guarantee the atomicity of a distributed (cross-server) update. In other words, it is possible for client A to make an update to co-master 1, and in the meantime, before it propagates to co-master 2, client B could make an update to co-master 2 that makes the update of client A work differently than it did on co-master 1. Thus, when the update of client A makes it to co-master 2, it produces tables that are different from what you have on co-master 1, even after all the updates from co-master 2 have also propagated. This means that you should not chain two servers together in a two-way replication relationship unless you are sure that your updates can safely happen in any order, or unless you take care of mis-ordered updates somehow in the client code.

You should also realize that two-way replication actually does not improve performance very much (if at all) as far as updates are concerned. Each server must do the same number of updates, just as you would have a single server do. The only difference is that there is a little less lock contention because the updates originating on another server are serialized in one slave thread. Even this benefit might be offset by network delays.

16.4.4.6: How can I use replication to improve performance of my system?

Set up one server as the master and direct all writes to it. Then configure as many slaves as you have the budget and rackspace for, and distribute the reads among the master and the slaves. You can also start the slaves with the `--skip-innodb`, `--low-priority-updates`, and `--delay-key-write=ALL` options to get speed improvements on the slave end. In this case, the slave uses nontransactional `MyISAM` tables instead of `InnoDB` tables to get more speed by eliminating transactional overhead.

16.4.4.7: What should I do to prepare client code in my own applications to use performance-enhancing replication?

See the guide to using replication as a scale-out solution, Section 15.3.3, “Using Replication for Scale-Out”.

16.4.4.8: When and how much can MySQL replication improve the performance of my system?

MySQL replication is most beneficial for a system that processes frequent reads and infrequent writes. In theory, by using a single-master/multiple-slave setup, you can scale the system by adding more slaves until you either run out of network bandwidth, or your update load grows to the point that the master cannot handle it.

To determine how many slaves you can use before the added benefits begin to level out, and how much you can improve performance of your site, you must know your query patterns, and determine empirically by benchmarking the relationship between the throughput for reads and writes on a typical master and a typical slave. The example here shows a rather simplified calculation of what you can get with replication for a hypothetical system. Let `reads` and `writes` denote the number of reads and writes per second, respectively.

Let's say that system load consists of 10% writes and 90% reads, and we have determined by benchmarking that `reads` is 1200 – 2 × `writes`. In other words, the system can do 1,200 reads per second with no writes, the average write is twice as slow as the average read, and the relationship is linear. Suppose that the master and each slave have the same capacity, and that we have one master and N slaves. Then we have for each server (master or slave):

`reads` = 1200 – 2 × `writes`

`reads` = 9 × `writes` / (N + 1) (reads are split, but writes replicated to all slaves)

9 × `writes` / (N + 1) + 2 × `writes` = 1200

`writes` = 1200 / (2 + 9/(N + 1))

The last equation indicates the maximum number of writes for N slaves, given a maximum possible read rate of 1,200 per minute and a ratio of nine reads per write.

This analysis yields the following conclusions:

- If N = 0 (which means we have no replication), our system can handle about 1200/11 = 109 writes per second.
- If N = 1, we get up to 184 writes per second.

- If `N` = 8, we get up to 400 writes per second.
- If `N` = 17, we get up to 480 writes per second.
- Eventually, as `N` approaches infinity (and our budget negative infinity), we can get very close to 600 writes per second, increasing system throughput about 5.5 times. However, with only eight servers, we increase it nearly four times.

Note that these computations assume infinite network bandwidth and neglect several other factors that could be significant on your system. In many cases, you may not be able to perform a computation similar to the one just shown that accurately predicts what will happen on your system if you add `N` replication slaves. However, answering the following questions should help you decide whether and by how much replication will improve the performance of your system:

- What is the read/write ratio on your system?
- How much more write load can one server handle if you reduce the reads?
- For how many slaves do you have bandwidth available on your network?

16.4.4.9: How can I use replication to provide redundancy or high availability?

How you implement redundancy is entirely dependent on your application and circumstances. High-availability solutions (with automatic failover) require active monitoring and either custom scripts or third party tools to provide the failover support from the original MySQL server to the slave.

To handle the process manually, you should be able to switch from a failed master to a pre-configured slave by altering your application to talk to the new server or by adjusting the DNS for the MySQL server from the failed server to the new server.

For more information and some example solutions, see Section 15.3.6, “Switching Masters During Failover”.

16.4.4.10: How do I tell whether a master server is using statement-based or row-based binary logging format?

Check the value of the `binlog_format` system variable:

```
mysql> SHOW VARIABLES LIKE 'binlog_format';
```

The value shown will be one of `STATEMENT`, `ROW`, or `MIXED`. For `MIXED` mode, row-based logging is preferred but replication switches automatically to statement-based logging under certain conditions; for information about when this may occur, see Section 5.2.4.3, “Mixed Binary Logging Format”.

16.4.4.11: How do I tell a slave to use row-based replication?

Slaves automatically know which format to use.

16.4.4.12: How do I prevent `GRANT` and `REVOKE` statements from replicating to slave machines?

Start the server with the `--replicate-wild-ignore-table=mysql.%` option to ignore replication for tables in the `mysql` database.

16.4.4.13: Does replication work on mixed operating systems (for example, the master runs on Linux while slaves run on Mac OS X and Windows)?

Yes.

16.4.4.14: Does replication work on mixed hardware architectures (for example, the master runs on a 64-bit machine while slaves run on 32-bit machines)?

Yes.

15.4.5. Troubleshooting Replication

If you have followed the instructions but your replication setup is not working, the first thing to do is *check the error log for messages*. Many users have lost time by not doing this soon enough after encountering problems.

If you cannot tell from the error log what the problem was, try the following techniques:

- Verify that the master has binary logging enabled by issuing a `SHOW MASTER STATUS` statement. If logging is enabled, `Position` is nonzero. If binary logging is not enabled, verify that you are running the master with the `--log-bin` option.

- Verify that the master and slave both were started with the `--server-id` option and that the ID value is unique on each server.
- Verify that the slave is running. Use `SHOW SLAVE STATUS` to check whether the `Slave_IO_Running` and `Slave_SQL_Running` values are both `Yes`. If not, verify the options that were used when starting the slave server. For example, `--skip-slave-start` prevents the slave threads from starting until you issue a `START SLAVE` statement.
- If the slave is running, check whether it established a connection to the master. Use `SHOW PROCESSLIST`, find the I/O and SQL threads and check their `State` column to see what they display. See Section 15.2.1, "Replication Implementation Details". If the I/O thread state says `Connecting to master`, check the following:
  - Verify the privileges for the user being used for replication on the master.
  - Check that the host name of the master is correct and that you are using the correct port to connect to the master. The port used for replication is the same as used for client network communication (the default is `3306`). For the host name, ensure that the name resolves to the correct IP address.
  - Check that networking has not been disabled on the master or slave. Look for the `skip-networking` option in the configuration file. If present, comment it out or remove it.
  - If the master has a firewall or IP filtering configuration, ensure that the network port being used for MySQL is not being filtered.
  - Check that you can reach the master by using `ping` or `traceroute`/`tracert` to reach the host.
- If the slave was running previously but has stopped, the reason usually is that some statement that succeeded on the master failed on the slave. This should never happen if you have taken a proper snapshot of the master, and never modified the data on the slave outside of the slave thread. If the slave stops unexpectedly, it is a bug or you have encountered one of the known replication limitations described in Section 15.4.1, "Replication Features and Issues". If it is a bug, see Section 15.4.6, "How to Report Replication Bugs or Problems", for instructions on how to report it.
- If a statement that succeeded on the master refuses to run on the slave, try the following procedure if it is not feasible to do a full database resynchronization by deleting the slave's databases and copying a new snapshot from the master:
  1. Determine whether the affected table on the slave is different from the master table. Try to understand how this happened. Then make the slave's table identical to the master's and run `START SLAVE`.
  2. If the preceding step does not work or does not apply, try to understand whether it would be safe to make the update manually (if needed) and then ignore the next statement from the master.
  3. If you decide that the slave can skip the next statement from the master, issue the following statements:

     ```
     mysql> SET GLOBAL sql_slave_skip_counter = N;
     mysql> START SLAVE;
     ```

     The value of *N* should be 1 if the next statement from the master does not use `AUTO_INCREMENT` or `LAST_INSERT_ID()`. Otherwise, the value should be 2. The reason for using a value of 2 for statements that use `AUTO_INCREMENT` or `LAST_INSERT_ID()` is that they take two events in the binary log of the master.

     See also Section 12.5.2.4, "`SET GLOBAL sql_slave_skip_counter` Syntax".
  4. If you are sure that the slave started out perfectly synchronized with the master, and that no one has updated the tables involved outside of the slave thread, then presumably the discrepancy is the result of a bug. If you are running the most recent version of MySQL, please report the problem. If you are running an older version, try upgrading to the latest production release to determine whether the problem persists.

15.4.6. How to Report Replication Bugs or Problems

When you have determined that there is no user error involved, and replication still either does not work at all or is unstable, it is time to send us a bug report. We need to obtain as much information as possible from you to be able to track down the bug. Please spend some time and effort in preparing a good bug report.

If you have a repeatable test case that demonstrates the bug, please enter it into our bugs database using the instructions given in Section 1.7, "How to Report Bugs or Problems". If you have a "phantom" problem (one that you cannot duplicate at will), use the following procedure:

1. Verify that no user error is involved. For example, if you update the slave outside of the slave thread, the data goes out of synchrony, and you can have unique key violations on updates. In this case, the slave thread stops and waits for you to clean up

the tables manually to bring them into synchrony. *This is not a replication problem. It is a problem of outside interference causing replication to fail.*

2. Run the slave with the `--log-slave-updates` and `--log-bin` options. These options cause the slave to log the updates that it receives from the master into its own binary logs.

3. Save all evidence before resetting the replication state. If we have no information or only sketchy information, it becomes difficult or impossible for us to track down the problem. The evidence you should collect is:

   - All binary log files from the master
   - All binary log files from the slave
   - The output of `SHOW MASTER STATUS` from the master at the time you discovered the problem
   - The output of `SHOW SLAVE STATUS` from the slave at the time you discovered the problem
   - Error logs from the master and the slave

4. Use `mysqlbinlog` to examine the binary logs. The following should be helpful to find the problem statement. *`log_file`* and *`log_pos`* are the `Master_Log_File` and `Read_Master_Log_Pos` values from `SHOW SLAVE STATUS`.

   ```
   shell> mysqlbinlog --start-position=log_pos log_file | head
   ```

After you have collected the evidence for the problem, try to isolate it as a separate test case first. Then enter the problem with as much information as possible into our bugs database using the instructions at Section 1.7, “How to Report Bugs or Problems”.

Chapter 16. Partitioning

This chapter discusses MySQL's implementation of *user-defined partitioning*. You can determine whether your MySQL Server supports partitioning by means of a `SHOW VARIABLES` statement such as this one:

```
mysql> SHOW VARIABLES LIKE '%partition%';

+-------------------+-------+
| Variable_name     | Value |
+-------------------+-------+
| have_partitioning | YES   |
+-------------------+-------+
1 row in set (0.00 sec)
```

You can also check the output of the `SHOW PLUGINS` statement, as shown here:

```
mysql> SHOW PLUGINS;
+------------+----------+----------------+---------+---------+
| Name       | Status   | Type           | Library | License |
+------------+----------+----------------+---------+---------+
| binlog     | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| partition  | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| ARCHIVE    | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| BLACKHOLE  | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| CSV        | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| FEDERATED  | DISABLED | STORAGE ENGINE | NULL    | GPL     |
| MEMORY     | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| InnoDB     | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| MRG_MYISAM | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| MyISAM     | ACTIVE   | STORAGE ENGINE | NULL    | GPL     |
| ndbcluster | DISABLED | STORAGE ENGINE | NULL    | GPL     |
+------------+----------+----------------+---------+---------+
11 rows in set (0.00 sec)
```

If you do not see the `have_partitioning` variable with the value `YES` listed in the output of an appropriate `SHOW VARIABLES` statement, or if you do not see the `partition` plugin listed with the value `ACTIVE` for the `Status` column in the output of `SHOW PLUGINS` (show in bold text in the example just given), then your version of MySQL was not built with partitioning support.

MySQL 5.5 Community binaries provided by Oracle include partitioning support. For information about partitioning support offered in commercial MySQL Server binaries, see *MySQL Enterprise Server 5.1* on the MySQL Web site at `http://www.mysql.com/products/enterprise/server.html`.

To enable partitioning if you are compiling MySQL 5.5 from source, the build must be configured with the `-DWITH_PARTITION_STORAGE_ENGINE` option. For more information about building MySQL, see Section 2.9, “Installing MySQL from Source”.

If your MySQL binary is built with partitioning support, nothing further needs to be done to enable it (for example, no special entries are required in your `my.cnf` file).

If you want to disable partitioning support, you can start the MySQL Server with the `--skip-partition` option, in which case the value of `have_partitioning` is `DISABLED`. However, if you do this, you cannot access any partitioned tables until the server is once again restarted without the `--skip-partition` option.

An introduction to partitioning and partitioning concepts may be found in Section 16.1, “Overview of Partitioning in MySQL”.

MySQL supports several types of partitioning, which are discussed in Section 16.2, “Partitioning Types”, as well as subpartitioning, which is described in Section 16.2.6, “Subpartitioning”.

Methods of adding, removing, and altering partitions in existing partitioned tables are covered in Section 16.3, “Partition Management”.

Table maintenance commands for use with partitioned tables are discussed in Section 16.3.3, “Maintenance of Partitions”.

The `PARTITIONS` table in the `INFORMATION_SCHEMA` database provides information about partitions and partitioned tables. See Section 18.19, “The `INFORMATION_SCHEMA PARTITIONS` Table”, for more information; for some examples of queries against this table, see Section 16.2.7, “How MySQL Partitioning Handles `NULL`”.

For known issues with partitioning in MySQL 5.5, see Section 16.5, “Restrictions and Limitations on Partitioning”.

You may also find the following resources to be useful when working with partitioned tables.

Additional Resources. Other sources of information about user-defined partitioning in MySQL include the following:

- MySQL Partitioning Forum

  This is the official discussion forum for those interested in or experimenting with MySQL Partitioning technology. It features announcements and updates from MySQL developers and others. It is monitored by members of the Partitioning Development and Documentation Teams.

- Mikael Ronström's Blog

  MySQL Partitioning Architect and Lead Developer Mikael Ronström frequently posts articles here concerning his work with MySQL Partitioning and MySQL Cluster.

- PlanetMySQL

  A MySQL news site featuring MySQL-related blogs, which should be of interest to anyone using my MySQL. We encourage you to check here for links to blogs kept by those working with MySQL Partitioning, or to have your own blog added to those covered.

MySQL 5.5 binaries are available from http://dev.mysql.com/downloads/mysql/5.5.html. However, for the latest partitioning bugfixes and feature additions, you can obtain the source from our Bazaar repository. To enable partitioning, the build must be configured with the `-DWITH_PARTITION_STORAGE_ENGINE` option. For more information about building MySQL, see Section 2.9, “Installing MySQL from Source”. If you have problems compiling a partitioning-enabled MySQL 5.5 build, check the MySQL Partitioning Forum and ask for assistance there if you do not find a solution to your problem already posted.

16.1. Overview of Partitioning in MySQL

This section provides a conceptual overview of partitioning in MySQL 5.5.

For information on partitioning restrictions and feature limitations, see Section 16.5, “Restrictions and Limitations on Partitioning”.

The SQL standard does not provide much in the way of guidance regarding the physical aspects of data storage. The SQL language itself is intended to work independently of any data structures or media underlying the schemas, tables, rows, or columns with which it works. Nonetheless, most advanced database management systems have evolved some means of determining the physical location to be used for storing specific pieces of data in terms of the file system, hardware or even both. In MySQL, the `InnoDB` storage engine has long supported the notion of a tablespace, and the MySQL Server, even prior to the introduction of partitioning, could be configured to employ different physical directories for storing different databases (see Section 7.11.3.1, “Using Symbolic Links”, for an explanation of how this is done).

Partitioning takes this notion a step further, by enabling you to distribute portions of individual tables across a file system according to rules which you can set largely as needed. In effect, different portions of a table are stored as separate tables in different locations. The user-selected rule by which the division of data is accomplished is known as a *partitioning function*, which in MySQL can be the modulus, simple matching against a set of ranges or value lists, an internal hashing function, or a linear hashing function. The function is selected according to the partitioning type specified by the user, and takes as its parameter the value of a user-supplied expression. This expression can be a column value, a function acting on one or more column values, or a set of one or more column values, depending on the type of partitioning that is used.

In the case of `RANGE`, `LIST`, and [`LINEAR`] `HASH` partitioning, the value of the partitioning column is passed to the partitioning function, which returns an integer value representing the number of the partition in which that particular record should be stored. This function must be nonconstant and nonrandom. It may not contain any queries, but may use an SQL expression that is valid in MySQL, as long as that expression returns either `NULL` or an integer *`intval`* such that

```
-MAXVALUE <= intval <= MAXVALUE
```

(`MAXVALUE` is used to represent the least upper bound for the type of integer in question. `-MAXVALUE` represents the greatest lower bound.)

For [`LINEAR`] `KEY`, `RANGE COLUMNS`, and `LIST COLUMNS` partitioning, the partitioning expression consists of a list of one or more columns.

For [`LINEAR`] `KEY` partitioning, the partitioning function is supplied by MySQL.

For more information about permitted partitioning column types and partitioning functions, see Section 16.2, “Partitioning Types”, as well as Section 12.1.14, “`CREATE TABLE` Syntax”, which provides partitioning syntax descriptions and additional examples. For information about restrictions on partitioning functions, see Section 16.5.3, “Partitioning Limitations Relating to Functions”.

This is known as *horizontal partitioning*—that is, different rows of a table may be assigned to different physical partitions. MySQL 5.5 does not support *vertical partitioning*, in which different columns of a table are assigned to different physical partitions. There are not at this time any plans to introduce vertical partitioning into MySQL 5.5.

For information about determining whether your MySQL Server binary supports user-defined partitioning, see Chapter 16, *Parti-*

tioning.

For creating partitioned tables, you can use most storage engines that are supported by your MySQL server; the MySQL partitioning engine runs in a separate layer and can interact with any of these. In MySQL 5.5, all partitions of the same partitioned table must use the same storage engine; for example, you cannot use `MyISAM` for one partition and `InnoDB` for another. However, there is nothing preventing you from using different storage engines for different partitioned tables on the same MySQL server or even in the same database.

MySQL partitioning cannot be used with the `MERGE`, `CSV`, or `FEDERATED` storage engines.

To employ a particular storage engine for a partitioned table, it is necessary only to use the `[STORAGE] ENGINE` option just as you would for a nonpartitioned table. However, you should keep in mind that `[STORAGE] ENGINE` (and other table options) need to be listed *before* any partitioning options are used in a `CREATE TABLE` statement. This example shows how to create a table that is partitioned by hash into 6 partitions and which uses the `InnoDB` storage engine:

```
CREATE TABLE ti (id INT, amount DECIMAL(7,2), tr_date DATE)
    ENGINE=INNODB
    PARTITION BY HASH( MONTH(tr_date) )
    PARTITIONS 6;
```

Each `PARTITION` clause can include a `[STORAGE] ENGINE` option, but in MySQL 5.5 this has no effect.

> **Important**
>
> Partitioning applies to all data and indexes of a table; you cannot partition only the data and not the indexes, or *vice versa*, nor can you partition only a portion of the table.

Data and indexes for each partition can be assigned to a specific directory using the `DATA DIRECTORY` and `INDEX DIRECTORY` options for the `PARTITION` clause of the `CREATE TABLE` statement used to create the partitioned table.

The `DATA DIRECTORY` and `INDEX DIRECTORY` options have no effect when defining partitions for tables using the `InnoDB` storage engine.

`DATA DIRECTORY` and `INDEX DIRECTORY` are not supported for individual partitions or subpartitions on Windows. These options are ignored on Windows, except that a warning is generated.

In addition, `MAX_ROWS` and `MIN_ROWS` can be used to determine the maximum and minimum numbers of rows, respectively, that can be stored in each partition. See Section 16.3, “Partition Management”, for more information on these options.

Some advantages of partitioning are listed here:

- Partitioning makes it possible to store more data in one table than can be held on a single disk or file system partition.
- Data that loses its usefulness can often be easily removed from a partitioned table by dropping the partition (or partitions) containing only that data. Conversely, the process of adding new data can in some cases be greatly facilitated by adding one or more new partitions for storing specifically that data.
- Some queries can be greatly optimized in virtue of the fact that data satisfying a given `WHERE` clause can be stored only on one or more partitions, which automatically excluding any remaining partitions from the search. Because partitions can be altered after a partitioned table has been created, you can reorganize your data to enhance frequent queries that may not have been often used when the partitioning scheme was first set up. This ability to exclude non-matching partitions (and thus any rows they contain) is often referred to as *partition pruning*. For more information, see Section 16.4, “Partition Pruning”.

Other benefits usually associated with partitioning include those in the following list. These features are not currently implemented in MySQL Partitioning, but are high on our list of priorities.

- Queries involving aggregate functions such as `SUM()` and `COUNT()` can easily be parallelized. A simple example of such a query might be `SELECT salesperson_id, COUNT(orders) as order_total FROM sales GROUP BY salesperson_id;`. By “parallelized,” we mean that the query can be run simultaneously on each partition, and the final result obtained merely by summing the results obtained for all partitions.
- Achieving greater query throughput in virtue of spreading data seeks over multiple disks.

Be sure to check this section and chapter frequently for updates as MySQL Partitioning development continues.

16.2. Partitioning Types

This section discusses the types of partitioning which are available in MySQL 5.5. These include the types listed here:

- **`RANGE` partitioning.** This type of partitioning assigns rows to partitions based on column values falling within a given range. See Section 16.2.1, “`RANGE` Partitioning”. MySQL 5.5 adds an extension, `RANGE COLUMNS`, to this type. See Section 16.2.3.1, “`RANGE COLUMNS` partitioning”.
- **`LIST` partitioning.** Similar to partitioning by `RANGE`, except that the partition is selected based on columns matching one of a set of discrete values. See Section 16.2.2, “`LIST` Partitioning”. MySQL 5.5 adds an extension, `LIST COLUMNS`, to this type. See Section 16.2.3.2, “`LIST COLUMNS` partitioning”.
- **`HASH` partitioning.** With this type of partitioning, a partition is selected based on the value returned by a user-defined expression that operates on column values in rows to be inserted into the table. The function may consist of any expression valid in MySQL that yields a nonnegative integer value. An extension to this type, `LINEAR HASH`, is also available. See Section 16.2.4, “`HASH` Partitioning”.
- **`KEY` partitioning.** This type of partitioning is similar to partitioning by `HASH`, except that only one or more columns to be evaluated are supplied, and the MySQL server provides its own hashing function. These columns can contain other than integer values, since the hashing function supplied by MySQL guarantees an integer result regardless of the column data type. An extension to this type, `LINEAR KEY`, is also available. See Section 16.2.5, “`KEY` Partitioning”.

A very common use of database partitioning is to segregate data by date. Some database systems support explicit date partitioning, which MySQL does not implement in 5.5. However, it is not difficult in MySQL to create partitioning schemes based on `DATE`, `TIME`, or `DATETIME` columns, or based on expressions making use of such columns.

When partitioning by `KEY` or `LINEAR KEY`, you can use a `DATE`, `TIME`, or `DATETIME` column as the partitioning column without performing any modification of the column value. For example, this table creation statement is perfectly valid in MySQL:

```
CREATE TABLE members (
    firstname VARCHAR(25) NOT NULL,
    lastname VARCHAR(25) NOT NULL,
    username VARCHAR(16) NOT NULL,
    email VARCHAR(35),
    joined DATE NOT NULL
)
PARTITION BY KEY(joined)
PARTITIONS 6;
```

In MySQL 5.5, it is also possible to use a `DATE` or `DATETIME` column as the partitioning column using `RANGE COLUMNS` and `LIST COLUMNS` partitioning.

MySQL's other partitioning types, however, require a partitioning expression that yields an integer value or `NULL`. If you wish to use date-based partitioning by `RANGE`, `LIST`, `HASH`, or `LINEAR HASH`, you can simply employ a function that operates on a `DATE`, `TIME`, or `DATETIME` column and returns such a value, as shown here:

```
CREATE TABLE members (
    firstname VARCHAR(25) NOT NULL,
    lastname VARCHAR(25) NOT NULL,
    username VARCHAR(16) NOT NULL,
    email VARCHAR(35),
    joined DATE NOT NULL
)
PARTITION BY RANGE( YEAR(joined) ) (
    PARTITION p0 VALUES LESS THAN (1960),
    PARTITION p1 VALUES LESS THAN (1970),
    PARTITION p2 VALUES LESS THAN (1980),
    PARTITION p3 VALUES LESS THAN (1990),
    PARTITION p4 VALUES LESS THAN MAXVALUE
);
```

Additional examples of partitioning using dates may be found in the following sections of this chapter:

- Section 16.2.1, “`RANGE` Partitioning”
- Section 16.2.4, “`HASH` Partitioning”
- Section 16.2.4.1, “`LINEAR HASH` Partitioning”

For more complex examples of date-based partitioning, see the following sections:

- Section 16.4, “Partition Pruning”
- Section 16.2.6, “Subpartitioning”

MySQL partitioning is optimized for use with the `TO_DAYS()`, `YEAR()`, and `TO_SECONDS()` functions. However, you can use other date and time functions that return an integer or `NULL`, such as `WEEKDAY()`, `DAYOFYEAR()`, or `MONTH()`. See Section 11.7, “Date and Time Functions”, for more information about such functions.

It is important to remember—regardless of the type of partitioning that you use—that partitions are always numbered automatically and in sequence when created, starting with `0`. When a new row is inserted into a partitioned table, it is these partition numbers that are used in identifying the correct partition. For example, if your table uses 4 partitions, these partitions are numbered `0`, `1`, `2`, and `3`. For the `RANGE` and `LIST` partitioning types, it is necessary to ensure that there is a partition defined for each partition number. For `HASH` partitioning, the user function employed must return an integer value greater than `0`. For `KEY` partitioning, this issue is taken care of automatically by the hashing function which the MySQL server employs internally.

Names of partitions generally follow the rules governing other MySQL identifiers, such as those for tables and databases. However, you should note that partition names are not case-sensitive. For example, the following `CREATE TABLE` statement fails as shown:

```
mysql> CREATE TABLE t2 (val INT)
    -> PARTITION BY LIST(val)(
    ->     PARTITION mypart VALUES IN (1,3,5),
    ->     PARTITION MyPart VALUES IN (2,4,6)
    -> );
ERROR 1488 (HY000): Duplicate partition name mypart
```

Failure occurs because MySQL sees no difference between the partition names `mypart` and `MyPart`.

When you specify the number of partitions for the table, this must be expressed as a positive, nonzero integer literal with no leading zeros, and may not be an expression such as `0.8E+01` or `6-2`, even if it evaluates to an integer value. Decimal fractions are not permitted.

In the sections that follow, we do not necessarily provide all possible forms for the syntax that can be used for creating each partition type; this information may be found in Section 12.1.14, “`CREATE TABLE` Syntax”.

16.2.1. `RANGE` Partitioning

A table that is partitioned by range is partitioned in such a way that each partition contains rows for which the partitioning expression value lies within a given range. Ranges should be contiguous but not overlapping, and are defined using the `VALUES LESS THAN` operator. For the next few examples, suppose that you are creating a table such as the following to hold personnel records for a chain of 20 video stores, numbered 1 through 20:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
);
```

This table can be partitioned by range in a number of ways, depending on your needs. One way would be to use the `store_id` column. For instance, you might decide to partition the table 4 ways by adding a `PARTITION BY RANGE` clause as shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE (store_id) (
    PARTITION p0 VALUES LESS THAN (6),
    PARTITION p1 VALUES LESS THAN (11),
    PARTITION p2 VALUES LESS THAN (16),
    PARTITION p3 VALUES LESS THAN (21)
);
```

In this partitioning scheme, all rows corresponding to employees working at stores 1 through 5 are stored in partition `p0`, to those employed at stores 6 through 10 are stored in partition `p1`, and so on. Note that each partition is defined in order, from lowest to highest. This is a requirement of the `PARTITION BY RANGE` syntax; you can think of it as being analogous to a series of `if ... elseif ...` statements in C or Java in this regard.

It is easy to determine that a new row containing the data `(72, 'Michael', 'Widenius', '1998-06-25', NULL, 13)` is inserted into partition `p2`, but what happens when your chain adds a 21st store? Under this scheme, there is no rule that covers a row whose `store_id` is greater than 20, so an error results because the server does not know where to place it. You can keep this from occurring by using a “catchall” `VALUES LESS THAN` clause in the `CREATE TABLE` statement that provides for all values greater than the highest value explicitly named:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE (store_id) (
    PARTITION p0 VALUES LESS THAN (6),
    PARTITION p1 VALUES LESS THAN (11),
    PARTITION p2 VALUES LESS THAN (16),
    PARTITION p3 VALUES LESS THAN MAXVALUE
);
```

> **Note**
>
> Another way to avoid an error when no matching value is found is to use the `IGNORE` keyword as part of the `INSERT` statement. For an example, see Section 16.2.2, “`LIST` Partitioning”. Also see Section 12.2.5, “`INSERT` Syntax”, for general information about `IGNORE`.

`MAXVALUE` represents an integer value that is always greater than the largest possible integer value (in mathematical language, it serves as a *least upper bound*). Now, any rows whose `store_id` column value is greater than or equal to 16 (the highest value defined) are stored in partition `p3`. At some point in the future—when the number of stores has increased to 25, 30, or more—you can use an `ALTER TABLE` statement to add new partitions for stores 21-25, 26-30, and so on (see Section 16.3, “Partition Management”, for details of how to do this).

In much the same fashion, you could partition the table based on employee job codes—that is, based on ranges of `job_code` column values. For example—assuming that two-digit job codes are used for regular (in-store) workers, three-digit codes are used for office and support personnel, and four-digit codes are used for management positions—you could create the partitioned table using the following statement:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE (job_code) (
    PARTITION p0 VALUES LESS THAN (100),
    PARTITION p1 VALUES LESS THAN (1000),
    PARTITION p2 VALUES LESS THAN (10000)
);
```

In this instance, all rows relating to in-store workers would be stored in partition `p0`, those relating to office and support staff in `p1`, and those relating to managers in partition `p2`.

It is also possible to use an expression in `VALUES LESS THAN` clauses. However, MySQL must be able to evaluate the expression's return value as part of a `LESS THAN` (`<`) comparison.

Rather than splitting up the table data according to store number, you can use an expression based on one of the two `DATE` columns instead. For example, let us suppose that you wish to partition based on the year that each employee left the company; that is, the value of `YEAR(separated)`. An example of a `CREATE TABLE` statement that implements such a partitioning scheme is shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY RANGE ( YEAR(separated) ) (
    PARTITION p0 VALUES LESS THAN (1991),
    PARTITION p1 VALUES LESS THAN (1996),
    PARTITION p2 VALUES LESS THAN (2001),
    PARTITION p3 VALUES LESS THAN MAXVALUE
);
```

In this scheme, for all employees who left before 1991, the rows are stored in partition `p0`; for those who left in the years 1991 through 1995, in `p1`; for those who left in the years 1996 through 2000, in `p2`; and for any workers who left after the year 2000, in `p3`.

It is also possible to partition a table by `RANGE`, based on the value of a `TIMESTAMP` column, using the `UNIX_TIMESTAMP()`

function, as shown in this example:

```
CREATE TABLE quarterly_report_status (
    report_id INT NOT NULL,
    report_status VARCHAR(20) NOT NULL,
    report_updated TIMESTAMP NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP
)
PARTITION BY RANGE ( UNIX_TIMESTAMP(report_updated) ) (
    PARTITION p0 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-01-01 00:00:00') ),
    PARTITION p1 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-04-01 00:00:00') ),
    PARTITION p2 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-07-01 00:00:00') ),
    PARTITION p3 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-10-01 00:00:00') ),
    PARTITION p4 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-01-01 00:00:00') ),
    PARTITION p5 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-04-01 00:00:00') ),
    PARTITION p6 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-07-01 00:00:00') ),
    PARTITION p7 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-10-01 00:00:00') ),
    PARTITION p8 VALUES LESS THAN ( UNIX_TIMESTAMP('2010-01-01 00:00:00') ),
    PARTITION p9 VALUES LESS THAN (MAXVALUE)
);
```

Any other expressions involving `TIMESTAMP` values are not permitted. (See Bug #42849.)

Range partitioning is particularly useful when one or more of the following conditions is true:

- You want or need to delete “old” data. If you are using the partitioning scheme shown immediately above, you can simply use `ALTER TABLE employees DROP PARTITION p0;` to delete all rows relating to employees who stopped working for the firm prior to 1991. (See Section 12.1.6, “`ALTER TABLE` Syntax”, and Section 16.3, “Partition Management”, for more information.) For a table with a great many rows, this can be much more efficient than running a `DELETE` query such as `DELETE FROM employees WHERE YEAR(separated) <= 1990;`.
- You want to use a column containing date or time values, or containing values arising from some other series.
- You frequently run queries that depend directly on the column used for partitioning the table. For example, when executing a query such as `EXPLAIN PARTITIONS SELECT COUNT(*) FROM employees WHERE separated BETWEEN '2000-01-01' AND '2000-12-31' GROUP BY store_id;`, MySQL can quickly determine that only partition `p2` needs to be scanned because the remaining partitions cannot contain any records satisfying the `WHERE` clause. See Section 16.4, “Partition Pruning”, for more information about how this is accomplished.

A variant on this type of partitioning, `RANGE COLUMNS` partitioning, was introduced in MySQL 5.5.0. Partitioning by `RANGE COLUMNS` makes it possible to employ multiple columns for defining partitioning ranges that apply both to placement of rows in partitions and for determining the inclusion or exclusion of specific partitions when performing partition pruning. See Section 16.2.3.1, “`RANGE COLUMNS` partitioning”, for more information.

Partitioning schemes based on time intervals. If you wish to implement a partitioning scheme based on ranges or intervals of time in MySQL 5.5, you have two options:

1. Partition the table by `RANGE`, and for the partitioning expression, employ a function operating on a `DATE`, `TIME`, or `DATETIME` column and returning an integer value, as shown here:

   ```
   CREATE TABLE members (
       firstname VARCHAR(25) NOT NULL,
       lastname VARCHAR(25) NOT NULL,
       username VARCHAR(16) NOT NULL,
       email VARCHAR(35),
       joined DATE NOT NULL
   )
   PARTITION BY RANGE( YEAR(joined) ) (
       PARTITION p0 VALUES LESS THAN (1960),
       PARTITION p1 VALUES LESS THAN (1970),
       PARTITION p2 VALUES LESS THAN (1980),
       PARTITION p3 VALUES LESS THAN (1990),
       PARTITION p4 VALUES LESS THAN MAXVALUE
   );
   ```

   Beginning with MySQL 5.5.1, it is also possible to partition a table by `RANGE` based on the value of a `TIMESTAMP` column, using the `UNIX_TIMESTAMP()` function, as shown in this example:

   ```
   CREATE TABLE quarterly_report_status (
       report_id INT NOT NULL,
       report_status VARCHAR(20) NOT NULL,
       report_updated TIMESTAMP NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP
   )
   PARTITION BY RANGE ( UNIX_TIMESTAMP(report_updated) ) (
       PARTITION p0 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-01-01 00:00:00') ),
       PARTITION p1 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-04-01 00:00:00') ),
       PARTITION p2 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-07-01 00:00:00') ),
       PARTITION p3 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-10-01 00:00:00') ),
       PARTITION p4 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-01-01 00:00:00') ),
       PARTITION p5 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-04-01 00:00:00') ),
   ```

```
    PARTITION p6 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-07-01 00:00:00') ),
    PARTITION p7 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-10-01 00:00:00') ),
    PARTITION p8 VALUES LESS THAN ( UNIX_TIMESTAMP('2010-01-01 00:00:00') ),
    PARTITION p9 VALUES LESS THAN (MAXVALUE)
);
```

Also beginning with MySQL 5.5.1, any other expressions involving `TIMESTAMP` values are not permitted. (See Bug #42849.)

> **Note**
>
> It is also possible in MySQL 5.5.1 and later to use `UNIX_TIMESTAMP(timestamp_column)` as a partitioning expression for tables that are partitioned by `LIST`. However, it is usually not practical to do so.

2. Partition the table by `RANGE COLUMNS`, using a `DATE` or `DATETIME` column as the partitioning column. For example, the `members` table could be defined using the `joined` column directly, as shown here:

```
CREATE TABLE members (
    firstname VARCHAR(25) NOT NULL,
    lastname VARCHAR(25) NOT NULL,
    username VARCHAR(16) NOT NULL,
    email VARCHAR(35),
    joined DATE NOT NULL
)
PARTITION BY RANGE COLUMNS(joined) (
    PARTITION p0 VALUES LESS THAN ('1960-01-01'),
    PARTITION p1 VALUES LESS THAN ('1970-01-01'),
    PARTITION p2 VALUES LESS THAN ('1980-01-01'),
    PARTITION p3 VALUES LESS THAN ('1990-01-01'),
    PARTITION p4 VALUES LESS THAN MAXVALUE
);
```

> **Note**
>
> The use of partitioning columns employing date or time types other than `DATE` or `DATETIME` is not supported with `RANGE COLUMNS`.

16.2.2. `LIST` Partitioning

List partitioning in MySQL is similar to range partitioning in many ways. As in partitioning by `RANGE`, each partition must be explicitly defined. The chief difference between the two types of partitioning is that, in list partitioning, each partition is defined and selected based on the membership of a column value in one of a set of value lists, rather than in one of a set of contiguous ranges of values. This is done by using `PARTITION BY LIST(`*`expr`*`)` where *`expr`* is a column value or an expression based on a column value and returning an integer value, and then defining each partition by means of a `VALUES IN (`*`value_list`*`)`, where *`value_list`* is a comma-separated list of integers.

> **Note**
>
> In MySQL 5.5, it is possible to match against only a list of integers (and possibly `NULL`—see Section 16.2.7, "How MySQL Partitioning Handles `NULL`") when partitioning by `LIST`.
>
> However, beginning with MySQL 5.5.0, other column types may be used in value lists when employing `LIST COLUMN` partitioning, which is described later in this section.

Unlike the case with partitions defined by range, list partitions do not need to be declared in any particular order. For more detailed syntactical information, see Section 12.1.14, "`CREATE TABLE` Syntax".

For the examples that follow, we assume that the basic definition of the table to be partitioned is provided by the `CREATE TABLE` statement shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
);
```

(This is the same table used as a basis for the examples in Section 16.2.1, "RANGE Partitioning".)

Suppose that there are 20 video stores distributed among 4 franchises as shown in the following table.

Region	**Store ID Numbers**
North	3, 5, 6, 9, 17
East	1, 2, 10, 11, 19, 20
West	4, 12, 13, 14, 18
Central	7, 8, 15, 16

To partition this table in such a way that rows for stores belonging to the same region are stored in the same partition, you could use the `CREATE TABLE` statement shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY LIST(store_id) (
    PARTITION pNorth VALUES IN (3,5,6,9,17),
    PARTITION pEast VALUES IN (1,2,10,11,19,20),
    PARTITION pWest VALUES IN (4,12,13,14,18),
    PARTITION pCentral VALUES IN (7,8,15,16)
);
```

This makes it easy to add or drop employee records relating to specific regions to or from the table. For instance, suppose that all stores in the West region are sold to another company. Beginning with MySQL 5.5.0, all rows relating to employees working at stores in that region can be deleted with the query `ALTER TABLE employees TRUNCATE PARTITION pWest`, which can be executed much more efficiently than the equivalent `DELETE` statement `DELETE FROM employees WHERE store_id IN (4,12,13,14,18);`. (Using `ALTER TABLE employees DROP PARTITION pWest` would also delete all of these rows, but would also remove the partition `pWest` from the definition of the table; you would need to use an `ALTER TABLE ... ADD PARTITION` statement to restore the table's original partitioning scheme.)

As with `RANGE` partitioning, it is possible to combine `LIST` partitioning with partitioning by hash or key to produce a composite partitioning (subpartitioning). See Section 16.2.6, “Subpartitioning”.

Unlike the case with `RANGE` partitioning, there is no “catch-all” such as `MAXVALUE`; all expected values for the partitioning expression should be covered in `PARTITION ... VALUES IN (...)` clauses. An `INSERT` statement containing an unmatched partitioning column value fails with an error, as shown in this example:

```
mysql> CREATE TABLE h2 (
    ->   c1 INT,
    ->   c2 INT
    -> )
    -> PARTITION BY LIST(c1) (
    ->   PARTITION p0 VALUES IN (1, 4, 7),
    ->   PARTITION p1 VALUES IN (2, 5, 8)
    -> );
Query OK, 0 rows affected (0.11 sec)

mysql> INSERT INTO h2 VALUES (3, 5);
ERROR 1525 (HY000): TABLE HAS NO PARTITION FOR VALUE 3
```

When inserting multiple rows using a single `INSERT` statement, any rows coming before the row containing the unmatched value are inserted, but any coming after it are not:

```
mysql> SELECT * FROM h2;
Empty set (0.00 sec)

mysql> INSERT INTO h2 VALUES (4, 7), (3, 5), (6, 0);
ERROR 1525 (HY000): TABLE HAS NO PARTITION FOR VALUE 3
mysql> SELECT * FROM h2;
+------+------+
| c1   | c2   |
+------+------+
|    4 |    7 |
+------+------+
1 row in set (0.00 sec)
```

You can cause this type of error to be ignored by using the `IGNORE` keyword. If you do so, rows containing unmatched partitioning column values are not inserted, but any rows with matching values *are* inserted, and no errors are reported:

```
mysql> TRUNCATE h2;
Query OK, 1 row affected (0.00 sec)

mysql> SELECT * FROM h2;
Empty set (0.00 sec)
```

```
mysql> INSERT IGNORE INTO h2 VALUES (2, 5), (6, 10), (7, 5), (3, 1), (1, 9);
Query OK, 3 rows affected (0.00 sec)
Records: 5  Duplicates: 2  Warnings: 0

mysql> SELECT * FROM h2;
+------+------+
| c1   | c2   |
+------+------+
|    7 |    5 |
|    1 |    9 |
|    2 |    5 |
+------+------+
3 rows in set (0.00 sec)
```

MySQL 5.5 provides support for `LIST COLUMNS` partitioning. This is a variant of `LIST` partitioning that enables you to use columns of types other than integer types for partitioning columns, as well as to use multiple columns as partitioning keys. For more information, see Section 16.2.3.2, “`LIST COLUMNS` partitioning”.

16.2.3. `COLUMNS` Partitioning

The next two sections discuss *`COLUMNS` partitioning*, which are variants on `RANGE` and `LIST` partitioning that were introduced in MySQL 5.5.0. `COLUMNS` partitioning enables the use of multiple columns in partitioning keys. All of these columns are taken into account both for the purpose of placing rows in partitions and for the determination of which partitions are to be checked for matching rows in partition pruning.

In addition, both `RANGE COLUMNS` partitioning and `LIST COLUMNS` partitioning support the use of non-integer columns for defining value ranges or list members. The permitted data types are shown in the following list:

- All integer types: `TINYINT`, `SMALLINT`, `MEDIUMINT`, `INT` (`INTEGER`), and `BIGINT`. (This is the same as with partitioning by `RANGE` and `LIST`.)

  Other numeric data types (such as `DECIMAL` or `FLOAT`) are not supported as partitioning columns.

- `DATE` and `DATETIME`.

  Columns using other data types relating to dates or times are not supported as partitioning columns.

- The following string types: `CHAR`, `VARCHAR`, `BINARY`, and `VARBINARY`.

  `TEXT` and `BLOB` columns are not supported as partitioning columns.

The discussions of `RANGE COLUMNS` and `LIST COLUMNS` partitioning in the next two sections assume that you are already familiar with partitioning based on ranges and lists as supported in MySQL 5.1 and later; for more information about these, see Section 16.2.1, “`RANGE` Partitioning”, and Section 16.2.2, “`LIST` Partitioning”, respectively.

16.2.3.1. `RANGE COLUMNS` partitioning

Range columns partitioning is similar to range partitioning, but enables you to define partitions using ranges based on multiple column values. In addition, you can define the ranges using columns of types other than integer types.

`RANGE COLUMNS` partitioning differs significantly from `RANGE` partitioning in the following ways:

- `RANGE COLUMNS` does not accept expressions, only names of columns.

- `RANGE COLUMNS` accepts a list of one or more columns.

  `RANGE COLUMNS` partitions are based on comparisons between *tuples* (lists of column values) rather than comparisons between scalar values. Placement of rows in `RANGE COLUMNS` partitions is also based on comparisons between tuples; this is discussed further later in this section.

- `RANGE COLUMNS` partitioning columns are not restricted to integer columns; string, `DATE` and `DATETIME` columns can also be used as partitioning columns. (See Section 16.2.3, “`COLUMNS` Partitioning”, for details.)

The basic syntax for creating a table partitioned by `RANGE COLUMNS` is shown here:

```
CREATE TABLE table_name
PARTITIONED BY RANGE COLUMNS(column_list) (
    PARTITION partition_name VALUES LESS THAN (value_list)[,
    PARTITION partition_name VALUES LESS THAN (value_list)][,
    ...]
)
```

```
column_list:
    column_name[, column_name][, ...]

value_list:
    value[, value][, ...]
```

> **Note**
>
> Not all `CREATE TABLE` options that can be used when creating partitioned tables are shown here. For complete information, see Section 12.1.14, "`CREATE TABLE` Syntax".

In the syntax just shown, *`column_list`* is a list of one or more columns (sometimes called a *partitioning column list*), and *`value_list`* is a list of values (that is, it is a *partition definition value list*). A *`value_list`* must be supplied for each partition definition, and each *`value_list`* must have the same number of values as the *`column_list`* has columns. Generally speaking, if you use *`N`* columns in the `COLUMNS` clause, then each `VALUES LESS THAN` clause must also be supplied with a list of *`N`* values.

The elements in the partitioning column list and in the value list defining each partition must occur in the same order. In addition, each element in the value list must be of the same data type as the corresponding element in the column list. However, the order of the column names in the partitioning column list and the value lists does not have to be the same as the order of the table column definitions in the main part of the `CREATE TABLE` statement. As with table partitioned by `RANGE`, you can use `MAXVALUE` to represent a value such that any legal value inserted into a given column is always less than this value. Here is an example of a `CREATE TABLE` statement that helps to illustrate all of these points:

```
mysql> CREATE TABLE rcx (
    ->     a INT,
    ->     b INT,
    ->     c CHAR(3),
    ->     d INT
    -> )
    -> PARTITION BY RANGE COLUMNS(a,d,c) (
    ->     PARTITION p0 VALUES LESS THAN (5,10,'ggg'),
    ->     PARTITION p1 VALUES LESS THAN (10,20,'mmmm'),
    ->     PARTITION p2 VALUES LESS THAN (15,30,'sss'),
    ->     PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE,MAXVALUE)
    -> );
Query OK, 0 rows affected (0.15 sec)
```

Table `rcx` contains the columns `a`, `b`, `c`, `d`. The partitioning column list supplied to the `COLUMNS` clause uses 3 of these columns, in the order `a`, `d`, `c`. Each value list used to define a partition contains 3 values in the same order; that is, each value list tuple has the form (`INT`, `INT`, `CHAR(3)`), which corresponds to the data types used by columns `a`, `d`, and `c` (in that order).

Placement of rows into partitions is determined by comparing the tuple from a row to be inserted that matches the column list in the `COLUMNS` clause with the tuples used in the `VALUES LESS THAN` clauses to define partitions of the table. Because we are comparing tuples (that is, lists or sets of values) rather than scalar values, the semantics of `VALUES LESS THAN` as used with `RANGE COLUMNS` partitions differs somewhat from the case with simple `RANGE` partitions. In `RANGE` partitioning, a row generating an expression value that is equal to a limiting value in a `VALUES LESS THAN` is never placed in the corresponding partition; however, when using `RANGE COLUMNS` partitioning, it is sometimes possible for a row whose partitioning column list's first element is equal in value to the that of the first element in a `VALUES LESS THAN` value list to be placed in the corresponding partition.

Consider the `RANGE` partitioned table created by this statement:

```
CREATE TABLE r1 (
    a INT,
    b INT
)
PARTITION BY RANGE (a)  (
    PARTITION p0 VALUES LESS THAN (5),
    PARTITION p1 VALUES LESS THAN (MAXVALUE)
);
```

If we insert 3 rows into this table such that the column value for `a` is `5` for each row, all 3 rows are stored in partition `p1` because the `a` column value is in each case not less than 5, as we can see by executing the proper query against the `INFORMATION_SCHEMA.PARTITIONS` table:

```
mysql> INSERT INTO r1 VALUES (5,10), (5,11), (5,12);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0

mysql> SELECT PARTITION_NAME,TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'r1';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          0 |
| p1             |          3 |
+----------------+------------+
2 rows in set (0.00 sec)
```

Now consider a similar table `rc1` that uses `RANGE COLUMNS` partitioning with both columns `a` and `b` referenced in the `COLUMNS` clause, created as shown here:

```
CREATE TABLE rc1 (
    a INT,
    b INT
)
PARTITION BY RANGE COLUMNS(a, b) (
    PARTITION p0 VALUES LESS THAN (5, 12),
    PARTITION p3 VALUES LESS THAN (MAXVALUE, MAXVALUE)
);
```

If we insert exactly the same rows into `rc1` as we just inserted into `r1`, the distribution of the rows is quite different:

```
mysql> INSERT INTO rc1 VALUES (5,10), (5,11), (5,12);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0

mysql> SELECT PARTITION_NAME,TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'rc1';
+--------------+----------------+------------+
| TABLE_SCHEMA | PARTITION_NAME | TABLE_ROWS |
+--------------+----------------+------------+
| p            | p0             |          2 |
| p            | p1             |          1 |
+--------------+----------------+------------+
2 rows in set (0.00 sec)
```

This is because we are comparing rows rather than scalar values. We can compare the row values inserted with the limiting row value from the `VALUES THAN LESS THAN` clause used to define partition `p0` in table `rc1`, like this:

```
mysql> SELECT (5,10) < (5,12), (5,11) < (5,12), (5,12) < (5,12);
+-----------------+-----------------+-----------------+
| (5,10) < (5,12) | (5,11) < (5,12) | (5,12) < (5,12) |
+-----------------+-----------------+-----------------+
|               1 |               1 |               0 |
+-----------------+-----------------+-----------------+
1 row in set (0.00 sec)
```

The 2 tuples `(5,10)` and `(5,11)` evaluate as less than `(5,12)`, so they are stored in partition `p0`. Since 5 is not less than 5 and 12 is not less than 12, `(5,12)` is considered not less than `(5,12)`, and is stored in partition `p1`.

The `SELECT` statement in the preceding example could also have been written using explicit row constructors, like this:

```
SELECT ROW(5,10) < ROW(5,12), ROW(5,11) < ROW(5,12), ROW(5,12) < ROW(5,12);
```

For more information about the use of row constructors in MySQL, see Section 12.2.10.5, “Row Subqueries”.

For a table partitioned by `RANGE COLUMNS` using only a single partitioning column, the storing of rows in partitions is the same as that of an equivalent table that is partitioned by `RANGE`. The following `CREATE TABLE` statement creates a table partitioned by `RANGE COLUMNS` using 1 partitioning column:

```
CREATE TABLE rx (
    a INT,
    b INT
)
PARTITION BY RANGE COLUMNS (a)  (
    PARTITION p0 VALUES LESS THAN (5),
    PARTITION p1 VALUES LESS THAN (MAXVALUE)
);
```

If we insert the rows `(5,10)`, `(5,11)`, and `(5,12)` into this table, we can see that their placement is the same as it is for the table `r` we created and populated earlier:

```
mysql> INSERT INTO rx VALUES (5,10), (5,11), (5,12);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0

mysql> SELECT PARTITION_NAME,TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'rx';
+--------------+----------------+------------+
| TABLE_SCHEMA | PARTITION_NAME | TABLE_ROWS |
+--------------+----------------+------------+
| p            | p0             |          0 |
| p            | p1             |          3 |
+--------------+----------------+------------+
2 rows in set (0.00 sec)
```

It is also possible to create tables partitioned by `RANGE COLUMNS` where limiting values for one or more columns are repeated in successive partition definitions. You can do this as long as the tuples of column values used to define the partitions are strictly increasing. For example, each of the following `CREATE TABLE` statements is valid:

```
CREATE TABLE rc2 (
    a INT,
    b INT
)
PARTITION BY RANGE COLUMNS(a,b) (
    PARTITION p0 VALUES LESS THAN (0,10),
    PARTITION p1 VALUES LESS THAN (10,20),
    PARTITION p2 VALUES LESS THAN (10,30),
    PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE)
 );

CREATE TABLE rc3 (
    a INT,
    b INT
)
PARTITION BY RANGE COLUMNS(a,b) (
    PARTITION p0 VALUES LESS THAN (0,10),
    PARTITION p1 VALUES LESS THAN (10,20),
    PARTITION p2 VALUES LESS THAN (10,30),
    PARTITION p3 VALUES LESS THAN (10,35),
    PARTITION p4 VALUES LESS THAN (20,40),
    PARTITION p5 VALUES LESS THAN (MAXVALUE,MAXVALUE)
 );
```

The following statement also succeeds, even though it might appear at first glance that it would not, since the limiting value of column `b` is 25 for partition `p0` and 20 for partition `p1`, and the limiting value of column `c` is 100 for partition `p1` and 50 for partition `p2`:

```
CREATE TABLE rc4 (
    a INT,
    b INT,
    c INT
)
PARTITION BY RANGE COLUMNS(a,b,c) (
    PARTITION p0 VALUES LESS THAN (0,25,50),
    PARTITION p1 VALUES LESS THAN (10,20,100),
    PARTITION p2 VALUES LESS THAN (10,30,50)
    PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE,MAXVALUE)
 );
```

When designing tables partitioned by `RANGE COLUMNS`, you can always test successive partition definitions by comparing the desired tuples using the `mysql` client, like this:

```
mysql> SELECT (0,25,50) < (10,20,100), (10,20,100) < (10,30,50);
+-------------------------+--------------------------+
| (0,25,50) < (10,20,100) | (10,20,100) < (10,30,50) |
+-------------------------+--------------------------+
|                       1 |                        1 |
+-------------------------+--------------------------+
1 row in set (0.00 sec)
```

If a `CREATE TABLE` statement contains partition definitions that are not in strictly increasing order, it fails with an error, as shown in this example:

```
mysql> CREATE TABLE rcf (
    ->     a INT,
    ->     b INT,
    ->     c INT
    -> )
    -> PARTITION BY RANGE COLUMNS(a,b,c) (
    ->     PARTITION p0 VALUES LESS THAN (0,25,50),
    ->     PARTITION p1 VALUES LESS THAN (20,20,100),
    ->     PARTITION p2 VALUES LESS THAN (10,30,50),
    ->     PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE,MAXVALUE)
    ->  );
ERROR 1493 (HY000): VALUES LESS THAN value must be strictly increasing for each partition
```

When you get such an error, you can deduce which partition definitions are invalid by making “less than” comparisons between their column lists. In this case, the problem is with the definition of partition `p2` because the tuple used to define it is not less than the tuple used to define partition `p3`, as shown here:

```
mysql> SELECT (0,25,50) < (20,20,100), (20,20,100) < (10,30,50);
+-------------------------+--------------------------+
| (0,25,50) < (20,20,100) | (20,20,100) < (10,30,50) |
+-------------------------+--------------------------+
|                       1 |                        0 |
+-------------------------+--------------------------+
1 row in set (0.00 sec)
```

It is also possible for `MAXVALUE` to appear for the same column in more than one `VALUES LESS THAN` clause when using `RANGE COLUMNS`. However, the limiting values for individual columns in successive partition definitions should otherwise be increasing, there should be no more than one partition defined where `MAXVALUE` is used as the upper limit for all column values, and this partition definition should appear last in the list of `PARTITION ... VALUES LESS THAN` clauses. In addition, you cannot use `MAXVALUE` as the limiting value for the first column in more than one partition definition.

As stated previously, it is also possible with `RANGE COLUMNS` partitioning to use non-integer columns as partitioning columns. (See Section 16.2.3, "`COLUMNS` Partitioning", for a complete listing of these.) Consider a table named `employees` (which is not partitioned), created using the following statement:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
);
```

Using `RANGE COLUMNS` partitioning, you can create a version of this table that stores each row in one of four partitions based on the employee's last name, like this:

```
CREATE TABLE employees_by_lname (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE COLUMNS (lname)  (
    PARTITION p0 VALUES LESS THAN ('g'),
    PARTITION p1 VALUES LESS THAN ('m'),
    PARTITION p2 VALUES LESS THAN ('t'),
    PARTITION p3 VALUES LESS THAN (MAXVALUE)
);
```

Alternatively, you could cause the `employees` table as created previously to be partitioned using this scheme by executing the following `ALTER TABLE` statement:

```
ALTER TABLE employees PARTITION BY RANGE COLUMNS (lname)  (
    PARTITION p0 VALUES LESS THAN ('g'),
    PARTITION p1 VALUES LESS THAN ('m'),
    PARTITION p2 VALUES LESS THAN ('t'),
    PARTITION p3 VALUES LESS THAN (MAXVALUE)
);
```

> **Note**
>
> Because different character sets and collations have different sort orders, the character sets and collations in use may effect which partition of a table partitioned by `RANGE COLUMNS` a given row is stored in when using string columns as partitioning columns. In addition, changing the character set or collation for a given database, table, or column after such a table is created may cause changes in how rows are distributed. For example, when using a case-sensitive collation, `'and'` sorts before `'Andersen'`, but when using a collation that is case insensitive, the reverse is true.
>
> For information about how MySQL handles character sets and collations, see Section 9.1, "Character Set Support".

Similarly, you can cause the `employees` table to be partitioned in such a way that each row is stored in one of several partitions based on the decade in which the corresponding employee was hired using the `ALTER TABLE` statement shown here:

```
ALTER TABLE employees PARTITION BY RANGE COLUMNS (hired)  (
    PARTITION p0 VALUES LESS THAN ('1970-01-01'),
    PARTITION p1 VALUES LESS THAN ('1980-01-01'),
    PARTITION p2 VALUES LESS THAN ('1990-01-01'),
    PARTITION p3 VALUES LESS THAN ('2000-01-01'),
    PARTITION p4 VALUES LESS THAN ('2010-01-01'),
    PARTITION p5 VALUES LESS THAN (MAXVALUE)
);
```

See Section 12.1.14, "`CREATE TABLE` Syntax", for additional information about `PARTITION BY RANGE COLUMNS` syntax.

16.2.3.2. `LIST COLUMNS` partitioning

MySQL 5.5 provides support for `LIST COLUMNS` partitioning. This is a variant of `LIST` partitioning that enables the use of multiple columns as partition keys, and for columns of data types other than integer types to be used as partitioning columns; you can use string types, `DATE`, and `DATETIME` columns. (For more information about permitted data types for `COLUMNS` partitioning columns, see Section 16.2.3, “`COLUMNS` Partitioning”.)

Suppose that you have a business that has customers in 12 cities which, for sales and marketing purposes, you organize into 4 regions of 3 cities each as shown in the following table:

Region	**Cities**
1	Oskarshamn, Högsby, Mönsterås
2	Vimmerby, Hultsfred, Västervik
3	Nässjö, Eksjö, Vetlanda
4	Uppvidinge, Alvesta, Växjo

With `LIST COLUMNS` partitioning, you can create a table for customer data that assigns a row to any of 4 partitions corresponding to these regions based on the name of the city where a customer resides, as shown here:

```
CREATE TABLE customers_1 (
    first_name VARCHAR(25),
    last_name VARCHAR(25),
    street_1 VARCHAR(30),
    street_2 VARCHAR(30),
    city VARCHAR(15),
    renewal DATE
)
PARTITION BY LIST COLUMNS(city) (
    PARTITION pRegion_1 VALUES IN('Oskarshamn', 'Högsby', 'Mönsterås'),
    PARTITION pRegion_2 VALUES IN('Vimmerby', 'Hultsfred', 'Västervik'),
    PARTITION pRegion_3 VALUES IN('Nässjö', 'Eksjö', 'Vetlanda'),
    PARTITION pRegion_4 VALUES IN('Uppvidinge', 'Alvesta', 'Växjo')
);
```

As with partitioning by `RANGE COLUMNS`, you do not need to use expressions in the `COLUMNS()` clause to convert column values into integers. (In fact, the use of expressions other than column names is not permitted with `COLUMNS()`.)

It is also possible to use `DATE` and `DATETIME` columns, as shown in the following example that uses the same name and columns as the `customers_1` table shown previously, but employs `LIST COLUMNS` partitioning based on the `renewal` column to store rows in one of 4 partitions depending on the week in February 2010 the customer's account is scheduled to renew:

```
CREATE TABLE customers_2 (
    first_name VARCHAR(25),
    last_name VARCHAR(25),
    street_1 VARCHAR(30),
    street_2 VARCHAR(30),
    city VARCHAR(15),
    renewal DATE
)
PARTITION BY LIST COLUMNS(renewal) (
    PARTITION pWeek_1 VALUES IN('2010-02-01', '2010-02-02', '2010-02-03',
        '2010-02-04', '2010-02-05', '2010-02-06', '2010-02-07'),
    PARTITION pWeek_2 VALUES IN('2010-02-08', '2010-02-09', '2010-02-10',
        '2010-02-11', '2010-02-12', '2010-02-13', '2010-02-14'),
    PARTITION pWeek_3 VALUES IN('2010-02-15', '2010-02-16', '2010-02-17',
        '2010-02-18', '2010-02-19', '2010-02-20', '2010-02-21'),
    PARTITION pWeek_4 VALUES IN('2010-02-22', '2010-02-23', '2010-02-24',
        '2010-02-25', '2010-02-26', '2010-02-27', '2010-02-28')
);
```

This works, but becomes cumbersome to define and maintain if the number of dates involved grows very large; in such cases, it is usually more practical to employ `RANGE` or `RANGE COLUMNS` partitioning instead. In this case, since the column we wish to use as the partitioning key is a `DATE` column, we use `RANGE COLUMNS` partitioning, as shown here:

```
CREATE TABLE customers_3 (
    first_name VARCHAR(25),
    last_name VARCHAR(25),
    street_1 VARCHAR(30),
    street_2 VARCHAR(30),
    city VARCHAR(15),
    renewal DATE
)
PARTITION BY RANGE COLUMNS(renewal) (
    PARTITION pWeek_1 VALUES LESS THAN('2010-02-09'),
    PARTITION pWeek_2 VALUES LESS THAN('2010-02-15'),
    PARTITION pWeek_3 VALUES LESS THAN('2010-02-22'),
    PARTITION pWeek_4 VALUES LESS THAN('2010-03-01')
);
```

See Section 16.2.3.1, “`RANGE COLUMNS` partitioning”, for more information.

In addition (as with `RANGE COLUMNS` partitioning), you can use multiple columns in the `COLUMNS()` clause.

See Section 12.1.14, “`CREATE TABLE` Syntax”, for additional information about `PARTITION BY LIST COLUMNS()` syntax.

16.2.4. `HASH` Partitioning

Partitioning by `HASH` is used primarily to ensure an even distribution of data among a predetermined number of partitions. With range or list partitioning, you must specify explicitly into which partition a given column value or set of column values is to be stored; with hash partitioning, MySQL takes care of this for you, and you need only specify a column value or expression based on a column value to be hashed and the number of partitions into which the partitioned table is to be divided.

To partition a table using `HASH` partitioning, it is necessary to append to the `CREATE TABLE` statement a `PARTITION BY HASH (expr)` clause, where *`expr`* is an expression that returns an integer. This can simply be the name of a column whose type is one of MySQL's integer types. In addition, you will most likely want to follow this with a `PARTITIONS num` clause, where *`num`* is a positive integer representing the number of partitions into which the table is to be divided.

For example, the following statement creates a table that uses hashing on the `store_id` column and is divided into 4 partitions:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY HASH(store_id)
PARTITIONS 4;
```

If you do not include a `PARTITIONS` clause, the number of partitions defaults to `1`.

Using the `PARTITIONS` keyword without a number following it results in a syntax error.

You can also use an SQL expression that returns an integer for *`expr`*. For instance, you might want to partition based on the year in which an employee was hired. This can be done as shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY HASH( YEAR(hired) )
PARTITIONS 4;
```

`expr` must return a nonconstant, nonrandom integer value (in other words, it should be varying but deterministic), and must not contain any prohibited constructs as described in Section 16.5, "Restrictions and Limitations on Partitioning". You should also keep in mind that this expression is evaluated each time a row is inserted or updated (or possibly deleted); this means that very complex expressions may give rise to performance issues, particularly when performing operations (such as batch inserts) that affect a great many rows at one time.

The most efficient hashing function is one which operates upon a single table column and whose value increases or decreases consistently with the column value, as this allows for "pruning" on ranges of partitions. That is, the more closely that the expression varies with the value of the column on which it is based, the more efficiently MySQL can use the expression for hash partitioning.

For example, where `date_col` is a column of type `DATE`, then the expression `TO_DAYS(date_col)` is said to vary directly with the value of `date_col`, because for every change in the value of `date_col`, the value of the expression changes in a consistent manner. The variance of the expression `YEAR(date_col)` with respect to `date_col` is not quite as direct as that of `TO_DAYS(date_col)`, because not every possible change in `date_col` produces an equivalent change in `YEAR(date_col)`. Even so, `YEAR(date_col)` is a good candidate for a hashing function, because it varies directly with a portion of `date_col` and there is no possible change in `date_col` that produces a disproportionate change in `YEAR(date_col)`.

By way of contrast, suppose that you have a column named `int_col` whose type is `INT`. Now consider the expression `POW(5-int_col,3) + 6`. This would be a poor choice for a hashing function because a change in the value of `int_col` is not guaranteed to produce a proportional change in the value of the expression. Changing the value of `int_col` by a given amount can produce by widely different changes in the value of the expression. For example, changing `int_col` from `5` to `6` produces a change of `-1` in the value of the expression, but changing the value of `int_col` from `6` to `7` produces a change of `-7` in the expression value.

In other words, the more closely the graph of the column value *versus* the value of the expression follows a straight line as traced by the equation `y=cx` where *`c`* is some nonzero constant, the better the expression is suited to hashing. This has to do with the fact that the more nonlinear an expression is, the more uneven the distribution of data among the partitions it tends to produce.

In theory, pruning is also possible for expressions involving more than one column value, but determining which of such expressions are suitable can be quite difficult and time-consuming. For this reason, the use of hashing expressions involving multiple columns is not particularly recommended.

When `PARTITION BY HASH` is used, MySQL determines which partition of *`num`* partitions to use based on the modulus of the result of the user function. In other words, for an expression *`expr`*, the partition in which the record is stored is partition number *`N`*, where `N = MOD(expr, num)`. Suppose that table `t1` is defined as follows, so that it has 4 partitions:

```
CREATE TABLE t1 (col1 INT, col2 CHAR(5), col3 DATE)
    PARTITION BY HASH( YEAR(col3) )
    PARTITIONS 4;
```

If you insert a record into `t1` whose `col3` value is `'2005-09-15'`, then the partition in which it is stored is determined as follows:

```
MOD(YEAR('2005-09-01'),4)
=  MOD(2005,4)
=  1
```

MySQL 5.5 also supports a variant of `HASH` partitioning known as *linear hashing* which employs a more complex algorithm for determining the placement of new rows inserted into the partitioned table. See Section 16.2.4.1, “`LINEAR HASH` Partitioning”, for a description of this algorithm.

The user function is evaluated each time a record is inserted or updated. It may also—depending on the circumstances—be evaluated when records are deleted.

> **Note**
>
> If a table to be partitioned has a `UNIQUE` key, then any columns supplied as arguments to the `HASH` user function or to the `KEY`'s *`column_list`* must be part of that key.

16.2.4.1. `LINEAR HASH` Partitioning

MySQL also supports linear hashing, which differs from regular hashing in that linear hashing utilizes a linear powers-of-two algorithm whereas regular hashing employs the modulus of the hashing function's value.

Syntactically, the only difference between linear-hash partitioning and regular hashing is the addition of the `LINEAR` keyword in the `PARTITION BY` clause, as shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY LINEAR HASH( YEAR(hired) )
PARTITIONS 4;
```

Given an expression *`expr`*, the partition in which the record is stored when linear hashing is used is partition number *`N`* from among *`num`* partitions, where *`N`* is derived according to the following algorithm:

1. Find the next power of 2 greater than *`num`*. We call this value *`V`*; it can be calculated as:

   ```
   V = POWER(2, CEILING(LOG(2, num)))
   ```

   (Suppose that *`num`* is 13. Then `LOG(2,13)` is 3.7004397181411. `CEILING(3.7004397181411)` is 4, and *`V`* = `POWER(2,4)`, which is 16.)

2. Set *`N`* = *`F`*(*`column_list`*) & (*`V`* - 1).

3. While *`N`* >= *`num`*:

   - Set *`V`* = CEIL(*`V`* / 2)
   - Set *`N`* = *`N`* & (*`V`* - 1)

Suppose that the table `t1`, using linear hash partitioning and having 6 partitions, is created using this statement:

```
CREATE TABLE t1 (col1 INT, col2 CHAR(5), col3 DATE)
```

```
    PARTITION BY LINEAR HASH( YEAR(col3) )
    PARTITIONS 6;
```

Now assume that you want to insert two records into `t1` having the `col3` column values `'2003-04-14'` and `'1998-10-19'`. The partition number for the first of these is determined as follows:

```
V = POWER(2, CEILING( LOG(2,6) )) = 8
N = YEAR('2003-04-14') & (8 - 1)
   = 2003 & 7
   = 3

(3 >= 6 is FALSE: record stored in partition #3)
```

The number of the partition where the second record is stored is calculated as shown here:

```
V = 8
N = YEAR('1998-10-19') & (8-1)
  = 1998 & 7
  = 6

(6 >= 6 is TRUE: additional step required)

N = 6 & CEILING(8 / 2)
  = 6 & 3
  = 2

(2 >= 6 is FALSE: record stored in partition #2)
```

The advantage in partitioning by linear hash is that the adding, dropping, merging, and splitting of partitions is made much faster, which can be beneficial when dealing with tables containing extremely large amounts (terabytes) of data. The disadvantage is that data is less likely to be evenly distributed between partitions as compared with the distribution obtained using regular hash partitioning.

16.2.5. `KEY` Partitioning

Partitioning by key is similar to partitioning by hash, except that where hash partitioning employs a user-defined expression, the hashing function for key partitioning is supplied by the MySQL server. This internal hashing function is based on the same algorithm as `PASSWORD()`.

The syntax rules for `CREATE TABLE ... PARTITION BY KEY` are similar to those for creating a table that is partitioned by hash. The major differences are listed here:

- `KEY` is used rather than `HASH`.
- `KEY` takes only a list of zero or more column names. Any columns used as the partitioning key must comprise part or all of the table's primary key, if the table has one. Where no column name is specified as the partitioning key, the table's primary key is used, if there is one. For example, the following `CREATE TABLE` statement is valid in MySQL 5.5:

  ```
  CREATE TABLE k1 (
      id INT NOT NULL PRIMARY KEY,
      name VARCHAR(20)
  )
  PARTITION BY KEY()
  PARTITIONS 2;
  ```

  If there is no primary key but there is a unique key, then the unique key is used for the partitioning key:

  ```
  CREATE TABLE k1 (
      id INT NOT NULL,
      name VARCHAR(20),
      UNIQUE KEY (id)
  )
  PARTITION BY KEY()
  PARTITIONS 2;
  ```

  However, if the unique key column were not defined as `NOT NULL`, then the previous statement would fail.

  In both of these cases, the partitioning key is the `id` column, even though it is not shown in the output of `SHOW CREATE TABLE` or in the `PARTITION_EXPRESSION` column of the `INFORMATION_SCHEMA.PARTITIONS` table.

  Unlike the case with other partitioning types, columns used for partitioning by `KEY` are not restricted to integer or `NULL` values. For example, the following `CREATE TABLE` statement is valid:

  ```
  CREATE TABLE tm1 (
      s1 CHAR(32) PRIMARY KEY
  )
  ```

```
PARTITION BY KEY(s1)
PARTITIONS 10;
```

The preceding statement would *not* be valid, were a different partitioning type to be specified. (In this case, simply using `PARTITION BY KEY()` would also be valid and have the same effect as `PARTITION BY KEY(s1)`, since `s1` is the table's primary key.)

For additional information about this issue, see Section 16.5, “Restrictions and Limitations on Partitioning”.

> **Important**
>
> For a key-partitioned table, you cannot execute an `ALTER TABLE DROP PRIMARY KEY`, as doing so generates the error `ERROR 1466 (HY000): FIELD IN LIST OF FIELDS FOR PARTITION FUNCTION NOT FOUND IN TABLE`.

It is also possible to partition a table by linear key. Here is a simple example:

```
CREATE TABLE tk (
    col1 INT NOT NULL,
    col2 CHAR(5),
    col3 DATE
)
PARTITION BY LINEAR KEY (col1)
PARTITIONS 3;
```

Using `LINEAR` has the same effect on `KEY` partitioning as it does on `HASH` partitioning, with the partition number being derived using a powers-of-two algorithm rather than modulo arithmetic. See Section 16.2.4.1, “`LINEAR HASH` Partitioning”, for a description of this algorithm and its implications.

16.2.6. Subpartitioning

Subpartitioning—also known as *composite partitioning*—is the further division of each partition in a partitioned table. Consider the following `CREATE TABLE` statement:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) )
    SUBPARTITION BY HASH( TO_DAYS(purchased) )
    SUBPARTITIONS 2 (
        PARTITION p0 VALUES LESS THAN (1990),
        PARTITION p1 VALUES LESS THAN (2000),
        PARTITION p2 VALUES LESS THAN MAXVALUE
    );
```

Table `ts` has 3 `RANGE` partitions. Each of these partitions—`p0`, `p1`, and `p2`—is further divided into 2 subpartitions. In effect, the entire table is divided into `3 * 2 = 6` partitions. However, due to the action of the `PARTITION BY RANGE` clause, the first 2 of these store only those records with a value less than 1990 in the `purchased` column.

In MySQL 5.5, it is possible to subpartition tables that are partitioned by `RANGE` or `LIST`. Subpartitions may use either `HASH` or `KEY` partitioning. This is also known as *composite partitioning*.

> **Note**
>
> `SUBPARTITION BY HASH` and `SUBPARTITION BY KEY` generally follow the same syntax rules as `PARTITION BY HASH` and `PARTITION BY KEY`, respectively. An exception to this is that `SUBPARTITION BY KEY` (unlike `PARTITION BY KEY`) does not currently support a default column, so the column used for this purpose must be specified, even if the table has an explicit primary key. This is a known issue which we are working to address; see Issues with subpartitions, for more information and an example.

It is also possible to define subpartitions explicitly using `SUBPARTITION` clauses to specify options for individual subpartitions. For example, a more verbose fashion of creating the same table `ts` as shown in the previous example would be:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) )
    SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990) (
            SUBPARTITION s0,
            SUBPARTITION s1
        ),
        PARTITION p1 VALUES LESS THAN (2000) (
            SUBPARTITION s2,
            SUBPARTITION s3
        ),
        PARTITION p2 VALUES LESS THAN MAXVALUE (
            SUBPARTITION s4,
            SUBPARTITION s5
        )
    );
```

Some syntactical items of note are listed here:

- Each partition must have the same number of subpartitions.
- If you explicitly define any subpartitions using `SUBPARTITION` on any partition of a partitioned table, you must define them all. In other words, the following statement will fail:

  ```
  CREATE TABLE ts (id INT, purchased DATE)
      PARTITION BY RANGE( YEAR(purchased) )
      SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
          PARTITION p0 VALUES LESS THAN (1990) (
              SUBPARTITION s0,
              SUBPARTITION s1
          ),
          PARTITION p1 VALUES LESS THAN (2000),
          PARTITION p2 VALUES LESS THAN MAXVALUE (
              SUBPARTITION s2,
              SUBPARTITION s3
          )
      );
  ```

  This statement would still fail even if it included a `SUBPARTITIONS 2` clause.
- Each `SUBPARTITION` clause must include (at a minimum) a name for the subpartition. Otherwise, you may set any desired option for the subpartition or allow it to assume its default setting for that option.
- Subpartition names must be unique across the entire table. For example, the following `CREATE TABLE` statement is valid in MySQL 5.5:

  ```
  CREATE TABLE ts (id INT, purchased DATE)
      PARTITION BY RANGE( YEAR(purchased) )
      SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
          PARTITION p0 VALUES LESS THAN (1990) (
              SUBPARTITION s0,
              SUBPARTITION s1
          ),
          PARTITION p1 VALUES LESS THAN (2000) (
              SUBPARTITION s2,
              SUBPARTITION s3
          ),
          PARTITION p2 VALUES LESS THAN MAXVALUE (
              SUBPARTITION s4,
              SUBPARTITION s5
          )
      );
  ```

Subpartitions can be used with especially large tables to distribute data and indexes across many disks. Suppose that you have 6 disks mounted as `/disk0`, `/disk1`, `/disk2`, and so on. Now consider the following example:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) )
    SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990) (
            SUBPARTITION s0
                DATA DIRECTORY = '/disk0/data'
                INDEX DIRECTORY = '/disk0/idx',
            SUBPARTITION s1
                DATA DIRECTORY = '/disk1/data'
                INDEX DIRECTORY = '/disk1/idx'
        ),
        PARTITION p1 VALUES LESS THAN (2000) (
            SUBPARTITION s2
                DATA DIRECTORY = '/disk2/data'
                INDEX DIRECTORY = '/disk2/idx',
            SUBPARTITION s3
                DATA DIRECTORY = '/disk3/data'
                INDEX DIRECTORY = '/disk3/idx'
        ),
        PARTITION p2 VALUES LESS THAN MAXVALUE (
            SUBPARTITION s4
                DATA DIRECTORY = '/disk4/data'
                INDEX DIRECTORY = '/disk4/idx',
            SUBPARTITION s5
                DATA DIRECTORY = '/disk5/data'
                INDEX DIRECTORY = '/disk5/idx'
        )
    );
```

In this case, a separate disk is used for the data and for the indexes of each `RANGE`. Many other variations are possible; another example might be:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE(YEAR(purchased))
    SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990) (
            SUBPARTITION s0a
                DATA DIRECTORY = '/disk0'
                INDEX DIRECTORY = '/disk1',
            SUBPARTITION s0b
                DATA DIRECTORY = '/disk2'
                INDEX DIRECTORY = '/disk3'
        ),
        PARTITION p1 VALUES LESS THAN (2000) (
            SUBPARTITION s1a
                DATA DIRECTORY = '/disk4/data'
                INDEX DIRECTORY = '/disk4/idx',
            SUBPARTITION s1b
                DATA DIRECTORY = '/disk5/data'
                INDEX DIRECTORY = '/disk5/idx'
        ),
        PARTITION p2 VALUES LESS THAN MAXVALUE (
            SUBPARTITION s2a,
            SUBPARTITION s2b
        )
    );
```

Here, the storage is as follows:

- Rows with `purchased` dates from before 1990 take up a vast amount of space, so are split up 4 ways, with a separate disk dedicated to the data and to the indexes for each of the two subpartitions (`s0a` and `s0b`) making up partition `p0`. In other words:
  - The data for subpartition `s0a` is stored on `/disk0`.
  - The indexes for subpartition `s0a` are stored on `/disk1`.
  - The data for subpartition `s0b` is stored on `/disk2`.
  - The indexes for subpartition `s0b` are stored on `/disk3`.
- Rows containing dates ranging from 1990 to 1999 (partition `p1`) do not require as much room as those from before 1990. These are split between 2 disks (`/disk4` and `/disk5`) rather than 4 disks as with the legacy records stored in `p0`:
  - Data and indexes belonging to `p1`'s first subpartition (`s1a`) are stored on `/disk4`—the data in `/disk4/data`, and the indexes in `/disk4/idx`.
  - Data and indexes belonging to `p1`'s second subpartition (`s1b`) are stored on `/disk5`—the data in `/disk5/data`, and the indexes in `/disk5/idx`.
- Rows reflecting dates from the year 2000 to the present (partition `p2`) do not take up as much space as required by either of the two previous ranges. Currently, it is sufficient to store all of these in the default location.

  In future, when the number of purchases for the decade beginning with the year 2000 grows to a point where the default location no longer provides sufficient space, the corresponding rows can be moved using an `ALTER TABLE ... REORGANIZE PARTITION` statement. See Section 16.3, “Partition Management”, for an explanation of how this can be done.

The `DATA DIRECTORY` and `INDEX DIRECTORY` options are not permitted in partition definitions when the `NO_DIR_IN_CREATE` server SQL mode is in effect. Beginning with MySQL 5.5.5, these options are also not permitted when defining subpartitions (Bug #42954).

16.2.7. How MySQL Partitioning Handles `NULL`

Partitioning in MySQL does nothing to disallow `NULL` as the value of a partitioning expression, whether it is a column value or the value of a user-supplied expression. Even though it is permitted to use `NULL` as the value of an expression that must otherwise yield an integer, it is important to keep in mind that `NULL` is not a number. MySQL's partitioning implementation treats `NULL` as being less than any non-`NULL` value, just as `ORDER BY` does.

This means that treatment of `NULL` varies between partitioning of different types, and may produce behavior which you do not expect if you are not prepared for it. This being the case, we discuss in this section how each MySQL partitioning type handles `NULL` values when determining the partition in which a row should be stored, and provide examples for each.

Handling of `NULL` with `RANGE` partitioning. If you insert a row into a table partitioned by `RANGE` such that the column value used to determine the partition is `NULL`, the row is inserted into the lowest partition. Consider these two tables in a database named `p`, created as follows:

```
mysql> CREATE TABLE t1 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY RANGE(c1) (
    ->     PARTITION p0 VALUES LESS THAN (0),
    ->     PARTITION p1 VALUES LESS THAN (10),
    ->     PARTITION p2 VALUES LESS THAN MAXVALUE
    -> );
Query OK, 0 rows affected (0.09 sec)

mysql> CREATE TABLE t2 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY RANGE(c1) (
    ->     PARTITION p0 VALUES LESS THAN (-5),
    ->     PARTITION p1 VALUES LESS THAN (0),
    ->     PARTITION p2 VALUES LESS THAN (10),
    ->     PARTITION p3 VALUES LESS THAN MAXVALUE
    -> );
Query OK, 0 rows affected (0.09 sec)
```

You can see the partitions created by these two `CREATE TABLE` statements using the following query against the `PARTITIONS` table in the `INFORMATION_SCHEMA` database:

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME LIKE 't_';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| t1         | p0             |          0 |              0 |           0 |
| t1         | p1             |          0 |              0 |           0 |
| t1         | p2             |          0 |              0 |           0 |
| t2         | p0             |          0 |              0 |           0 |
| t2         | p1             |          0 |              0 |           0 |
| t2         | p2             |          0 |              0 |           0 |
| t2         | p3             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
7 rows in set (0.00 sec)
```

(For more information about this table, see Section 18.19, “The `INFORMATION_SCHEMA PARTITIONS` Table”.) Now let us populate each of these tables with a single row containing a `NULL` in the column used as the partitioning key, and verify that the rows were inserted using a pair of `SELECT` statements:

```
mysql> INSERT INTO t1 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO t2 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)

mysql> SELECT * FROM t1;
+------+--------+
| id   | name   |
+------+--------+
| NULL | mothra |
+------+--------+
1 row in set (0.00 sec)

mysql> SELECT * FROM t2;
+------+--------+
| id   | name   |
+------+--------+
| NULL | mothra |
+------+--------+
1 row in set (0.00 sec)
```

You can see which partitions are used to store the inserted rows by rerunning the previous query against `INFORMATION_SCHEMA.PARTITIONS` and inspecting the output:

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME LIKE 't_';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| t1         | p0             |          1 |             20 |          20 |
| t1         | p1             |          0 |              0 |           0 |
| t1         | p2             |          0 |              0 |           0 |
| t2         | p0             |          1 |             20 |          20 |
| t2         | p1             |          0 |              0 |           0 |
| t2         | p2             |          0 |              0 |           0 |
| t2         | p3             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
7 rows in set (0.01 sec)
```

You can also demonstrate that these rows were stored in the lowest partition of each table by dropping these partitions, and then re-running the `SELECT` statements:

```
mysql> ALTER TABLE t1 DROP PARTITION p0;
Query OK, 0 rows affected (0.16 sec)

mysql> ALTER TABLE t2 DROP PARTITION p0;
Query OK, 0 rows affected (0.16 sec)

mysql> SELECT * FROM t1;
Empty set (0.00 sec)

mysql> SELECT * FROM t2;
Empty set (0.00 sec)
```

(For more information on `ALTER TABLE ... DROP PARTITION`, see Section 12.1.6, “`ALTER TABLE` Syntax”.)

`NULL` is also treated in this way for partitioning expressions that use SQL functions. Suppose that we define a table using a `CREATE TABLE` statement such as this one:

```
CREATE TABLE tndate (
    id INT,
    dt DATE
)
PARTITION BY RANGE( YEAR(dt) ) (
    PARTITION p0 VALUES LESS THAN (1990),
    PARTITION p1 VALUES LESS THAN (2000),
    PARTITION p2 VALUES LESS THAN MAXVALUE
);
```

As with other MySQL functions, `YEAR(NULL)` returns `NULL`. A row with a `dt` column value of `NULL` is treated as though the partitioning expression evaluated to a value less than any other value, and so is inserted into partition `p0`.

Handling of `NULL` with `LIST` partitioning. A table that is partitioned by `LIST` admits `NULL` values if and only if one of its partitions is defined using that value-list that contains `NULL`. The converse of this is that a table partitioned by `LIST` which does not explicitly use `NULL` in a value list rejects rows resulting in a `NULL` value for the partitioning expression, as shown in this example:

```
mysql> CREATE TABLE ts1 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY LIST(c1) (
    ->     PARTITION p0 VALUES IN (0, 3, 6),
    ->     PARTITION p1 VALUES IN (1, 4, 7),
    ->     PARTITION p2 VALUES IN (2, 5, 8)
    -> );
Query OK, 0 rows affected (0.01 sec)

mysql> INSERT INTO ts1 VALUES (9, 'mothra');
ERROR 1504 (HY000): Table has no partition for value 9

mysql> INSERT INTO ts1 VALUES (NULL, 'mothra');
ERROR 1504 (HY000): Table has no partition for value NULL
```

Only rows having a `c1` value between `0` and `8` inclusive can be inserted into `ts1`. `NULL` falls outside this range, just like the number `9`. We can create tables `ts2` and `ts3` having value lists containing `NULL`, as shown here:

```
mysql> CREATE TABLE ts2 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY LIST(c1) (
    ->     PARTITION p0 VALUES IN (0, 3, 6),
    ->     PARTITION p1 VALUES IN (1, 4, 7),
    ->     PARTITION p2 VALUES IN (2, 5, 8),
    ->     PARTITION p3 VALUES IN (NULL)
    -> );
Query OK, 0 rows affected (0.01 sec)

mysql> CREATE TABLE ts3 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY LIST(c1) (
    ->     PARTITION p0 VALUES IN (0, 3, 6),
    ->     PARTITION p1 VALUES IN (1, 4, 7, NULL),
    ->     PARTITION p2 VALUES IN (2, 5, 8)
    -> );
Query OK, 0 rows affected (0.01 sec)
```

When defining value lists for partitioning, you can (and should) treat `NULL` just as you would any other value. For example, both `VALUES IN (NULL)` and `VALUES IN (1, 4, 7, NULL)` are valid, as are `VALUES IN (1, NULL, 4, 7)`, `VALUES`

`IN (NULL, 1, 4, 7)`, and so on. You can insert a row having `NULL` for column `c1` into each of the tables `ts2` and `ts3`:

```
mysql> INSERT INTO ts2 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO ts3 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)
```

By issuing the appropriate query against `INFORMATION_SCHEMA.PARTITIONS`, you can determine which partitions were used to store the rows just inserted (we assume, as in the previous examples, that the partitioned tables were created in the `p` database):

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME LIKE 'ts_';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| ts2        | p0             |          0 |              0 |           0 |
| ts2        | p1             |          0 |              0 |           0 |
| ts2        | p2             |          0 |              0 |           0 |
| ts2        | p3             |          1 |             20 |          20 |
| ts3        | p0             |          0 |              0 |           0 |
| ts3        | p1             |          1 |             20 |          20 |
| ts3        | p2             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
7 rows in set (0.01 sec)
```

As shown earlier in this section, you can also verify which partitions were used for storing the rows by deleting these partitions and then performing a `SELECT`.

Handling of `NULL` with `HASH` and `KEY` partitioning. `NULL` is handled somewhat differently for tables partitioned by `HASH` or `KEY`. In these cases, any partition expression that yields a `NULL` value is treated as though its return value were zero. We can verify this behavior by examining the effects on the file system of creating a table partitioned by `HASH` and populating it with a record containing appropriate values. Suppose that you have a table `th` (also in the `p` database) created using the following statement:

```
mysql> CREATE TABLE th (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY HASH(c1)
    -> PARTITIONS 2;
Query OK, 0 rows affected (0.00 sec)
```

The partitions belonging to this table can be viewed using the query shown here:

```
mysql> SELECT TABLE_NAME,PARTITION_NAME,TABLE_ROWS,AVG_ROW_LENGTH,DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME ='th';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| th         | p0             |          0 |              0 |           0 |
| th         | p1             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
2 rows in set (0.00 sec)
```

Note that `TABLE_ROWS` for each partition is 0. Now insert two rows into `th` whose `c1` column values are `NULL` and 0, and verify that these rows were inserted, as shown here:

```
mysql> INSERT INTO th VALUES (NULL, 'mothra'), (0, 'gigan');
Query OK, 1 row affected (0.00 sec)

mysql> SELECT * FROM th;
+------+---------+
| c1   | c2      |
+------+---------+
| NULL | mothra  |
+------+---------+
|    0 | gigan   |
+------+---------+
2 rows in set (0.01 sec)
```

Recall that for any integer *`N`*, the value of `NULL MOD N` is always `NULL`. For tables that are partitioned by `HASH` or `KEY`, this result is treated for determining the correct partition as `0`. Checking the `INFORMATION_SCHEMA.PARTITIONS` table once again, we can see that both rows were inserted into partition `p0`:

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME ='th';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| th         | p0             |          2 |             20 |          20 |
| th         | p1             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
2 rows in set (0.00 sec)
```

If you repeat this example using `PARTITION BY KEY` in place of `PARTITION BY HASH` in the definition of the table, you can verify easily that `NULL` is also treated like 0 for this type of partitioning.

16.3. Partition Management

MySQL 5.5 provides a number of ways to modify partitioned tables. It is possible to add, drop, redefine, merge, or split existing partitions. All of these actions can be carried out using the partitioning extensions to the `ALTER TABLE` statement. There are also ways to obtain information about partitioned tables and partitions. We discuss these topics in the sections that follow.

- For information about partition management in tables partitioned by `RANGE` or `LIST`, see Section 16.3.1, “Management of `RANGE` and `LIST` Partitions”.
- For a discussion of managing `HASH` and `KEY` partitions, see Section 16.3.2, “Management of `HASH` and `KEY` Partitions”.
- See Section 16.3.4, “Obtaining Information About Partitions”, for a discussion of mechanisms provided in MySQL 5.5 for obtaining information about partitioned tables and partitions.
- For a discussion of performing maintenance operations on partitions, see Section 16.3.3, “Maintenance of Partitions”.

> **Note**
>
> In MySQL 5.5, all partitions of a partitioned table must have the same number of subpartitions, and it is not possible to change the subpartitioning once the table has been created.

To change a table's partitioning scheme, it is necessary only to use the `ALTER TABLE` statement with a *`partition_options`* clause. This clause has the same syntax as that as used with `CREATE TABLE` for creating a partitioned table, and always begins with the keywords `PARTITION BY`. Suppose that you have a table partitioned by range using the following `CREATE TABLE` statement:

```
CREATE TABLE trb3 (id INT, name VARCHAR(50), purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990),
        PARTITION p1 VALUES LESS THAN (1995),
        PARTITION p2 VALUES LESS THAN (2000),
        PARTITION p3 VALUES LESS THAN (2005)
    );
```

To repartition this table so that it is partitioned by key into two partitions using the `id` column value as the basis for the key, you can use this statement:

```
ALTER TABLE trb3 PARTITION BY KEY(id) PARTITIONS 2;
```

This has the same effect on the structure of the table as dropping the table and re-creating it using `CREATE TABLE trb3 PARTITION BY KEY(id) PARTITIONS 2;`.

`ALTER TABLE ... ENGINE = ...` changes only the storage engine used by the table, and leaves the table's partitioning scheme intact. Use `ALTER TABLE ... REMOVE PARTITIONING` to remove a table's partitioning. See Section 12.1.6, “`ALTER TABLE` Syntax”.

> **Important**
>
> Only a single `PARTITION BY`, `ADD PARTITION`, `DROP PARTITION`, `REORGANIZE PARTITION`, or `COALESCE PARTITION` clause can be used in a given `ALTER TABLE` statement. If you (for example) wish to drop a partition and reorganize a table's remaining partitions, you must do so in two separate `ALTER TABLE` statements (one using `DROP PARTITION` and then a second one using `REORGANIZE PARTITIONS`).

Beginning with MySQL 5.5.0, it is possible to delete all rows from one or more selected partitions using `ALTER TABLE ... TRUNCATE PARTITION`.

16.3.1. Management of `RANGE` and `LIST` Partitions

Range and list partitions are very similar with regard to how the adding and dropping of partitions are handled. For this reason we discuss the management of both sorts of partitioning in this section. For information about working with tables that are partitioned by hash or key, see Section 16.3.2, “Management of `HASH` and `KEY` Partitions”. Dropping a `RANGE` or `LIST` partition is more straightforward than adding one, so we discuss this first.

Dropping a partition from a table that is partitioned by either `RANGE` or by `LIST` can be accomplished using the `ALTER TABLE` statement with a `DROP PARTITION` clause. Here is a very basic example, which supposes that you have already created a table which is partitioned by range and then populated with 10 records using the following `CREATE TABLE` and `INSERT` statements:

```
mysql> CREATE TABLE tr (id INT, name VARCHAR(50), purchased DATE)
    ->     PARTITION BY RANGE( YEAR(purchased) ) (
    ->         PARTITION p0 VALUES LESS THAN (1990),
    ->         PARTITION p1 VALUES LESS THAN (1995),
    ->         PARTITION p2 VALUES LESS THAN (2000),
    ->         PARTITION p3 VALUES LESS THAN (2005)
    ->     );
Query OK, 0 rows affected (0.01 sec)

mysql> INSERT INTO tr VALUES
    ->     (1, 'desk organiser', '2003-10-15'),
    ->     (2, 'CD player', '1993-11-05'),
    ->     (3, 'TV set', '1996-03-10'),
    ->     (4, 'bookcase', '1982-01-10'),
    ->     (5, 'exercise bike', '2004-05-09'),
    ->     (6, 'sofa', '1987-06-05'),
    ->     (7, 'popcorn maker', '2001-11-22'),
    ->     (8, 'aquarium', '1992-08-04'),
    ->     (9, 'study desk', '1984-09-16'),
    ->     (10, 'lava lamp', '1998-12-25');
Query OK, 10 rows affected (0.01 sec)
```

You can see which items should have been inserted into partition `p2` as shown here:

```
mysql> SELECT * FROM tr
    -> WHERE purchased BETWEEN '1995-01-01' AND '1999-12-31';
+------+-----------+------------+
| id   | name      | purchased  |
+------+-----------+------------+
|    3 | TV set    | 1996-03-10 |
|   10 | lava lamp | 1998-12-25 |
+------+-----------+------------+
2 rows in set (0.00 sec)
```

To drop the partition named `p2`, execute the following command:

```
mysql> ALTER TABLE tr DROP PARTITION p2;
Query OK, 0 rows affected (0.03 sec)
```

It is very important to remember that, *when you drop a partition, you also delete all the data that was stored in that partition*. You can see that this is the case by re-running the previous `SELECT` query:

```
mysql> SELECT * FROM tr WHERE purchased
    -> BETWEEN '1995-01-01' AND '1999-12-31';
Empty set (0.00 sec)
```

Because of this, you must have the `DROP` privilege for a table before you can execute `ALTER TABLE ... DROP PARTITION` on that table.

If you wish to drop all data from all partitions while preserving the table definition and its partitioning scheme, use the `TRUNCATE TABLE` statement. (See Section 12.1.27, “`TRUNCATE TABLE` Syntax”.)

If you intend to change the partitioning of a table *without* losing data, use `ALTER TABLE ... REORGANIZE PARTITION` instead. See below or in Section 12.1.6, “`ALTER TABLE` Syntax”, for information about `REORGANIZE PARTITION`.

If you now execute a `SHOW CREATE TABLE` statement, you can see how the partitioning makeup of the table has been changed:

```
mysql> SHOW CREATE TABLE tr\G
*************************** 1. row ***************************
       Table: tr
Create Table: CREATE TABLE `tr` (
  `id` int(11) default NULL,
  `name` varchar(50) default NULL,
  `purchased` date default NULL
) ENGINE=MyISAM DEFAULT CHARSET=latin1
PARTITION BY RANGE ( YEAR(purchased) ) (
  PARTITION p0 VALUES LESS THAN (1990) ENGINE = MyISAM,
  PARTITION p1 VALUES LESS THAN (1995) ENGINE = MyISAM,
  PARTITION p3 VALUES LESS THAN (2005) ENGINE = MyISAM
)
1 row in set (0.01 sec)
```

When you insert new rows into the changed table with `purchased` column values between `'1995-01-01'` and `'2004-12-31'` inclusive, those rows will be stored in partition `p3`. You can verify this as follows:

```
mysql> INSERT INTO tr VALUES (11, 'pencil holder', '1995-07-12');
Query OK, 1 row affected (0.00 sec)
```

```
mysql> SELECT * FROM tr WHERE purchased
    -> BETWEEN '1995-01-01' AND '2004-12-31';
+------+----------------+------------+
| id   | name           | purchased  |
+------+----------------+------------+
|   11 | pencil holder  | 1995-07-12 |
|    1 | desk organiser | 2003-10-15 |
|    5 | exercise bike  | 2004-05-09 |
|    7 | popcorn maker  | 2001-11-22 |
+------+----------------+------------+
4 rows in set (0.00 sec)

mysql> ALTER TABLE tr DROP PARTITION p3;
Query OK, 0 rows affected (0.03 sec)

mysql> SELECT * FROM tr WHERE purchased
    -> BETWEEN '1995-01-01' AND '2004-12-31';
Empty set (0.00 sec)
```

Note that the number of rows dropped from the table as a result of `ALTER TABLE ... DROP PARTITION` is not reported by the server as it would be by the equivalent `DELETE` query.

Dropping `LIST` partitions uses exactly the same `ALTER TABLE ... DROP PARTITION` syntax as used for dropping `RANGE` partitions. However, there is one important difference in the effect this has on your use of the table afterward: You can no longer insert into the table any rows having any of the values that were included in the value list defining the deleted partition. (See Section 16.2.2, “`LIST` Partitioning”, for an example.)

To add a new range or list partition to a previously partitioned table, use the `ALTER TABLE ... ADD PARTITION` statement. For tables which are partitioned by `RANGE`, this can be used to add a new range to the end of the list of existing partitions. Suppose that you have a partitioned table containing membership data for your organization, which is defined as follows:

```
CREATE TABLE members (
    id INT,
    fname VARCHAR(25),
    lname VARCHAR(25),
    dob DATE
)
PARTITION BY RANGE( YEAR(dob) ) (
    PARTITION p0 VALUES LESS THAN (1970),
    PARTITION p1 VALUES LESS THAN (1980),
    PARTITION p2 VALUES LESS THAN (1990)
);
```

Suppose further that the minimum age for members is 16. As the calendar approaches the end of 2005, you realize that you will soon be admitting members who were born in 1990 (and later in years to come). You can modify the `members` table to accommodate new members born in the years 1990 to 1999 as shown here:

```
ALTER TABLE ADD PARTITION (PARTITION p3 VALUES LESS THAN (2000));
```

> **Important**
>
> With tables that are partitioned by range, you can use `ADD PARTITION` to add new partitions to the high end of the partitions list only. Trying to add a new partition in this manner between or before existing partitions will result in an error as shown here:
>
> ```
> mysql> ALTER TABLE members
>      >     ADD PARTITION (
>      >     PARTITION p3 VALUES LESS THAN (1960));
> ERROR 1463 (HY000): VALUES LESS THAN value must be strictly »
>    increasing for each partition
> ```

In a similar fashion, you can add new partitions to a table that is partitioned by `LIST`. Suppose a table `tt` is defined using the following `CREATE TABLE` statement:

```
CREATE TABLE tt (
    id INT,
    data INT
)
PARTITION BY LIST(data) (
    PARTITION p0 VALUES IN (5, 10, 15),
    PARTITION p1 VALUES IN (6, 12, 18)
);
```

You can add a new partition in which to store rows having the `data` column values `7`, `14`, and `21` as shown:

```
ALTER TABLE tt ADD PARTITION (PARTITION p2 VALUES IN (7, 14, 21));
```

Note that you *cannot* add a new `LIST` partition encompassing any values that are already included in the value list of an existing partition. If you attempt to do so, an error will result:

```
mysql> ALTER TABLE tt ADD PARTITION
     >     (PARTITION np VALUES IN (4, 8, 12));
ERROR 1465 (HY000): Multiple definition of same constant »
                    in list partitioning
```

Because any rows with the `data` column value `12` have already been assigned to partition `p1`, you cannot create a new partition on table `tt` that includes `12` in its value list. To accomplish this, you could drop `p1`, and add `np` and then a new `p1` with a modified definition. However, as discussed earlier, this would result in the loss of all data stored in `p1`—and it is often the case that this is not what you really want to do. Another solution might appear to be to make a copy of the table with the new partitioning and to copy the data into it using `CREATE TABLE ... SELECT ...`, then drop the old table and rename the new one, but this could be very time-consuming when dealing with a large amounts of data. This also might not be feasible in situations where high availability is a requirement.

You can add multiple partitions in a single `ALTER TABLE ... ADD PARTITION` statement as shown here:

```
CREATE TABLE employees (
  id INT NOT NULL,
  fname VARCHAR(50) NOT NULL,
  lname VARCHAR(50) NOT NULL,
  hired DATE NOT NULL
)
PARTITION BY RANGE( YEAR(hired) ) (
  PARTITION p1 VALUES LESS THAN (1991),
  PARTITION p2 VALUES LESS THAN (1996),
  PARTITION p3 VALUES LESS THAN (2001),
  PARTITION p4 VALUES LESS THAN (2005)
);

ALTER TABLE employees ADD PARTITION (
    PARTITION p5 VALUES LESS THAN (2010),
    PARTITION p6 VALUES LESS THAN MAXVALUE
);
```

Fortunately, MySQL's partitioning implementation provides ways to redefine partitions without losing data. Let us look first at a couple of simple examples involving `RANGE` partitioning. Recall the `members` table which is now defined as shown here:

```
mysql> SHOW CREATE TABLE members\G
*************************** 1. row ***************************
       Table: members
Create Table: CREATE TABLE `members` (
  `id` int(11) default NULL,
  `fname` varchar(25) default NULL,
  `lname` varchar(25) default NULL,
  `dob` date default NULL
) ENGINE=MyISAM DEFAULT CHARSET=latin1
PARTITION BY RANGE ( YEAR(dob) ) (
  PARTITION p0 VALUES LESS THAN (1970) ENGINE = MyISAM,
  PARTITION p1 VALUES LESS THAN (1980) ENGINE = MyISAM,
  PARTITION p2 VALUES LESS THAN (1990) ENGINE = MyISAM.
  PARTITION p3 VALUES LESS THAN (2000) ENGINE = MyISAM
)
```

Suppose that you would like to move all rows representing members born before 1960 into a separate partition. As we have already seen, this cannot be done using `ALTER TABLE ... ADD PARTITION`. However, you can use another partition-related extension to `ALTER TABLE` to accomplish this:

```
ALTER TABLE members REORGANIZE PARTITION p0 INTO (
    PARTITION s0 VALUES LESS THAN (1960),
    PARTITION s1 VALUES LESS THAN (1970)
);
```

In effect, this command splits partition `p0` into two new partitions `s0` and `s1`. It also moves the data that was stored in `p0` into the new partitions according to the rules embodied in the two `PARTITION ... VALUES ...` clauses, so that `s0` contains only those records for which `YEAR(dob)` is less than 1960 and `s1` contains those rows in which `YEAR(dob)` is greater than or equal to 1960 but less than 1970.

A `REORGANIZE PARTITION` clause may also be used for merging adjacent partitions. You can return the `members` table to its previous partitioning as shown here:

```
ALTER TABLE members REORGANIZE PARTITION s0,s1 INTO (
    PARTITION p0 VALUES LESS THAN (1970)
);
```

No data is lost in splitting or merging partitions using `REORGANIZE PARTITION`. In executing the above statement, MySQL moves all of the records that were stored in partitions `s0` and `s1` into partition `p0`.

The general syntax for `REORGANIZE PARTITION` is shown here:

```
ALTER TABLE tbl_name
    REORGANIZE PARTITION partition_list
    INTO (partition_definitions);
```

Here, *`tbl_name`* is the name of the partitioned table, and *`partition_list`* is a comma-separated list of names of one or more existing partitions to be changed. *`partition_definitions`* is a comma-separated list of new partition definitions, which follow the same rules as for the *`partition_definitions`* list used in `CREATE TABLE` (see Section 12.1.14, "`CREATE TABLE` Syntax"). It should be noted that you are not limited to merging several partitions into one, or to splitting one partition into many, when using `REORGANIZE PARTITION`. For example, you can reorganize all four partitions of the `members` table into two, as follows:

```
ALTER TABLE members REORGANIZE PARTITION p0,p1,p2,p3 INTO (
    PARTITION m0 VALUES LESS THAN (1980),
    PARTITION m1 VALUES LESS THAN (2000)
);
```

You can also use `REORGANIZE PARTITION` with tables that are partitioned by `LIST`. Let us return to the problem of adding a new partition to the list-partitioned `tt` table and failing because the new partition had a value that was already present in the value-list of one of the existing partitions. We can handle this by adding a partition that contains only nonconflicting values, and then reorganizing the new partition and the existing one so that the value which was stored in the existing one is now moved to the new one:

```
ALTER TABLE tt ADD PARTITION (PARTITION np VALUES IN (4, 8));
ALTER TABLE tt REORGANIZE PARTITION p1,np INTO (
    PARTITION p1 VALUES IN (6, 18),
    PARTITION np VALUES in (4, 8, 12)
);
```

Here are some key points to keep in mind when using `ALTER TABLE ... REORGANIZE PARTITION` to repartition tables that are partitioned by `RANGE` or `LIST`:

- The `PARTITION` clauses used to determine the new partitioning scheme are subject to the same rules as those used with a `CREATE TABLE` statement.

  Most importantly, you should remember that the new partitioning scheme cannot have any overlapping ranges (applies to tables partitioned by `RANGE`) or sets of values (when reorganizing tables partitioned by `LIST`).

- The combination of partitions in the *`partition_definitions`* list should account for the same range or set of values overall as the combined partitions named in the *`partition_list`*.

  For instance, in the `members` table used as an example in this section, partitions `p1` and `p2` together cover the years 1980 through 1999. Therefore, any reorganization of these two partitions should cover the same range of years overall.

- For tables partitioned by `RANGE`, you can reorganize only adjacent partitions; you cannot skip over range partitions.

  For instance, you could not reorganize the `members` table used as an example in this section using a statement beginning with `ALTER TABLE members REORGANIZE PARTITION p0,p2 INTO ...` because `p0` covers the years prior to 1970 and `p2` the years from 1990 through 1999 inclusive, and thus the two are not adjacent partitions.

- You cannot use `REORGANIZE PARTITION` to change the table's partitioning type; that is, you cannot (for example) change `RANGE` partitions to `HASH` partitions or *vice versa*. You also cannot use this command to change the partitioning expression or column. To accomplish either of these tasks without dropping and re-creating the table, you can use `ALTER TABLE ... PARTITION BY ...`. For example:

  ```
  ALTER TABLE members
      PARTITION BY HASH( YEAR(dob) )
      PARTITIONS 8;
  ```

16.3.2. Management of `HASH` and `KEY` Partitions

Tables which are partitioned by hash or by key are very similar to one another with regard to making changes in a partitioning setup, and both differ in a number of ways from tables which have been partitioned by range or list. For that reason, this section addresses the modification of tables partitioned by hash or by key only. For a discussion of adding and dropping of partitions of tables that are partitioned by range or list, see Section 16.3.1, "Management of `RANGE` and `LIST` Partitions".

You cannot drop partitions from tables that are partitioned by `HASH` or `KEY` in the same way that you can from tables that are partitioned by `RANGE` or `LIST`. However, you can merge `HASH` or `KEY` partitions using the `ALTER TABLE ... COALESCE PARTITION` statement. Suppose that you have a table containing data about clients, which is divided into twelve partitions. The `clients` table is defined as shown here:

```
CREATE TABLE clients (
    id INT,
    fname VARCHAR(30),
    lname VARCHAR(30),
    signed DATE
)
PARTITION BY HASH( MONTH(signed) )
PARTITIONS 12;
```

To reduce the number of partitions from twelve to eight, execute the following `ALTER TABLE` command:

```
mysql> ALTER TABLE clients COALESCE PARTITION 4;
Query OK, 0 rows affected (0.02 sec)
```

`COALESCE` works equally well with tables that are partitioned by `HASH`, `KEY`, `LINEAR HASH`, or `LINEAR KEY`. Here is an example similar to the previous one, differing only in that the table is partitioned by `LINEAR KEY`:

```
mysql> CREATE TABLE clients_lk (
    ->     id INT,
    ->     fname VARCHAR(30),
    ->     lname VARCHAR(30),
    ->     signed DATE
    -> )
    -> PARTITION BY LINEAR KEY(signed)
    -> PARTITIONS 12;
Query OK, 0 rows affected (0.03 sec)

mysql> ALTER TABLE clients_lk COALESCE PARTITION 4;
Query OK, 0 rows affected (0.06 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

Note that the number following `COALESCE PARTITION` is the number of partitions to merge into the remainder—in other words, it is the number of partitions to remove from the table.

If you attempt to remove more partitions than the table has, the result is an error like the one shown:

```
mysql> ALTER TABLE clients COALESCE PARTITION 18;
ERROR 1478 (HY000): Cannot remove all partitions, use DROP TABLE instead
```

To increase the number of partitions for the `clients` table from 12 to 18. use `ALTER TABLE ... ADD PARTITION` as shown here:

```
ALTER TABLE clients ADD PARTITION PARTITIONS 6;
```

16.3.3. Maintenance of Partitions

A number of table and partition maintenance tasks can be carried out using SQL statements intended for such purposes on partitioned tables in MySQL 5.5.

Table maintenance of partitioned tables can be accomplished using the statements `CHECK TABLE`, `OPTIMIZE TABLE`, `ANALYZE TABLE`, and `REPAIR TABLE`, which are supported for partitioned tables.

You can use a number of extensions to `ALTER TABLE` for performing operations of this type on one or more partitions directly, as described in the following list:

- **Rebuilding partitions.** Rebuilds the partition; this has the same effect as dropping all records stored in the partition, then reinserting them. This can be useful for purposes of defragmentation.

  Example:

  ```
  ALTER TABLE t1 REBUILD PARTITION p0, p1;
  ```

- **Optimizing partitions.** If you have deleted a large number of rows from a partition or if you have made many changes to a partitioned table with variable-length rows (that is, having `VARCHAR`, `BLOB`, or `TEXT` columns), you can use `ALTER TABLE ... OPTIMIZE PARTITION` to reclaim any unused space and to defragment the partition data file.

  Example:

  ```
  ALTER TABLE t1 OPTIMIZE PARTITION p0, p1;
  ```

  Using `OPTIMIZE PARTITION` on a given partition is equivalent to running `CHECK PARTITION`, `ANALYZE PARTITION`, and `REPAIR PARTITION` on that partition.

- **Analyzing partitions.** This reads and stores the key distributions for partitions.

  Example:

  ```
  ALTER TABLE t1 ANALYZE PARTITION p3;
  ```

- **Repairing partitions.** This repairs corrupted partitions.

  Example:

  ```
  ALTER TABLE t1 REPAIR PARTITION p0,p1;
  ```

- **Checking partitions.** You can check partitions for errors in much the same way that you can use `CHECK TABLE` with nonpartitioned tables.

  Example:

  ```
  ALTER TABLE trb3 CHECK PARTITION p1;
  ```

  This command will tell you if the data or indexes in partition `p1` of table `t1` are corrupted. If this is the case, use `ALTER TABLE ... REPAIR PARTITION` to repair the partition.

Each of the statements in the list just shown also supports the keyword `ALL` in place of the list of partition names. Using `ALL` causes the statement to act on all partitions in the table.

The use of `mysqlcheck` and `myisamchk` is not supported with partitioned tables.

Beginning with MySQL 5.5.0, you can also truncate partitions using `ALTER TABLE ... TRUNCATE PARTITION`. This statement can be used to delete all rows from one or more partitions in much the same way that `TRUNCATE TABLE` deletes all rows from a table.

`ALTER TABLE ... TRUNCATE PARTITION ALL` truncates all partitions in the table.

16.3.4. Obtaining Information About Partitions

This section discusses obtaining information about existing partitions, which can be done in a number of ways. Methods of obtaining such information include the following:

- Using the `SHOW CREATE TABLE` statement to view the partitioning clauses used in creating a partitioned table.
- Using the `SHOW TABLE STATUS` statement to determine whether a table is partitioned.
- Querying the `INFORMATION_SCHEMA.PARTITIONS` table.
- Using the statement `EXPLAIN PARTITIONS SELECT` to see which partitions are used by a given `SELECT`.

As discussed elsewhere in this chapter, `SHOW CREATE TABLE` includes in its output the `PARTITION BY` clause used to create a partitioned table. For example:

```
mysql> SHOW CREATE TABLE trb3\G
*************************** 1. row ***************************
       Table: trb3
Create Table: CREATE TABLE `trb3` (
  `id` int(11) default NULL,
  `name` varchar(50) default NULL,
  `purchased` date default NULL
) ENGINE=MyISAM DEFAULT CHARSET=latin1
PARTITION BY RANGE (YEAR(purchased)) (
  PARTITION p0 VALUES LESS THAN (1990) ENGINE = MyISAM,
  PARTITION p1 VALUES LESS THAN (1995) ENGINE = MyISAM,
  PARTITION p2 VALUES LESS THAN (2000) ENGINE = MyISAM,
  PARTITION p3 VALUES LESS THAN (2005) ENGINE = MyISAM
)
1 row in set (0.00 sec)
```

The output from `SHOW TABLE STATUS` for partitioned tables is the same as that for nonpartitioned tables, except that the `Create_options` column contains the string `partitioned`. The `Engine` column contains the name of the storage engine used by all partitions of the table. (See Section 12.4.5.37, "`SHOW TABLE STATUS` Syntax", for more information about this statement.)

You can also obtain information about partitions from `INFORMATION_SCHEMA`, which contains a `PARTITIONS` table. See Section 18.19, “The `INFORMATION_SCHEMA PARTITIONS` Table”.

It is possible to determine which partitions of a partitioned table are involved in a given `SELECT` query using `EXPLAIN PARTITIONS`. The `PARTITIONS` keyword adds a `partitions` column to the output of `EXPLAIN` listing the partitions from which records would be matched by the query.

Suppose that you have a table `trb1` created and populated as follows:

```
CREATE TABLE trb1 (id INT, name VARCHAR(50), purchased DATE)
    PARTITION BY RANGE(id)
    (
        PARTITION p0 VALUES LESS THAN (3),
        PARTITION p1 VALUES LESS THAN (7),
        PARTITION p2 VALUES LESS THAN (9),
        PARTITION p3 VALUES LESS THAN (11)
    );

INSERT INTO trb1 VALUES
    (1, 'desk organiser', '2003-10-15'),
    (2, 'CD player', '1993-11-05'),
    (3, 'TV set', '1996-03-10'),
    (4, 'bookcase', '1982-01-10'),
    (5, 'exercise bike', '2004-05-09'),
    (6, 'sofa', '1987-06-05'),
    (7, 'popcorn maker', '2001-11-22'),
    (8, 'aquarium', '1992-08-04'),
    (9, 'study desk', '1984-09-16'),
    (10, 'lava lamp', '1998-12-25');
```

You can see which partitions are used in a query such as `SELECT * FROM trb1;`, as shown here:

```
mysql> EXPLAIN PARTITIONS SELECT * FROM trb1\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: trb1
   partitions: p0,p1,p2,p3
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 10
        Extra: Using filesort
```

In this case, all four partitions are searched. However, when a limiting condition making use of the partitioning key is added to the query, you can see that only those partitions containing matching values are scanned, as shown here:

```
mysql> EXPLAIN PARTITIONS SELECT * FROM trb1 WHERE id < 5\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: trb1
   partitions: p0,p1
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 10
        Extra: Using where
```

`EXPLAIN PARTITIONS` provides information about keys used and possible keys, just as with the standard `EXPLAIN SELECT` statement:

```
mysql> ALTER TABLE trb1 ADD PRIMARY KEY (id);
Query OK, 10 rows affected (0.03 sec)
Records: 10  Duplicates: 0  Warnings: 0

mysql> EXPLAIN PARTITIONS SELECT * FROM trb1 WHERE id < 5\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: trb1
   partitions: p0,p1
         type: range
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: NULL
         rows: 7
        Extra: Using where
```

You should take note of the following restrictions and limitations on `EXPLAIN PARTITIONS`:

- You cannot use the `PARTITIONS` and `EXTENDED` keywords together in the same `EXPLAIN ... SELECT` statement. Attempting to do so produces a syntax error.
- If `EXPLAIN PARTITIONS` is used to examine a query against a nonpartitioned table, no error is produced, but the value of the `partitions` column is always `NULL`.

The `rows` column of `EXPLAIN PARTITIONS` output displays the total number of rows in the table.

See also Section 12.8.2, “`EXPLAIN` Syntax”.

16.4. Partition Pruning

This section discusses an optimization known as *partition pruning*. The core concept behind partition pruning is relatively simple, and can be described as “Do not scan partitions where there can be no matching values”. Suppose that you have a partitioned table `t1` defined by this statement:

```
CREATE TABLE t1 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY RANGE( region_code ) (
    PARTITION p0 VALUES LESS THAN (64),
    PARTITION p1 VALUES LESS THAN (128),
    PARTITION p2 VALUES LESS THAN (192),
    PARTITION p3 VALUES LESS THAN MAXVALUE
);
```

Consider the case where you wish to obtain results from a query such as this one:

```
SELECT fname, lname, region_code, dob
    FROM t1
    WHERE region_code > 125 AND region_code < 130;
```

It is easy to see that none of the rows which ought to be returned will be in either of the partitions `p0` or `p3`; that is, we need to search only in partitions `p1` and `p2` to find matching rows. By doing so, it is possible to expend much less time and effort in finding matching rows than would be required to scan all partitions in the table. This “cutting away” of unneeded partitions is known as *pruning*. When the optimizer can make use of partition pruning in performing a query, execution of the query can be an order of magnitude faster than the same query against a nonpartitioned table containing the same column definitions and data.

The query optimizer can perform pruning whenever a `WHERE` condition can be reduced to either one of the following two cases:

- *`partition_column = constant`*
- `partition_column IN (constant1, constant2, ..., constantN)`

In the first case, the optimizer simply evaluates the partitioning expression for the value given, determines which partition contains that value, and scans only this partition. In many cases, the equal sign can be replaced with another arithmetic comparison, including `<`, `>`, `<=`, `>=`, and `<>`. Some queries using `BETWEEN` in the `WHERE` clause can also take advantage of partition pruning. See the examples later in this section.

In the second case, the optimizer evaluates the partitioning expression for each value in the list, creates a list of matching partitions, and then scans only the partitions in this partition list.

Pruning can also be applied to short ranges, which the optimizer can convert into equivalent lists of values. For instance, in the previous example, the `WHERE` clause can be converted to `WHERE region_code IN (125, 126, 127, 128, 129, 130)`. Then the optimizer can determine that the first three values in the list are found in partition `p1`, the remaining three values in partition `p2`, and that the other partitions contain no relevant values and so do not need to be searched for matching rows.

Beginning with MySQL 5.5.0, the optimizer can also perform pruning for queries that involve comparisons of the preceding types on multiple columns for tables that use `RANGE COLUMNS` or `LIST COLUMNS` partitioning.

This type of optimization can be applied whenever the partitioning expression consists of an equality or a range which can be reduced to a set of equalities, or when the partitioning expression represents an increasing or decreasing relationship. Pruning can also be applied for tables partitioned on a `DATE` or `DATETIME` column when the partitioning expression uses the `YEAR()` or `TO_DAYS()` function. In addition, in MySQL 5.5, pruning can be applied for such tables when the partitioning expression uses the `TO_SECONDS()` function.

Suppose that table `t2`, defined as shown here, is partitioned on a `DATE` column:

```
CREATE TABLE t2 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY RANGE( YEAR(dob) ) (
    PARTITION d0 VALUES LESS THAN (1970),
    PARTITION d1 VALUES LESS THAN (1975),
    PARTITION d2 VALUES LESS THAN (1980),
    PARTITION d3 VALUES LESS THAN (1985),
    PARTITION d4 VALUES LESS THAN (1990),
    PARTITION d5 VALUES LESS THAN (2000),
    PARTITION d6 VALUES LESS THAN (2005),
    PARTITION d7 VALUES LESS THAN MAXVALUE
);
```

The following queries on `t2` can make of use partition pruning:

```
SELECT * FROM t2 WHERE dob = '1982-06-23';

SELECT * FROM t2 WHERE dob BETWEEN '1991-02-15' AND '1997-04-25';

SELECT * FROM t2 WHERE dob >= '1984-06-21' AND dob <= '1999-06-21'
```

In the case of the last query, the optimizer can also act as follows:

1. *Find the partition containing the low end of the range.*

   `YEAR('1984-06-21')` yields the value `1984`, which is found in partition `d3`.

2. *Find the partition containing the high end of the range.*

   `YEAR('1999-06-21')` evaluates to `1999`, which is found in partition `d5`.

3. *Scan only these two partitions and any partitions that may lie between them.*

   In this case, this means that only partitions `d3`, `d4`, and `d5` are scanned. The remaining partitions may be safely ignored (and are ignored).

> **Important**
>
> Invalid `DATE` and `DATETIME` values referenced in the `WHERE` clause of a query on a partitioned table are treated as `NULL`. This means that a query such as `SELECT * FROM partitioned_table WHERE date_column < '2008-12-00'` does not return any values (see Bug #40972).

So far, we have looked only at examples using `RANGE` partitioning, but pruning can be applied with other partitioning types as well.

Consider a table that is partitioned by `LIST`, where the partitioning expression is increasing or decreasing, such as the table `t3` shown here. (In this example, we assume for the sake of brevity that the `region_code` column is limited to values between 1 and 10 inclusive.)

```
CREATE TABLE t3 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY LIST(region_code) (
    PARTITION r0 VALUES IN (1, 3),
    PARTITION r1 VALUES IN (2, 5, 8),
    PARTITION r2 VALUES IN (4, 9),
    PARTITION r3 VALUES IN (6, 7, 10)
);
```

For a query such as `SELECT * FROM t3 WHERE region_code BETWEEN 1 AND 3`, the optimizer determines in which partitions the values 1, 2, and 3 are found (`r0` and `r1`) and skips the remaining ones (`r2` and `r3`).

For tables that are partitioned by `HASH` or `KEY`, partition pruning is also possible in cases in which the `WHERE` clause uses a simple `=` relation against a column used in the partitioning expression. Consider a table created like this:

```
CREATE TABLE t4 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY KEY(region_code)
PARTITIONS 8;
```

Any query, such as this one, that compares a column value with a constant can be pruned:

```
SELECT * FROM t4 WHERE region_code = 7;
```

Pruning can also be employed for short ranges, because the optimizer can turn such conditions into `IN` relations. For example, using the same table `t4` as defined previously, queries such as these can be pruned:

```
SELECT * FROM t4 WHERE region_code > 2 AND region_code < 6;

SELECT * FROM t4 WHERE region_code BETWEEN 3 AND 5;
```

In both these cases, the `WHERE` clause is transformed by the optimizer into `WHERE region_code IN (3, 4, 5)`.

> **Important**
>
> This optimization is used only if the range size is smaller than the number of partitions. Consider this query:
>
> ```
> SELECT * FROM t4 WHERE region_code BETWEEN 4 AND 12;
> ```
>
> The range in the `WHERE` clause covers 9 values (4, 5, 6, 7, 8, 9, 10, 11, 12), but `t4` has only 8 partitions. This means that the previous query cannot be pruned.

Pruning can be used only on integer columns of tables partitioned by `HASH` or `KEY`. For example, this query on table `t4` cannot use pruning because `dob` is a `DATE` column:

```
SELECT * FROM t4 WHERE dob >= '2001-04-14' AND dob <= '2005-10-15';
```

However, if the table stores year values in an `INT` column, then a query having `WHERE year_col >= 2001 AND year_col <= 2005` can be pruned.

> **Note**
>
> In MySQL 5.1, a query against a table partitioned by `KEY` and having a composite partitioning key could be pruned only if the query's `WHERE` clause compared every column in the key to a constant. In MySQL 5.5, it is possible to prune queries against such tables even if the `WHERE` clause does not reference every column in the partitioning key.

16.5. Restrictions and Limitations on Partitioning

This section discusses current restrictions and limitations on MySQL partitioning support.

Prohibited constructs. The following constructs are not permitted in partitioning expressions:

- Stored procedures, stored functions, UDFs, or plugins.
- Declared variables or user variables.

For a list of SQL functions which are permitted in partitioning expressions, see Section 16.5.3, “Partitioning Limitations Relating to Functions”.

Arithmetic and logical operators. Use of the arithmetic operators `+`, `-`, and `*` is permitted in partitioning expressions. However, the result must be an integer value or `NULL` (except in the case of `[LINEAR] KEY` partitioning, as discussed elsewhere in this chapter; see Section 16.2, “Partitioning Types”, for more information).

The `DIV` operator is also supported, and the `/` operator is not permitted. (Bug #30188, Bug #33182)

The bit operators `|`, `&`, `^`, `<<`, `>>`, and `~` are not permitted in partitioning expressions.

Server SQL mode. Tables employing user-defined partitioning do not preserve the SQL mode in effect at the time that they were created. As discussed in Section 5.1.6, “Server SQL Modes”, the results of many MySQL functions and operators may change according to the server SQL mode. Therefore, a change in the SQL mode at any time after the creation of partitioned tables may lead to major changes in the behavior of such tables, and could easily lead to corruption or loss of data. For these reasons, *it is strongly recommended that you never change the server SQL mode after creating partitioned tables*.

Examples. The following examples illustrate some changes in behavior of partitioned tables due to a change in the server SQL mode:

1. **Error handling.** Suppose that you create a partitioned table whose partitioning expression is one such as `column DIV 0` or `column MOD 0`, as shown here:

```
mysql> CREATE TABLE tn (c1 INT)
    ->     PARTITION BY LIST(1 DIV c1) (
    ->       PARTITION p0 VALUES IN (NULL),
    ->       PARTITION p1 VALUES IN (1)
    -> );
Query OK, 0 rows affected (0.05 sec)
```

The default behavior for MySQL is to return `NULL` for the result of a division by zero, without producing any errors:

```
mysql> SELECT @@sql_mode;
+------------+
| @@sql_mode |
+------------+
|            |
+------------+
1 row in set (0.00 sec)


mysql> INSERT INTO tn VALUES (NULL), (0), (1);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0
```

However, changing the server SQL mode to treat division by zero as an error and to enforce strict error handling causes the same `INSERT` statement to fail, as shown here:

```
mysql> SET sql_mode='STRICT_ALL_TABLES,ERROR_FOR_DIVISION_BY_ZERO';
Query OK, 0 rows affected (0.00 sec)

mysql> INSERT INTO tn VALUES (NULL), (0), (1);
ERROR 1365 (22012): Division by 0
```

2. **Table accessibility.** Sometimes a change in the server SQL mode can make partitioned tables unusable. The following `CREATE TABLE` statement can be executed successfully only if the `NO_UNSIGNED_SUBTRACTION` mode is in effect:

```
mysql> SELECT @@sql_mode;
+------------+
| @@sql_mode |
+------------+
|            |
+------------+
1 row in set (0.00 sec)

mysql> CREATE TABLE tu (c1 BIGINT UNSIGNED)
    ->   PARTITION BY RANGE(c1 - 10) (
    ->     PARTITION p0 VALUES LESS THAN (-5),
    ->     PARTITION p1 VALUES LESS THAN (0),
    ->     PARTITION p2 VALUES LESS THAN (5),
    ->     PARTITION p3 VALUES LESS THAN (10),
    ->     PARTITION p4 VALUES LESS THAN (MAXVALUE)
    -> );
ERROR 1563 (HY000): Partition constant is out of partition function domain

mysql> SET sql_mode='NO_UNSIGNED_SUBTRACTION';
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @@sql_mode;
+-------------------------+
| @@sql_mode              |
+-------------------------+
| NO_UNSIGNED_SUBTRACTION |
+-------------------------+
1 row in set (0.00 sec)

mysql> CREATE TABLE tu (c1 BIGINT UNSIGNED)
    ->   PARTITION BY RANGE(c1 - 10) (
    ->     PARTITION p0 VALUES LESS THAN (-5),
    ->     PARTITION p1 VALUES LESS THAN (0),
    ->     PARTITION p2 VALUES LESS THAN (5),
    ->     PARTITION p3 VALUES LESS THAN (10),
    ->     PARTITION p4 VALUES LESS THAN (MAXVALUE)
    -> );
Query OK, 0 rows affected (0.05 sec)
```

If you remove the `NO_UNSIGNED_SUBTRACTION` server SQL mode after creating `tu`, you may no longer be able to access this table:

```
mysql> SET sql_mode='';
Query OK, 0 rows affected (0.00 sec)
```

```
mysql> SELECT * FROM tu;
ERROR 1563 (HY000): Partition constant is out of partition function domain
mysql> INSERT INTO tu VALUES (20);
ERROR 1563 (HY000): Partition constant is out of partition function domain
```

Server SQL modes also impact replication of partitioned tables. Differing SQL modes on master and slave can lead to partitioning expressions being evaluated differently; this can cause the distribution of data among partitions to be different in the master's and slave's copies of a given table, and may even cause inserts into partitioned tables that succeed on the master to fail on the slave. For best results, you should always use the same server SQL mode on the master and on the slave.

Performance considerations. Some affects of partitioning operations on performance are given in the following list:

- **File system operations.** Partitioning and repartitioning operations (such as `ALTER TABLE` with `PARTITION BY ...`, `REORGANIZE PARTITIONS`, or `REMOVE PARTITIONING`) depend on file system operations for their implementation. This means that the speed of these operations is affected by such factors as file system type and characteristics, disk speed, swap space, file handling efficiency of the operating system, and MySQL server options and variables that relate to file handling. In particular, you should make sure that `large_files_support` is enabled and that `open_files_limit` is set properly. For partitioned tables using the `MyISAM` storage engine, increasing `myisam_max_sort_file_size` may improve performance; partitioning and repartitioning operations involving `InnoDB` tables may be made more efficient by enabling `innodb_file_per_table`.

  See also Maximum number of partitions.

- **Table locks.** The process executing a partitioning operation on a table takes a write lock on the table. Reads from such tables are relatively unaffected; pending `INSERT` and `UPDATE` operations are performed as soon as the partitioning operation has completed.

- **Storage engine.** Partitioning operations, queries, and update operations generally tend to be faster with `MyISAM` tables than with `InnoDB` tables.

- **Use of indexes and partition pruning.** As with nonpartitioned tables, proper use of indexes can speed up queries on partitioned tables significantly. In addition, designing partitioned tables and queries on these tables to take advantage of *partition pruning* can improve performance dramatically. See Section 16.4, “Partition Pruning”, for more information.

- **Performance with `LOAD DATA`.** In MySQL 5.5, `LOAD DATA` uses buffering to improve performance. You should be aware that the buffer uses 130 KB memory per partition to achieve this.

Maximum number of partitions. The maximum possible number of partitions for a given table is 1024. This includes subpartitions.

If, when creating tables with a large number of partitions (but less than the maximum), you encounter an error message such as `Got error ... from storage engine: Out of resources when opening file`, you may be able to address the issue by increasing the value of the `open_files_limit` system variable. However, this is dependent on the operating system, and may not be possible or advisable on all platforms; see Section C.5.2.18, “`'File' Not Found` and Similar Errors”, for more information. In some cases, using large numbers (hundreds) of partitions may also not be advisable due to other concerns, so using more partitions does not automatically lead to better results.

See also File system operations.

Per-partition key caches. In MySQL 5.5, key caches are supported for partitioned `MyISAM` tables, using the `CACHE INDEX` and `LOAD INDEX INTO CACHE` statements. Key caches may be defined for one, several, or all partitions, and indexes for one, several, or all partitions may be preloaded into key caches.

Foreign keys not supported. Partitioned tables do not support foreign keys. More specifically, this means that the following two statements are true:

1. Definitions of tables employing user-defined partitioning may not contain foreign key references to other tables.
2. No table definition may contain a foreign key reference to a partitioned table.

The scope of these restrictions includes tables that use the `InnoDB` storage engine.

`ALTER TABLE ... ORDER BY`. An `ALTER TABLE ... ORDER BY column` statement run against a partitioned table causes ordering of rows only within each partition.

FULLTEXT indexes. Partitioned tables do not support `FULLTEXT` indexes. This includes partitioned tables employing the `My-`

`ISAM` storage engine.

Spatial columns. Columns with spatial data types such as `POINT` or `GEOMETRY` cannot be used in partitioned tables.

Temporary tables. Temporary tables cannot be partitioned. (Bug #17497)

Log tables. It is not possible to partition the log tables; an `ALTER TABLE ... PARTITION BY ...` statement on such a table fails with an error.

Data type of partitioning key. A partitioning key must be either an integer column or an expression that resolves to an integer. The column or expression value may also be `NULL`. (See Section 16.2.7, “How MySQL Partitioning Handles `NULL`”.)

There are two exceptions to this restriction:

1. When partitioning by [`LINEAR`] `KEY`, it is possible to use columns of other types as partitioning keys, because MySQL's internal key-hashing functions produce the correct data type from these types. For example, the following `CREATE TABLE` statement is valid:

   ```
   CREATE TABLE tkc (c1 CHAR)
   PARTITION BY KEY(c1)
   PARTITIONS 4;
   ```

2. When partitioning by `RANGE COLUMNS` or `LIST COLUMNS`, it is possible to use string, `DATE`, and `DATETIME` columns. For example, each of the following `CREATE TABLE` statements is valid:

   ```
   CREATE TABLE rc (c1 INT, c2 DATE)
   PARTITION BY RANGE COLUMNS(c2) (
       PARTITION p0 VALUES LESS THAN('1990-01-01'),
       PARTITION p1 VALUES LESS THAN('1995-01-01'),
       PARTITION p2 VALUES LESS THAN('2000-01-01'),
       PARTITION p3 VALUES LESS THAN('2005-01-01'),
       PARTITION p4 VALUES LESS THAN(MAXVALUE)
   );

   CREATE TABLE lc (c1 INT, c2 CHAR(1))
   PARTITION BY LIST COLUMNS(c2) (
       PARTITION p0 VALUES IN('a', 'd', 'g', 'j', 'm', 'p', 's', 'v', 'y'),
       PARTITION p1 VALUES IN('b', 'e', 'h', 'k', 'n', 'q', 't', 'w', 'z'),
       PARTITION p2 VALUES IN('c', 'f', 'i', 'l', 'o', 'r', 'u', 'x', NULL)
   );
   ```

Neither of the preceding exceptions applies to `BLOB` or `TEXT` column types.

Subqueries. A partitioning key may not be a subquery, even if that subquery resolves to an integer value or `NULL`.

Issues with subpartitions. Subpartitions must use `HASH` or `KEY` partitioning. Only `RANGE` and `LIST` partitions may be subpartitioned; `HASH` and `KEY` partitions cannot be subpartitioned.

Currently, `SUBPARTITION BY KEY` requires that the subpartitioning column or columns be specified explicitly, unlike the case with `PARTITION BY KEY`, where it can be omitted (in which case the table's primary key column is used by default). Consider the table created by this statement:

```
CREATE TABLE ts (
    id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    name VARCHAR(30)
);
```

You can create a table having the same columns, partitioned by `KEY`, using a statement such as this one:

```
CREATE TABLE ts (
    id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    name VARCHAR(30)
)
PARTITION BY KEY()
PARTITIONS 4;
```

The previous statement is treated as though it had been written like this, with the table's primary key column used as the partitioning column:

```
CREATE TABLE ts (
    id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    name VARCHAR(30)
)
PARTITION BY KEY(id)
PARTITIONS 4;
```

However, the following statement that attempts to create a subpartitioned table using the default column as the subpartitioning column fails, and the column must be specified for the statement to succeed, as shown here:

```
mysql> CREATE TABLE ts (
    ->     id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    ->     name VARCHAR(30)
    -> )
    -> PARTITION BY RANGE(id)
    -> SUBPARTITION BY KEY()
    -> SUBPARTITIONS 4
    -> (
    ->     PARTITION p0 VALUES LESS THAN (100),
    ->     PARTITION p1 VALUES LESS THAN (MAXVALUE)
    -> );
ERROR 1064 (42000): You have an error in your SQL syntax; check the manual that
corresponds to your MySQL server version for the right syntax to use near ')

mysql> CREATE TABLE ts (
    ->     id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    ->     name VARCHAR(30)
    -> )
    -> PARTITION BY RANGE(id)
    -> SUBPARTITION BY KEY(id)
    -> SUBPARTITIONS 4
    -> (
    ->     PARTITION p0 VALUES LESS THAN (100),
    ->     PARTITION p1 VALUES LESS THAN (MAXVALUE)
    -> );
Query OK, 0 rows affected (0.07 sec)
```

This is a known issue (see Bug #51470).

`DELAYED` option not supported. Use of `INSERT DELAYED` to insert rows into a partitioned table is not supported. Attempting to do so fails with an error.

`DATA DIRECTORY` and `INDEX DIRECTORY` options. `DATA DIRECTORY` and `INDEX DIRECTORY` are subject to the following restrictions when used with partitioned tables:

- Table-level `DATA DIRECTORY` and `INDEX DIRECTORY` options are ignored (see Bug #32091).
- On Windows, the `DATA DIRECTORY` and `INDEX DIRECTORY` options are not supported for individual partitions or subpartitions (Bug #30459).

Repairing and rebuilding partitioned tables. The statements `CHECK TABLE`, `OPTIMIZE TABLE`, `ANALYZE TABLE`, and `REPAIR TABLE` are supported for partitioned tables.

In addition, you can use `ALTER TABLE ... REBUILD PARTITION` to rebuild one or more partitions of a partitioned table; `ALTER TABLE ... REORGANIZE PARTITION` also causes partitions to be rebuilt. See Section 12.1.6, "`ALTER TABLE` Syntax", for more information about these two statements.

`mysqlcheck` and `myisamchk` are not supported with partitioned tables.

16.5.1. Partitioning Keys, Primary Keys, and Unique Keys

This section discusses the relationship of partitioning keys with primary keys and unique keys. The rule governing this relationship can be expressed as follows: All columns used in the partitioning expression for a partitioned table must be part of every unique key that the table may have.

In other words, *every unique key on the table must use every column in the table's partitioning expression*. (This also includes the table's primary key, since it is by definition a unique key. This particular case is discussed later in this section.) For example, each of the following table creation statements is invalid:

```
CREATE TABLE t1 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col2)
)
PARTITION BY HASH(col3)
PARTITIONS 4;

CREATE TABLE t2 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1),
    UNIQUE KEY (col3)
)
```

```
PARTITION BY HASH(col1 + col3)
PARTITIONS 4;
```

In each case, the proposed table would have at least one unique key that does not include all columns used in the partitioning expression.

Each of the following statements is valid, and represents one way in which the corresponding invalid table creation statement could be made to work:

```
CREATE TABLE t1 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col2, col3)
)
PARTITION BY HASH(col3)
PARTITIONS 4;

CREATE TABLE t2 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col3)
)
PARTITION BY HASH(col1 + col3)
PARTITIONS 4;
```

This example shows the error produced in such cases:

```
mysql> CREATE TABLE t3 (
    ->     col1 INT NOT NULL,
    ->     col2 DATE NOT NULL,
    ->     col3 INT NOT NULL,
    ->     col4 INT NOT NULL,
    ->     UNIQUE KEY (col1, col2),
    ->     UNIQUE KEY (col3)
    -> )
    -> PARTITION BY HASH(col1 + col3)
    -> PARTITIONS 4;
ERROR 1491 (HY000): A PRIMARY KEY MUST INCLUDE ALL COLUMNS IN THE TABLE'S PARTITIONING FUNCTION
```

The `CREATE TABLE` statement fails because both `col1` and `col3` are included in the proposed partitioning key, but neither of these columns is part of both of unique keys on the table. This shows one possible fix for the invalid table definition:

```
mysql> CREATE TABLE t3 (
    ->     col1 INT NOT NULL,
    ->     col2 DATE NOT NULL,
    ->     col3 INT NOT NULL,
    ->     col4 INT NOT NULL,
    ->     UNIQUE KEY (col1, col2, col3),
    ->     UNIQUE KEY (col3)
    -> )
    -> PARTITION BY HASH(col3)
    -> PARTITIONS 4;
Query OK, 0 rows affected (0.05 sec)
```

In this case, the proposed partitioning key `col3` is part of both unique keys, and the table creation statement succeeds.

The following table cannot be partitioned at all, because there is no way to include in a partitioning key any columns that belong to both unique keys:

```
CREATE TABLE t4 (
    col1 INT NOT NULL,
    col2 INT NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col3),
    UNIQUE KEY (col2, col4)
);
```

Since every primary key is by definition a unique key, this restriction also includes the table's primary key, if it has one. For example, the next two statements are invalid:

```
CREATE TABLE t5 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col2)
)
PARTITION BY HASH(col3)
```

```
PARTITIONS 4;

CREATE TABLE t6 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col3),
    UNIQUE KEY(col2)
)
PARTITION BY HASH( YEAR(col2) )
PARTITIONS 4;
```

In both cases, the primary key does not include all columns referenced in the partitioning expression. However, both of the next two statements are valid:

```
CREATE TABLE t7 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col2)
)
PARTITION BY HASH(col1 + YEAR(col2))
PARTITIONS 4;

CREATE TABLE t8 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col2, col4),
    UNIQUE KEY(col2, col1)
)
PARTITION BY HASH(col1 + YEAR(col2))
PARTITIONS 4;
```

If a table has no unique keys—this includes having no primary key—then this restriction does not apply, and you may use any column or columns in the partitioning expression as long as the column type is compatible with the partitioning type.

For the same reason, you cannot later add a unique key to a partitioned table unless the key includes all columns used by the table's partitioning expression. Consider the partitioned table created as shown here:

```
mysql> CREATE TABLE t_no_pk (c1 INT, c2 INT)
    ->     PARTITION BY RANGE(c1) (
    ->         PARTITION p0 VALUES LESS THAN (10),
    ->         PARTITION p1 VALUES LESS THAN (20),
    ->         PARTITION p2 VALUES LESS THAN (30),
    ->         PARTITION p3 VALUES LESS THAN (40)
    ->     );
Query OK, 0 rows affected (0.12 sec)
```

It is possible to add a primary key to `t_no_pk` using either of these `ALTER TABLE` statements:

```
#  possible PK
mysql> ALTER TABLE t_no_pk ADD PRIMARY KEY(c1);
Query OK, 0 rows affected (0.13 sec)
Records: 0  Duplicates: 0  Warnings: 0

# drop this PK
mysql> ALTER TABLE t_no_pk DROP PRIMARY KEY;
Query OK, 0 rows affected (0.10 sec)
Records: 0  Duplicates: 0  Warnings: 0

#  use another possible PK
mysql> ALTER TABLE t_no_pk ADD PRIMARY KEY(c1, c2);
Query OK, 0 rows affected (0.12 sec)
Records: 0  Duplicates: 0  Warnings: 0

# drop this PK
mysql> ALTER TABLE t_no_pk DROP PRIMARY KEY;
Query OK, 0 rows affected (0.09 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

However, the next statement fails, because `c1` is part of the partitioning key, but is not part of the proposed primary key:

```
#  fails with error 1503
mysql> ALTER TABLE t_no_pk ADD PRIMARY KEY(c2);
ERROR 1503 (HY000): A PRIMARY KEY MUST INCLUDE ALL COLUMNS IN THE TABLE'S PARTITIONING FUNCTION
```

Since `t_no_pk` has only `c1` in its partitioning expression, attempting to adding a unique key on `c2` alone fails. However, you can add a unique key that uses both `c1` and `c2`.

These rules also apply to existing nonpartitioned tables that you wish to partition using `ALTER TABLE ... PARTITION BY`.

Consider a table `np_pk` created as shown here:

```
mysql> CREATE TABLE np_pk (
    ->     id INT NOT NULL AUTO_INCREMENT,
    ->     name VARCHAR(50),
    ->     added DATE,
    ->     PRIMARY KEY (id)
    -> );
Query OK, 0 rows affected (0.08 sec)
```

The following `ALTER TABLE` statement fails with an error, because the `added` column is not part of any unique key in the table:

```
mysql> ALTER TABLE np_pk
    ->     PARTITION BY HASH( TO_DAYS(added) )
    ->     PARTITIONS 4;
ERROR 1503 (HY000): A PRIMARY KEY MUST INCLUDE ALL COLUMNS IN THE TABLE'S PARTITIONING FUNCTION
```

However, this statement using the `id` column for the partitioning column is valid, as shown here:

```
mysql> ALTER TABLE np_pk
    ->     PARTITION BY HASH(id)
    ->     PARTITIONS 4;
Query OK, 0 rows affected (0.11 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

In the case of `np_pk`, the only column that may be used as part of a partitioning expression is `id`; if you wish to partition this table using any other column or columns in the partitioning expression, you must first modify the table, either by adding the desired column or columns to the primary key, or by dropping the primary key altogether.

16.5.2. Partitioning Limitations Relating to Storage Engines

The following limitations apply to the use of storage engines with user-defined partitioning of tables.

`MERGE` storage engine. User-defined partitioning and the `MERGE` storage engine are not compatible. Tables using the `MERGE` storage engine cannot be partitioned. Partitioned tables cannot be merged.

`FEDERATED` storage engine. Partitioning of `FEDERATED` tables is not supported; it is not possible to create partitioned `FEDERATED` tables.

`CSV` storage engine. Partitioned tables using the `CSV` storage engine are not supported; it is not possible to create partitioned `CSV` tables.

Upgrading partitioned tables. When performing an upgrade, tables which are partitioned by `KEY` must be dumped and reloaded.

Same storage engine for all partitions. All partitions of a partitioned table must use the same storage engine and it must be the same storage engine used by the table as a whole. In addition, if one does not specify an engine on the table level, then one must do either of the following when creating or altering a partitioned table:

- Do *not* specify any engine for *any* partition or subpartition
- Specify the engine for *all* partitions or subpartitions

16.5.3. Partitioning Limitations Relating to Functions

This section discusses limitations in MySQL Partitioning relating specifically to functions used in partitioning expressions.

Only the MySQL functions shown in the following table are supported in partitioning expressions.

`ABS()`	`CEILING()` (see `CEILING()` and `FLOOR()`)	`DAY()`
`DAYOFMONTH()`	`DAYOFWEEK()`	`DAYOFYEAR()`
`DATEDIFF()`	`EXTRACT()` (see `EXTRACT()` function with WEEK specifier)	`FLOOR()` (see `CEILING()` and `FLOOR()`)
`HOUR()`	`MICROSECOND()`	`MINUTE()`
`MOD()`	`MONTH()`	`QUARTER()`
`SECOND()`	`TIME_TO_SEC()`	`TO_DAYS()`
`TO_SECONDS()` (implemented in MySQL 5.5.0)	`UNIX_TIMESTAMP()` (permitted beginning with MySQL 5.5.1 and fully suppor-	`WEEKDAY()`

	ted beginning with MySQL 5.5.15, with `TIMESTAMP` columns)	
`YEAR()`		`YEARWEEK()`

In MySQL 5.5, partition pruning is supported only for the `TO_DAYS()`, `TO_SECONDS()`, and `YEAR()` functions. In addition, beginning with MySQL 5.5.15, `UNIX_TIMESTAMP()` is treated as monotonic in partitioning expressions. See Section 16.4, “Partition Pruning”, for more information.

`CEILING()` and `FLOOR()`. Each of these functions returns an integer only if it is passed an argument of an exact numeric type, such as one of the `INT` types or `DECIMAL`. This means, for example, that the following `CREATE TABLE` statement fails with an error, as shown here:

```
mysql> CREATE TABLE t (c FLOAT) PARTITION BY LIST( FLOOR(c) )(
    ->     PARTITION p0 VALUES IN (1,3,5),
    ->     PARTITION p1 VALUES IN (2,4,6)
    -> );
ERROR 1490 (HY000): The PARTITION function returns the wrong type
```

`EXTRACT()` function with `WEEK` specifier. The value returned by the `EXTRACT()` function, when used as `EXTRACT(WEEK FROM col)`, depends on the value of the `default_week_format` system variable. For this reason, beginning with MySQL 5.5.9, `EXTRACT()` is longer permitted as a partitioning function when it specifies the unit as `WEEK`. (Bug #54483)

See Section 11.6.2, “Mathematical Functions”, for more information about the return types of these functions, as well as Section 10.2, “Numeric Types”.

Chapter 17. Stored Programs and Views

This chapter discusses stored programs and views, which are database objects defined in terms of SQL code that is stored on the server for later execution.

Stored programs include these objects:

- Stored routines, that is, stored procedures and functions. A stored procedure is invoked using the `CALL` statement. A procedure does not have a return value but can modify its parameters for later inspection by the caller. It can also generate result sets to be returned to the client program. A stored function is used much like a built-in function. you invoke it in an expression and it returns a value during expression evaluation.
- Triggers. A trigger is a named database object that is associated with a table and that is activated when a particular event occurs for the table, such as an insert or update.
- Events. An event is a task that the server runs according to schedule.

Views are stored queries that when referenced produce a result set. A view acts as a virtual table.

This chapter describes how to use stored programs and views. The following sections provide additional information about SQL syntax for statements related to these objects:

- For each object type, there are `CREATE`, `ALTER`, and `DROP` statements that control which objects exist and how they are defined. See Section 12.1, "Data Definition Statements".
- The `CALL` statement is used to invoke stored procedures. See Section 12.2.1, "`CALL` Syntax".
- Stored program definitions include a body that may use compound statements, loops, conditionals, and declared variables. See Section 12.7, "MySQL Compound-Statement Syntax".

17.1. Defining Stored Programs

Each stored program contains a body that consists of an SQL statement. This statement may be a compound statement made up of several statements separated by semicolon (`;`) characters. For example, the following stored procedure has a body made up of a `BEGIN ... END` block that contains a `SET` statement and a `REPEAT` loop that itself contains another `SET` statement:

```
CREATE PROCEDURE dorepeat(p1 INT)
BEGIN
  SET @x = 0;
  REPEAT SET @x = @x + 1; UNTIL @x > p1 END REPEAT;
END;
```

If you use the `mysql` client program to define a stored program that contains the semicolon characters within its definition, a problem arises. By default, `mysql` itself recognizes semicolon as a statement delimiter, so you must redefine the delimiter temporarily to cause `mysql` to pass the entire stored program definition to the server.

To redefine the `mysql` delimiter, use the `delimiter` command. The following example shows how to do this for the `dorepeat()` procedure just shown. The delimiter is changed to `//` to enable the entire definition to be passed to the server as a single statement, and then restored to `;` before invoking the procedure. This enables the `;` delimiter used in the procedure body to be passed through to the server rather than being interpreted by `mysql` itself.

```
mysql> delimiter //

mysql> CREATE PROCEDURE dorepeat(p1 INT)
    -> BEGIN
    ->   SET @x = 0;
    ->   REPEAT SET @x = @x + 1; UNTIL @x > p1 END REPEAT;
    -> END
    -> //
Query OK, 0 rows affected (0.00 sec)

mysql> delimiter ;

mysql> CALL dorepeat(1000);
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT @x;
+------+
| @x   |
+------+
| 1001 |
+------+
1 row in set (0.00 sec)
```

You can redefine the delimiter to a string other than `//`, and the delimiter can consist of a single character or multiple characters. You should avoid the use of the backslash ("`\`") character because that is the escape character for MySQL.

The following is an example of a function that takes a parameter, performs an operation using an SQL function, and returns the result. In this case, it is unnecessary to use `delimiter` because the function definition contains no internal `;` statement delimiters:

```
mysql> CREATE FUNCTION hello (s CHAR(20))
mysql> RETURNS CHAR(50) DETERMINISTIC
    -> RETURN CONCAT('Hello, ',s,'!');
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT hello('world');
+----------------+
| hello('world') |
+----------------+
| Hello, world!  |
+----------------+
1 row in set (0.00 sec)
```

17.2. Using Stored Routines (Procedures and Functions)

Stored routines (procedures and functions) are supported in MySQL 5.5. A stored routine is a set of SQL statements that can be stored in the server. Once this has been done, clients don't need to keep reissuing the individual statements but can refer to the stored routine instead.

Stored routines require the `proc` table in the `mysql` database. This table is created during the MySQL 5.5 installation procedure. If you are upgrading to MySQL 5.5 from an earlier version, be sure to update your grant tables to make sure that the `proc` table exists. See Section 4.4.7, "`mysql_upgrade` — Check Tables for MySQL Upgrade".

Stored routines can be particularly useful in certain situations:

- When multiple client applications are written in different languages or work on different platforms, but need to perform the same database operations.
- When security is paramount. Banks, for example, use stored procedures and functions for all common operations. This provides a consistent and secure environment, and routines can ensure that each operation is properly logged. In such a setup, applications and users would have no access to the database tables directly, but can only execute specific stored routines.

Stored routines can provide improved performance because less information needs to be sent between the server and the client. The tradeoff is that this does increase the load on the database server because more of the work is done on the server side and less is done on the client (application) side. Consider this if many client machines (such as Web servers) are serviced by only one or a few database servers.

Stored routines also enable you to have libraries of functions in the database server. This is a feature shared by modern application languages that enable such design internally (for example, by using classes). Using these client application language features is beneficial for the programmer even outside the scope of database use.

MySQL follows the SQL:2003 syntax for stored routines, which is also used by IBM's DB2.

The MySQL implementation of stored routines is still in progress. All syntax described here is supported and any limitations and extensions are documented where appropriate.

Additional Resources

- You may find the Stored Procedures User Forum of use when working with stored procedures and functions.
- For answers to some commonly asked questions regarding stored routines in MySQL, see Section B.4, "MySQL 5.5 FAQ: Stored Procedures and Functions".
- There are some restrictions on the use of stored routines. See Section E.1, "Restrictions on Stored Routines, Triggers, and Events".
- Binary logging for stored routines takes place as described in Section 17.7, "Binary Logging of Stored Programs".

17.2.1. Stored Routine Syntax

A stored routine is either a procedure or a function. Stored routines are created with the `CREATE PROCEDURE` and `CREATE FUNCTION` statements (see Section 12.1.12, “`CREATE PROCEDURE` and `CREATE FUNCTION` Syntax”). A procedure is invoked using a `CALL` statement (see Section 12.2.1, “`CALL` Syntax”), and can only pass back values using output variables. A function can be called from inside a statement just like any other function (that is, by invoking the function's name), and can return a scalar value. The body of a stored routine can use compound statements (see Section 12.7, “MySQL Compound-Statement Syntax”).

Stored routines can be dropped with the `DROP PROCEDURE` and `DROP FUNCTION` statements (see Section 12.1.21, “`DROP PROCEDURE` and `DROP FUNCTION` Syntax”), and altered with the `ALTER PROCEDURE` and `ALTER FUNCTION` statements (see Section 12.1.4, “`ALTER PROCEDURE` Syntax”).

A stored procedure or function is associated with a particular database. This has several implications:

- When the routine is invoked, an implicit `USE` *`db_name`* is performed (and undone when the routine terminates). `USE` statements within stored routines are not permitted.
- You can qualify routine names with the database name. This can be used to refer to a routine that is not in the current database. For example, to invoke a stored procedure `p` or function `f` that is associated with the `test` database, you can say `CALL test.p()` or `test.f()`.
- When a database is dropped, all stored routines associated with it are dropped as well.

Stored functions cannot be recursive.

Recursion in stored procedures is permitted but disabled by default. To enable recursion, set the `max_sp_recursion_depth` server system variable to a value greater than zero. Stored procedure recursion increases the demand on thread stack space. If you increase the value of `max_sp_recursion_depth`, it may be necessary to increase thread stack size by increasing the value of `thread_stack` at server startup. See Section 5.1.3, “Server System Variables”, for more information.

MySQL supports a very useful extension that enables the use of regular `SELECT` statements (that is, without using cursors or local variables) inside a stored procedure. The result set of such a query is simply sent directly to the client. Multiple `SELECT` statements generate multiple result sets, so the client must use a MySQL client library that supports multiple result sets. This means the client must use a client library from a version of MySQL at least as recent as 4.1. The client should also specify the `CLIENT_MULTI_RESULTS` option when it connects. For C programs, this can be done with the `mysql_real_connect()` C API function. See Section 20.9.3.52, “`mysql_real_connect()`”, and Section 20.9.13, “C API Support for Multiple Statement Execution”.

17.2.2. Stored Routines and MySQL Privileges

The MySQL grant system takes stored routines into account as follows:

- The `CREATE ROUTINE` privilege is needed to create stored routines.
- The `ALTER ROUTINE` privilege is needed to alter or drop stored routines. This privilege is granted automatically to the creator of a routine if necessary, and dropped from the creator when the routine is dropped.
- The `EXECUTE` privilege is required to execute stored routines. However, this privilege is granted automatically to the creator of a routine if necessary (and dropped from the creator when the routine is dropped). Also, the default `SQL SECURITY` characteristic for a routine is `DEFINER`, which enables users who have access to the database with which the routine is associated to execute the routine.
- If the `automatic_sp_privileges` system variable is 0, the `EXECUTE` and `ALTER ROUTINE` privileges are not automatically granted to and dropped from the routine creator.
- The creator of a routine is the account used to execute the `CREATE` statement for it. This might not be the same as the account named as the `DEFINER` in the routine definition.

The server manipulates the `mysql.proc` table in response to statements that create, alter, or drop stored routines. It is not supported that the server will notice manual manipulation of this table.

17.2.3. Stored Routine Metadata

Metadata about stored routines can be obtained as follows:

- Query the `ROUTINES` table of the `INFORMATION_SCHEMA` database. See Section 18.14, “The `INFORMATION_SCHEMA ROUTINES` Table”.

- Use the `SHOW CREATE PROCEDURE` and `SHOW CREATE FUNCTION` statements to see routine definitions. See Section 12.4.5.11, “`SHOW CREATE PROCEDURE` Syntax”.
- Use the `SHOW PROCEDURE STATUS` and `SHOW FUNCTION STATUS` statements to see routine characteristics. See Section 12.4.5.29, “`SHOW PROCEDURE STATUS` Syntax”.

17.2.4. Stored Procedures, Functions, Triggers, and `LAST_INSERT_ID()`

Within the body of a stored routine (procedure or function) or a trigger, the value of `LAST_INSERT_ID()` changes the same way as for statements executed outside the body of these kinds of objects (see Section 11.14, “Information Functions”). The effect of a stored routine or trigger upon the value of `LAST_INSERT_ID()` that is seen by following statements depends on the kind of routine:

- If a stored procedure executes statements that change the value of `LAST_INSERT_ID()`, the changed value is seen by statements that follow the procedure call.
- For stored functions and triggers that change the value, the value is restored when the function or trigger ends, so following statements do not see a changed value.

17.3. Using Triggers

A trigger is a named database object that is associated with a table, and that activates when a particular event occurs for the table. Some uses for triggers are to perform checks of values to be inserted into a table or to perform calculations on values involved in an update.

A trigger is defined to activate when an `INSERT`, `DELETE`, or `UPDATE` statement executes for the associated table. A trigger can be set to activate either before or after the triggering statement. For example, you can have a trigger activate before each row that is inserted into a table or after each row that is updated.

> **Important**
>
> MySQL triggers are activated by SQL statements *only*. They are not activated by changes in views, nor by changes to tables made by APIs that do not transmit SQL statements to the MySQL Server. This means that triggers are not activated by changes in `INFORMATION_SCHEMA` or `performance_schema` tables, because these tables are actually views.

To use triggers if you have upgraded to MySQL 5.5 from an older release that did not support triggers, you should upgrade your grant tables so that they contain the trigger-related privileges. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

The following discussion describes the syntax for creating and dropping triggers, and shows some examples of how to use them.

Additional Resources

- You may find the Triggers User Forum of use when working with views.
- For answers to some commonly asked questions regarding triggers in MySQL, see Section B.5, “MySQL 5.5 FAQ: Triggers”.
- There are some restrictions on the use of triggers; see Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.
- Binary logging for triggers takes place as described in Section 17.7, “Binary Logging of Stored Programs”.

17.3.1. Trigger Syntax

To create a trigger or drop a trigger, use the `CREATE TRIGGER` or `DROP TRIGGER` statement. The syntax for these statements is described in Section 12.1.15, “`CREATE TRIGGER` Syntax”, and Section 12.1.24, “`DROP TRIGGER` Syntax”.

Here is a simple example that associates a trigger with a table for `INSERT` statements. The trigger acts as an accumulator, summing the values inserted into one of the columns of the table.

```
mysql> CREATE TABLE account (acct_num INT, amount DECIMAL(10,2));
Query OK, 0 rows affected (0.03 sec)

mysql> CREATE TRIGGER ins_sum BEFORE INSERT ON account
    -> FOR EACH ROW SET @sum = @sum + NEW.amount;
```

```
Query OK, 0 rows affected (0.06 sec)
```

The `CREATE TRIGGER` statement creates a trigger named `ins_sum` that is associated with the `account` table. It also includes clauses that specify the trigger activation time, the triggering event, and what to do with the trigger activates:

- The keyword `BEFORE` indicates the trigger action time. In this case, the trigger should activate before each row inserted into the table. The other permissible keyword here is `AFTER`.
- The keyword `INSERT` indicates the event that activates the trigger. In the example, `INSERT` statements cause trigger activation. You can also create triggers for `DELETE` and `UPDATE` statements.
- The statement following `FOR EACH ROW` defines the statement to execute each time the trigger activates, which occurs once for each row affected by the triggering statement. In the example, the triggered statement is a simple `SET` that accumulates the values inserted into the `amount` column. The statement refers to the column as `NEW.amount` which means "the value of the `amount` column to be inserted into the new row."

To use the trigger, set the accumulator variable to zero, execute an `INSERT` statement, and then see what value the variable has afterward:

```
mysql> SET @sum = 0;
mysql> INSERT INTO account VALUES(137,14.98),(141,1937.50),(97,-100.00);
mysql> SELECT @sum AS 'Total amount inserted';
+-----------------------+
| Total amount inserted |
+-----------------------+
| 1852.48               |
+-----------------------+
```

In this case, the value of `@sum` after the `INSERT` statement has executed is `14.98 + 1937.50 - 100`, or `1852.48`.

To destroy the trigger, use a `DROP TRIGGER` statement. You must specify the schema name if the trigger is not in the default schema:

```
mysql> DROP TRIGGER test.ins_sum;
```

Triggers for a table are also dropped if you drop the table.

Trigger names exist in the schema namespace, meaning that all triggers must have unique names within a schema. Triggers in different schemas can have the same name.

In addition to the requirement that trigger names be unique for a schema, there are other limitations on the types of triggers you can create. In particular, you cannot have two triggers for a table that have the same activation time and activation event. For example, you cannot define two `BEFORE INSERT` triggers or two `AFTER UPDATE` triggers for a table. This should rarely be a significant limitation, because it is possible to define a trigger that executes multiple statements by using the `BEGIN ... END` compound statement construct after `FOR EACH ROW`. (An example appears later in this section.)

The `OLD` and `NEW` keywords enable you to access columns in the rows affected by a trigger. (`OLD` and `NEW` are not case sensitive.) In an `INSERT` trigger, only `NEW.col_name` can be used; there is no old row. In a `DELETE` trigger, only `OLD.col_name` can be used; there is no new row. In an `UPDATE` trigger, you can use `OLD.col_name` to refer to the columns of a row before it is updated and `NEW.col_name` to refer to the columns of the row after it is updated.

A column named with `OLD` is read only. You can refer to it (if you have the `SELECT` privilege), but not modify it. A column named with `NEW` can be referred to if you have the `SELECT` privilege for it. In a `BEFORE` trigger, you can also change its value with `SET NEW.col_name = value` if you have the `UPDATE` privilege for it. This means you can use a trigger to modify the values to be inserted into a new row or that are used to update a row.

In a `BEFORE` trigger, the `NEW` value for an `AUTO_INCREMENT` column is 0, not the automatically generated sequence number that will be generated when the new record actually is inserted.

`OLD` and `NEW` are MySQL extensions to triggers.

By using the `BEGIN ... END` construct, you can define a trigger that executes multiple statements. Within the `BEGIN` block, you also can use other syntax that is permitted within stored routines such as conditionals and loops. However, just as for stored routines, if you use the `mysql` program to define a trigger that executes multiple statements, it is necessary to redefine the `mysql` statement delimiter so that you can use the `;` statement delimiter within the trigger definition. The following example illustrates these points. It defines an `UPDATE` trigger that checks the new value to be used for updating each row, and modifies the value to be within the range from 0 to 100. This must be a `BEFORE` trigger because the value needs to be checked before it is used to update the row:

```
mysql> delimiter //
mysql> CREATE TRIGGER upd_check BEFORE UPDATE ON account
```

```
    -> FOR EACH ROW
    -> BEGIN
    ->     IF NEW.amount < 0 THEN
    ->         SET NEW.amount = 0;
    ->     ELSEIF NEW.amount > 100 THEN
    ->         SET NEW.amount = 100;
    ->     END IF;
    -> END;//
mysql> delimiter ;
```

It can be easier to define a stored procedure separately and then invoke it from the trigger using a simple `CALL` statement. This is also advantageous if you want to invoke the same routine from within several triggers.

There are some limitations on what can appear in statements that a trigger executes when activated:

- The trigger cannot use the `CALL` statement to invoke stored procedures that return data to the client or that use dynamic SQL. (Stored procedures are permitted to return data to the trigger through `OUT` or `INOUT` parameters.)
- The trigger cannot use statements that explicitly or implicitly begin or end a transaction such as `START TRANSACTION`, `COMMIT`, or `ROLLBACK`.

MySQL handles errors during trigger execution as follows:

- If a `BEFORE` trigger fails, the operation on the corresponding row is not performed.
- A `BEFORE` trigger is activated by the *attempt* to insert or modify the row, regardless of whether the attempt subsequently succeeds.
- An `AFTER` trigger is executed only if the `BEFORE` trigger (if any) and the row operation both execute successfully.
- An error during either a `BEFORE` or `AFTER` trigger results in failure of the entire statement that caused trigger invocation.
- For transactional tables, failure of a statement should cause rollback of all changes performed by the statement. Failure of a trigger causes the statement to fail, so trigger failure also causes rollback. For nontransactional tables, such rollback cannot be done, so although the statement fails, any changes performed prior to the point of the error remain in effect.

17.3.2. Trigger Metadata

Metadata about triggers can be obtained as follows:

- Query the `TRIGGERS` table of the `INFORMATION_SCHEMA` database. See Section 18.16, “The `INFORMATION_SCHEMA` `TRIGGERS` Table”.
- Use the `SHOW TRIGGERS` statement. See Section 12.4.5.39, “`SHOW TRIGGERS` Syntax”.

17.4. Using the Event Scheduler

The *MySQL Event Scheduler* manages the scheduling and execution of events: Tasks that run according to schedule. The following discussion covers the Event Scheduler and is divided into the following sections:

- Section 17.4.1, “Event Scheduler Overview”, provides an introduction to and conceptual overview of MySQL Events.
- Section 17.4.3, “Event Syntax”, discusses the SQL statements for creating, altering, and dropping MySQL Events.
- Section 17.4.4, “Event Metadata”, shows how to obtain information about events and how this information is stored by the MySQL Server.
- Section 17.4.6, “The Event Scheduler and MySQL Privileges”, discusses the privileges required to work with events and the ramifications that events have with regard to privileges when executing.

Stored routines require the `event` table in the `mysql` database. This table is created during the MySQL 5.5 installation procedure. If you are upgrading to MySQL 5.5 from an earlier version, be sure to update your grant tables to make sure that the `event` table exists. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

Additional Resources

- You may find the MySQL Event Scheduler User Forum of use when working with scheduled events.
- There are some restrictions on the use of events; see Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.
- Binary logging for events takes place as described in Section 17.7, “Binary Logging of Stored Programs”.

17.4.1. Event Scheduler Overview

MySQL Events are tasks that run according to a schedule. Therefore, we sometimes refer to them as *scheduled* events. When you create an event, you are creating a named database object containing one or more SQL statements to be executed at one or more regular intervals, beginning and ending at a specific date and time. Conceptually, this is similar to the idea of the Unix `crontab` (also known as a “cron job”) or the Windows Task Scheduler.

Scheduled tasks of this type are also sometimes known as “temporal triggers”, implying that these are objects that are triggered by the passage of time. While this is essentially correct, we prefer to use the term *events* to avoid confusion with triggers of the type discussed in Section 17.3, “Using Triggers”. Events should more specifically not be confused with “temporary triggers”. Whereas a trigger is a database object whose statements are executed in response to a specific type of event that occurs on a given table, a (scheduled) event is an object whose statements are executed in response to the passage of a specified time interval.

While there is no provision in the SQL Standard for event scheduling, there are precedents in other database systems, and you may notice some similarities between these implementations and that found in the MySQL Server.

MySQL Events have the following major features and properties:

- In MySQL 5.5, an event is uniquely identified by its name and the schema to which it is assigned.
- An event performs a specific action according to a schedule. This action consists of an SQL statement, which can be a compound statement in a `BEGIN ... END` block if desired (see Section 12.7, “MySQL Compound-Statement Syntax”). An event's timing can be either *one-time* or *recurrent*. A one-time event executes one time only. A recurrent event repeats its action at a regular interval, and the schedule for a recurring event can be assigned a specific start day and time, end day and time, both, or neither. (By default, a recurring event's schedule begins as soon as it is created, and continues indefinitely, until it is disabled or dropped.)

  If a repeating event does not terminate within its scheduling interval, the result may be multiple instances of the event executing simultaneously. If this is undesirable, you should institute a mechanism to prevent simultaneous instances. For example, you could use the `GET_LOCK()` function, or row or table locking.
- Users can create, modify, and drop scheduled events using SQL statements intended for these purposes. Syntactically invalid event creation and modification statements fail with an appropriate error message. *A user may include statements in an event's action which require privileges that the user does not actually have*. The event creation or modification statement succeeds but the event's action fails. See Section 17.4.6, “The Event Scheduler and MySQL Privileges” for details.
- Many of the properties of an event can be set or modified using SQL statements. These properties include the event's name, timing, persistence (that is, whether it is preserved following the expiration of its schedule), status (enabled or disabled), action to be performed, and the schema to which it is assigned. See Section 12.1.2, “`ALTER EVENT` Syntax”.

  The default definer of an event is the user who created the event, unless the event has been altered, in which case the definer is the user who issued the last `ALTER EVENT` statement affecting that event. An event can be modified by any user having the `EVENT` privilege on the database for which the event is defined. See Section 17.4.6, “The Event Scheduler and MySQL Privileges”.
- An event's action statement may include most SQL statements permitted within stored routines. For restrictions, see Section E.1, “Restrictions on Stored Routines, Triggers, and Events”.

17.4.2. Event Scheduler Configuration

Events are executed by a special *event scheduler thread*; when we refer to the Event Scheduler, we actually refer to this thread. When running, the event scheduler thread and its current state can be seen by users having the `PROCESS` privilege in the output of `SHOW PROCESSLIST`, as shown in the discussion that follows.

The global `event_scheduler` system variable determines whether the Event Scheduler is enabled and running on the server. It has one of these 3 values, which affect event scheduling as described here:

- `OFF`: The Event Scheduler is stopped. The event scheduler thread does not run, is not shown in the output of `SHOW PROCESSLIST`, and no scheduled events are executed. `OFF` is the default value for `event_scheduler`.

  When the Event Scheduler is stopped (`event_scheduler` is `OFF`), it can be started by setting the value of `event_scheduler` to `ON`. (See next item.)

- `ON`: The Event Scheduler is started; the event scheduler thread runs and executes all scheduled events.

  When the Event Scheduler is `ON`, the event scheduler thread is listed in the output of `SHOW PROCESSLIST` as a daemon process, and its state is represented as shown here:

  ```
  mysql> SHOW PROCESSLIST\G
  *************************** 1. row ***************************
       Id: 1
     User: root
     Host: localhost
       db: NULL
  Command: Query
     Time: 0
    State: NULL
     Info: show processlist
  *************************** 2. row ***************************
       Id: 2
     User: event_scheduler
     Host: localhost
       db: NULL
  Command: Daemon
     Time: 3
    State: Waiting for next activation
     Info: NULL
  2 rows in set (0.00 sec)
  ```

  Event scheduling can be stopped by setting the value of `event_scheduler` to `OFF`.

- `DISABLED`: This value renders the Event Scheduler nonoperational. When the Event Scheduler is `DISABLED`, the event scheduler thread does not run (and so does not appear in the output of `SHOW PROCESSLIST`). In addition, the Event Scheduler state cannot be changed at runtime.

If the Event Scheduler status has not been set to `DISABLED`, `event_scheduler` can be toggled between `ON` and `OFF` (using `SET`). It is also possible to use `0` for `OFF`, and `1` for `ON` when setting this variable. Thus, any of the following 4 statements can be used in the `mysql` client to turn on the Event Scheduler:

```
SET GLOBAL event_scheduler = ON;
SET @@global.event_scheduler = ON;
SET GLOBAL event_scheduler = 1;
SET @@global.event_scheduler = 1;
```

Similarly, any of these 4 statements can be used to turn off the Event Scheduler:

```
SET GLOBAL event_scheduler = OFF;
SET @@global.event_scheduler = OFF;
SET GLOBAL event_scheduler = 0;
SET @@global.event_scheduler = 0;
```

Although `ON` and `OFF` have numeric equivalents, the value displayed for `event_scheduler` by `SELECT` or `SHOW VARIABLES` is always one of `OFF`, `ON`, or `DISABLED`. *`DISABLED` has no numeric equivalent*. For this reason, `ON` and `OFF` are usually preferred over `1` and `0` when setting this variable.

Note that attempting to set `event_scheduler` without specifying it as a global variable causes an error:

```
mysql< SET @@event_scheduler = OFF;
ERROR 1229 (HY000): Variable 'event_scheduler' is a GLOBAL
variable and should be set with SET GLOBAL
```

> **Important**
>
> It is possible to set the Event Scheduler to `DISABLED` only at server startup. If `event_scheduler` is `ON` or `OFF`, you cannot set it to `DISABLED` at runtime. Also, if the Event Scheduler is set to `DISABLED` at startup, you cannot change the value of `event_scheduler` at runtime.

To disable the event scheduler, use one of the following two methods:

- As a command-line option when starting the server:

  ```
  --event-scheduler=DISABLED
  ```

- In the server configuration file (`my.cnf`, or `my.ini` on Windows systems), include the line where it will be read by the server (for example, in a `[mysqld]` section):

  ```
  event_scheduler=DISABLED
  ```

To enable the Event Scheduler, restart the server without the `--event-scheduler=DISABLED` command-line option, or after removing or commenting out the line containing `event-scheduler=DISABLED` in the server configuration file, as appropriate. Alternatively, you can use `ON` (or `1`) or `OFF` (or `0`) in place of the `DISABLED` value when starting the server.

> **Note**
>
> You can issue event-manipulation statements when `event_scheduler` is set to `DISABLED`. No warnings or errors are generated in such cases (provided that the statements are themselves valid). However, scheduled events cannot execute until this variable is set to `ON` (or `1`). Once this has been done, the event scheduler thread executes all events whose scheduling conditions are satisfied.

Starting the MySQL server with the `--skip-grant-tables` option causes `event_scheduler` to be set to `DISABLED`, overriding any other value set either on the command line or in the `my.cnf` or `my.ini` file (Bug #26807).

For SQL statements used to create, alter, and drop events, see Section 17.4.3, “Event Syntax”.

MySQL 5.5 provides an `EVENTS` table in the `INFORMATION_SCHEMA` database. This table can be queried to obtain information about scheduled events which have been defined on the server. See Section 17.4.4, “Event Metadata”, and Section 18.20, “The `INFORMATION_SCHEMA EVENTS` Table”, for more information.

For information regarding event scheduling and the MySQL privilege system, see Section 17.4.6, “The Event Scheduler and MySQL Privileges”.

17.4.3. Event Syntax

MySQL 5.5 provides several SQL statements for working with scheduled events:

- New events are defined using the `CREATE EVENT` statement. See Section 12.1.9, “`CREATE EVENT` Syntax”.
- The definition of an existing event can be changed by means of the `ALTER EVENT` statement. See Section 12.1.2, “`ALTER EVENT` Syntax”.
- When a scheduled event is no longer wanted or needed, it can be deleted from the server by its definer using the `DROP EVENT` statement. See Section 12.1.18, “`DROP EVENT` Syntax”. Whether an event persists past the end of its schedule also depends on its `ON COMPLETION` clause, if it has one. See Section 12.1.9, “`CREATE EVENT` Syntax”.

  An event can be dropped by any user having the `EVENT` privilege for the database on which the event is defined. See Section 17.4.6, “The Event Scheduler and MySQL Privileges”.

17.4.4. Event Metadata

Metadata about events can be obtained as follows:

- Query the `event` table of the `mysql` database.
- Query the `EVENTS` table of the `INFORMATION_SCHEMA` database. See Section 18.20, “The `INFORMATION_SCHEMA EVENTS` Table”.
- Use the `SHOW CREATE EVENT` statement. See Section 12.4.5.9, “`SHOW CREATE EVENT` Syntax”.
- Use the `SHOW EVENTS` statement. See Section 12.4.5.19, “`SHOW EVENTS` Syntax”.

Event Scheduler Time Representation

Each session in MySQL has a session time zone (STZ). This is the session `time_zone` value that is initialized from the server's global `time_zone` value when the session begins but may be changed during the session.

The session time zone that is current when a `CREATE EVENT` or `ALTER EVENT` statement executes is used to interpret times specified in the event definition. This becomes the event time zone (ETZ); that is, the time zone that is used for event scheduling and is in effect within the event as it executes.

For representation of event information in the `mysql.event` table, the `execute_at`, `starts`, and `ends` times are converted to UTC and stored along with the event time zone. This enables event execution to proceed as defined regardless of any subsequent changes to the server time zone or daylight saving time effects. The `last_executed` time is also stored in UTC.

If you select information from `mysql.event`, the times just mentioned are retrieved as UTC values. These times can also be obtained by selecting from the `INFORMATION_SCHEMA.EVENTS` table or from `SHOW EVENTS`, but they are reported as ETZ values. Other times available from these sources indicate when an event was created or last altered; these are displayed as STZ values. The following table summarizes representation of event times.

Value	`mysql.event`	`INFORMATION_SCHEMA.EVENTS`	`SHOW EVENTS`
Execute at	UTC	ETZ	ETZ
Starts	UTC	ETZ	ETZ
Ends	UTC	ETZ	ETZ
Last executed	UTC	ETZ	n/a
Created	STZ	STZ	n/a
Last altered	STZ	STZ	n/a

17.4.5. Event Scheduler Status

The Event Scheduler writes information about event execution that terminates with an error or warning to the MySQL Server's error log. See Section 17.4.6, “The Event Scheduler and MySQL Privileges” for an example.

Information about the state of the Event Scheduler for debugging and troubleshooting purposes can be obtained by running `mysqladmin debug` (see Section 4.5.2, “`mysqladmin` — Client for Administering a MySQL Server”); after running this command, the server's error log contains output relating to the Event Scheduler, similar to what is shown here:

```
Events status:
LLA = Last Locked At  LUA = Last Unlocked At
WOC = Waiting On Condition  DL = Data Locked

Event scheduler status:
State      : INITIALIZED
Thread id  : 0
LLA        : init_scheduler:313
LUA        : init_scheduler:318
WOC        : NO
Workers    : 0
Executed   : 0
Data locked: NO

Event queue status:
Element count   : 1
Data locked     : NO
Attempting lock : NO
LLA             : init_queue:148
LUA             : init_queue:168
WOC             : NO
Next activation : 0000-00-00 00:00:00
```

In statements that occur as part of events executed by the Event Scheduler, diagnostics messages (not only errors, but also warnings) are written to the error log, and, on Windows, to the application event log. For frequently executed events, it is possible for this to result in many logged messages. For example, for `SELECT ... INTO var_list` statements, if the query returns no rows, a warning with error code 1329 occurs (`No data`), and the variable values remain unchanged. If the query returns multiple rows, error 1172 occurs (`Result consisted of more than one row`). For either condition, you can avoid having the warnings be logged by declaring a condition handler; see Section 12.7.4.2, “`DECLARE` for Handlers”. For statements that may retrieve multiple rows, another strategy is to use `LIMIT 1` to limit the result set to a single row.

17.4.6. The Event Scheduler and MySQL Privileges

To enable or disable the execution of scheduled events, it is necessary to set the value of the global `event_scheduler` system variable. This requires the `SUPER` privilege.

The `EVENT` privilege governs the creation, modification, and deletion of events. This privilege can be bestowed using `GRANT`. For example, this `GRANT` statement confers the `EVENT` privilege for the schema named `myschema` on the user `jon@ghidora`:

```
GRANT EVENT ON myschema.* TO jon@ghidora;
```

(We assume that this user account already exists, and that we wish for it to remain unchanged otherwise.)

To grant this same user the `EVENT` privilege on all schemas, use the following statement:

```
GRANT EVENT ON *.* TO jon@ghidora;
```

The `EVENT` privilege has global or schema-level scope. Therefore, trying to grant it on a single table results in an error as shown:

```
mysql> GRANT EVENT ON myschema.mytable TO jon@ghidora;
ERROR 1144 (42000): Illegal GRANT/REVOKE command; please
consult the manual to see which privileges can be used
```

It is important to understand that an event is executed with the privileges of its definer, and that it cannot perform any actions for which its definer does not have the requisite privileges. For example, suppose that `jon@ghidora` has the `EVENT` privilege for `myschema`. Suppose also that this user has the `SELECT` privilege for `myschema`, but no other privileges for this schema. It is possible for `jon@ghidora` to create a new event such as this one:

```
CREATE EVENT e_store_ts
    ON SCHEDULE
      EVERY 10 SECOND
    DO
      INSERT INTO myschema.mytable VALUES (UNIX_TIMESTAMP());
```

The user waits for a minute or so, and then performs a `SELECT * FROM mytable;` query, expecting to see several new rows in the table. Instead, the table is empty. Since the user does not have the `INSERT` privilege for the table in question, the event has no effect.

If you inspect the MySQL error log (*`hostname.err`*), you can see that the event is executing, but the action it is attempting to perform fails, as indicated by `RetCode=0`:

```
060209 22:39:44 [Note]     EVEX EXECUTING event newdb.e [EXPR:10]
060209 22:39:44 [Note]     EVEX EXECUTED event newdb.e  [EXPR:10]. RetCode=0
060209 22:39:54 [Note]     EVEX EXECUTING event newdb.e [EXPR:10]
060209 22:39:54 [Note]     EVEX EXECUTED event newdb.e  [EXPR:10]. RetCode=0
060209 22:40:04 [Note]     EVEX EXECUTING event newdb.e [EXPR:10]
060209 22:40:04 [Note]     EVEX EXECUTED event newdb.e  [EXPR:10]. RetCode=0
```

Since this user very likely does not have access to the error log, it is possible to verify whether the event's action statement is valid by executing it directly:

```
mysql> INSERT INTO myschema.mytable VALUES (UNIX_TIMESTAMP());
ERROR 1142 (42000): INSERT command denied to user
'jon'@'ghidora' for table 'mytable'
```

Inspection of the `INFORMATION_SCHEMA.EVENTS` table shows that `e_store_ts` exists and is enabled, but its `LAST_EXECUTED` column is `NULL`:

```
mysql> SELECT * FROM INFORMATION_SCHEMA.EVENTS
     >     WHERE EVENT_NAME='e_store_ts'
     >     AND EVENT_SCHEMA='myschema'\G
*************************** 1. row ***************************
   EVENT_CATALOG: NULL
    EVENT_SCHEMA: myschema
      EVENT_NAME: e_store_ts
         DEFINER: jon@ghidora
      EVENT_BODY: SQL
EVENT_DEFINITION: INSERT INTO myschema.mytable VALUES (UNIX_TIMESTAMP())
      EVENT_TYPE: RECURRING
      EXECUTE_AT: NULL
  INTERVAL_VALUE: 5
  INTERVAL_FIELD: SECOND
        SQL_MODE: NULL
          STARTS: 0000-00-00 00:00:00
            ENDS: 0000-00-00 00:00:00
          STATUS: ENABLED
   ON_COMPLETION: NOT PRESERVE
         CREATED: 2006-02-09 22:36:06
    LAST_ALTERED: 2006-02-09 22:36:06
   LAST_EXECUTED: NULL
   EVENT_COMMENT:
1 row in set (0.00 sec)
```

To rescind the `EVENT` privilege, use the `REVOKE` statement. In this example, the `EVENT` privilege on the schema `myschema` is removed from the `jon@ghidora` user account:

```
REVOKE EVENT ON myschema.* FROM jon@ghidora;
```

> **Important**
>
> Revoking the `EVENT` privilege from a user does not delete or disable any events that may have been created by that user.
>
> An event is not migrated or dropped as a result of renaming or dropping the user who created it.

Suppose that the user `jon@ghidora` has been granted the `EVENT` and `INSERT` privileges on the `myschema` schema. This user then creates the following event:

```
CREATE EVENT e_insert
    ON SCHEDULE
      EVERY 7 SECOND
    DO
      INSERT INTO myschema.mytable;
```

After this event has been created, `root` revokes the `EVENT` privilege for `jon@ghidora`. However, `e_insert` continues to execute, inserting a new row into `mytable` each seven seconds. The same would be true if `root` had issued either of these statements:

- `DROP USER jon@ghidora;`
- `RENAME USER jon@ghidora TO someotherguy@ghidora;`

You can verify that this is true by examining the `mysql.event` table (discussed later in this section) or the `INFORMATION_SCHEMA.EVENTS` table (see Section 18.20, "The `INFORMATION_SCHEMA EVENTS` Table") before and after issuing a `DROP USER` or `RENAME USER` statement.

Event definitions are stored in the `mysql.event` table. To drop an event created by another user account, the MySQL `root` user (or another user with the necessary privileges) can delete rows from this table. For example, to remove the event `e_insert` shown previously, `root` can use the following statement:

```
DELETE FROM mysql.event
    WHERE db = 'myschema'
      AND definer = 'jon@ghidora'
      AND name = 'e_insert';
```

It is very important to match the event name, database schema name, and user account when deleting rows from the `mysql.event` table. This is because the same user can create different events of the same name in different schemas.

Users' `EVENT` privileges are stored in the `Event_priv` columns of the `mysql.user` and `mysql.db` tables. In both cases, this column holds one of the values '`Y`' or '`N`'. '`N`' is the default. `mysql.user.Event_priv` is set to '`Y`' for a given user only if that user has the global `EVENT` privilege (that is, if the privilege was bestowed using `GRANT EVENT ON *.*`). For a schema-level `EVENT` privilege, `GRANT` creates a row in `mysql.db` and sets that row's `Db` column to the name of the schema, the `User` column to the name of the user, and the `Event_priv` column to '`Y`'. There should never be any need to manipulate these tables directly, since the `GRANT EVENT` and `REVOKE EVENT` statements perform the required operations on them.

Five status variables provide counts of event-related operations (but *not* of statements executed by events; see Section E.1, "Restrictions on Stored Routines, Triggers, and Events"). These are:

- `Com_create_event`: The number of `CREATE EVENT` statements executed since the last server restart.
- `Com_alter_event`: The number of `ALTER EVENT` statements executed since the last server restart.
- `Com_drop_event`: The number of `DROP EVENT` statements executed since the last server restart.
- `Com_show_create_event`: The number of `SHOW CREATE EVENT` statements executed since the last server restart.
- `Com_show_events`: The number of `SHOW EVENTS` statements executed since the last server restart.

You can view current values for all of these at one time by running the statement `SHOW STATUS LIKE '%event%';`.

17.5. Using Views

Views (including updatable views) are available in MySQL Server 5.5. Views are stored queries that when invoked produce a result set. A view acts as a virtual table.

To use views if you have upgraded to MySQL 5.5 from an older release that did not support views, you should upgrade your grant tables so that they contain the view-related privileges. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

The following discussion describes the syntax for creating and dropping views, and shows some examples of how to use them.

Additional Resources

- You may find the Views User Forum of use when working with views.
- For answers to some commonly asked questions regarding views in MySQL, see Section B.6, “MySQL 5.5 FAQ: Views”.
- There are some restrictions on the use of views; see Section E.5, “Restrictions on Views”.

17.5.1. View Syntax

The `CREATE VIEW` statement creates a new view (see Section 12.1.16, “`CREATE VIEW` Syntax”). To alter the definition of a view or drop a view, use `ALTER VIEW` (see Section 12.1.7, “`ALTER VIEW` Syntax”), or `DROP VIEW` (see Section 12.1.25, “`DROP VIEW` Syntax”).

A view can be created from many kinds of `SELECT` statements. It can refer to base tables or other views. It can use joins, `UNION`, and subqueries. The `SELECT` need not even refer to any tables. The following example defines a view that selects two columns from another table, as well as an expression calculated from those columns:

```
mysql> CREATE TABLE t (qty INT, price INT);
mysql> INSERT INTO t VALUES(3, 50), (5, 60);
mysql> CREATE VIEW v AS SELECT qty, price, qty*price AS value FROM t;
mysql> SELECT * FROM v;
+------+-------+-------+
| qty  | price | value |
+------+-------+-------+
|    3 |    50 |   150 |
|    5 |    60 |   300 |
+------+-------+-------+
mysql> SELECT * FROM v WHERE qty = 5;
+------+-------+-------+
| qty  | price | value |
+------+-------+-------+
|    5 |    60 |   300 |
+------+-------+-------+
```

17.5.2. View Processing Algorithms

The optional `ALGORITHM` clause for `CREATE VIEW` or `ALTER VIEW` is a MySQL extension to standard SQL. It affects how MySQL processes the view. `ALGORITHM` takes three values: `MERGE`, `TEMPTABLE`, or `UNDEFINED`. The default algorithm is `UNDEFINED` if no `ALGORITHM` clause is present.

For `MERGE`, the text of a statement that refers to the view and the view definition are merged such that parts of the view definition replace corresponding parts of the statement.

For `TEMPTABLE`, the results from the view are retrieved into a temporary table, which then is used to execute the statement.

For `UNDEFINED`, MySQL chooses which algorithm to use. It prefers `MERGE` over `TEMPTABLE` if possible, because `MERGE` is usually more efficient and because a view cannot be updatable if a temporary table is used.

A reason to choose `TEMPTABLE` explicitly is that locks can be released on underlying tables after the temporary table has been created and before it is used to finish processing the statement. This might result in quicker lock release than the `MERGE` algorithm so that other clients that use the view are not blocked as long.

A view algorithm can be `UNDEFINED` for three reasons:

- No `ALGORITHM` clause is present in the `CREATE VIEW` statement.
- The `CREATE VIEW` statement has an explicit `ALGORITHM = UNDEFINED` clause.
- `ALGORITHM = MERGE` is specified for a view that can be processed only with a temporary table. In this case, MySQL generates a warning and sets the algorithm to `UNDEFINED`.

As mentioned earlier, `MERGE` is handled by merging corresponding parts of a view definition into the statement that refers to the view. The following examples briefly illustrate how the `MERGE` algorithm works. The examples assume that there is a view `v_merge` that has this definition:

```
CREATE ALGORITHM = MERGE VIEW v_merge (vc1, vc2) AS
SELECT c1, c2 FROM t WHERE c3 > 100;
```

Example 1: Suppose that we issue this statement:

```
SELECT * FROM v_merge;
```

MySQL handles the statement as follows:

- `v_merge` becomes `t`
- `*` becomes `vc1, vc2`, which corresponds to `c1, c2`
- The view `WHERE` clause is added

The resulting statement to be executed becomes:

```
SELECT c1, c2 FROM t WHERE c3 > 100;
```

Example 2: Suppose that we issue this statement:

```
SELECT * FROM v_merge WHERE vc1 < 100;
```

This statement is handled similarly to the previous one, except that `vc1 < 100` becomes `c1 < 100` and the view `WHERE` clause is added to the statement `WHERE` clause using an `AND` connective (and parentheses are added to make sure the parts of the clause are executed with correct precedence). The resulting statement to be executed becomes:

```
SELECT c1, c2 FROM t WHERE (c3 > 100) AND (c1 < 100);
```

Effectively, the statement to be executed has a `WHERE` clause of this form:

```
WHERE (select WHERE) AND (view WHERE)
```

If the `MERGE` algorithm cannot be used, a temporary table must be used instead. `MERGE` cannot be used if the view contains any of the following constructs:

- Aggregate functions (`SUM()`, `MIN()`, `MAX()`, `COUNT()`, and so forth)
- `DISTINCT`
- `GROUP BY`
- `HAVING`
- `LIMIT`
- `UNION` or `UNION ALL`
- Subquery in the select list
- Refers only to literal values (in this case, there is no underlying table)

17.5.3. Updatable and Insertable Views

Some views are updatable. That is, you can use them in statements such as `UPDATE`, `DELETE`, or `INSERT` to update the contents of the underlying table. For a view to be updatable, there must be a one-to-one relationship between the rows in the view and the rows in the underlying table. There are also certain other constructs that make a view nonupdatable. To be more specific, a view is not updatable if it contains any of the following:

- Aggregate functions (`SUM()`, `MIN()`, `MAX()`, `COUNT()`, and so forth)
- `DISTINCT`

- `GROUP BY`
- `HAVING`
- `UNION` or `UNION ALL`
- Subquery in the select list
- Certain joins (see additional join discussion later in this section)
- Nonupdatable view in the `FROM` clause
- A subquery in the `WHERE` clause that refers to a table in the `FROM` clause
- Refers only to literal values (in this case, there is no underlying table to update)
- Uses `ALGORITHM = TEMPTABLE` (use of a temporary table always makes a view nonupdatable)
- Multiple references to any column of a base table.

With respect to insertability (being updatable with `INSERT` statements), an updatable view is insertable if it also satisfies these additional requirements for the view columns:

- There must be no duplicate view column names.
- The view must contain all columns in the base table that do not have a default value.
- The view columns must be simple column references and not derived columns. A derived column is one that is not a simple column reference but is derived from an expression. These are examples of derived columns:

  ```
  3.14159
  col1 + 3
  UPPER(col2)
  col3 / col4
  (subquery)
  ```

A view that has a mix of simple column references and derived columns is not insertable, but it can be updatable if you update only those columns that are not derived. Consider this view:

```
CREATE VIEW v AS SELECT col1, 1 AS col2 FROM t;
```

This view is not insertable because `col2` is derived from an expression. But it is updatable if the update does not try to update `col2`. This update is permissible:

```
UPDATE v SET col1 = 0;
```

This update is not permissible because it attempts to update a derived column:

```
UPDATE v SET col2 = 0;
```

It is sometimes possible for a multiple-table view to be updatable, assuming that it can be processed with the `MERGE` algorithm. For this to work, the view must use an inner join (not an outer join or a `UNION`). Also, only a single table in the view definition can be updated, so the `SET` clause must name only columns from one of the tables in the view. Views that use `UNION ALL` are not permitted even though they might be theoretically updatable, because the implementation uses temporary tables to process them.

For a multiple-table updatable view, `INSERT` can work if it inserts into a single table. `DELETE` is not supported.

`INSERT DELAYED` is not supported for views.

If a table contains an `AUTO_INCREMENT` column, inserting into an insertable view on the table that does not include the `AUTO_INCREMENT` column does not change the value of `LAST_INSERT_ID()`, because the side effects of inserting default values into columns not part of the view should not be visible.

The `WITH CHECK OPTION` clause can be given for an updatable view to prevent inserts or updates to rows except those for which the `WHERE` clause in the *`select_statement`* is true.

In a `WITH CHECK OPTION` clause for an updatable view, the `LOCAL` and `CASCADED` keywords determine the scope of check testing when the view is defined in terms of another view. The `LOCAL` keyword restricts the `CHECK OPTION` only to the view being defined. `CASCADED` causes the checks for underlying views to be evaluated as well. When neither keyword is given, the default is `CASCADED`. Consider the definitions for the following table and set of views:

```
mysql> CREATE TABLE t1 (a INT);
mysql> CREATE VIEW v1 AS SELECT * FROM t1 WHERE a < 2
    -> WITH CHECK OPTION;
mysql> CREATE VIEW v2 AS SELECT * FROM v1 WHERE a > 0
    -> WITH LOCAL CHECK OPTION;
mysql> CREATE VIEW v3 AS SELECT * FROM v1 WHERE a > 0
    -> WITH CASCADED CHECK OPTION;
```

Here the `v2` and `v3` views are defined in terms of another view, `v1`. `v2` has a `LOCAL` check option, so inserts are tested only against the `v2` check. `v3` has a `CASCADED` check option, so inserts are tested not only against its own check, but against those of underlying views. The following statements illustrate these differences:

```
mysql> INSERT INTO v2 VALUES (2);
Query OK, 1 row affected (0.00 sec)
mysql> INSERT INTO v3 VALUES (2);
ERROR 1369 (HY000): CHECK OPTION failed 'test.v3'
```

MySQL sets a flag, called the view updatability flag, at `CREATE VIEW` time. The flag is set to `YES` (true) if `UPDATE` and `DELETE` (and similar operations) are legal for the view. Otherwise, the flag is set to `NO` (false). The `IS_UPDATABLE` column in the `INFORMATION_SCHEMA.VIEWS` table displays the status of this flag. It means that the server always knows whether a view is updatable. If the view is not updatable, statements such `UPDATE`, `DELETE`, and `INSERT` are illegal and will be rejected. (Note that even if a view is updatable, it might not be possible to insert into it, as described elsewhere in this section.)

The updatability of views may be affected by the value of the `updatable_views_with_limit` system variable. See Section 5.1.3, “Server System Variables”.

17.5.4. View Metadata

Metadata about views can be obtained as follows:

- Query the `VIEWS` table of the `INFORMATION_SCHEMA` database. See Section 18.15, “The `INFORMATION_SCHEMA VIEWS` Table”.
- Use the `SHOW CREATE VIEW` statement. See Section 12.4.5.14, “`SHOW CREATE VIEW` Syntax”.

17.6. Access Control for Stored Programs and Views

Stored programs and views are defined prior to use and, when referenced, execute within a security context that determines their privileges. These privileges are controlled by their `DEFINER` attribute, and, if there is one, their `SQL SECURITY` characteristic.

All stored programs (procedures, functions, triggers, and events) and views can have a `DEFINER` attribute that names a MySQL account. If the `DEFINER` attribute is omitted from a stored program or view definition, the default account is the user who creates the object.

In addition, stored routines (procedures and functions) and views can have a `SQL SECURITY` characteristic with a value of `DEFINER` or `INVOKER` to specify whether the object executes in definer or invoker context. If the `SQL SECURITY` characteristic is omitted, the default is definer context.

Triggers and events have no `SQL SECURITY` characteristic and always execute in definer context. The server invokes these objects automatically as necessary, so there is no invoking user.

Definer and invoker security contexts differ as follows:

- A stored program or view that executes in definer security context executes with the privileges of the account named by its `DEFINER` attribute. These privileges may be entirely different from those of the invoking user. The invoker must have appropriate privileges to reference the object (for example, `EXECUTE` to call a stored procedure or `SELECT` to select from a view), but when the object executes, the invoker's privileges are ignored and only the `DEFINER` account privileges matter. If this account has few privileges, the object is correspondingly limited in the operations it can perform. If the `DEFINER` account is highly privileged (such as a `root` account), the object can perform powerful operations *no matter who invokes it.*
- A stored routine or view that executes in invoker security context can perform only operations for which the invoker has privileges. The `DEFINER` attribute can be specified but has no effect for objects that execute in invoker context.

Consider the following stored procedure:

```
CREATE DEFINER = 'admin'@'localhost' PROCEDURE p1()
```

```
SQL SECURITY DEFINER
BEGIN
  UPDATE t1 SET counter = counter + 1;
END;
```

Any user who has the `EXECUTE` privilege for `p1` can invoke it with a `CALL` statement. However, when `p1` executes, it does so in `DEFINER` security context and thus executes with the privileges of `'admin'@'localhost'`, the account named in the `DEFINER` attribute. This account must have the `EXECUTE` privilege for `p1` as well as the `UPDATE` privilege for the table `t1`. Otherwise, the procedure fails.

Now consider this stored procedure, which is identical to `p1` except that its `SQL SECURITY` characteristic is `INVOKER`:

```
CREATE DEFINER = 'admin'@'localhost' PROCEDURE p2()
SQL SECURITY INVOKER
BEGIN
  UPDATE t1 SET counter = counter + 1;
END;
```

`p2`, unlike `p1`, executes in `INVOKER` security context. The `DEFINER` attribute is irrelevant and `p2` executes with the privileges of the invoking user. `p2` fails if the invoker lacks the `EXECUTE` privilege for `p2` or the `UPDATE` privilege for the table `t1`.

MySQL uses the following rules to control which accounts a user can specify in an object `DEFINER` attribute:

- You can specify a `DEFINER` value other than your own account only if you have the `SUPER` privilege.
- If you do not have the `SUPER` privilege, the only legal user value is your own account, either specified literally or by using `CURRENT_USER`. You cannot set the definer to some other account.

To minimize the risk potential for stored program and view creation and use, follow these guidelines:

- For a stored routine or view, use `SQL SECURITY INVOKER` in the object definition when possible so that it can be used only by users with permissions appropriate for the operations performed by the object.
- If you create definer-context stored programs or views while using an account that has the `SUPER` privilege, specify an explicit `DEFINER` attribute that names an account possessing only the privileges required for the operations performed by the object. Specify a highly privileged `DEFINER` account only when absolutely necessary.
- Administrators can prevent users from specifying highly privileged `DEFINER` accounts by not granting them the `SUPER` privilege.
- Definer-context objects should be written keeping in mind that they may be able to access data for which the invoking user has no privileges. In some cases, you can prevent reference to these objects by not granting unauthorized users particular privileges:
  - A stored procedure or function cannot be referenced by a user who does not have the `EXECUTE` privilege for it.
  - A view cannot be referenced by a user who does not have the appropriate privilege for it (`SELECT` to select from it, `INSERT` to insert into it, and so forth).

  However, no such control exists for triggers because users do not reference them directly. A trigger always executes in `DEFINER` context and is activated by access to the table with which it is associated, even ordinary table accesses by users with no special privileges. If the `DEFINER` account is highly privileged, the trigger can perform sensitive or dangerous operations. This remains true if the `SUPER` and `TRIGGER` privileges needed to create the trigger are revoked from the account of the user who created it. Administrators should be especially careful about granting users that combination of privileges.

17.7. Binary Logging of Stored Programs

The binary log contains information about SQL statements that modify database contents. This information is stored in the form of "events" that describe the modifications. The binary log has two important purposes:

- For replication, the binary log is used on master replication servers as a record of the statements to be sent to slave servers. The master server sends the events contained in its binary log to its slaves, which execute those events to make the same data changes that were made on the master. See Section 15.2, "Replication Implementation".
- Certain data recovery operations require use of the binary log. After a backup file has been restored, the events in the binary log that were recorded after the backup was made are re-executed. These events bring databases up to date from the point of the backup. See Section 6.3.2, "Using Backups for Recovery".

However, there are certain binary logging issues that apply with respect to stored programs (stored procedures and functions, triggers, and events), if logging occurs at the statement level:

- In some cases, it is possible that a statement will affect different sets of rows on a master and a slave.
- Replicated statements executed on a slave are processed by the slave SQL thread, which has full privileges. It is possible for a procedure to follow different execution paths on master and slave servers, so a user can write a routine containing a dangerous statement that will execute only on the slave where it is processed by a thread that has full privileges.
- If a stored program that modifies data is nondeterministic, it is not repeatable. This can result in different data on a master and slave, or cause restored data to differ from the original data.

This section describes how MySQL 5.5 handles binary logging for stored programs. It states the current conditions that the implementation places on the use of stored programs, and what you can do to avoid problems. It also provides additional information about the reasons for these conditions.

In general, the issues described here result when binary logging occurs at the SQL statement level. If you use row-based binary logging, the log contains changes made to individual rows as a result of executing SQL statements. When routines or triggers execute, row changes are logged, not the statements that make the changes. For stored procedures, this means that the `CALL` statement is not logged. For stored functions, row changes made within the function are logged, not the function invocation. For triggers, row changes made by the trigger are logged. On the slave side, only the row changes are seen, not the stored program invocation. For general information about row-based logging, see Section 15.1.2, “Replication Formats”.

Unless noted otherwise, the remarks here assume that you have enabled binary logging by starting the server with the `--log-bin` option. (See Section 5.2.4, “The Binary Log”.) If the binary log is not enabled, replication is not possible, nor is the binary log available for data recovery.

The current conditions on the use of stored functions in MySQL 5.5 can be summarized as follows. These conditions do not apply to stored procedures or Event Scheduler events and they do not apply unless binary logging is enabled.

- To create or alter a stored function, you must have the `SUPER` privilege, in addition to the `CREATE ROUTINE` or `ALTER ROUTINE` privilege that is normally required. (Depending on the `DEFINER` value in the function definition, `SUPER` might be required regardless of whether binary logging is enabled. See Section 12.1.12, “`CREATE PROCEDURE` and `CREATE FUNCTION` Syntax”.)
- When you create a stored function, you must declare either that it is deterministic or that it does not modify data. Otherwise, it may be unsafe for data recovery or replication.

  By default, for a `CREATE FUNCTION` statement to be accepted, at least one of `DETERMINISTIC`, `NO SQL`, or `READS SQL DATA` must be specified explicitly. Otherwise an error occurs:

  ```
  ERROR 1418 (HY000): This function has none of DETERMINISTIC, NO SQL,
  or READS SQL DATA in its declaration and binary logging is enabled
  (you *might* want to use the less safe log_bin_trust_function_creators
  variable)
  ```

  This function is deterministic (and does not modify data), so it is safe:

  ```
  CREATE FUNCTION f1(i INT)
  RETURNS INT
  DETERMINISTIC
  READS SQL DATA
  BEGIN
    RETURN i;
  END;
  ```

  This function uses `UUID()`, which is not deterministic, so the function also is not deterministic and is not safe:

  ```
  CREATE FUNCTION f2()
  RETURNS CHAR(36) CHARACTER SET utf8
  BEGIN
    RETURN UUID();
  END;
  ```

  This function modifies data, so it may not be safe:

  ```
  CREATE FUNCTION f3(p_id INT)
  RETURNS INT
  BEGIN
    UPDATE t SET modtime = NOW() WHERE id = p_id;
    RETURN ROW_COUNT();
  END;
  ```

Assessment of the nature of a function is based on the “honesty” of the creator: MySQL does not check that a function declared `DETERMINISTIC` is free of statements that produce nondeterministic results.

- Although it is possible to create a deterministic stored function without specifying `DETERMINISTIC`, you cannot execute this function using statement-based binary logging. To execute such a function, you must use row-based or mixed binary logging. Alternatively, if you explicitly specify `DETERMINISTIC` in the function definition, you can use any kind of logging, including statement-based logging.
- To relax the preceding conditions on function creation (that you must have the `SUPER` privilege and that a function must be declared deterministic or to not modify data), set the global `log_bin_trust_function_creators` system variable to 1. By default, this variable has a value of 0, but you can change it like this:

  ```
  mysql> SET GLOBAL log_bin_trust_function_creators = 1;
  ```

  You can also set this variable by using the `--log-bin-trust-function-creators=1` option when starting the server.

  If binary logging is not enabled, `log_bin_trust_function_creators` does not apply. `SUPER` is not required for function creation unless, as described previously, the `DEFINER` value in the function definition requires it.
- For information about built-in functions that may be unsafe for replication (and thus cause stored functions that use them to be unsafe as well), see Section 15.4.1, “Replication Features and Issues”.

Triggers are similar to stored functions, so the preceding remarks regarding functions also apply to triggers with the following exception: `CREATE TRIGGER` does not have an optional `DETERMINISTIC` characteristic, so triggers are assumed to be always deterministic. However, this assumption might in some cases be invalid. For example, the `UUID()` function is nondeterministic (and does not replicate). You should be careful about using such functions in triggers.

Triggers can update tables, so error messages similar to those for stored functions occur with `CREATE TRIGGER` if you do not have the required privileges. On the slave side, the slave uses the trigger `DEFINER` attribute to determine which user is considered to be the creator of the trigger.

The rest of this section provides additional detail about the logging implementation and its implications. You need not read it unless you are interested in the background on the rationale for the current logging-related conditions on stored routine use. This discussion applies only for statement-based logging, and not for row-based logging, with the exception of the first item: `CREATE` and `DROP` statements are logged as statements regardless of the logging mode.

- The server writes `CREATE EVENT`, `CREATE PROCEDURE`, `CREATE FUNCTION`, `ALTER EVENT`, `ALTER PROCEDURE`, `ALTER FUNCTION`, `DROP EVENT`, `DROP PROCEDURE`, and `DROP FUNCTION` statements to the binary log.
- A stored function invocation is logged as a `SELECT` statement if the function changes data and occurs within a statement that would not otherwise be logged. This prevents nonreplication of data changes that result from use of stored functions in nonlogged statements. For example, `SELECT` statements are not written to the binary log, but a `SELECT` might invoke a stored function that makes changes. To handle this, a `SELECT func_name()` statement is written to the binary log when the given function makes a change. Suppose that the following statements are executed on the master:

  ```
  CREATE FUNCTION f1(a INT) RETURNS INT
  BEGIN
    IF (a < 3) THEN
      INSERT INTO t2 VALUES (a);
    END IF;
    RETURN 0;
  END;

  CREATE TABLE t1 (a INT);
  INSERT INTO t1 VALUES (1),(2),(3);

  SELECT f1(a) FROM t1;
  ```

  When the `SELECT` statement executes, the function `f1()` is invoked three times. Two of those invocations insert a row, and MySQL logs a `SELECT` statement for each of them. That is, MySQL writes the following statements to the binary log:

  ```
  SELECT f1(1);
  SELECT f1(2);
  ```

  The server also logs a `SELECT` statement for a stored function invocation when the function invokes a stored procedure that causes an error. In this case, the server writes the `SELECT` statement to the log along with the expected error code. On the slave, if the same error occurs, that is the expected result and replication continues. Otherwise, replication stops.

- Logging stored function invocations rather than the statements executed by a function has a security implication for replication, which arises from two factors:

  - It is possible for a function to follow different execution paths on master and slave servers.

  - Statements executed on a slave are processed by the slave SQL thread which has full privileges.

  The implication is that although a user must have the `CREATE ROUTINE` privilege to create a function, the user can write a function containing a dangerous statement that will execute only on the slave where it is processed by a thread that has full privileges. For example, if the master and slave servers have server ID values of 1 and 2, respectively, a user on the master server could create and invoke an unsafe function `unsafe_func()` as follows:

  ```
  mysql> delimiter //
  mysql> CREATE FUNCTION unsafe_func () RETURNS INT
      -> BEGIN
      ->   IF @@server_id=2 THEN dangerous_statement; END IF;
      ->   RETURN 1;
      -> END;
      -> //
  mysql> delimiter ;
  mysql> INSERT INTO t VALUES(unsafe_func());
  ```

  The `CREATE FUNCTION` and `INSERT` statements are written to the binary log, so the slave will execute them. Because the slave SQL thread has full privileges, it will execute the dangerous statement. Thus, the function invocation has different effects on the master and slave and is not replication-safe.

  To guard against this danger for servers that have binary logging enabled, stored function creators must have the `SUPER` privilege, in addition to the usual `CREATE ROUTINE` privilege that is required. Similarly, to use `ALTER FUNCTION`, you must have the `SUPER` privilege in addition to the `ALTER ROUTINE` privilege. Without the `SUPER` privilege, an error will occur:

  ```
  ERROR 1419 (HY000): You do not have the SUPER privilege and
  binary logging is enabled (you *might* want to use the less safe
  log_bin_trust_function_creators variable)
  ```

  If you do not want to require function creators to have the `SUPER` privilege (for example, if all users with the `CREATE ROUTINE` privilege on your system are experienced application developers), set the global `log_bin_trust_function_creators` system variable to 1. You can also set this variable by using the `--log-bin-trust-function-creators=1` option when starting the server. If binary logging is not enabled, `log_bin_trust_function_creators` does not apply. `SUPER` is not required for function creation unless, as described previously, the `DEFINER` value in the function definition requires it.

- If a function that performs updates is nondeterministic, it is not repeatable. This can have two undesirable effects:

  - It will make a slave different from the master.

  - Restored data will be different from the original data.

  To deal with these problems, MySQL enforces the following requirement: On a master server, creation and alteration of a function is refused unless you declare the function to be deterministic or to not modify data. Two sets of function characteristics apply here:

  - The `DETERMINISTIC` and `NOT DETERMINISTIC` characteristics indicate whether a function always produces the same result for given inputs. The default is `NOT DETERMINISTIC` if neither characteristic is given. To declare that a function is deterministic, you must specify `DETERMINISTIC` explicitly.

  - The `CONTAINS SQL`, `NO SQL`, `READS SQL DATA`, and `MODIFIES SQL DATA` characteristics provide information about whether the function reads or writes data. Either `NO SQL` or `READS SQL DATA` indicates that a function does not change data, but you must specify one of these explicitly because the default is `CONTAINS SQL` if no characteristic is given.

  By default, for a `CREATE FUNCTION` statement to be accepted, at least one of `DETERMINISTIC`, `NO SQL`, or `READS SQL DATA` must be specified explicitly. Otherwise an error occurs:

  ```
  ERROR 1418 (HY000): This function has none of DETERMINISTIC, NO SQL,
  or READS SQL DATA in its declaration and binary logging is enabled
  (you *might* want to use the less safe log_bin_trust_function_creators
  variable)
  ```

  If you set `log_bin_trust_function_creators` to 1, the requirement that functions be deterministic or not modify data is dropped.

- Stored procedure calls are logged at the statement level rather than at the `CALL` level. That is, the server does not log the `CALL` statement, it logs those statements within the procedure that actually execute. As a result, the same changes that occur on the master will be observed on slave servers. This prevents problems that could result from a procedure having different execution paths on different machines.

In general, statements executed within a stored procedure are written to the binary log using the same rules that would apply were the statements to be executed in standalone fashion. Some special care is taken when logging procedure statements because statement execution within procedures is not quite the same as in nonprocedure context:

- A statement to be logged might contain references to local procedure variables. These variables do not exist outside of stored procedure context, so a statement that refers to such a variable cannot be logged literally. Instead, each reference to a local variable is replaced by this construct for logging purposes:

  ```
  NAME_CONST(var_name, var_value)
  ```

  `var_name` is the local variable name, and *`var_value`* is a constant indicating the value that the variable has at the time the statement is logged. `NAME_CONST()` has a value of *`var_value`*, and a "name" of *`var_name`*. Thus, if you invoke this function directly, you get a result like this:

  ```
  mysql> SELECT NAME_CONST('myname', 14);
  +--------+
  | myname |
  +--------+
  |     14 |
  +--------+
  ```

  `NAME_CONST()` enables a logged standalone statement to be executed on a slave with the same effect as the original statement that was executed on the master within a stored procedure.

  The use of `NAME_CONST()` can result in a problem for `CREATE TABLE ... SELECT` statements when the source column expressions refer to local variables. Converting these references to `NAME_CONST()` expressions can result in column names that are different on the master and slave servers, or names that are too long to be legal column identifiers. A workaround is to supply aliases for columns that refer to local variables. Consider this statement when `myvar` has a value of 1:

  ```
  CREATE TABLE t1 SELECT myvar;
  ```

  That will be rewritten as follows:

  ```
  CREATE TABLE t1 SELECT NAME_CONST(myvar, 1);
  ```

  To ensure that the master and slave tables have the same column names, write the statement like this:

  ```
  CREATE TABLE t1 SELECT myvar AS myvar;
  ```

  The rewritten statement becomes:

  ```
  CREATE TABLE t1 SELECT NAME_CONST(myvar, 1) AS myvar;
  ```

- A statement to be logged might contain references to user-defined variables. To handle this, MySQL writes a `SET` statement to the binary log to make sure that the variable exists on the slave with the same value as on the master. For example, if a statement refers to a variable `@my_var`, that statement will be preceded in the binary log by the following statement, where *`value`* is the value of `@my_var` on the master:

  ```
  SET @my_var = value;
  ```

- Procedure calls can occur within a committed or rolled-back transaction. Transactional context is accounted for so that the transactional aspects of procedure execution are replicated correctly. That is, the server logs those statements within the procedure that actually execute and modify data, and also logs `BEGIN`, `COMMIT`, and `ROLLBACK` statements as necessary. For example, if a procedure updates only transactional tables and is executed within a transaction that is rolled back, those updates are not logged. If the procedure occurs within a committed transaction, `BEGIN` and `COMMIT` statements are logged with the updates. For a procedure that executes within a rolled-back transaction, its statements are logged using the same rules that would apply if the statements were executed in standalone fashion:

  - Updates to transactional tables are not logged.
  - Updates to nontransactional tables are logged because rollback does not cancel them.
  - Updates to a mix of transactional and nontransactional tables are logged surrounded by `BEGIN` and `ROLLBACK` so that slaves will make the same changes and rollbacks as on the master.

- A stored procedure call is *not* written to the binary log at the statement level if the procedure is invoked from within a stored function. In that case, the only thing logged is the statement that invokes the function (if it occurs within a statement that is logged) or a `DO` statement (if it occurs within a statement that is not logged). For this reason, care should be exercised in the use of stored functions that invoke a procedure, even if the procedure is otherwise safe in itself.

Chapter 18. `INFORMATION_SCHEMA` Tables

`INFORMATION_SCHEMA` provides access to database metadata.

Metadata is data about the data, such as the name of a database or table, the data type of a column, or access privileges. Other terms that sometimes are used for this information are *data dictionary* and *system catalog*.

`INFORMATION_SCHEMA` is the information database, the place that stores information about all the other databases that the MySQL server maintains. Inside `INFORMATION_SCHEMA` there are several read-only tables. They are actually views, not base tables, so there are no files associated with them.

In effect, we have a database named `INFORMATION_SCHEMA`, although the server does not create a database directory with that name. It is possible to select `INFORMATION_SCHEMA` as the default database with a `USE` statement, but it is possible only to read the contents of tables. You cannot insert into them, update them, or delete from them.

The fact that `INFORMATION_SCHEMA` tables are actually views also means that you cannot set triggers on them. See Section 17.3, "Using Triggers".

Here is an example of a statement that retrieves information from `INFORMATION_SCHEMA`:

```
mysql> SELECT table_name, table_type, engine
    -> FROM information_schema.tables
    -> WHERE table_schema = 'db5'
    -> ORDER BY table_name DESC;
+------------+------------+--------+
| table_name | table_type | engine |
+------------+------------+--------+
| v56        | VIEW       | NULL   |
| v3         | VIEW       | NULL   |
| v2         | VIEW       | NULL   |
| v          | VIEW       | NULL   |
| tables     | BASE TABLE | MyISAM |
| t7         | BASE TABLE | MyISAM |
| t3         | BASE TABLE | MyISAM |
| t2         | BASE TABLE | MyISAM |
| t          | BASE TABLE | MyISAM |
| pk         | BASE TABLE | InnoDB |
| loop       | BASE TABLE | MyISAM |
| kurs       | BASE TABLE | MyISAM |
| k          | BASE TABLE | MyISAM |
| into       | BASE TABLE | MyISAM |
| goto       | BASE TABLE | MyISAM |
| fk2        | BASE TABLE | InnoDB |
| fk         | BASE TABLE | InnoDB |
+------------+------------+--------+
17 rows in set (0.01 sec)
```

Explanation: The statement requests a list of all the tables in database `db5`, in reverse alphabetic order, showing just three pieces of information: the name of the table, its type, and its storage engine.

The definition for character columns (for example, `TABLES.TABLE_NAME`) is generally `VARCHAR(N) CHARACTER SET utf8` where `N` is at least 64. MySQL uses the default collation for this character set (`utf8_general_ci`) for all searches, sorts, comparisons, and other string operations on such columns. However, searches in `INFORMATION_SCHEMA` string columns are also affected by file system case sensitivity. For more information, see Section 9.1.7.9, "Collation and `INFORMATION_SCHEMA` Searches".

Each MySQL user has the right to access these tables, but can see only the rows in the tables that correspond to objects for which the user has the proper access privileges. In some cases (for example, the `ROUTINE_DEFINITION` column in the `INFORMATION_SCHEMA.ROUTINES` table), users who have insufficient privileges will see `NULL`.

The `SELECT ... FROM INFORMATION_SCHEMA` statement is intended as a more consistent way to provide access to the information provided by the various `SHOW` statements that MySQL supports (`SHOW DATABASES`, `SHOW TABLES`, and so forth). Using `SELECT` has these advantages, compared to `SHOW`:

- It conforms to Codd's rules. That is, all access is done on tables.
- Nobody needs to learn a new statement syntax. Because they already know how `SELECT` works, they only need to learn the object names.
- The implementor need not worry about adding keywords.
- There are millions of possible output variations, instead of just one. This provides more flexibility for applications that have varying requirements about what metadata they need.
- Migration is easier because every other DBMS does it this way.

However, because `SHOW` is popular and because it might be confusing were it to disappear, the advantages of conventional syntax are not a sufficient reason to eliminate `SHOW`. In fact, along with the implementation of `INFORMATION_SCHEMA`, there are enhancements to `SHOW` as well. These are described in Section 18.31, “Extensions to `SHOW` Statements”.

There is no difference between the privileges required for `SHOW` statements and those required to select information from `INFORMATION_SCHEMA`. In either case, you have to have some privilege on an object in order to see information about it.

`INFORMATION_SCHEMA` queries that search for information from more than one database might take a long time and impact performance. To check the efficiency of a query, you can use `EXPLAIN`. For information about `EXPLAIN` output that is specific to interpreting the cost of `INFORMATION_SCHEMA` queries, see Section 7.2.4, “Optimizing `INFORMATION_SCHEMA` Queries”.

The implementation for the `INFORMATION_SCHEMA` table structures in MySQL follows the ANSI/ISO SQL:2003 standard Part 11 *Schemata*. Our intent is approximate compliance with SQL:2003 core feature F021 *Basic information schema*.

Users of SQL Server 2000 (which also follows the standard) may notice a strong similarity. However, MySQL has omitted many columns that are not relevant for our implementation, and added columns that are MySQL-specific. One such column is the `ENGINE` column in the `INFORMATION_SCHEMA.TABLES` table.

Although other DBMSs use a variety of names, like `syscat` or `system`, the standard name is `INFORMATION_SCHEMA`.

The following sections describe each of the tables and columns that are in `INFORMATION_SCHEMA`. For each column, there are three pieces of information:

- “`INFORMATION_SCHEMA` Name” indicates the name for the column in the `INFORMATION_SCHEMA` table. This corresponds to the standard SQL name unless the “Remarks” field says “MySQL extension.”
- “`SHOW` Name” indicates the equivalent field name in the closest `SHOW` statement, if there is one.
- “Remarks” provides additional information where applicable. If this field is `NULL`, it means that the value of the column is always `NULL`. If this field says “MySQL extension,” the column is a MySQL extension to standard SQL.

To avoid using any name that is reserved in the standard or in DB2, SQL Server, or Oracle, we changed the names of some columns marked “MySQL extension”. (For example, we changed `COLLATION` to `TABLE_COLLATION` in the `TABLES` table.) See the list of reserved words near the end of this article: http://web.archive.org/web/20070409075643rn_1/www.dbazine.com/db2/db2-disarticles/gulutzan5.

Each section indicates what `SHOW` statement is equivalent to a `SELECT` that retrieves information from `INFORMATION_SCHEMA`, if there is such a statement. For `SHOW` statements that display information for the default database if you omit a `FROM` *`db_name`* clause, you can often select information for the default database by adding an `AND TABLE_SCHEMA = SCHEMA()` condition to the `WHERE` clause of a query that retrieves information from an `INFORMATION_SCHEMA` table.

> **Note**
>
> At present, there are some missing columns and some columns out of order. We are working on this and updating the documentation as changes are made.

For answers to questions that are often asked concerning the `INFORMATION_SCHEMA` database, see Section B.7, “MySQL 5.5 FAQ: `INFORMATION_SCHEMA`”.

18.1. The `INFORMATION_SCHEMA SCHEMATA` Table

A schema is a database, so the `SCHEMATA` table provides information about databases.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`CATALOG_NAME`		`def`
`SCHEMA_NAME`		Database
`DEFAULT_CHARACTER_SET_NAME`		
`DEFAULT_COLLATION_NAME`		
`SQL_PATH`		`NULL`

The following statements are equivalent:

```
SELECT SCHEMA_NAME AS `Database`
  FROM INFORMATION_SCHEMA.SCHEMATA
  [WHERE SCHEMA_NAME LIKE 'wild']
```

```
SHOW DATABASES
  [LIKE 'wild']
```

18.2. The `INFORMATION_SCHEMA TABLES` Table

The `TABLES` table provides information about tables in databases.

`INFORMATION_SCHEMA` Name	**`SHOW` Name**	**Remarks**
`TABLE_CATALOG`		`def`
`TABLE_SCHEMA`	`Table_`...	
`TABLE_NAME`	`Table_`...	
`TABLE_TYPE`		
`ENGINE`	`Engine`	MySQL extension
`VERSION`	`Version`	The version number of the table's `.frm` file, MySQL extension
`ROW_FORMAT`	`Row_format`	MySQL extension
`TABLE_ROWS`	`Rows`	MySQL extension
`AVG_ROW_LENGTH`	`Avg_row_length`	MySQL extension
`DATA_LENGTH`	`Data_length`	MySQL extension
`MAX_DATA_LENGTH`	`Max_data_length`	MySQL extension
`INDEX_LENGTH`	`Index_length`	MySQL extension
`DATA_FREE`	`Data_free`	MySQL extension
`AUTO_INCREMENT`	`Auto_increment`	MySQL extension
`CREATE_TIME`	`Create_time`	MySQL extension
`UPDATE_TIME`	`Update_time`	MySQL extension
`CHECK_TIME`	`Check_time`	MySQL extension
`TABLE_COLLATION`	`Collation`	MySQL extension
`CHECKSUM`	`Checksum`	MySQL extension
`CREATE_OPTIONS`	`Create_options`	MySQL extension
`TABLE_COMMENT`	`Comment`	MySQL extension

Notes:

- `TABLE_SCHEMA` and `TABLE_NAME` are a single field in a `SHOW` display, for example `Table_in_db1`.
- `TABLE_TYPE` should be `BASE TABLE` or `VIEW`. Currently, the `TABLES` table does not list `TEMPORARY` tables.
- For partitioned tables, the `ENGINE` column shows the name of the storage engine used by all partitions. (Previously, this column showed `PARTITION` for such tables.)
- The `TABLE_ROWS` column is `NULL` if the table is in the `INFORMATION_SCHEMA` database.

  For `InnoDB` tables, the row count is only a rough estimate used in SQL optimization. (This is also true if the `InnoDB` table is partitioned.)
- The `DATA_FREE` column shows the free space in bytes for `InnoDB` tables.
- We have nothing for the table's default character set. `TABLE_COLLATION` is close, because collation names begin with a character set name.
- The `CREATE_OPTIONS` column shows `partitioned` if the table is partitioned.

The following statements are equivalent:

```
SELECT table_name FROM INFORMATION_SCHEMA.TABLES
  WHERE table_schema = 'db_name'
  [AND table_name LIKE 'wild']

SHOW TABLES
  FROM db_name
  [LIKE 'wild']
```

18.3. The INFORMATION_SCHEMA COLUMNS Table

The `COLUMNS` table provides information about columns in tables.

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
`TABLE_CATALOG`		`def`
`TABLE_SCHEMA`		
`TABLE_NAME`		
`COLUMN_NAME`	`Field`	
`ORDINAL_POSITION`		see notes
`COLUMN_DEFAULT`	`Default`	
`IS_NULLABLE`	`Null`	
`DATA_TYPE`	`Type`	
`CHARACTER_MAXIMUM_LENGTH`	`Type`	
`CHARACTER_OCTET_LENGTH`		
`NUMERIC_PRECISION`	`Type`	
`NUMERIC_SCALE`	`Type`	
`CHARACTER_SET_NAME`		
`COLLATION_NAME`	`Collation`	
`COLUMN_TYPE`	`Type`	MySQL extension
`COLUMN_KEY`	`Key`	MySQL extension
`EXTRA`	`Extra`	MySQL extension
`PRIVILEGES`	`Privileges`	MySQL extension
`COLUMN_COMMENT`	`Comment`	MySQL extension

Notes:

- In `SHOW`, the `Type` display includes values from several different `COLUMNS` columns.
- `ORDINAL_POSITION` is necessary because you might want to say `ORDER BY ORDINAL_POSITION`. Unlike `SHOW`, `SELECT` does not have automatic ordering.
- `CHARACTER_OCTET_LENGTH` should be the same as `CHARACTER_MAXIMUM_LENGTH`, except for multi-byte character sets.
- `CHARACTER_SET_NAME` can be derived from `Collation`. For example, if you say `SHOW FULL COLUMNS FROM t`, and you see in the `Collation` column a value of `latin1_swedish_ci`, the character set is what is before the first underscore: `latin1`.

The following statements are nearly equivalent:

```
SELECT COLUMN_NAME, DATA_TYPE, IS_NULLABLE, COLUMN_DEFAULT
  FROM INFORMATION_SCHEMA.COLUMNS
  WHERE table_name = 'tbl_name'
  [AND table_schema = 'db_name']
  [AND column_name LIKE 'wild']

SHOW COLUMNS
  FROM tbl_name
  [FROM db_name]
  [LIKE 'wild']
```

18.4. The INFORMATION_SCHEMA STATISTICS Table

The `STATISTICS` table provides information about table indexes.

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
`TABLE_CATALOG`		`def`
`TABLE_SCHEMA`		= Database
`TABLE_NAME`	`Table`	
`NON_UNIQUE`	`Non_unique`	
`INDEX_SCHEMA`		= Database
`INDEX_NAME`	`Key_name`	
`SEQ_IN_INDEX`	`Seq_in_index`	
`COLUMN_NAME`	`Column_name`	
`COLLATION`	`Collation`	
`CARDINALITY`	`Cardinality`	
`SUB_PART`	`Sub_part`	MySQL extension
`PACKED`	`Packed`	MySQL extension
`NULLABLE`	`Null`	MySQL extension
`INDEX_TYPE`	`Index_type`	MySQL extension
`COMMENT`	`Comment`	MySQL extension

Notes:

- There is no standard table for indexes. The preceding list is similar to what SQL Server 2000 returns for `sp_statistics`, except that we replaced the name `QUALIFIER` with `CATALOG` and we replaced the name `OWNER` with `SCHEMA`.

  Clearly, the preceding table and the output from `SHOW INDEX` are derived from the same parent. So the correlation is already close.

The following statements are equivalent:

```
SELECT * FROM INFORMATION_SCHEMA.STATISTICS
  WHERE table_name = 'tbl_name'
  AND table_schema = 'db_name'

SHOW INDEX
  FROM tbl_name
  FROM db_name
```

18.5. The INFORMATION_SCHEMA USER_PRIVILEGES Table

The `USER_PRIVILEGES` table provides information about global privileges. This information comes from the `mysql.user` grant table.

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
`GRANTEE`		`'user_name'@'host_name'` value, MySQL extension
`TABLE_CATALOG`		`def`, MySQL extension
`PRIVILEGE_TYPE`		MySQL extension
`IS_GRANTABLE`		MySQL extension

Notes:

- This is a nonstandard table. It takes its values from the `mysql.user` table.

18.6. The INFORMATION_SCHEMA SCHEMA_PRIVILEGES Table

The `SCHEMA_PRIVILEGES` table provides information about schema (database) privileges. This information comes from the `mysql.db` grant table.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`GRANTEE`		`'user_name'@'host_name'` value, MySQL extension
`TABLE_CATALOG`		`def`, MySQL extension
`TABLE_SCHEMA`		MySQL extension
`PRIVILEGE_TYPE`		MySQL extension
`IS_GRANTABLE`		MySQL extension

Notes:

- This is a nonstandard table. It takes its values from the `mysql.db` table.

18.7. The `INFORMATION_SCHEMA TABLE_PRIVILEGES` Table

The `TABLE_PRIVILEGES` table provides information about table privileges. This information comes from the `mysql.tables_priv` grant table.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`GRANTEE`		`'user_name'@'host_name'` value
`TABLE_CATALOG`		`def`
`TABLE_SCHEMA`		
`TABLE_NAME`		
`PRIVILEGE_TYPE`		
`IS_GRANTABLE`		

Notes:

- `PRIVILEGE_TYPE` can contain one (and only one) of these values: `SELECT`, `INSERT`, `UPDATE`, `REFERENCES`, `ALTER`, `INDEX`, `DROP`, `CREATE VIEW`.

The following statements are *not* equivalent:

```
SELECT ... FROM INFORMATION_SCHEMA.TABLE_PRIVILEGES

SHOW GRANTS ...
```

18.8. The `INFORMATION_SCHEMA COLUMN_PRIVILEGES` Table

The `COLUMN_PRIVILEGES` table provides information about column privileges. This information comes from the `mysql.columns_priv` grant table.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`GRANTEE`		`'user_name'@'host_name'` value
`TABLE_CATALOG`		`def`
`TABLE_SCHEMA`		
`TABLE_NAME`		
`COLUMN_NAME`		
`PRIVILEGE_TYPE`		
`IS_GRANTABLE`		

Notes:

- In the output from `SHOW FULL COLUMNS`, the privileges are all in one field and in lowercase, for example, `select,insert,update,references`. In `COLUMN_PRIVILEGES`, there is one privilege per row, in uppercase.
- `PRIVILEGE_TYPE` can contain one (and only one) of these values: `SELECT`, `INSERT`, `UPDATE`, `REFERENCES`.
- If the user has `GRANT OPTION` privilege, `IS_GRANTABLE` should be `YES`. Otherwise, `IS_GRANTABLE` should be `NO`. The output does not list `GRANT OPTION` as a separate privilege.

The following statements are *not* equivalent:

```
SELECT ... FROM INFORMATION_SCHEMA.COLUMN_PRIVILEGES

SHOW GRANTS ...
```

18.9. The `INFORMATION_SCHEMA CHARACTER_SETS` Table

The `CHARACTER_SETS` table provides information about available character sets.

`INFORMATION_SCHEMA` Name	**`SHOW` Name**	**Remarks**
`CHARACTER_SET_NAME`	`Charset`	
`DEFAULT_COLLATE_NAME`	`Default collation`	
`DESCRIPTION`	`Description`	MySQL extension
`MAXLEN`	`Maxlen`	MySQL extension

The following statements are equivalent:

```
SELECT * FROM INFORMATION_SCHEMA.CHARACTER_SETS
  [WHERE CHARACTER_SET_NAME LIKE 'wild']

SHOW CHARACTER SET
  [LIKE 'wild']
```

18.10. The `INFORMATION_SCHEMA COLLATIONS` Table

The `COLLATIONS` table provides information about collations for each character set.

`INFORMATION_SCHEMA` Name	**`SHOW` Name**	**Remarks**
`COLLATION_NAME`	`Collation`	
`CHARACTER_SET_NAME`	`Charset`	MySQL extension
`ID`	`Id`	MySQL extension
`IS_DEFAULT`	`Default`	MySQL extension
`IS_COMPILED`	`Compiled`	MySQL extension
`SORTLEN`	`Sortlen`	MySQL extension

- `COLLATION_NAME` is the collation name.
- `CHARACTER_SET_NAME` is the name of the character set with which the collation is associated.
- `ID` is the collation ID.
- `IS_DEFAULT` indicates whether the collation is the default for its character set.
- `IS_COMPILED` indicates whether the character set is compiled into the server.
- `SORTLEN` is related to the amount of memory required to sort strings expressed in the character set.

Collation information is also available from the `SHOW COLLATION` statement. The following statements are equivalent:

```
SELECT COLLATION_NAME FROM INFORMATION_SCHEMA.COLLATIONS
  [WHERE COLLATION_NAME LIKE 'wild']
```

```
SHOW COLLATION
  [LIKE 'wild']
```

18.11. The INFORMATION_SCHEMA COLLATION_CHARACTER_SET_APPLICABILITY Table

The `COLLATION_CHARACTER_SET_APPLICABILITY` table indicates what character set is applicable for what collation. The columns are equivalent to the first two display fields that we get from `SHOW COLLATION`.

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
`COLLATION_NAME`	`Collation`	
`CHARACTER_SET_NAME`	`Charset`	

18.12. The INFORMATION_SCHEMA TABLE_CONSTRAINTS Table

The `TABLE_CONSTRAINTS` table describes which tables have constraints.

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
`CONSTRAINT_CATALOG`		`def`
`CONSTRAINT_SCHEMA`		
`CONSTRAINT_NAME`		
`TABLE_SCHEMA`		
`TABLE_NAME`		
`CONSTRAINT_TYPE`		

Notes:

- The `CONSTRAINT_TYPE` value can be `UNIQUE`, `PRIMARY KEY`, or `FOREIGN KEY`.
- The `UNIQUE` and `PRIMARY KEY` information is about the same as what you get from the `Key_name` field in the output from `SHOW INDEX` when the `Non_unique` field is `0`.
- The `CONSTRAINT_TYPE` column can contain one of these values: `UNIQUE`, `PRIMARY KEY`, `FOREIGN KEY`, `CHECK`. This is a `CHAR` (not `ENUM`) column. The `CHECK` value is not available until we support `CHECK`.

18.13. The INFORMATION_SCHEMA KEY_COLUMN_USAGE Table

The `KEY_COLUMN_USAGE` table describes which key columns have constraints.

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
`CONSTRAINT_CATALOG`		`def`
`CONSTRAINT_SCHEMA`		
`CONSTRAINT_NAME`		
`TABLE_CATALOG`		`def`
`TABLE_SCHEMA`		
`TABLE_NAME`		
`COLUMN_NAME`		
`ORDINAL_POSITION`		
`POSITION_IN_UNIQUE_CONSTRAINT`		
`REFERENCED_TABLE_SCHEMA`		
`REFERENCED_TABLE_NAME`		
`REFERENCED_COLUMN_NAME`		

Notes:

- If the constraint is a foreign key, then this is the column of the foreign key, not the column that the foreign key references.
- The value of `ORDINAL_POSITION` is the column's position within the constraint, not the column's position within the table. Column positions are numbered beginning with 1.
- The value of `POSITION_IN_UNIQUE_CONSTRAINT` is `NULL` for unique and primary-key constraints. For foreign-key constraints, it is the ordinal position in key of the table that is being referenced.

  Suppose that there are two tables name `t1` and `t3` that have the following definitions:

  ```
  CREATE TABLE t1
  (
      s1 INT,
      s2 INT,
      s3 INT,
      PRIMARY KEY(s3)
  ) ENGINE=InnoDB;

  CREATE TABLE t3
  (
      s1 INT,
      s2 INT,
      s3 INT,
      KEY(s1),
      CONSTRAINT CO FOREIGN KEY (s2) REFERENCES t1(s3)
  ) ENGINE=InnoDB;
  ```

  For those two tables, the `KEY_COLUMN_USAGE` table has two rows:

  - One row with `CONSTRAINT_NAME` = `'PRIMARY'`, `TABLE_NAME` = `'t1'`, `COLUMN_NAME` = `'s3'`, `ORDINAL_POSITION` = `1`, `POSITION_IN_UNIQUE_CONSTRAINT` = `NULL`.
  - One row with `CONSTRAINT_NAME` = `'CO'`, `TABLE_NAME` = `'t3'`, `COLUMN_NAME` = `'s2'`, `ORDINAL_POSITION` = `1`, `POSITION_IN_UNIQUE_CONSTRAINT` = `1`.

18.14. The `INFORMATION_SCHEMA ROUTINES` Table

The `ROUTINES` table provides information about stored routines (both procedures and functions). The `ROUTINES` table does not include user-defined functions (UDFs) at this time.

The column named "`mysql.proc` name" indicates the `mysql.proc` table column that corresponds to the `INFORMATION_SCHEMA.ROUTINES` table column, if any.

`INFORMATION_SCHEMA` Name	**`mysql.proc` Name**	**Remarks**
`SPECIFIC_NAME`	`specific_name`	
`ROUTINE_CATALOG`		`def`
`ROUTINE_SCHEMA`	`db`	
`ROUTINE_NAME`	`name`	
`ROUTINE_TYPE`	`type`	`{PROCEDURE|FUNCTION}`
`DATA_TYPE`		same as for `COLUMNS` table
`CHARACTER_MAXIMUM_LENGTH`		same as for `COLUMNS` table
`CHARACTER_OCTET_LENGTH`		same as for `COLUMNS` table
`NUMERIC_PRECISION`		same as for `COLUMNS` table
`NUMERIC_SCALE`		same as for `COLUMNS` table
`CHARACTER_SET_NAME`		same as for `COLUMNS` table
`COLLATION_NAME`		same as for `COLUMNS` table
`DTD_IDENTIFIER`		data type descriptor
`ROUTINE_BODY`		`SQL`
`ROUTINE_DEFINITION`	`body`	
`EXTERNAL_NAME`		`NULL`
`EXTERNAL_LANGUAGE`	`language`	`NULL`
`PARAMETER_STYLE`		`SQL`

`INFORMATION_SCHEMA` **Name**	**`mysql.proc`** **Name**	**Remarks**
`IS_DETERMINISTIC`	`is_deterministic`	
`SQL_DATA_ACCESS`	`sql_data_access`	
`SQL_PATH`		`NULL`
`SECURITY_TYPE`	`security_type`	
`CREATED`	`created`	
`LAST_ALTERED`	`modified`	
`SQL_MODE`	`sql_mode`	MySQL extension
`ROUTINE_COMMENT`	`comment`	MySQL extension
`DEFINER`	`definer`	MySQL extension
`CHARACTER_SET_CLIENT`		MySQL extension
`COLLATION_CONNECTION`		MySQL extension
`DATABASE_COLLATION`		MySQL extension

Notes:

- MySQL calculates `EXTERNAL_LANGUAGE` thus:
  - If `mysql.proc.language='SQL'`, `EXTERNAL_LANGUAGE` is `NULL`
  - Otherwise, `EXTERNAL_LANGUAGE` is what is in `mysql.proc.language`. However, we do not have external languages yet, so it is always `NULL`.
- `CHARACTER_SET_CLIENT` is the session value of the `character_set_client` system variable when the routine was created. `COLLATION_CONNECTION` is the session value of the `collation_connection` system variable when the routine was created. `DATABASE_COLLATION` is the collation of the database with which the routine is associated.
- The `DATA_TYPE`, `CHARACTER_MAXIMUM_LENGTH`, `CHARACTER_OCTET_LENGTH`, `NUMERIC_PRECISION`, `NUMERIC_SCALE`, `CHARACTER_SET_NAME`, and `COLLATION_NAME` columns provide information about the data type for the `RETURNS` clause of stored functions. If a stored routine is a stored procedure, these columns all are `NULL`. These columns were added in MySQL 5.5.3.

  Information about stored function `RETURNS` data types is also available in the `PARAMETERS` table. The return value data type row for a function can be identified as the row that has an `ORDINAL_POSITION` value of 0.

18.15. The `INFORMATION_SCHEMA VIEWS` Table

The `VIEWS` table provides information about views in databases. You must have the `SHOW VIEW` privilege to access this table.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`TABLE_CATALOG`		`def`
`TABLE_SCHEMA`		
`TABLE_NAME`		
`VIEW_DEFINITION`		
`CHECK_OPTION`		
`IS_UPDATABLE`		
`DEFINER`		
`SECURITY_TYPE`		
`CHARACTER_SET_CLIENT`		MySQL extension
`COLLATION_CONNECTION`		MySQL extension

Notes:

- The `VIEW_DEFINITION` column has most of what you see in the `Create Table` field that `SHOW CREATE VIEW` produces. Skip the words before `SELECT` and skip the words `WITH CHECK OPTION`. Suppose that the original statement was:

```
CREATE VIEW v AS
  SELECT s2,s1 FROM t
  WHERE s1 > 5
  ORDER BY s1
  WITH CHECK OPTION;
```

Then the view definition looks like this:

```
SELECT s2,s1 FROM t WHERE s1 > 5 ORDER BY s1
```

- The `CHECK_OPTION` column has a value of `NONE`, `CASCADE`, or `LOCAL`.
- MySQL sets a flag, called the view updatability flag, at `CREATE VIEW` time. The flag is set to `YES` (true) if `UPDATE` and `DELETE` (and similar operations) are legal for the view. Otherwise, the flag is set to `NO` (false). The `IS_UPDATABLE` column in the `VIEWS` table displays the status of this flag. It means that the server always knows whether a view is updatable. If the view is not updatable, statements such `UPDATE`, `DELETE`, and `INSERT` are illegal and will be rejected. (Note that even if a view is updatable, it might not be possible to insert into it; for details, refer to Section 12.1.16, “`CREATE VIEW` Syntax”.)
- The `DEFINER` column indicates who defined the view. `SECURITY_TYPE` has a value of `DEFINER` or `INVOKER`.
- `CHARACTER_SET_CLIENT` is the session value of the `character_set_client` system variable when the view was created. `COLLATION_CONNECTION` is the session value of the `collation_connection` system variable when the view was created.

MySQL lets you use different `sql_mode` settings to tell the server the type of SQL syntax to support. For example, you might use the `ANSI` SQL mode to ensure MySQL correctly interprets the standard SQL concatenation operator, the double bar (`||`), in your queries. If you then create a view that concatenates items, you might worry that changing the `sql_mode` setting to a value different from `ANSI` could cause the view to become invalid. But this is not the case. No matter how you write out a view definition, MySQL always stores it the same way, in a canonical form. Here is an example that shows how the server changes a double bar concatenation operator to a `CONCAT()` function:

```
mysql> SET sql_mode = 'ANSI';
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE VIEW test.v AS SELECT 'a' || 'b' as col1;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT VIEW_DEFINITION FROM INFORMATION_SCHEMA.VIEWS
    -> WHERE TABLE_SCHEMA = 'test' AND TABLE_NAME = 'v';
+----------------------------------+
| VIEW_DEFINITION                  |
+----------------------------------+
| select concat('a','b') AS `col1` |
+----------------------------------+
1 row in set (0.00 sec)
```

The advantage of storing a view definition in canonical form is that changes made later to the value of `sql_mode` will not affect the results from the view. However an additional consequence is that comments prior to `SELECT` are stripped from the definition by the server.

18.16. The `INFORMATION_SCHEMA TRIGGERS` Table

The `TRIGGERS` table provides information about triggers. You can see results only for databases and tables for which you have the `TRIGGER` privilege.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`TRIGGER_CATALOG`		`def`
`TRIGGER_SCHEMA`		
`TRIGGER_NAME`	`Trigger`	
`EVENT_MANIPULATION`	`Event`	
`EVENT_OBJECT_CATALOG`		`def`
`EVENT_OBJECT_SCHEMA`		
`EVENT_OBJECT_TABLE`	`Table`	
`ACTION_ORDER`		`0`
`ACTION_CONDITION`		`NULL`
`ACTION_STATEMENT`	`Statement`	

`INFORMATION_SCHEMA` Name	**`SHOW` Name**	**Remarks**
`ACTION_ORIENTATION`		`ROW`
`ACTION_TIMING`	`Timing`	
`ACTION_REFERENCE_OLD_TABLE`		`NULL`
`ACTION_REFERENCE_NEW_TABLE`		`NULL`
`ACTION_REFERENCE_OLD_ROW`		`OLD`
`ACTION_REFERENCE_NEW_ROW`		`NEW`
`CREATED`		`NULL` (`0`)
`SQL_MODE`		MySQL extension
`DEFINER`		MySQL extension
`CHARACTER_SET_CLIENT`		MySQL extension
`COLLATION_CONNECTION`		MySQL extension
`DATABASE_COLLATION`		MySQL extension

Notes:

- The `TRIGGER_SCHEMA` and `TRIGGER_NAME` columns contain the name of the database in which the trigger occurs and the trigger name, respectively.
- The `EVENT_MANIPULATION` column contains one of the values `'INSERT'`, `'DELETE'`, or `'UPDATE'`.
- As noted in Section 17.3, “Using Triggers”, every trigger is associated with exactly one table. The `EVENT_OBJECT_SCHEMA` and `EVENT_OBJECT_TABLE` columns contain the database in which this table occurs, and the table's name.
- The `ACTION_ORDER` column contains the ordinal position of the trigger's action within the list of all similar triggers on the same table. Currently, this value is always `0`, because it is not possible to have more than one trigger with the same `EVENT_MANIPULATION` and `ACTION_TIMING` on the same table.
- The `ACTION_STATEMENT` column contains the statement to be executed when the trigger is invoked. This is the same as the text displayed in the `Statement` column of the output from `SHOW TRIGGERS`. Note that this text uses UTF-8 encoding.
- The `ACTION_ORIENTATION` column always contains the value `'ROW'`.
- The `ACTION_TIMING` column contains one of the two values `'BEFORE'` or `'AFTER'`.
- The columns `ACTION_REFERENCE_OLD_ROW` and `ACTION_REFERENCE_NEW_ROW` contain the old and new column identifiers, respectively. This means that `ACTION_REFERENCE_OLD_ROW` always contains the value `'OLD'` and `ACTION_REFERENCE_NEW_ROW` always contains the value `'NEW'`.
- The `SQL_MODE` column shows the server SQL mode that was in effect at the time when the trigger was created (and thus which remains in effect for this trigger whenever it is invoked, *regardless of the current server SQL mode*). The possible range of values for this column is the same as that of the `sql_mode` system variable. See Section 5.1.6, “Server SQL Modes”.
- The `DEFINER` column indicates who defined the trigger.
- `CHARACTER_SET_CLIENT` is the session value of the `character_set_client` system variable when the trigger was created. `COLLATION_CONNECTION` is the session value of the `collation_connection` system variable when the trigger was created. `DATABASE_COLLATION` is the collation of the database with which the trigger is associated.
- The following columns currently always contain `NULL`: `ACTION_CONDITION`, `ACTION_REFERENCE_OLD_TABLE`, `ACTION_REFERENCE_NEW_TABLE`, and `CREATED`.

Example, using the `ins_sum` trigger defined in Section 17.3, “Using Triggers”:

```
mysql> SELECT * FROM INFORMATION_SCHEMA.TRIGGERS\G
*************************** 1. row ***************************
           TRIGGER_CATALOG: def
            TRIGGER_SCHEMA: test
              TRIGGER_NAME: ins_sum
        EVENT_MANIPULATION: INSERT
      EVENT_OBJECT_CATALOG: def
       EVENT_OBJECT_SCHEMA: test
        EVENT_OBJECT_TABLE: account
              ACTION_ORDER: 0
          ACTION_CONDITION: NULL
          ACTION_STATEMENT: SET @sum = @sum + NEW.amount
        ACTION_ORIENTATION: ROW
             ACTION_TIMING: BEFORE
ACTION_REFERENCE_OLD_TABLE: NULL
ACTION_REFERENCE_NEW_TABLE: NULL
  ACTION_REFERENCE_OLD_ROW: OLD
  ACTION_REFERENCE_NEW_ROW: NEW
                   CREATED: NULL
                  SQL_MODE:
                   DEFINER: me@localhost
```

See also Section 12.4.5.39, “`SHOW TRIGGERS` Syntax”.

18.17. The `INFORMATION_SCHEMA PLUGINS` Table

The `PLUGINS` table provides information about server plugins.

`INFORMATION_SCHEMA` Name	**`SHOW` Name**	**Remarks**
`PLUGIN_NAME`	`Name`	MySQL extension
`PLUGIN_VERSION`		MySQL extension
`PLUGIN_STATUS`	`Status`	MySQL extension
`PLUGIN_TYPE`	`Type`	MySQL extension
`PLUGIN_TYPE_VERSION`		MySQL extension
`PLUGIN_LIBRARY`	`Library`	MySQL extension
`PLUGIN_LIBRARY_VERSION`		MySQL extension
`PLUGIN_AUTHOR`		MySQL extension
`PLUGIN_DESCRIPTION`		MySQL extension
`PLUGIN_LICENSE`		MySQL extension
`LOAD_OPTION`		MySQL extension

Notes:

- The `PLUGINS` table is a nonstandard table.
- `PLUGIN_NAME` is the name used to refer to the plugin in statements such as `INSTALL PLUGIN` and `UNINSTALL PLUGIN`.
- `PLUGIN_VERSION` is the version from the plugin's general type descriptor.
- `PLUGIN_STATUS` indicates the plugin status, one of `ACTIVE`, `INACTIVE`, `DISABLED`, or `DELETED`.
- `PLUGIN_TYPE` indicates the type of plugin, such as `STORAGE ENGINE`, `INFORMATION_SCHEMA`, or `AUTHENTICATION`.
- `PLUGIN_TYPE_VERSION` is the version from the plugin's type-specific descriptor.
- `PLUGIN_LIBRARY` is the name of the plugin shared object file. This is the name used to refer to the plugin file in statements such as `INSTALL PLUGIN` and `UNINSTALL PLUGIN`. This file is located in the directory named by the `plugin_dir` system variable. If the library name is `NULL`, the plugin is compiled in and cannot be uninstalled with `UNINSTALL PLUGIN`.
- `PLUGIN_LIBRARY_VERSION` indicates the plugin API interface version.
- `PLUGIN_AUTHOR` names the plugin author.
- `PLUGIN_DESCRIPTION` provides a short description of the plugin.
- `PLUGIN_LICENSE` indicates how the plugin is licensed; for example, `GPL`.
- `LOAD_OPTION` indicates how the plugin was loaded. The value is `OFF`, `ON`, `FORCE`, or `FORCE_PLUS_PERMANENT`. See Section 5.1.7.1, “Installing and Uninstalling Plugins”. This column was added in MySQL 5.5.7.

For plugins installed with `INSTALL PLUGIN`, the `PLUGIN_NAME` and `PLUGIN_LIBRARY` values are also registered in the `mysql.plugin` table.

These statements are equivalent:

```
SELECT
```

```
  PLUGIN_NAME, PLUGIN_STATUS, PLUGIN_TYPE,
  PLUGIN_LIBRARY, PLUGIN_LICENSE
FROM INFORMATION_SCHEMA.PLUGINS;

SHOW PLUGINS;
```

For information about plugin data structures that form the basis of the information in the `PLUGINS` table, see Section 21.2, “The MySQL Plugin API”.

Plugin information is also available using the `SHOW PLUGINS` statement. See Section 12.4.5.26, “`SHOW PLUGINS` Syntax”.

18.18. The `INFORMATION_SCHEMA ENGINES` Table

The `PLUGINS` table provides information about storage engines.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`ENGINE`	`Engine`	MySQL extension
`SUPPORT`	`Support`	MySQL extension
`COMMENT`	`Comment`	MySQL extension
`TRANSACTIONS`	`Transactions`	MySQL extension
`XA`	`XA`	MySQL extension
`SAVEPOINTS`	`Savepoints`	MySQL extension

Notes:

- The `ENGINES` table is a nonstandard table.

See also Section 12.4.5.17, “`SHOW ENGINES` Syntax”.

18.19. The `INFORMATION_SCHEMA PARTITIONS` Table

The `PARTITIONS` table provides information about table partitions. See Chapter 16, *Partitioning*, for more information about partitioning tables.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`TABLE_CATALOG`		MySQL extension
`TABLE_SCHEMA`		MySQL extension
`TABLE_NAME`		MySQL extension
`PARTITION_NAME`		MySQL extension
`SUBPARTITION_NAME`		MySQL extension
`PARTITION_ORDINAL_POSITION`		MySQL extension
`SUBPARTITION_ORDINAL_POSITION`		MySQL extension
`PARTITION_METHOD`		MySQL extension
`SUBPARTITION_METHOD`		MySQL extension
`PARTITION_EXPRESSION`		MySQL extension
`SUBPARTITION_EXPRESSION`		MySQL extension
`PARTITION_DESCRIPTION`		MySQL extension
`TABLE_ROWS`		MySQL extension
`AVG_ROW_LENGTH`		MySQL extension
`DATA_LENGTH`		MySQL extension
`MAX_DATA_LENGTH`		MySQL extension
`INDEX_LENGTH`		MySQL extension
`DATA_FREE`		MySQL extension
`CREATE_TIME`		MySQL extension
`UPDATE_TIME`		MySQL extension

`INFORMATION_SCHEMA` Name	**`SHOW` Name**	**Remarks**
`CHECK_TIME`		MySQL extension
`CHECKSUM`		MySQL extension
`PARTITION_COMMENT`		MySQL extension
`NODEGROUP`		MySQL extension
`TABLESPACE_NAME`		MySQL extension

Notes:

- The `PARTITIONS` table is a nonstandard table.

  Each record in this table corresponds to an individual partition or subpartition of a partitioned table.
- `TABLE_CATALOG`: This column is always `def`.
- `TABLE_SCHEMA`: This column contains the name of the database to which the table belongs.
- `TABLE_NAME`: This column contains the name of the table containing the partition.
- `PARTITION_NAME`: The name of the partition.
- `SUBPARTITION_NAME`: If the `PARTITIONS` table record represents a subpartition, then this column contains the name of subpartition; otherwise it is `NULL`.
- `PARTITION_ORDINAL_POSITION`: All partitions are indexed in the same order as they are defined, with `1` being the number assigned to the first partition. The indexing can change as partitions are added, dropped, and reorganized; the number shown is this column reflects the current order, taking into account any indexing changes.
- `SUBPARTITION_ORDINAL_POSITION`: Subpartitions within a given partition are also indexed and reindexed in the same manner as partitions are indexed within a table.
- `PARTITION_METHOD`: One of the values `RANGE`, `LIST`, `HASH`, `LINEAR HASH`, `KEY`, or `LINEAR KEY`; that is, one of the available partitioning types as discussed in Section 16.2, "Partitioning Types".
- `SUBPARTITION_METHOD`: One of the values `HASH`, `LINEAR HASH`, `KEY`, or `LINEAR KEY`; that is, one of the available subpartitioning types as discussed in Section 16.2.6, "Subpartitioning".
- `PARTITION_EXPRESSION`: This is the expression for the partitioning function used in the `CREATE TABLE` or `ALTER TABLE` statement that created the table's current partitioning scheme.

  For example, consider a partitioned table created in the `test` database using this statement:

  ```
  CREATE TABLE tp (
      c1 INT,
      c2 INT,
      c3 VARCHAR(25)
  )
  PARTITION BY HASH(c1 + c2)
  PARTITIONS 4;
  ```

  The `PARTITION_EXPRESSION` column in a PARTITIONS table record for a partition from this table displays `c1 + c2`, as shown here:

  ```
  mysql> SELECT DISTINCT PARTITION_EXPRESSION
       >     FROM INFORMATION_SCHEMA.PARTITIONS
       >     WHERE TABLE_NAME='tp' AND TABLE_SCHEMA='test';
  +----------------------+
  | PARTITION_EXPRESSION |
  +----------------------+
  | c1 + c2              |
  +----------------------+
  1 row in set (0.09 sec)
  ```
- `SUBPARTITION_EXPRESSION`: This works in the same fashion for the subpartitioning expression that defines the subpartitioning for a table as `PARTITION_EXPRESSION` does for the partitioning expression used to define a table's partitioning.

  If the table has no subpartitions, then this column is `NULL`.
- `PARTITION_DESCRIPTION`: This column is used for RANGE and LIST partitions. For a `RANGE` partition, it contains the

value set in the partition's `VALUES LESS THAN` clause, which can be either an integer or `MAXVALUE`. For a `LIST` partition, this column contains the values defined in the partition's `VALUES IN` clause, which is a comma-separated list of integer values.

For partitions whose `PARTITION_METHOD` is other than `RANGE` or `LIST`, this column is always `NULL`.

- `TABLE_ROWS`: The number of table rows in the partition.

  For partitioned `InnoDB` tables, the row count given in the `TABLE_ROWS` column is only an estimated value used in SQL optimization, and may not always be exact.

- `AVG_ROW_LENGTH`: The average length of the rows stored in this partition or subpartition, in bytes.

  This is the same as `DATA_LENGTH` divided by `TABLE_ROWS`.

- `DATA_LENGTH`: The total length of all rows stored in this partition or subpartition, in bytes—that is, the total number of bytes stored in the partition or subpartition.

- `MAX_DATA_LENGTH`: The maximum number of bytes that can be stored in this partition or subpartition.

- `INDEX_LENGTH`: The length of the index file for this partition or subpartition, in bytes.

- `DATA_FREE`: The number of bytes allocated to the partition or subpartition but not used.

- `CREATE_TIME`: The time of the partition's or subpartition's creation.

- `UPDATE_TIME`: The time that the partition or subpartition was last modified.

- `CHECK_TIME`: The last time that the table to which this partition or subpartition belongs was checked.

  > **Note**
  >
  > Some storage engines do not update this time; for tables using these storage engines, this value is always `NULL`.

- `CHECKSUM`: The checksum value, if any; otherwise, this column is `NULL`.

- `PARTITION_COMMENT`: This column contains the text of any comment made for the partition.

  The default value for this column is an empty string.

- `NODEGROUP`: This is the nodegroup to which the partition belongs. This is relevant only to MySQL Cluster tables; otherwise the value of this column is always `0`.

- `TABLESPACE_NAME`: This column contains the name of the tablespace to which the partition belongs. Currently, the value of this column is always `DEFAULT`.

- A nonpartitioned table has one record in `INFORMATION_SCHEMA.PARTITIONS`; however, the values of the `PARTITION_NAME`, `SUBPARTITION_NAME`, `PARTITION_ORDINAL_POSITION`, `SUBPARTITION_ORDINAL_POSITION`, `PARTITION_METHOD`, `SUBPARTITION_METHOD`, `PARTITION_EXPRESSION`, `SUBPARTITION_EXPRESSION`, and `PARTITION_DESCRIPTION` columns are all `NULL`. (The `PARTITION_COMMENT` column in this case is blank.)

18.20. The `INFORMATION_SCHEMA EVENTS` Table

The `EVENTS` table provides information about scheduled events, which are discussed in Section 17.4, “Using the Event Scheduler”. The `SHOW Name` values correspond to column names of the `SHOW EVENTS` statement.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`EVENT_CATALOG`		`def`, MySQL extension
`EVENT_SCHEMA`	`Db`	MySQL extension
`EVENT_NAME`	`Name`	MySQL extension
`DEFINER`	`Definer`	MySQL extension
`TIME_ZONE`	`Time zone`	MySQL extension
`EVENT_BODY`		MySQL extension
`EVENT_DEFINITION`		MySQL extension
`EVENT_TYPE`	`Type`	MySQL extension

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`EXECUTE_AT`	`Execute at`	MySQL extension
`INTERVAL_VALUE`	`Interval value`	MySQL extension
`INTERVAL_FIELD`	`Interval field`	MySQL extension
`SQL_MODE`		MySQL extension
`STARTS`	`Starts`	MySQL extension
`ENDS`	`Ends`	MySQL extension
`STATUS`	`Status`	MySQL extension
`ON_COMPLETION`		MySQL extension
`CREATED`		MySQL extension
`LAST_ALTERED`		MySQL extension
`LAST_EXECUTED`		MySQL extension
`EVENT_COMMENT`		MySQL extension
`ORIGINATOR`	`Originator`	MySQL extension
`CHARACTER_SET_CLIENT`	`character_set_client`	MySQL extension
`COLLATION_CONNECTION`	`collation_connection`	MySQL extension
`DATABASE_COLLATION`	`Database Collation`	MySQL extension

Notes:

- The `EVENTS` table is a nonstandard table.
- `EVENT_CATALOG`: The value of this column is always `def`.
- `EVENT_SCHEMA`: The name of the schema (database) to which this event belongs.
- `EVENT_NAME`: The name of the event.
- `DEFINER`: The account of the user who created the event, in `'user_name'@'host_name'` format.
- `TIME_ZONE`: The event time zone, which is the time zone used for scheduling the event and that is in effect within the event as it executes. The default value is `SYSTEM`.
- `EVENT_BODY`: The language used for the statements in the event's `DO` clause; in MySQL 5.5, this is always `SQL`.

  This column is not to be confused with the column of the same name (now named `EVENT_DEFINITION`) that existed in earlier MySQL versions.
- `EVENT_DEFINITION`: The text of the SQL statement making up the event's `DO` clause; in other words, the statement executed by this event.
- `EVENT_TYPE`: The event repetition type, either `ONE TIME` (transient) or `RECURRING` (repeating).
- `EXECUTE_AT`: For a one-time event, this is the `DATETIME` value specified in the `AT` clause of the `CREATE EVENT` statement used to create the event, or of the last `ALTER EVENT` statement that modified the event. The value shown in this column reflects the addition or subtraction of any `INTERVAL` value included in the event's `AT` clause. For example, if an event is created using `ON SCHEDULE AT CURRENT_TIMESTAMP + '1:6' DAY_HOUR`, and the event was created at 2006-02-09 14:05:30, the value shown in this column would be `'2006-02-10 20:05:30'`.

  If the event's timing is determined by an `EVERY` clause instead of an `AT` clause (that is, if the event is recurring), the value of this column is `NULL`.
- `INTERVAL_VALUE`: For recurring events, this column contains the numeric portion of the event's `EVERY` clause.

  For a one-time event (that is, an event whose timing is determined by an `AT` clause), this column is `NULL`.
- `INTERVAL_FIELD`: For recurring events, this column contains the units portion of the `EVERY` clause governing the timing of the event. Thus, this column contains a value such as '`YEAR`', '`QUARTER`', '`DAY`', and so on.

  For a one-time event (that is, an event whose timing is determined by an `AT` clause), this column is `NULL`.

- `SQL_MODE`: The SQL mode in effect at the time the event was created or altered.
- `STARTS`: For a recurring event whose definition includes a `STARTS` clause, this column contains the corresponding `DATETIME` value. As with the `EXECUTE_AT` column, this value resolves any expressions used.

  If there is no `STARTS` clause affecting the timing of the event, this column is `NULL`
- `ENDS`: For a recurring event whose definition includes a `ENDS` clause, this column contains the corresponding `DATETIME` value. As with the `EXECUTE_AT` column, this value resolves any expressions used.

  If there is no `ENDS` clause affecting the timing of the event, this column is `NULL`.
- `STATUS`: One of the three values `ENABLED`, `DISABLED`, or `SLAVESIDE_DISABLED`.

  `SLAVESIDE_DISABLED` indicates that the creation of the event occurred on another MySQL server acting as a replication master and was replicated to the current MySQL server which is acting as a slave, but the event is not presently being executed on the slave. See Section 15.4.1.8, “Replication of Invoked Features”, for more information.
- `ON_COMPLETION`: One of the two values `PRESERVE` or `NOT PRESERVE`.
- `CREATED`: The date and time when the event was created. This is a `DATETIME` value.
- `LAST_ALTERED`: The date and time when the event was last modified. This is a `DATETIME` value. If the event has not been modified since its creation, this column holds the same value as the `CREATED` column.
- `LAST_EXECUTED`: The date and time when the event last executed. A `DATETIME` value. If the event has never executed, this column is `NULL`.

  `LAST_EXECUTED` indicates when the event started. As a result, the `ENDS` column is never less than `LAST_EXECUTED`.
- `EVENT_COMMENT`: The text of a comment, if the event has one. If not, the value of this column is an empty string.
- `ORIGINATOR`: The server ID of the MySQL server on which the event was created; used in replication. The default value is 0.
- `CHARACTER_SET_CLIENT` is the session value of the `character_set_client` system variable when the event was created. `COLLATION_CONNECTION` is the session value of the `collation_connection` system variable when the event was created. `DATABASE_COLLATION` is the collation of the database with which the event is associated.

Example: Suppose that the user `jon@ghidora` creates an event named `e_daily`, and then modifies it a few minutes later using an `ALTER EVENT` statement, as shown here:

```
DELIMITER |

CREATE EVENT e_daily
    ON SCHEDULE
      EVERY 1 DAY
    COMMENT 'Saves total number of sessions then clears the table each day'
    DO
      BEGIN
        INSERT INTO site_activity.totals (time, total)
          SELECT CURRENT_TIMESTAMP, COUNT(*)
            FROM site_activity.sessions;
        DELETE FROM site_activity.sessions;
      END |

DELIMITER ;

ALTER EVENT e_daily
    ENABLED;
```

(Note that comments can span multiple lines.)

This user can then run the following `SELECT` statement, and obtain the output shown:

```
mysql> SELECT * FROM INFORMATION_SCHEMA.EVENTS
     > WHERE EVENT_NAME = 'e_daily'
     > AND EVENT_SCHEMA = 'myschema'\G
*************************** 1. row ***************************
       EVENT_CATALOG: def
        EVENT_SCHEMA: test
          EVENT_NAME: e_daily
             DEFINER: paul@localhost
           TIME_ZONE: SYSTEM
          EVENT_BODY: SQL
    EVENT_DEFINITION: BEGIN
        INSERT INTO site_activity.totals (time, total)
          SELECT CURRENT_TIMESTAMP, COUNT(*)
            FROM site_activity.sessions;
        DELETE FROM site_activity.sessions;
```

```
      END
          EVENT_TYPE: RECURRING
          EXECUTE_AT: NULL
      INTERVAL_VALUE: 1
      INTERVAL_FIELD: DAY
            SQL_MODE:
              STARTS: 2008-09-03 12:13:39
                ENDS: NULL
              STATUS: ENABLED
       ON_COMPLETION: NOT PRESERVE
             CREATED: 2008-09-03 12:13:39
        LAST_ALTERED: 2008-09-03 12:13:39
       LAST_EXECUTED: NULL
       EVENT_COMMENT: Saves total number of sessions then clears the
                      table each day
          ORIGINATOR: 1
CHARACTER_SET_CLIENT: latin1
COLLATION_CONNECTION: latin1_swedish_ci
  DATABASE_COLLATION: latin1_swedish_ci
```

Times in the `EVENTS` table are displayed using the event time zone or the current session time zone, as described in Section 17.4.4, “Event Metadata”.

See also Section 12.4.5.19, “`SHOW EVENTS` Syntax”.

18.21. The `INFORMATION_SCHEMA FILES` Table

The `FILES` table provides information about the files in which MySQL tablespace data is stored.

`INFORMATION_SCHEMA` Name	**`SHOW` Name**	**Remarks**
`FILE_ID`		MySQL extension
`FILE_NAME`		MySQL extension
`FILE_TYPE`		MySQL extension
`TABLESPACE_NAME`		MySQL extension
`TABLE_CATALOG`		MySQL extension
`TABLE_SCHEMA`		MySQL extension
`TABLE_NAME`		MySQL extension
`LOGFILE_GROUP_NAME`		MySQL extension
`LOGFILE_GROUP_NUMBER`		MySQL extension
`ENGINE`		MySQL extension
`FULLTEXT_KEYS`		MySQL extension
`DELETED_ROWS`		MySQL extension
`UPDATE_COUNT`		MySQL extension
`FREE_EXTENTS`		MySQL extension
`TOTAL_EXTENTS`		MySQL extension
`EXTENT_SIZE`		MySQL extension
`INITIAL_SIZE`		MySQL extension
`MAXIMUM_SIZE`		MySQL extension
`AUTOEXTEND_SIZE`		MySQL extension
`CREATION_TIME`		MySQL extension
`LAST_UPDATE_TIME`		MySQL extension
`LAST_ACCESS_TIME`		MySQL extension
`RECOVER_TIME`		MySQL extension
`TRANSACTION_COUNTER`		MySQL extension
`VERSION`		MySQL extension
`ROW_FORMAT`		MySQL extension
`TABLE_ROWS`		MySQL extension
`AVG_ROW_LENGTH`		MySQL extension
`DATA_LENGTH`		MySQL extension
`MAX_DATA_LENGTH`		MySQL extension
`INDEX_LENGTH`		MySQL extension

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`DATA_FREE`		MySQL extension
`CREATE_TIME`		MySQL extension
`UPDATE_TIME`		MySQL extension
`CHECK_TIME`		MySQL extension
`CHECKSUM`		MySQL extension
`STATUS`		MySQL extension
`EXTRA`		MySQL extension

Notes:

- `FILE_ID` column values are auto-generated.
- `FILE_NAME` is the name of a data file created by `CREATE TABLESPACE` or `ALTER TABLESPACE`.
- `FILE_TYPE` is the tablespace file type.
- `TABLESPACE_NAME` is the name of the tablespace with which the file is associated.
- Currently, the value of the `TABLESPACE_CATALOG` column is always `NULL`.
- `TABLE_NAME` is the name of the table with which the file is associated, if any.
- The `EXTENT_SIZE` is always `0`.
- There are no `SHOW` statements associated with the `FILES` table.

18.22. The `INFORMATION_SCHEMA TABLESPACES` Table

The `TABLESPACES` table provides information about active tablespaces. The table was added in MySQL 5.5.3.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`TABLESPACE_NAME`		MySQL extension
`ENGINE`		MySQL extension
`TABLESPACE_TYPE`		MySQL extension
`LOGFILE_GROUP_NAME`		MySQL extension
`EXTENT_SIZE`		MySQL extension
`AUTOEXTEND_SIZE`		MySQL extension
`MAXIMUM_SIZE`		MySQL extension
`NODEGROUP_ID`		MySQL extension
`TABLESPACE_COMMENT`		MySQL extension

18.23. The `INFORMATION_SCHEMA PROCESSLIST` Table

The `PROCESSLIST` table provides information about which threads are running.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`ID`	`Id`	MySQL extension
`USER`	`User`	MySQL extension
`HOST`	`Host`	MySQL extension
`DB`	`db`	MySQL extension
`COMMAND`	`Command`	MySQL extension
`TIME`	`Time`	MySQL extension
`STATE`	`State`	MySQL extension

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`INFO`	`Info`	MySQL extension

For an extensive description of the table columns, see Section 12.4.5.30, “`SHOW PROCESSLIST` Syntax”.

Notes:

- The `PROCESSLIST` table is a nonstandard table.
- Like the output from the corresponding `SHOW` statement, the `PROCESSLIST` table will only show information about your own threads, unless you have the `PROCESS` privilege, in which case you will see information about other threads, too. As an anonymous user, you cannot see any rows at all.
- If an SQL statement refers to `INFORMATION_SCHEMA.PROCESSLIST`, then MySQL will populate the entire table once, when statement execution begins, so there is read consistency during the statement. There is no read consistency for a multi-statement transaction, though.

The following statements are equivalent:

```
SELECT * FROM INFORMATION_SCHEMA.PROCESSLIST

SHOW FULL PROCESSLIST
```

18.24. The `INFORMATION_SCHEMA REFERENTIAL_CONSTRAINTS` Table

The `REFERENTIAL_CONSTRAINTS` table provides information about foreign keys.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
CONSTRAINT_CATALOG		def
CONSTRAINT_SCHEMA		
CONSTRAINT_NAME		
UNIQUE_CONSTRAINT_CATALOG		def
UNIQUE_CONSTRAINT_SCHEMA		
UNIQUE_CONSTRAINT_NAME		
MATCH_OPTION		
UPDATE_RULE		
DELETE_RULE		
TABLE_NAME		
REFERENCED_TABLE_NAME		

Notes:

- `TABLE_NAME` has the same value as `TABLE_NAME` in `INFORMATION_SCHEMA.TABLE_CONSTRAINTS`.
- `CONSTRAINT_SCHEMA` and `CONSTRAINT_NAME` identify the foreign key.
- `UNIQUE_CONSTRAINT_SCHEMA`, `UNIQUE_CONSTRAINT_NAME`, and `REFERENCED_TABLE_NAME` identify the referenced key.
- The only valid value at this time for `MATCH_OPTION` is `NONE`.
- The possible values for `UPDATE_RULE` or `DELETE_RULE` are `CASCADE`, `SET NULL`, `SET DEFAULT`, `RESTRICT`, `NO ACTION`.

18.25. The `INFORMATION_SCHEMA GLOBAL_STATUS` and `SES-`

SION_STATUS Tables

The GLOBAL_STATUS and SESSION_STATUS tables provide information about server status variables. Their contents correspond to the information produced by the SHOW GLOBAL STATUS and SHOW SESSION STATUS statements (see Section 12.4.5.36, "SHOW STATUS Syntax").

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
VARIABLE_NAME	Variable_name	
VARIABLE_VALUE	Value	

Notes:

- The VARIABLE_VALUE column for each of these tables is defined as VARCHAR(20480).

18.26. The INFORMATION_SCHEMA GLOBAL_VARIABLES and SESSION_VARIABLES Tables

The GLOBAL_VARIABLES and SESSION_VARIABLES tables provide information about server status variables. Their contents correspond to the information produced by the SHOW GLOBAL VARIABLES and SHOW SESSION VARIABLES statements (see Section 12.4.5.40, "SHOW VARIABLES Syntax").

INFORMATION_SCHEMA Name	**SHOW Name**	**Remarks**
VARIABLE_NAME	Variable_name	
VARIABLE_VALUE	Value	

Notes:

- The VARIABLE_VALUE column for each of these tables is defined as VARCHAR(20480).

18.27. The INFORMATION_SCHEMA PARAMETERS Table

The PARAMETERS table provides information about stored procedure and function parameters, and about return values for stored functions. Parameter information is similar to the contents of the `param_list` column in the `mysql.proc` table.

INFORMATION_SCHEMA Name	**mysql.proc Name**	**Remarks**
SPECIFIC_CATALOG		def
SPECIFIC_SCHEMA	db	routine database
SPECIFIC_NAME	name	routine name
ORDINAL_POSITION		1, 2, 3, ... for parameters, 0 for function RETURNS clause
PARAMETER_MODE		IN, OUT, INOUT (NULL for RETURNS)
PARAMETER_NAME		parameter name (NULL for RETURNS)
DATA_TYPE		same as for COLUMNS table
CHARACTER_MAXIMUM_LENGTH		same as for COLUMNS table
CHARACTER_OCTET_LENGTH		same as for COLUMNS table
NUMERIC_PRECISION		same as for COLUMNS table
NUMERIC_SCALE		same as for COLUMNS table
CHARACTER_SET_NAME		same as for COLUMNS table
COLLATION_NAME		same as for COLUMNS table
DTD_IDENTIFIER		same as for COLUMNS table
ROUTINE_TYPE	type	same as for ROUTINES table

Notes:

- The `PARAMETERS` table was added in MySQL 5.5.3.
- For successive parameters of a stored procedure or function, the `ORDINAL_POSITION` values are 1, 2, 3, and so forth. For a stored function, there is also a row that describes the data type for the `RETURNS` clause. The return value is not a true parameter, so the row that describes it has these unique characteristics:
    - The `ORDINAL_POSITION` value is 0.
    - The `PARAMETER_NAME` and `PARAMETER_MODE` values are `NULL` because the return value has no name and the mode does not apply.

18.28. The `INFORMATION_SCHEMA PROFILING` Table

The `PROFILING` table provides statement profiling information. Its contents correspond to the information produced by the `SHOW PROFILES` and `SHOW PROFILE` statements (see Section 12.4.5.32, “`SHOW PROFILES` Syntax”). The table is empty unless the `profiling` session variable is set to 1.

`INFORMATION_SCHEMA` **Name**	**`SHOW`** **Name**	**Remarks**
`QUERY_ID`	`Query_ID`	
`SEQ`		
`STATE`	`Status`	
`DURATION`	`Duration`	
`CPU_USER`	`CPU_user`	
`CPU_SYSTEM`	`CPU_system`	
`CONTEXT_VOLUNTARY`	`Context_voluntary`	
`CONTEXT_INVOLUNTARY`	`Context_involuntary`	
`BLOCK_OPS_IN`	`Block_ops_in`	
`BLOCK_OPS_OUT`	`Block_ops_out`	
`MESSAGES_SENT`	`Messages_sent`	
`MESSAGES_RECEIVED`	`Messages_received`	
`PAGE_FAULTS_MAJOR`	`Page_faults_major`	
`PAGE_FAULTS_MINOR`	`Page_faults_minor`	
`SWAPS`	`Swaps`	
`SOURCE_FUNCTION`	`Source_function`	
`SOURCE_FILE`	`Source_file`	
`SOURCE_LINE`	`Source_line`	

Notes:

- `QUERY_ID` is a numeric statement identifier.
- `SEQ` is a sequence number indicating the display order for rows with the same `QUERY_ID` value.
- `STATE` is the profiling state to which the row measurements apply.
- `DURATION` indicates how long statement execution remained in the given state, in seconds.
- `CPU_USER` and `CPU_SYSTEM` indicate user and system CPU use, in seconds.
- `CONTEXT_VOLUNTARY` and `CONTEXT_INVOLUNTARY` indicate how many voluntary and involuntary context switches occurred.
- `BLOCK_OPS_IN` and `BLOCK_OPS_OUT` indicate the number of block input and output operations.
- `MESSAGES_SENT` and `MESSAGES_RECEIVED` indicate the number of communication messages sent and received.

- PAGE_FAULTS_MAJOR and PAGE_FAULTS_MINOR indicate the number of major and minor page faults.
- SWAPS indicates how many swaps occurred.
- SOURCE_FUNCTION, SOURCE_FILE, and SOURCE_LINE provide information indicating where in the source code the profiled state executes.

18.29. INFORMATION_SCHEMA Tables for InnoDB

The InnoDB tables related to the InnoDB storage engine help you to monitor ongoing InnoDB activity, to detect inefficiencies before they turn into issues, or to troubleshoot performance and capacity issues that do occur. As your database becomes bigger and busier, running up against the limits of your hardware capacity, you monitor and tune these aspects to keep the database running smoothly. The monitoring information deals with:

- InnoDB table compression, a feature whose use depends on a balance between I/O reduction, CPU usage, buffer pool management, and how much compression is possible for your data.
- Transactions and locks, features that balance high performance for a single operation, against the ability to run multiple operations concurrently. (Transactions are the high-level, user-visible aspect of concurrency. Locks are the low-level mechanism that transactions use to avoid reading or writing unreliable data.)

18.29.1. The INFORMATION_SCHEMA INNODB_CMP and INNODB_CMP_RESET Tables

The INNODB_CMP and INNODB_CMP_RESET tables contain status information on operations related to compressed InnoDB tables.

Table 18.1. Columns of INNODB_CMP and INNODB_CMP_RESET

Column name	Description
PAGE_SIZE	Compressed page size in bytes.
COMPRESS_OPS	Number of times a B-tree page of the size PAGE_SIZE has been compressed. Pages are compressed whenever an empty page is created or the space for the uncompressed modification log runs out.
COMPRESS_OPS_OK	Number of times a B-tree page of the size PAGE_SIZE has been successfully compressed. This count should never exceed COMPRESS_OPS.
COMPRESS_TIME	Total time in seconds spent in attempts to compress B-tree pages of the size PAGE_SIZE.
UNCOMPRESS_OPS	Number of times a B-tree page of the size PAGE_SIZE has been uncompressed. B-tree pages are uncompressed whenever compression fails or at first access when the uncompressed page does not exist in the buffer pool.
UNCOMPRESS_TIME	Total time in seconds spent in uncompressing B-tree pages of the size PAGE_SIZE.

Notes:

- Use these tables to measure the effectiveness of InnoDB table compression in your database. For usage information, see Section 13.4.6.1.3, “Using the Compression Information Schema Tables”.

18.29.2. The INFORMATION_SCHEMA INNODB_CMPMEM and INNODB_CMPMEM_RESET Tables

The INNODB_CMPMEM and INNODB_CMPMEM_RESET tables contain status information on compressed pages within the InnoDB buffer pool.

Table 18.2. Columns of INNODB_CMPMEM and INNODB_CMPMEM_RESET

Column name	Description
PAGE_SIZE	Block size in bytes. Each record of this table describes blocks of this size.

Column name	Description
`PAGES_USED`	Number of blocks of the size `PAGE_SIZE` that are currently in use.
`PAGES_FREE`	Number of blocks of the size `PAGE_SIZE` that are currently available for allocation. This column shows the external fragmentation in the memory pool. Ideally, these numbers should be at most 1.
`RELOCATION_OPS`	Number of times a block of the size `PAGE_SIZE` has been relocated. The buddy system can relocate the allocated "buddy neighbor" of a freed block when it tries to form a bigger freed block. Reading from the table `INNODB_CMPMEM_RESET` resets this count.
`RELOCATION_TIME`	Total time in microseconds spent in relocating blocks of the size `PAGE_SIZE`. Reading from the table `INNODB_CMPMEM_RESET` resets this count.

Notes:

- Use these tables to measure the effectiveness of `InnoDB` table compression in your database. For usage information, see Section 13.4.6.1.3, "Using the Compression Information Schema Tables".

18.29.3. The `INFORMATION_SCHEMA INNODB_TRX` Table

The `INNODB_TRX` table contains information about every transaction currently executing inside `InnoDB`, including whether the transaction is waiting for a lock, when the transaction started, and the SQL statement the transaction is executing.

Table 18.3. `INNODB_TRX` Columns

Column name	Description
`TRX_ID`	Unique transaction ID number, internal to `InnoDB`.
`TRX_WEIGHT`	The weight of a transaction, reflecting (but not necessarily the exact count of) the number of rows altered and the number of rows locked by the transaction. To resolve a deadlock, `InnoDB` selects the transaction with the smallest weight as the "victim" to rollback. Transactions that have changed non-transactional tables are considered heavier than others, regardless of the number of altered and locked rows.
`TRX_STATE`	Transaction execution state. One of `RUNNING`, `LOCK WAIT`, `ROLLING BACK` or `COMMITTING`.
`TRX_STARTED`	Transaction start time.
`TRX_REQUESTED_LOCK_ID`	ID of the lock the transaction is currently waiting for (if `TRX_STATE` is `LOCK WAIT`, otherwise `NULL`). Details about the lock can be found by joining with `INNODB_LOCKS` on `LOCK_ID`.
`TRX_WAIT_STARTED`	Time when the transaction started waiting on the lock (if `TRX_STATE` is `LOCK WAIT`, otherwise `NULL`).
`TRX_MYSQL_THREAD_ID`	MySQL thread ID. Can be used for joining with `PROCESSLIST` on `ID`. See Section 13.4.6.3.3, "Possible Inconsistency with `PROCESSLIST`".
`TRX_QUERY`	The SQL query that is being executed by the transaction.
`TRX_OPERATION_STATE`	The transaction's current operation, or `NULL`.
`TRX_TABLES_IN_USE`	The number of InnoDB tables used while processing the current SQL statement of this transaction.
`TRX_TABLES_LOCKED`	Number of InnoDB tables that currently have any locks. (Because these are row locks, not table locks, the tables can usually still be read from and written to by multiple transactions, despite some rows being locked.)
`TRX_LOCK_STRUCTS`	The number of locks reserved by the transaction.
`TRX_LOCK_MEMORY_BYTES`	Total size taken up by the lock structures of this transaction in memory.
`TRX_ROWS_LOCKED`	Approximate number or rows locked by this transaction. The value might include delete-marked rows that are physically present but not visible to the transaction.
`TRX_ROWS_MODIFIED`	The number of modified and inserted rows in this transaction.
`TRX_CONCURRENCY_TICKETS`	A value indicating how much work the current transaction can do before being swapped out, as specified by the `innodb_concurrency_tickets` option.
`TRX_ISOLATION_LEVEL`	The isolation level of the current transaction.
`TRX_UNIQUE_CHECKS`	Whether unique checks are turned on or off for the current transaction. (They might be turned off during a bulk data load, for example.)

Column name	Description
`TRX_FOREIGN_KEY_CHECKS`	Whether foreign key checks are turned on or off for the current transaction. (They might be turned off during a bulk data load, for example.)
`TRX_LAST_FOREIGN_KEY_ERROR`	Detailed error message for last FK error, or `NULL`.
`TRX_ADAPTIVE_HASH_LATCHED`	Whether or not the adaptive hash index is locked by the current transaction. (Only a single transaction at a time can modify the adaptive hash index.)
`TRX_ADAPTIVE_HASH_TIMEOUT`	Whether to relinquish the search latch immediately for the adaptive hash index, or reserve it across calls from MySQL. When there is no AHI contention, this value remains zero and statements reserve the latch until they finish. During times of contention, it counts down to zero, and statements release the latch immediately after each row lookup.

Notes:

- Use this table to help diagnose performance problems that occur during times of heavy concurrent load. For usage information, see Section 13.4.6.2.4, “Using the Transaction Information Schema Tables”.

18.29.4. The `INFORMATION_SCHEMA INNODB_LOCKS` Table

The `INNODB_LOCKS` table contains information about each lock that an `InnoDB` transaction has requested but not yet acquired, and each lock that a transaction holds that is blocking another transaction.

Table 18.4. `INNODB_LOCKS` Columns

Column name	Description
`LOCK_ID`	Unique lock ID number, internal to `InnoDB`. Should be treated as an opaque string. Although `LOCK_ID` currently contains `TRX_ID`, the format of the data in `LOCK_ID` is not guaranteed to remain the same in future releases. You should not write programs that parse the `LOCK_ID` value.
`LOCK_TRX_ID`	ID of the transaction holding this lock. Details about the transaction can be found by joining with `INNODB_TRX` on `TRX_ID`.
`LOCK_MODE`	Mode of the lock. One of `S`, `X`, `IS`, `IX`, `S_GAP`, `X_GAP`, `IS_GAP`, `IX_GAP`, or `AUTO_INC` for shared, exclusive, intention shared, intention exclusive row locks, shared and exclusive gap locks, intention shared and intention exclusive gap locks, and auto-increment table level lock, respectively. Refer to the sections Section 13.3.9.1, “`InnoDB` Lock Modes” and Section 13.3.9, “The `InnoDB` Transaction Model and Locking” for information on `InnoDB` locking.
`LOCK_TYPE`	Type of the lock. One of `RECORD` or `TABLE` for record (row) level or table level locks, respectively.
`LOCK_TABLE`	Name of the table that has been locked or contains locked records.
`LOCK_INDEX`	Name of the index if `LOCK_TYPE='RECORD'`, otherwise `NULL`.
`LOCK_SPACE`	Tablespace ID of the locked record if `LOCK_TYPE='RECORD'`, otherwise `NULL`.
`LOCK_PAGE`	Page number of the locked record if `LOCK_TYPE='RECORD'`, otherwise `NULL`.
`LOCK_REC`	Heap number of the locked record within the page if `LOCK_TYPE='RECORD'`, otherwise `NULL`.
`LOCK_DATA`	Primary key of the locked record if `LOCK_TYPE='RECORD'`, otherwise `NULL`. This column contains the value(s) of the primary key column(s) in the locked row, formatted as a valid SQL string (ready to be copied to SQL commands). If there is no primary key then the `InnoDB` internal unique row ID number is used. When the page containing the locked record is not in the buffer pool (in the case that it was paged out to disk while the lock was held), `InnoDB` does not fetch the page from disk, to avoid unnecessary disk operations. Instead, `LOCK_DATA` is set to `NULL`.

Notes:

- Use this table to help diagnose performance problems that occur during times of heavy concurrent load. For usage information, see Section 13.4.6.2.4, “Using the Transaction Information Schema Tables”.

18.29.5. The `INFORMATION_SCHEMA INNODB_LOCK_WAITS` Table

The `INNODB_LOCK_WAITS` table contains one or more rows for each blocked `InnoDB` transaction, indicating the lock it has requested and any locks that are blocking that request.

Table 18.5. INNODB_LOCK_WAITS Columns

Column name	Description
`REQUESTING_TRX_ID`	ID of the requesting transaction.
`REQUESTED_LOCK_ID`	ID of the lock for which a transaction is waiting. Details about the lock can be found by joining with `INNODB_LOCKS` on `LOCK_ID`.
`BLOCKING_TRX_ID`	ID of the blocking transaction.
`BLOCKING_LOCK_ID`	ID of a lock held by a transaction blocking another transaction from proceeding. Details about the lock can be found by joining with `INNODB_LOCKS` on `LOCK_ID`.

Notes:

- Use this table to help diagnose performance problems that occur during times of heavy concurrent load. For usage information, see Section 13.4.6.2.4, “Using the Transaction Information Schema Tables”.

18.30. Other `INFORMATION_SCHEMA` Tables

We intend to implement additional `INFORMATION_SCHEMA` tables.

18.31. Extensions to `SHOW` Statements

Some extensions to `SHOW` statements accompany the implementation of `INFORMATION_SCHEMA`:

- `SHOW` can be used to get information about the structure of `INFORMATION_SCHEMA` itself.
- Several `SHOW` statements accept a `WHERE` clause that provides more flexibility in specifying which rows to display.

`INFORMATION_SCHEMA` is an information database, so its name is included in the output from `SHOW DATABASES`. Similarly, `SHOW TABLES` can be used with `INFORMATION_SCHEMA` to obtain a list of its tables:

```
mysql> SHOW TABLES FROM INFORMATION_SCHEMA;
+---------------------------------------+
| Tables_in_INFORMATION_SCHEMA          |
+---------------------------------------+
| CHARACTER_SETS                        |
| COLLATIONS                            |
| COLLATION_CHARACTER_SET_APPLICABILITY |
| COLUMNS                               |
| COLUMN_PRIVILEGES                     |
| ENGINES                               |
| EVENTS                                |
| FILES                                 |
| GLOBAL_STATUS                         |
| GLOBAL_VARIABLES                      |
| KEY_COLUMN_USAGE                      |
| PARTITIONS                            |
| PLUGINS                               |
| PROCESSLIST                           |
| REFERENTIAL_CONSTRAINTS               |
| ROUTINES                              |
| SCHEMATA                              |
| SCHEMA_PRIVILEGES                     |
| SESSION_STATUS                        |
| SESSION_VARIABLES                     |
| STATISTICS                            |
| TABLES                                |
| TABLE_CONSTRAINTS                     |
| TABLE_PRIVILEGES                      |
| TRIGGERS                              |
| USER_PRIVILEGES                       |
| VIEWS                                 |
+---------------------------------------+
27 rows in set (0.00 sec)
```

`SHOW COLUMNS` and `DESCRIBE` can display information about the columns in individual `INFORMATION_SCHEMA` tables.

`SHOW` statements that accept a `LIKE` clause to limit the rows displayed also permit a `WHERE` clause that specifies more general conditions that selected rows must satisfy:

```
SHOW CHARACTER SET
SHOW COLLATION
SHOW COLUMNS
SHOW DATABASES
SHOW FUNCTION STATUS
SHOW INDEX
SHOW OPEN TABLES
SHOW PROCEDURE STATUS
SHOW STATUS
SHOW TABLE STATUS
SHOW TABLES
SHOW TRIGGERS
SHOW VARIABLES
```

The `WHERE` clause, if present, is evaluated against the column names displayed by the `SHOW` statement. For example, the `SHOW CHARACTER SET` statement produces these output columns:

```
mysql> SHOW CHARACTER SET;
+----------+-----------------------------+---------------------+--------+
| Charset  | Description                 | Default collation   | Maxlen |
+----------+-----------------------------+---------------------+--------+
| big5     | Big5 Traditional Chinese    | big5_chinese_ci     |      2 |
| dec8     | DEC West European           | dec8_swedish_ci     |      1 |
| cp850    | DOS West European           | cp850_general_ci    |      1 |
| hp8      | HP West European            | hp8_english_ci      |      1 |
| koi8r    | KOI8-R Relcom Russian       | koi8r_general_ci    |      1 |
| latin1   | cp1252 West European        | latin1_swedish_ci   |      1 |
| latin2   | ISO 8859-2 Central European | latin2_general_ci   |      1 |
...
```

To use a `WHERE` clause with `SHOW CHARACTER SET`, you would refer to those column names. As an example, the following statement displays information about character sets for which the default collation contains the string `'japanese'`:

```
mysql> SHOW CHARACTER SET WHERE `Default collation` LIKE '%japanese%';
+---------+---------------------------+---------------------+--------+
| Charset | Description               | Default collation   | Maxlen |
+---------+---------------------------+---------------------+--------+
| ujis    | EUC-JP Japanese           | ujis_japanese_ci    |      3 |
| sjis    | Shift-JIS Japanese        | sjis_japanese_ci    |      2 |
| cp932   | SJIS for Windows Japanese | cp932_japanese_ci   |      2 |
| eucjpms | UJIS for Windows Japanese | eucjpms_japanese_ci |      3 |
+---------+---------------------------+---------------------+--------+
```

This statement displays the multi-byte character sets:

```
mysql> SHOW CHARACTER SET WHERE Maxlen > 1;
+---------+---------------------------+---------------------+--------+
| Charset | Description               | Default collation   | Maxlen |
+---------+---------------------------+---------------------+--------+
| big5    | Big5 Traditional Chinese  | big5_chinese_ci     |      2 |
| ujis    | EUC-JP Japanese           | ujis_japanese_ci    |      3 |
| sjis    | Shift-JIS Japanese        | sjis_japanese_ci    |      2 |
| euckr   | EUC-KR Korean             | euckr_korean_ci     |      2 |
| gb2312  | GB2312 Simplified Chinese | gb2312_chinese_ci   |      2 |
| gbk     | GBK Simplified Chinese    | gbk_chinese_ci      |      2 |
| utf8    | UTF-8 Unicode             | utf8_general_ci     |      3 |
| ucs2    | UCS-2 Unicode             | ucs2_general_ci     |      2 |
| cp932   | SJIS for Windows Japanese | cp932_japanese_ci   |      2 |
| eucjpms | UJIS for Windows Japanese | eucjpms_japanese_ci |      3 |
+---------+---------------------------+---------------------+--------+
```

Chapter 19. MySQL Performance Schema

The MySQL Performance Schema is a feature for monitoring MySQL Server execution at a low level. The Performance Schema is available as of MySQL 5.5.3 and has these characteristics:

- The Performance Schema provides a way to inspect internal execution of the server at runtime. It is implemented using the `PERFORMANCE_SCHEMA` storage engine and the `performance_schema` database. The Performance Schema focuses primarily on performance data. This differs from `INFORMATION_SCHEMA`, which serves for inspection of metadata.

- The Performance Schema monitors server events. An “event” is anything the server does that takes time and has been instrumented so that timing information can be collected. In general, an event could be a function call, a wait for the operating system, a stage of an SQL statement execution such as parsing or sorting, or an entire statement or group of statements. Currently, event collection provides access to information about synchronization calls (such as for mutexes) and disk I/O calls for the server and for several storage engines.

- Performance Schema events are distinct from events written to the server's binary log (which describe data modifications) and Event Scheduler events (which are a type of stored program).

- Current events are available, as well as event histories and summaries. This enables you to determine how many times instrumented activities were performed and how much time they took. Event information is available to show the activities of specific threads, or activity associated with particular objects such as a mutex or file.

- The `PERFORMANCE_SCHEMA` storage engine collects event data using “instrumentation points” in server source code.

- Collected events are stored in tables in the `performance_schema` database. These tables can be queried using `SELECT` statements like other tables.

- Performance Schema configuration can be modified dynamically by updating tables in the `performance_schema` database through SQL statements. Configuration changes affect data collection immediately.

- Tables in the `performance_schema` database are views or temporary tables that use no persistent on-disk storage.

- Monitoring is available on all platforms supported by MySQL.

  Some limitations might apply: The types of timers might vary per platform. Instruments that apply to storage engines might not be implemented for all storage engines. Instrumentation of each third-party engine is the responsibility of the engine maintainer. See also Section E.8, “Performance Schema Restrictions”.

- Data collection is implemented by modifying the server source code to add instrumentation. There are no separate threads associated with the Performance Schema, unlike other features such as replication or the Event Scheduler.

The Performance Schema is intended to provide access to useful information about server execution while having minimal impact on server performance. The implementation follows these design goals:

- Activating the Performance Schema causes no changes in server behavior. For example, it does not cause thread scheduling to change, and it does not cause query execution plans (as shown by `EXPLAIN`) to change.

- No memory allocation is done beyond that which occurs during server startup. By using early allocation of structures with a fixed size, it is never necessary to resize or reallocate them, which is critical for achieving good runtime performance.

- Server monitoring occurs continuously and unobtrusively with very little overhead. Activating the Performance Schema does not make the server unusable.

- The parser is unchanged. There are no new keywords or statements.

- Execution of server code proceeds normally even if the Performance Schema fails internally.

- When there is a choice between performing processing during event collection initially or during event retrieval later, priority is given to making collection faster. This is because collection is ongoing whereas retrieval is on demand and might never happen at all.

- It is easy to add new instrumentation points.

- Instrumentation is versioned. If the instrumentation implementation changes, previously instrumented code will continue to work. This benefits developers of third-party plugins because it is not necessary to upgrade each plugin to stay synchronized with the latest Performance Schema changes.

19.1. Performance Schema Quick Start

This section briefly introduces the Performance Schema with examples that show how to use it. For additional examples, see Section 19.11, “Using the Performance Schema to Diagnose Problems”.

For the Performance Schema to be available, support for it must have been configured when MySQL was built. You can verify whether this is the case by checking the server's help output. If the Performance Schema is available, the output will mention several variables with names that begin with `performance_schema`:

```
shell> mysqld --verbose --help
...
  --performance_schema
                      Enable the performance schema.
  --performance_schema_events_waits_history_long_size=#
                      Number of rows in events_waits_history_long.
...
```

If such variables do not appear in the output, your server has not been built to support the Performance Schema. In this case, see Section 19.2, “Performance Schema Configuration”.

Assuming that the Performance Schema is available, it is disabled by default. To enable it, start the server with the `performance_schema` variable enabled. For example, use these lines in your `my.cnf` file:

```
[mysqld]
performance_schema
```

When the server starts, it sees `performance_schema` and attempts to initialize the Performance Schema. To verify successful initialization, use this statement:

```
mysql> SHOW VARIABLES LIKE 'performance_schema';
+--------------------+-------+
| Variable_name      | Value |
+--------------------+-------+
| performance_schema | ON    |
+--------------------+-------+
```

A value of `ON` means that the Performance Schema initialized successfully and is ready for use. A value of `OFF` means that some error occurred. Check the server error log for information about what went wrong.

The Performance Schema is implemented as a storage engine. If this engine is available (which you should already have checked earlier), you should see it listed with a `SUPPORT` value of `YES` in the output from the `INFORMATION_SCHEMA.ENGINES` table or the `SHOW ENGINES` statement:

```
mysql> SELECT * FROM INFORMATION_SCHEMA.ENGINES
    -> WHERE ENGINE='PERFORMANCE_SCHEMA'\G
*************************** 1. row ***************************
      ENGINE: PERFORMANCE_SCHEMA
     SUPPORT: YES
     COMMENT: Performance Schema
TRANSACTIONS: NO
          XA: NO
  SAVEPOINTS: NO

mysql> SHOW ENGINES\G
...
      Engine: PERFORMANCE_SCHEMA
     Support: YES
     Comment: Performance Schema
Transactions: NO
          XA: NO
  Savepoints: NO
...
```

The `PERFORMANCE_SCHEMA` storage engine operates on tables in the `performance_schema` database. You can make `performance_schema` the default database so that references to its tables need not be qualified with the database name:

```
mysql> USE performance_schema;
```

Many examples in this chapter assume that `performance_schema` is the default database.

Performance Schema tables are stored in the `performance_schema` database. Information about the structure of this database and its tables can be obtained, as for any other database, by selecting from the `INFORMATION_SCHEMA` database or by using `SHOW` statements. For example, use either of these statements to see what Performance Schema tables exist:

```
mysql> SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
    -> WHERE TABLE_SCHEMA = 'performance_schema';
+----------------------------------------------+
| TABLE_NAME                                   |
+----------------------------------------------+
| cond_instances                               |
| events_waits_current                         |
| events_waits_history                         |
| events_waits_history_long                    |
| events_waits_summary_by_instance             |
| events_waits_summary_by_thread_by_event_name |
| events_waits_summary_global_by_event_name    |
| file_instances                               |
| file_summary_by_event_name                   |
| file_summary_by_instance                     |
| mutex_instances                              |
| performance_timers                           |
| rwlock_instances                             |
| setup_consumers                              |
| setup_instruments                            |
| setup_timers                                 |
| threads                                      |
+----------------------------------------------+

mysql> SHOW TABLES FROM performance_schema;
+----------------------------------------------+
| Tables_in_performance_schema                 |
+----------------------------------------------+
| cond_instances                               |
| events_waits_current                         |
| events_waits_history                         |
...
```

The number of Performance Schema tables is expected to increase over time as implementation of additional instrumentation proceeds.

The name of the `performance_schema` database is lowercase, as are the names of tables within it. Queries should specify the names in lowercase.

> **Note**
>
> Before MySQL 5.5.8, the table names were uppercase, which caused problems on some systems for certain values of the `lower_case_table_names` system variable.

To see the structure of individual tables, use `SHOW CREATE TABLE`:

```
mysql> SHOW CREATE TABLE setup_timers\G
*************************** 1. row ***************************
       Table: setup_timers
Create Table: CREATE TABLE `setup_timers` (
  `NAME` varchar(64) NOT NULL,
  `TIMER_NAME` enum('CYCLE','NANOSECOND','MICROSECOND','MILLISECOND','TICK')
   NOT NULL
) ENGINE=PERFORMANCE_SCHEMA DEFAULT CHARSET=utf8
```

Table structure is also available by selecting from tables such as `INFORMATION_SCHEMA.COLUMNS` or by using statements such as `SHOW COLUMNS`.

Tables in the `performance_schema` database can be grouped according to the type of information in them: Current events, event histories and summaries, object instances, and setup (configuration) information. The following examples illustrate a few uses for these tables. For detailed information about the tables in each group, see Section 19.7, “Performance Schema Table Descriptions”.

To see what the server is doing at the moment, examine the `events_waits_current` table. It contains one row per thread showing each thread's most recent monitored event:

```
mysql> SELECT * FROM events_waits_current\G
*************************** 1. row ***************************
            THREAD_ID: 0
             EVENT_ID: 5523
           EVENT_NAME: wait/synch/mutex/mysys/THR_LOCK::mutex
               SOURCE: thr_lock.c:525
          TIMER_START: 201660494489586
            TIMER_END: 201660494576112
           TIMER_WAIT: 86526
                SPINS: NULL
        OBJECT_SCHEMA: NULL
          OBJECT_NAME: NULL
          OBJECT_TYPE: NULL
OBJECT_INSTANCE_BEGIN: 142270668
     NESTING_EVENT_ID: NULL
            OPERATION: lock
      NUMBER_OF_BYTES: NULL
                FLAGS: 0
...
```

This event indicates that thread 0 was waiting for 86,526 picoseconds to acquire a lock on `THR_LOCK::mutex`, a mutex in the `mysys` subsystem. The first few columns provide the following information:

- The ID columns indicate which thread the event comes from and the event number.
- `EVENT_NAME` indicates what was instrumented and `SOURCE` indicates which source file contains the instrumented code.
- The timer columns show when the event started and stopped and how long it took. If an event is still in progress, the `TIMER_END` and `TIMER_WAIT` values are `NULL`. Timer values are approximate and expressed in picoseconds. For information about timers and event time collection, see Section 19.2.3.1, “Performance Schema Event Timing”.

The history tables contain the same kind of rows as the current-events table but have more rows and show what the server has been doing “recently” rather than “currently.” The `events_waits_history` and `events_waits_history_long` tables contain the most recent 10 events per thread and most recent 10,000 events, respectively. For example, to see information for recent events produced by thread 13, do this:

```
mysql> SELECT EVENT_ID, EVENT_NAME, TIMER_WAIT
    -> FROM events_waits_history WHERE THREAD_ID = 13
    -> ORDER BY EVENT_ID;
+----------+-----------------------------------------+------------+
| EVENT_ID | EVENT_NAME                              | TIMER_WAIT |
+----------+-----------------------------------------+------------+
|       86 | wait/synch/mutex/mysys/THR_LOCK::mutex  |     686322 |
|       87 | wait/synch/mutex/mysys/THR_LOCK_malloc  |     320535 |
|       88 | wait/synch/mutex/mysys/THR_LOCK_malloc  |     339390 |
|       89 | wait/synch/mutex/mysys/THR_LOCK_malloc  |     377100 |
|       90 | wait/synch/mutex/sql/LOCK_plugin        |     614673 |
|       91 | wait/synch/mutex/sql/LOCK_open          |     659925 |
|       92 | wait/synch/mutex/sql/THD::LOCK_thd_data |     494001 |
|       93 | wait/synch/mutex/mysys/THR_LOCK_malloc  |     222489 |
|       94 | wait/synch/mutex/mysys/THR_LOCK_malloc  |     214947 |
|       95 | wait/synch/mutex/mysys/LOCK_alarm       |     312993 |
+----------+-----------------------------------------+------------+
```

As new events are added to a history table, older events are discarded if the table is full.

Summary tables provide aggregate information for all events over time. The tables in this group summarize event data in different ways. To see which instruments have been executed the most times or have taken the most wait time, sort the `events_waits_summary_global_by_event_name` table on the `COUNT_STAR` or `SUM_TIMER_WAIT` column, which correspond to a `COUNT(*)` or `SUM(TIMER_WAIT)` value, respectively, calculated over all events:

```
mysql> SELECT EVENT_NAME, COUNT_STAR
    -> FROM events_waits_summary_global_by_event_name
    -> ORDER BY COUNT_STAR DESC LIMIT 10;
+---------------------------------------------------+------------+
| EVENT_NAME                                        | COUNT_STAR |
+---------------------------------------------------+------------+
| wait/synch/mutex/mysys/THR_LOCK_malloc            |       6419 |
| wait/io/file/sql/FRM                              |        452 |
| wait/synch/mutex/sql/LOCK_plugin                  |        337 |
| wait/synch/mutex/mysys/THR_LOCK_open              |        187 |
| wait/synch/mutex/mysys/LOCK_alarm                 |        147 |
| wait/synch/mutex/sql/THD::LOCK_thd_data           |        115 |
| wait/io/file/myisam/kfile                         |        102 |
| wait/synch/mutex/sql/LOCK_global_system_variables |         89 |
| wait/synch/mutex/mysys/THR_LOCK::mutex            |         89 |
| wait/synch/mutex/sql/LOCK_open                    |         88 |
+---------------------------------------------------+------------+

mysql> SELECT EVENT_NAME, SUM_TIMER_WAIT
    -> FROM events_waits_summary_global_by_event_name
    -> ORDER BY SUM_TIMER_WAIT DESC LIMIT 10;
+----------------------------------------+----------------+
| EVENT_NAME                             | SUM_TIMER_WAIT |
+----------------------------------------+----------------+
| wait/io/file/sql/MYSQL_LOG             |     1599816582 |
| wait/synch/mutex/mysys/THR_LOCK_malloc |     1530083250 |
| wait/io/file/sql/binlog_index          |     1385291934 |
| wait/io/file/sql/FRM                   |     1292823243 |
| wait/io/file/myisam/kfile              |      411193611 |
| wait/io/file/myisam/dfile              |      322401645 |
| wait/synch/mutex/mysys/LOCK_alarm      |      145126935 |
| wait/io/file/sql/casetest              |      104324715 |
| wait/synch/mutex/sql/LOCK_plugin       |       86027823 |
| wait/io/file/sql/pid                   |       72591750 |
+----------------------------------------+----------------+
```

These results show that the `THR_LOCK_malloc` mutex is “hot,” both in terms of how often it is used and amount of time that threads wait attempting to acquire it.

> **Note**
>
> The `THR_LOCK_malloc` mutex is used only in debug builds. In production builds it is not hot because it is nonexistent.

Instance tables document what types of objects are instrumented. An instrumented object, when used by the server, produces an event. These tables provide event names and explanatory notes or status information. For example, the `file_instances` table lists instances of instruments for file I/O operations and their associated files:

```
mysql> SELECT * FROM file_instances\G
*************************** 1. row ***************************
 FILE_NAME: /opt/mysql-log/60500/binlog.000007
EVENT_NAME: wait/io/file/sql/binlog
OPEN_COUNT: 0
*************************** 2. row ***************************
 FILE_NAME: /opt/mysql/60500/data/mysql/tables_priv.MYI
EVENT_NAME: wait/io/file/myisam/kfile
OPEN_COUNT: 1
*************************** 3. row ***************************
 FILE_NAME: /opt/mysql/60500/data/mysql/columns_priv.MYI
EVENT_NAME: wait/io/file/myisam/kfile
OPEN_COUNT: 1
...
```

Setup tables are used to configure and display monitoring characteristics. For example, to see which event timer is selected, query the `setup_timers` tables:

```
mysql> SELECT * FROM setup_timers;
+------+------------+
| NAME | TIMER_NAME |
+------+------------+
| wait | CYCLE      |
+------+------------+
```

`setup_instruments` lists the set of instruments for which events can be collected and shows which of them are enabled:

```
mysql> SELECT * FROM setup_instruments;
+------------------------------------------------------------+---------+-------+
| NAME                                                       | ENABLED | TIMED |
+------------------------------------------------------------+---------+-------+
...
| wait/synch/mutex/sql/LOCK_global_read_lock                 | YES     | YES   |
| wait/synch/mutex/sql/LOCK_global_system_variables          | YES     | YES   |
| wait/synch/mutex/sql/LOCK_lock_db                          | YES     | YES   |
| wait/synch/mutex/sql/LOCK_manager                          | YES     | YES   |
...
| wait/synch/rwlock/sql/LOCK_grant                           | YES     | YES   |
| wait/synch/rwlock/sql/LOGGER::LOCK_logger                  | YES     | YES   |
| wait/synch/rwlock/sql/LOCK_sys_init_connect                | YES     | YES   |
| wait/synch/rwlock/sql/LOCK_sys_init_slave                  | YES     | YES   |
...
| wait/io/file/sql/binlog                                    | YES     | YES   |
| wait/io/file/sql/binlog_index                              | YES     | YES   |
| wait/io/file/sql/casetest                                  | YES     | YES   |
| wait/io/file/sql/dbopt                                     | YES     | YES   |
...
```

To understand how to interpret instrument names, see Section 19.4, “Performance Schema Instrument Naming Conventions”.

To control whether events are collected for an instrument, set its `ENABLED` value to `YES` or `NO`. For example:

```
mysql> UPDATE setup_instruments SET ENABLED = 'NO'
    -> WHERE NAME = 'wait/synch/mutex/sql/LOCK_mysql_create_db';
```

The Performance Schema uses collected events to update tables in the `performance_schema` database, which act as “consumers” of event information. The `setup_consumers` table lists the available consumers and shows which of them are enabled:

```
mysql> SELECT * FROM setup_consumers;
+----------------------------------------------+---------+
| NAME                                         | ENABLED |
+----------------------------------------------+---------+
| events_waits_current                         | YES     |
| events_waits_history                         | YES     |
| events_waits_history_long                    | YES     |
| events_waits_summary_by_thread_by_event_name | YES     |
| events_waits_summary_by_event_name           | YES     |
| events_waits_summary_by_instance             | YES     |
| file_summary_by_event_name                   | YES     |
| file_summary_by_instance                     | YES     |
+----------------------------------------------+---------+
```

To control whether the Performance Schema maintains a consumer as a destination for event information, set its `ENABLED` value.

For more information about the setup tables and how to use them to control event collection, see Section 19.2.3.2, “Performance Schema Event Filtering”.

There are some miscellaneous tables that do not fall into any of the previous groups. For example, `performance_timers` lists the available event timers and their characteristics. For information about timers, see Section 19.2.3.1, “Performance Schema Event Timing”.

19.2. Performance Schema Configuration

To use the MySQL Performance Schema, these configuration considerations apply:

- The Performance Schema must be configured into MySQL Server at build time to make it available. Performance Schema support is included in binary MySQL distributions. If you are building from source, you must ensure that it is configured into the build as described in Section 19.2.1, “Performance Schema Build Configuration”.
- The Performance Schema must be enabled at server startup to enable event collection to occur. Specific Performance Schema features can be enabled at server startup or at runtime to control which types of event collection occur. See Section 19.2.2, “Performance Schema Startup Configuration”, Section 19.2.3, “Performance Schema Runtime Configuration”, and Section 19.2.3.2, “Performance Schema Event Filtering”.

19.2.1. Performance Schema Build Configuration

For the Performance Schema to be available, it must be configured into the MySQL server at build time. Binary MySQL distributions provided by Oracle Corporation are configured to support the Performance Schema. If you use a binary MySQL distribution from another provider, check with the provider whether the distribution has been appropriately configured.

If you build MySQL from a source distribution, enable the Performance Schema by running `CMake` with the `WITH_PERFSCHEMA_STORAGE_ENGINE` option enabled:

```
shell> cmake . -DWITH_PERFSCHEMA_STORAGE_ENGINE=1
```

Configuring MySQL with the `-DWITHOUT_PERFSCHEMA_STORAGE_ENGINE=1` option prevents inclusion of the Performance Schema, so if you want it included, do not use this option. See Section 2.9.4, “MySQL Source-Configuration Options”.

If you install MySQL over a previous installation that was configured without the Performance Schema (or with an older version of the Performance Schema that may not have all the current tables), run `mysql_upgrade` after starting the server to ensure that the `performance_schema` database exists with all current tables. Then restart the server. One indication that you need to do this is the presence of messages such as the following in the error log:

```
[ERROR] Native table 'performance_schema'.'events_waits_history'
has the wrong structure
[ERROR] Native table 'performance_schema'.'events_waits_history_long'
has the wrong structure
...
```

To verify whether a server was built with Performance Schema support, check its help output. If the Performance Schema is available, the output will mention several variables with names that begin with `performance_schema`:

```
shell> mysqld --verbose --help
...
  --performance_schema
                      Enable the performance schema.
  --performance_schema_events_waits_history_long_size=#
                      Number of rows in events_waits_history_long.
...
```

You can also connect to the server and look for a line that names the `PERFORMANCE_SCHEMA` storage engine in the output from `SHOW ENGINES`:

```
mysql> SHOW ENGINES\G
...
      Engine: PERFORMANCE_SCHEMA
     Support: YES
     Comment: Performance Schema
Transactions: NO
          XA: NO
  Savepoints: NO
...
```

If the Performance Schema was not configured into the server at build time, no row for `PERFORMANCE_SCHEMA` will appear in the output from `SHOW ENGINES`. You might see `performance_schema` listed in the output from `SHOW DATABASES`, but it will have no tables and you will not be able to use it.

A line for `PERFORMANCE_SCHEMA` in the `SHOW ENGINES` output means that the Performance Schema is available, not that it is enabled. To enable it, you must do so at server startup, as described in the next section.

19.2.2. Performance Schema Startup Configuration

The Performance Schema is disabled by default. To enable it, start the server with the `performance_schema` variable enabled. For example, use these lines in your `my.cnf` file:

```
[mysqld]
performance_schema
```

When the server starts, it writes Performance Schema status information to the error log:

- `Performance schema enabled` indicates successful initialization.
- `Performance schema disabled (reason: start parameters)` indicates that you did not enable the Performance Schema by enabling the `performance_schema` variable.
- `Performance schema disabled (reason: init failed)` indicates that you enabled `performance_schema` but some kind of error occurred that prevented the Performance Schema from initializing successfully. For example, you may have specified other Performance Schema variables with values too large for memory allocation to succeed.

If the server is unable to allocate any internal buffer during Performance Schema initialization, the Performance Schema disables itself and sets `performance_schema` to `OFF`, and the server runs without instrumentation.

The Performance Schema includes several system variables that provide configuration information:

```
mysql> SHOW VARIABLES LIKE 'perf%';
+---------------------------------------------------+---------+
| Variable_name                                     | Value   |
+---------------------------------------------------+---------+
| performance_schema                                | ON      |
| performance_schema_events_waits_history_long_size | 10000   |
| performance_schema_events_waits_history_size      | 10      |
| performance_schema_max_cond_classes               | 80      |
| performance_schema_max_cond_instances             | 1000    |
| performance_schema_max_file_classes               | 50      |
| performance_schema_max_file_handles               | 32768   |
| performance_schema_max_file_instances             | 10000   |
| performance_schema_max_mutex_classes              | 200     |
| performance_schema_max_mutex_instances            | 1000000 |
| performance_schema_max_rwlock_classes             | 30      |
| performance_schema_max_rwlock_instances           | 1000000 |
| performance_schema_max_table_handles              | 100000  |
| performance_schema_max_table_instances            | 50000   |
| performance_schema_max_thread_classes             | 50      |
| performance_schema_max_thread_instances           | 1000    |
+---------------------------------------------------+---------+
```

The `performance_schema` variable is `ON` or `OFF` to indicate whether the Performance Schema is enabled or disabled. The other variables indicate table sizes (number of rows) or memory allocation values.

> **Note**
>
> With the Performance Schema enabled, the number of Performance Schema instances affects the server memory footprint, perhaps to a large extent. It may be necessary to tune the values of Performance Schema system variables to find the number of instances that balances insufficient instrumentation against excessive memory consumption.

To change the value of Performance Schema system variables, set them at server startup. For example, put the following lines in a `my.cnf` file to change the sizes of the history tables:

```
[mysqld]
performance_schema
performance_schema_events_waits_history_size=20
performance_schema_events_waits_history_long_size=15000
```

19.2.3. Performance Schema Runtime Configuration

Performance Schema setup tables contain information about monitoring configuration:

```
mysql> SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
    -> WHERE TABLE_SCHEMA = 'performance_schema'
    -> AND TABLE_NAME LIKE 'setup%';
+-------------------+
| TABLE_NAME        |
+-------------------+
| setup_consumers   |
| setup_instruments |
| setup_timers      |
+-------------------+
```

You can examine the contents of these tables to obtain information about Performance Schema monitoring characteristics. If you have the `UPDATE` privilege, you can change Performance Schema operation by modifying setup tables to affect how monitoring occurs. For additional details about these tables, see Section 19.7.1, “Performance Schema Setup Tables”.

To see which event timer is selected, query the `setup_timers` tables:

```
mysql> SELECT * FROM setup_timers;
+------+------------+
| NAME | TIMER_NAME |
+------+------------+
| wait | CYCLE      |
+------+------------+
```

The `NAME` value indicates the type of instrument to which the timer applies, and `TIMER_NAME` indicates which timer applies to those instruments. The timer applies to instruments where their name begins with a component matching the `NAME` value. Currently, there are only “wait” instruments, so this table has only one row and the timer applies to all instruments.

To change the timer, update the `NAME` value. For example, to use the `NANOSECOND` timer:

```
mysql> UPDATE setup_timers SET TIMER_NAME = 'NANOSECOND'
    -> WHERE NAME = 'wait';

mysql> SELECT * FROM setup_timers;
+------+------------+
| NAME | TIMER_NAME |
+------+------------+
| wait | NANOSECOND |
+------+------------+
```

For discussion of timers, see Section 19.2.3.1, “Performance Schema Event Timing”.

The `setup_instruments` and `setup_consumers` tables list the instruments for which events can be collected and the types of consumers for which event information actually is collected, respectively. Section 19.2.3.2, “Performance Schema Event Filtering”, discusses how you can modify these tables to affect event collection.

If there are Performance Schema configuration changes that must be made at runtime using SQL statements and you would like to these changes take effect each time the server starts, put the statements in a file and start the server with the `--init-file=file_name` option. This strategy can also be useful if you have multiple monitoring configurations, each tailored to produce a different kind of monitoring, such as casual server health monitoring, incident investigation, application behavior troubleshooting, and so forth. Put the statements for each monitoring configuration into their own file and specify the appropriate file as the `--init-file` argument when you start the server.

19.2.3.1. Performance Schema Event Timing

Events are collected by means of instrumentation added to the server source code. Instruments time events, which is how the Performance Schema provides an idea of how long events take. It is also possible to configure instruments not to collect timing information. This section discusses the available timers and their characteristics, and how timing values are represented in events.

Two tables provide timer information:

- `performance_timers` lists the available timers and their characteristics.
- `setup_timers` indicates which timers are used for which instruments.

Each timer row in `setup_timers` must refer to one of the timers listed in `performance_timers`.

Timers vary in precision and the amount of overhead they involve. To see what timers are available and their characteristics, check the `performance_timers` table:

```
mysql> SELECT * FROM performance_timers;
+-------------+-----------------+------------------+----------------+
| TIMER_NAME  | TIMER_FREQUENCY | TIMER_RESOLUTION | TIMER_OVERHEAD |
+-------------+-----------------+------------------+----------------+
| CYCLE       |      2389029850 |                1 |             72 |
| NANOSECOND  |            NULL |             NULL |           NULL |
| MICROSECOND |         1000000 |                1 |            585 |
| MILLISECOND |            1035 |                1 |            738 |
| TICK        |             101 |                1 |            630 |
+-------------+-----------------+------------------+----------------+
```

The `TIMER_NAME` column shows the names of the available timers. `CYCLE` refers to the timer that is based on the CPU (processor) cycle counter. If the values associated with a given timer name are `NULL`, that timer is not supported on your platform. The rows that do not have `NULL` indicate which timers you can use in `setup_timers`.

`TIMER_FREQUENCY` indicates the number of timer units per second. For a cycle timer, the frequency is generally related to the CPU speed. The value shown was obtained on a system with a 2.4GHz processor. The other timers are based on fixed fractions of seconds. For `TICK`, the frequency may vary by platform (for example, some use 100 ticks/second, others 1000 ticks/second).

`TIMER_RESOLUTION` indicates the number of timer units by which timer values increase at a time. If a timer has a resolution of 10, its value increases by 10 each time.

`TIMER_OVERHEAD` is the minimal number of cycles of overhead to obtain one timing with the given timer. The overhead per event is twice the value displayed because the timer is invoked at the beginning and end of the event.

To see which timer is in effect or to change the timer, access the `setup_timers` table:

```
mysql> SELECT * FROM setup_timers;
+------+------------+
| NAME | TIMER_NAME |
+------+------------+
| wait | CYCLE      |
+------+------------+

mysql> UPDATE setup_timers SET TIMER_NAME = 'MICROSECOND'
    -> WHERE NAME = 'wait';

mysql> SELECT * FROM setup_timers;
+------+-------------+
| NAME | TIMER_NAME  |
+------+-------------+
| wait | MICROSECOND |
+------+-------------+
```

By default, the Performance Schema uses the best timer available for each instrument type, but you can select a different one. Generally the best timer is `CYCLE`, which uses the CPU cycle counter whenever possible to provide high precision and low overhead.

The precision offered by the cycle counter depends on processor speed. If the processor runs at 1 GHz (one billion cycles/second) or higher, the cycle counter delivers sub-nanosecond precision. Using the cycle counter is much cheaper than getting the actual time of day. For example, the standard `gettimeofday()` function can take hundreds of cycles, which is an unacceptable overhead for data gathering that may occur thousands or millions of times per second.

Cycle counters also have disadvantages:

- End users expect to see timings in wall-clock units, such as fractions of a second. Converting from cycles to fractions of seconds can be expensive. For this reason, the conversion is a quick and fairly rough multiplication operation.
- Processor cycle rate might change, such as when a laptop goes into power-saving mode or when a CPU slows down to reduce heat generation. If a processor's cycle rate fluctuates, conversion from cycles to real-time units is subject to error.
- Cycle counters might be unreliable or unavailable depending on the processor or the operating system. For example, on Pentiums, the instruction is `RDTSC` (an assembly-language rather than a C instruction) and it is theoretically possible for the operating system to prevent user-mode programs from using it.
- Some processor details related to out-of-order execution or multiprocessor synchronization might cause the counter to seem fast or slow by up to 1000 cycles.

Currently, MySQL works with cycle counters on x386 (Windows, Mac OS X, Linux, Solaris, and other Unix flavors), PowerPC, and IA-64.

The `setup_instruments` table has an `ENABLED` column to indicate the instruments for which to collect events. The table also has a `TIMED` column to indicate which instruments are timed. If an instrument is not enabled, it produces no events. If an enabled instrument is not timed, events produced by the instrument have `NULL` for the `TIMER_START`, `TIMER_END`, and `TIMER_WAIT` timer values. This in turn causes those values to be ignored when calculating the sum, minimum, maximum, and average time values in summary tables.

Within events, times are stored in picoseconds (trillionths of a second) to normalize them to a standard unit, regardless of which timer is selected. The timer used for an event is the one in effect when event timing begins. This timer is used to convert start and end values to picoseconds for storage in the event.

Modifications to the `setup_timers` table affect monitoring immediately. Events already in progress use the original timer for the begin time and the new timer for the end time, which leads to unpredictable results. If you make timer changes, you may want to use `TRUNCATE TABLE` to reset Performance Schema statistics.

The timer baseline (“time zero”) occurs at Performance Schema initialization during server startup. `TIMER_START` and `TIMER_END` values in events represent picoseconds since the baseline. `TIMER_WAIT` values are durations in picoseconds.

Picosecond values in events are approximate. Their accuracy is subject to the usual forms of error associated with conversion from one unit to another. If the `CYCLE` timer is used and the processor rate varies, there might be drift. For these reasons, it is not reasonable to look at the `TIMER_START` value for an event as an accurate measure of time elapsed since server startup. On the other hand, it is reasonable to use `TIMER_START` or `TIMER_WAIT` values in `ORDER BY` clauses to order events by start time or duration.

The choice of picoseconds in events rather than a value such as microseconds has a performance basis. One implementation goal was to show results in a uniform time unit, regardless of the timer. In an ideal world this time unit would look like a wall-clock unit and be reasonably precise; in other words, microseconds. But to convert cycles or nanoseconds to microseconds, it would be necessary to perform a division for every instrumentation. Division is expensive on many platforms. Multiplication is not expensive, so that is what is used. Therefore, the time unit is an integer multiple of the highest possible `TIMER_FREQUENCY` value, using a multiplier large enough to ensure that there is no major precision loss. The result is that the time unit is “picoseconds.” This precision is spurious, but the decision enables overhead to be minimized.

19.2.3.2. Performance Schema Event Filtering

Events are processed in a producer/consumer fashion:

- Instrumented code is the source for events and produces events to be collected. The `setup_instruments` table lists the instruments for which events can be collected, whether they are enabled, and whether to collect timing information:

```
mysql> SELECT * FROM setup_instruments;
+------------------------------------------------------------+---------+-------+
| NAME                                                       | ENABLED | TIMED |
+------------------------------------------------------------+---------+-------+
...
| wait/synch/mutex/sql/LOCK_global_read_lock                 | YES     | YES   |
| wait/synch/mutex/sql/LOCK_global_system_variables          | YES     | YES   |
| wait/synch/mutex/sql/LOCK_lock_db                          | YES     | YES   |
| wait/synch/mutex/sql/LOCK_manager                          | YES     | YES   |
...
| wait/synch/rwlock/sql/LOCK_grant                           | YES     | YES   |
| wait/synch/rwlock/sql/LOGGER::LOCK_logger                  | YES     | YES   |
| wait/synch/rwlock/sql/LOCK_sys_init_connect                | YES     | YES   |
| wait/synch/rwlock/sql/LOCK_sys_init_slave                  | YES     | YES   |
...
| wait/io/file/sql/binlog                                    | YES     | YES   |
| wait/io/file/sql/binlog_index                              | YES     | YES   |
| wait/io/file/sql/casetest                                  | YES     | YES   |
| wait/io/file/sql/dbopt                                     | YES     | YES   |
...
```

- Performance Schema tables are the destinations for events and consume events. The `setup_consumers` table lists the types of consumers to which event information can be sent:

```
mysql> SELECT * FROM setup_consumers;
+----------------------------------------------+---------+
| NAME                                         | ENABLED |
+----------------------------------------------+---------+
| events_waits_current                         | YES     |
| events_waits_history                         | YES     |
| events_waits_history_long                    | YES     |
| events_waits_summary_by_thread_by_event_name | YES     |
| events_waits_summary_by_event_name           | YES     |
| events_waits_summary_by_instance             | YES     |
| file_summary_by_event_name                   | YES     |
| file_summary_by_instance                     | YES     |
+----------------------------------------------+---------+
```

Filtering can be done at different stages of performance monitoring:

- **Pre-filtering.** This is done by modifying Performance Schema configuration so that only certain types of events are collected from producers, and collected events update only certain consumers. This type of filtering is done by the Performance Schema and has a global effect that applies to all users.

  Reasons to use pre-filtering:

  - Pre-filtering reduces overhead. The overhead should be minimal even with all instruments enabled, but perhaps you want to reduce it further. Or you do not care about timing events and want to disable the timing code to eliminate timing overhead.
  - You can avoid filling the current-events or history tables with events in which you have no interest. Pre-filtering leaves more “room” in these tables for instances of rows for enabled instrument types. If you enable only file instruments with pre-

filtering, no rows are collected for nonfile instruments. With post-filtering, nonfile events are collected, leaving fewer rows for file events.

  - You can avoid maintaining some kinds of event tables. If you disable a consumer, the server does not spend time maintaining it. For example, if you do not care about event histories, you can disable the history table consumers to improve performance.

- **Post-filtering.** This involves the use of `WHERE` clauses in queries that select information from Performance Schema tables, to specify which of the available events you want to see. This type of filtering is performed on a per-user basis because individual users select which of the available events are of interest.

  Reasons to use post-filtering:

  - To avoid making decisions for individual users about which event information is of interest.
  - To use the Performance Schema to investigate a performance issue when the restrictions to impose using pre-filtering are not known in advance.

The following sections provide more detail about pre-filtering and provide guidelines for naming instruments or consumers in filtering operations. For information about writing queries to retrieve information (post-filtering), see Section 19.3, “Performance Schema Queries”.

19.2.3.2.1. Event Pre-Filtering

Pre-filtering is done by modifying Performance Schema configuration so that only certain types of events are collected from producers, and collected events update only certain consumers. This type of filtering is done by the Performance Schema and has a global effect that applies to all users.

Pre-filtering can be applied to either the producer or consumer stage of event processing:

- To affect pre-filtering at the producer stage, modify the `setup_instruments` table. An instrument can be enabled or disabled by setting its `ENABLED` value to `YES` or `NO`. An instrument can be configured whether to collect timing information by setting its `TIMED` value to `YES` or `NO`.
- To affect pre-filtering at the consumer stage, modify the `setup_consumers` table. A consumer can be enabled or disabled by setting its `ENABLED` value to `YES` or `NO`.

Here are some examples that show the types of pre-filtering operations available:

- Disable all instruments:

  ```
  mysql> UPDATE setup_instruments SET ENABLED = 'NO';
  ```

  Now no events will be collected. This change, like other pre-filtering operations, affects other users as well, even if they want to see event information.

- Disable all file instruments, adding them to the current set of disabled instruments:

  ```
  mysql> UPDATE setup_instruments SET ENABLED = 'NO'
      -> WHERE NAME LIKE 'wait/io/file/%';
  ```

- Disable only file instruments, enable all other instruments:

  ```
  mysql> UPDATE setup_instruments
      -> SET ENABLED = IF(NAME LIKE 'wait/io/file/%', 'NO', 'YES');
  ```

  The preceding queries use the `LIKE` operator and the pattern `'wait/io/file/%'` to match all instrument names that begin with `'wait/io/file/`. For additional information about specifying patterns to select instruments, see Section 19.2.3.2.2, “Naming Instruments or Consumers for Filtering Operations”.

- Enable all but those instruments in the `mysys` library:

  ```
  mysql> UPDATE setup_instruments
      -> SET ENABLED = CASE WHEN NAME LIKE '%/mysys/%' THEN 'YES' ELSE 'NO' END;
  ```

- Disable a specific instrument:

```
mysql> UPDATE setup_instruments SET ENABLED = 'NO'
    -> WHERE NAME = 'wait/synch/mutex/mysys/TMPDIR_mutex';
```

- To toggle the state of an instrument, “flip” its `ENABLED` value:

```
mysql> UPDATE setup_instruments
    -> SET ENABLED = IF(ENABLED = 'YES', 'NO', 'YES')
    -> WHERE NAME = 'wait/synch/mutex/mysys/TMPDIR_mutex';
```

- Disable timing for all events:

```
mysql> UPDATE setup_instruments SET TIMED = 'NO';
```

Setting the `TIMED` column for instruments affects Performance Schema table contents as described in Section 19.2.3.1, “Performance Schema Event Timing”.

When you change the monitoring configuration, the Performance Schema does not flush the history tables. Events already collected remain in the current-events and history tables until displaced by newer events. If you disable instruments, you might need to wait a while before events for them are displaced by newer events of interest. Alternatively, use `TRUNCATE TABLE` to empty the history tables.

After making instrumentation changes, you might want to truncate the summary tables as well to clear aggregate information for previously collected events. The effect of `TRUNCATE TABLE` for summary tables is to reset the summary columns to 0 or `NULL`, not to remove rows.

If you disable a consumer, the server does not spend time maintaining it. For example, you can disable the history table consumers if you do not care about historical event information:

```
mysql> UPDATE setup_consumers
    -> SET ENABLED = 'NO' WHERE NAME LIKE '%history%';
```

19.2.3.2.2. Naming Instruments or Consumers for Filtering Operations

Names given for filtering operations can be as specific or general as required. To indicate a single instrument or consumer, specify its name in full:

```
mysql> UPDATE setup_instruments
    -> SET ENABLED = 'NO'
    -> WHERE NAME = 'wait/synch/mutex/myisammrg/MYRG_INFO::mutex';

mysql> UPDATE setup_consumers
    -> SET ENABLED = 'NO' WHERE NAME = 'file_summary_by_instance';
```

To specify a group of instruments or consumers, use a pattern that matches the group members:

```
mysql> UPDATE setup_instruments
    -> SET ENABLED = 'NO'
    -> WHERE NAME LIKE 'wait/synch/mutex/%';

mysql> UPDATE setup_consumers
    -> SET ENABLED = 'NO' WHERE NAME LIKE '%history%';
```

If you use a pattern, it should be chosen so that it matches all the items of interest and no others. For example, to select all file I/O instruments, it is better to use a pattern that includes the entire instrument name prefix:

```
... WHERE NAME LIKE 'wait/io/file/%';
```

A pattern of `'%/file/%'` will match other instruments that have a component of `'/file/'` anywhere in the name. Even less suitable is the pattern `'%file%'` because it will match instruments with `'file'` anywhere in the name, such as `wait/synch/mutex/sql/LOCK_des_key_file`.

To check which instrument or consumer names a pattern matches, perform a simple test:

```
mysql> SELECT NAME FROM setup_instruments WHERE NAME LIKE 'pattern';

mysql> SELECT NAME FROM setup_consumers WHERE NAME LIKE 'pattern';
```

19.3. Performance Schema Queries

Pre-filtering limits which event information is collected and is independent of any particular user. By contrast, post-filtering is performed by individual users through the use of queries with appropriate `WHERE` clauses that restrict what event information to select from the events available after pre-filtering has been applied.

In Section 19.2.3.2.1, “Event Pre-Filtering”, an example showed how to pre-filter for file instruments. If the event tables contain both file and nonfile information, post-filtering is another way to see information only for file events. Add a `WHERE` clause to queries to restrict event selection appropriately:

```
mysql> SELECT THREAD_ID, NUMBER_OF_BYTES
    -> FROM events_waits_history
    -> WHERE EVENT_NAME LIKE 'wait/io/file/%'
    -> AND NUMBER_OF_BYTES IS NOT NULL;
+-----------+-----------------+
| THREAD_ID | NUMBER_OF_BYTES |
+-----------+-----------------+
|        11 |              66 |
|        11 |              47 |
|        11 |             139 |
|         5 |              24 |
|         5 |             834 |
+-----------+-----------------+
```

19.4. Performance Schema Instrument Naming Conventions

An instrument name consists of a sequence of components separated by `'/'` characters. Example names:

```
wait/io/file/myisam/log
wait/io/file/mysys/charset
wait/synch/cond/mysys/COND_alarm
wait/synch/cond/sql/BINLOG::update_cond
wait/synch/mutex/mysys/BITMAP_mutex
wait/synch/mutex/sql/LOCK_delete
wait/synch/rwlock/innodb/trx_sys_lock
wait/synch/rwlock/sql/Query_cache_query::lock
```

The instrument name space has a tree-like structure. The components of an instrument name from left to right provide a progression from more general to more specific. The number of components a name has depends on the type of instrument.

The interpretation of a given component in a name depends on the components to the left of it. For example, `myisam` appears in both of the following names, but `myisam` in the first name is related to file I/O, whereas in the second it is related to a synchronization instrument:

```
wait/io/file/myisam/log
wait/synch/cond/myisam/MI_SORT_INFO::cond
```

Instrument names consist of a prefix with a structure defined by the Performance Schema implementation and a suffix defined by the developer implementing the instrument code. The top-level component of an instrument prefix indicates the type of instrument. This component also determines which event timer in the `setup_timers` table applies to the instrument. For the prefix part of instrument names, the top level indicates the type of instrument.

The suffix part of instrument names comes from the code for the instruments themselves. Suffixes may include levels such as these:

- A name for the major component (a server module such as `myisam`, `innodb`, `mysys`, or `sql`) or a plugin name.
- The name of a variable in the code, in the form *`XXX`* (a global variable) or *`CCC`*`::`*`MMM`* (a member *`MMM`* in class *`CCC`*). Examples: `COND_thread_cache`, `THR_LOCK_myisam`, `BINLOG::LOCK_index`.

In MySQL 5.5, there is a single top-level component, `wait`, indicating a wait instrument. The naming tree for wait instruments has this structure:

- `wait/io`

  An instrumented I/O operation.

  - `wait/io/file`

    An instrumented file I/O operation. For files, the wait is the time waiting for the file operation to complete (for example, a call to `fwrite()`). Due to caching, the physical file I/O on the disk might not happen within this call.

- `wait/sync`

An instrumented synchronization object. For synchronization objects, the `TIMER_WAIT` time includes the amount of time blocked while attempting to acquire a lock on the object, if any.

- `wait/sync/cond`

  A condition is used by one thread to signal to other threads that something they were waiting for has happened. If a single thread was waiting for a condition, it can wake up and proceed with its execution. If several threads were waiting, they can all wake up and compete for the resource for which they were waiting.

- `wait/sync/mutex`

  A mutual exclusion object used to permit access to a resource (such as a section of executable code) while preventing other threads from accessing the resource.

- `wait/sync/rwlock`

  A read/write lock object used to lock a specific variable for access while preventing its use by other threads. A shared read lock can be acquired simultaneously by multiple threads. An exclusive write lock can be acquired by only one thread at a time.

19.5. Performance Schema Status Monitoring

There are several status variables associated with the Performance Schema:

```
mysql> SHOW STATUS LIKE 'perf%';
+------------------------------------------+-------+
| Variable_name                            | Value |
+------------------------------------------+-------+
| Performance_schema_cond_classes_lost     | 0     |
| Performance_schema_cond_instances_lost   | 0     |
| Performance_schema_file_classes_lost     | 0     |
| Performance_schema_file_handles_lost     | 0     |
| Performance_schema_file_instances_lost   | 0     |
| Performance_schema_locker_lost           | 0     |
| Performance_schema_mutex_classes_lost    | 0     |
| Performance_schema_mutex_instances_lost  | 0     |
| Performance_schema_rwlock_classes_lost   | 0     |
| Performance_schema_rwlock_instances_lost | 0     |
| Performance_schema_table_handles_lost    | 0     |
| Performance_schema_table_instances_lost  | 0     |
| Performance_schema_thread_classes_lost   | 0     |
| Performance_schema_thread_instances_lost | 0     |
+------------------------------------------+-------+
```

The Performance Schema status variables provide information about instrumentation that could not be loaded or created due to memory constraints. Names for these variables have several forms:

- `Performance_schema_xxx_classes_lost` indicates how many instruments of type *`xxx`* could not be loaded.
- `Performance_schema_xxx_instances_lost` indicates how many instances of object type *`xxx`* could not be created.
- `Performance_schema_xxx_handles_lost` indicates how many instances of object type *`xxx`* could not be opened.
- `Performance_schema_locker_lost` indicates how many events are “lost” or not recorded.

For example, if a mutex is instrumented in the server source but the server cannot allocate memory for the instrumentation at runtime, it increments `Performance_schema_mutex_classes_lost`. The mutex still functions as a synchronization object (that is, the server continues to function normally), but performance data for it will not be collected. If the instrument can be allocated, it can be used for initializing instrumented mutex instances. For a singleton mutex such as a global mutex, there will be only one instance. Other mutexes have an instance per connection, or per page in various caches and data buffers, so the number of instances varies over time. Increasing the maximum number of connections or the maximum size of some buffers will increase the maximum number of instances that might be allocated at once. If the server cannot create a given instrumented mutex instance, it increments `Performance_schema_mutex_instances_lost`.

Suppose that the following conditions hold:

- The server was started with the `--performance_schema_max_mutex_classes=200` option and thus has room for 200 mutex instruments.
- 150 mutex instruments have been loaded already.

- The plugin named `plugin_a` contains 40 mutex instruments.
- The plugin named `plugin_b` contains 20 mutex instruments.

The server allocates mutex instruments for the plugins depending on how many they need and how many are available, as illustrated by the following sequence of statements:

```
INSTALL PLUGIN plugin_a
```

The server now has 150+40 = 190 mutex instruments.

```
UNINSTALL PLUGIN plugin_a;
```

The server still has 190 instruments. All the historical data generated by the plugin code is still available, but new events for the instruments are not collected.

```
INSTALL PLUGIN plugin_a;
```

The server detects that the 40 instruments are already defined, so no new instruments are created, and previously assigned internal memory buffers are reused. The server still has 190 instruments.

```
INSTALL PLUGIN plugin_b;
```

The server has room for 200-190 = 10 instruments (in this case, mutex classes), and sees that the plugin contains 20 new instruments. 10 instruments are loaded, and 10 are discarded or “lost.” The `Performance_schema_mutex_classes_lost` indicates the number of instruments (mutex classes) lost:

```
mysql> SHOW STATUS LIKE "perf%mutex_classes_lost";
+---------------------------------------+-------+
| Variable_name                         | Value |
+---------------------------------------+-------+
| Performance_schema_mutex_classes_lost | 10    |
+---------------------------------------+-------+
1 row in set (0.10 sec)
```

The instrumentation still works and collects (partial) data for `plugin_b`.

When the server cannot create a mutex instrument, these results occur:

- No row for the instrument is inserted into the `setup_instruments` table.
- `Performance_schema_mutex_classes_lost` increases by 1.
- `Performance_schema_mutex_instances_lost` does not change. (When the mutex instrument is not created, it cannot be used to create instrumented mutex instances later.)

The pattern just described applies to all types of instruments, not just mutexes.

A value of `Performance_schema_mutex_classes_lost` greater than 0 can happen in two cases:

- To save a few bytes of memory, you start the server with `--performance_schema_max_mutex_classes=N`, where `N` is less than the default value. The default value is chosen to be sufficient to load all the plugins provided in the MySQL distribution, but this can be reduced if some plugins are never loaded. For example, you might choose not to load some of the storage engines in the distribution.
- You load a third-party plugin that is instrumented for the Performance Schema but do not allow for the plugin's instrumentation memory requirements when you start the server. Because it comes from a third party, the instrument memory consumption of this engine is not accounted for in the default value chosen for `performance_schema_max_mutex_classes`.

  If the server has insufficient resources for the plugin's instruments and you do not explicitly allocate more using `--performance_schema_max_mutex_classes=N`, loading the plugin leads to starvation of instruments.

If the value chosen for `performance_schema_max_mutex_classes` is too small, no error is reported in the error log and there is no failure at runtime. However, the content of the tables in the `performance_schema` database will miss events. The `Performance_schema_mutex_classes_lost` status variable is the only visible sign to indicate that some events were dropped internally due to failure to create instruments.

If an instrument is not lost, it is known to the Performance Schema, and is used when instrumenting instances. For example, `wait/synch/mutex/sql/LOCK_delete` is the name of a mutex instrument in the `setup_instruments` table. This single instrument is used when creating in the code (in `THD::LOCK_delete`) however many instances of the mutex are needed as the server runs. In this case, `LOCK_delete` is a mutex that is per connection (`THD`), so if a server has 1000 connections, there are 1000 threads, and 1000 instrumented `LOCK_delete` mutex instances (`THD::LOCK_delete`).

If the server does not have room for all these 1000 instrumented mutexes (instances), some mutexes are created with instrumentation, and some are created without instrumentation. If the server can create only 800 instances, 200 instances are lost. The server continues to run, but increments `Performance_schema_mutex_instances_lost` by 200 to indicate that instances could not be created.

A value of `Performance_schema_mutex_instances_lost` greater than 0 can happen when the code initializes more mutexes at runtime than were allocated for `--performance_schema_max_mutex_instances=N`.

The bottom line is that if `SHOW STATUS LIKE 'perf%'` says that nothing was lost (all values are zero), the Performance Schema data is accurate and can be relied upon. If something was lost, the data is incomplete, and the Performance Schema could not record everything given the insufficient amount of memory it was given to use. In this case, the specific `Performance_schema_xxx_lost` variable indicates the problem area.

It might be appropriate in some cases to cause deliberate instrument starvation. For example, if you do not care about performance data for file I/O, you can start the server with all Performance Schema parameters related to file I/O set to 0. No memory will be allocated for file-related classes, instances, or handles, and all file events will be lost.

Use `SHOW ENGINE PERFORMANCE_SCHEMA STATUS` to inspect the internal operation of the Performance Schema code:

```
mysql> SHOW ENGINE PERFORMANCE_SCHEMA STATUS\G
...
*************************** 3. row ***************************
  Type: performance_schema
  Name: events_waits_history.row_size
Status: 76
*************************** 4. row ***************************
  Type: performance_schema
  Name: events_waits_history.row_count
Status: 10000
*************************** 5. row ***************************
  Type: performance_schema
  Name: events_waits_history.memory
Status: 760000
...
*************************** 57. row ***************************
  Type: performance_schema
  Name: performance_schema.memory
Status: 26459600
...
```

The intent of this statement is to help the DBA to understand the effects that different options have on memory requirements. For a description of the field meanings, see Section 12.4.5.16, "`SHOW ENGINE` Syntax".

19.6. Performance Schema General Table Characteristics

The database name `performance_schema` is lowercase. The names of tables in the database are uppercase. Normal case sensitivity rules apply, so on systems with case-sensitive file names, the database name and table names must be specified in the lettercase just indicated. This behavior can be modified by setting the `lower_case_table_names` system variable.

Most tables in the `performance_schema` database are read only and cannot be modified. Some of the setup tables have columns that can be modified to affect Performance Schema operation. Truncation is permitted to clear collected events, so `TRUNCATE TABLE` can be used on tables containing those kinds of information, such as tables named with a prefix of `events_waits_`.

`TRUNCATE TABLE` can also be used with summary tables, but the effect is to reset the summary columns to 0 or `NULL`, not to remove rows.

Privileges are as for other databases and tables:

- To retrieve from `performance_schema` tables, you must have the `SELECT` privilege.
- To change those columns that can be modified, you must have the `UPDATE` privilege.
- To truncate tables that can be truncated, you must have the `DROP` privilege.

19.7. Performance Schema Table Descriptions

Tables in the `performance_schema` database can be grouped as follows:

- Setup tables. These tables are used to configure and display monitoring characteristics.
- Current events table. The `events_waits_current` table contains the most recent event for each thread.
- History tables. These tables have the same structure as `events_waits_current` but contain more rows. The `events_waits_history` table contains the most recent 10 events per thread. `events_waits_history_long` contains the most recent 10,000 events.

  To change the sizes of these tables, set the `performance_schema_events_waits_history_size` and `performance_schema_events_waits_history_long_size` system variables at server startup.
- Summary tables. These tables contain information aggregated over groups of events, including those that have been discarded from the history tables.
- Instance tables. These tables document what types of objects are instrumented. An instrumented object, when used by the server, produces an event. These tables provide event names and explanatory notes or status information.
- Miscellaneous tables. These do not fall into any of the other table groups.

19.7.1. Performance Schema Setup Tables

The setup tables provide information about the current instrumentation and enable the monitoring configuration to be changed. For this reason, some columns in these tables can be changed if you have the `UPDATE` privilege.

The use of tables rather than individual variables for setup information provides a high degree of flexibility in modifying Performance Schema configuration. For example, you can use a single statement with standard SQL syntax to make multiple simultaneous configuration changes.

These setup tables are available:

- `setup_consumers`: The types of consumers for which event information can be stored
- `setup_instruments`: The classes of instrumented objects for which events can be collected
- `setup_timers`: The current event timer

19.7.1.1. The `setup_consumers` Table

The `setup_consumers` table lists the types of consumers for which event information can be stored:

```
mysql> SELECT * FROM setup_consumers;
+----------------------------------------------+---------+
| NAME                                         | ENABLED |
+----------------------------------------------+---------+
| events_waits_current                         | YES     |
| events_waits_history                         | YES     |
| events_waits_history_long                    | YES     |
| events_waits_summary_by_thread_by_event_name | YES     |
| events_waits_summary_by_event_name           | YES     |
| events_waits_summary_by_instance             | YES     |
| file_summary_by_event_name                   | YES     |
| file_summary_by_instance                     | YES     |
+----------------------------------------------+---------+
```

The `setup_consumers` table has these columns:

- `NAME`

  The consumer name.
- `ENABLED`

  Whether the consumer is enabled. This column can be modified. If you disable a consumer, the server does not spend time adding event information to it.

Disabling the `events_waits_current` consumer disables everything else that depends on waits, such as the `events_waits_history` and `events_waits_history_long` tables, and all summary tables.

19.7.1.2. The `setup_instruments` Table

The `setup_instruments` table lists classes of instrumented objects for which events can be collected:

```
mysql> SELECT * FROM setup_instruments;
+------------------------------------------------------------+---------+-------+
| NAME                                                       | ENABLED | TIMED |
+------------------------------------------------------------+---------+-------+
...
| wait/synch/mutex/sql/LOCK_global_read_lock                 | YES     | YES   |
| wait/synch/mutex/sql/LOCK_global_system_variables          | YES     | YES   |
| wait/synch/mutex/sql/LOCK_lock_db                          | YES     | YES   |
| wait/synch/mutex/sql/LOCK_manager                          | YES     | YES   |
...
| wait/synch/rwlock/sql/LOCK_grant                           | YES     | YES   |
| wait/synch/rwlock/sql/LOGGER::LOCK_logger                  | YES     | YES   |
| wait/synch/rwlock/sql/LOCK_sys_init_connect                | YES     | YES   |
| wait/synch/rwlock/sql/LOCK_sys_init_slave                  | YES     | YES   |
...
| wait/io/file/sql/binlog                                    | YES     | YES   |
| wait/io/file/sql/binlog_index                              | YES     | YES   |
| wait/io/file/sql/casetest                                  | YES     | YES   |
| wait/io/file/sql/dbopt                                     | YES     | YES   |
...
```

Each instrument added to the source code provides a row for this table, even when the instrumented code is not executed. When an instrument is enabled and executed, instrumented instances are created, which are visible in the `*_instances` tables.

The `setup_instruments` table has these columns:

- `NAME`

  The instrument name. Instrument names have multiple parts and form a hierarchy, as discussed in Section 19.4, “Performance Schema Instrument Naming Conventions”. Events produced from execution of an instrument have an `EVENT_NAME` value that is taken from the instrument `NAME` value. (Events do not really have a “name,” but this provides a way to associate events with instruments.)

- `ENABLED`

  Whether the instrument is enabled. This column can be modified. A disabled instrument produces no events.

- `TIMED`

  Whether the instrument is timed. This column can be modified.

  If an enabled instrument is not timed, the instrument code is enabled, but the timer is not. Events produced by the instrument have `NULL` for the `TIMER_START`, `TIMER_END`, and `TIMER_WAIT` timer values. This in turn causes those values to be ignored when calculating the sum, minimum, maximum, and average time values in summary tables.

19.7.1.3. The `setup_timers` Table

The `setup_timers` table shows the currently selected event timer:

```
mysql> SELECT * FROM setup_timers;
+------+------------+
| NAME | TIMER_NAME |
+------+------------+
| wait | CYCLE      |
+------+------------+
```

The `setup_timers.TIMER_NAME` value can be changed to select a different timer. The value can be any of the values in the `performance_timers.TIMER_NAME` column. For an explanation of how event timing occurs, see Section 19.2.3.1, “Performance Schema Event Timing”.

The `setup_timers` table has these columns:

- `NAME`

  The type of instrument the timer is used for.

- `TIMER_NAME`

The timer that applies to the instrument type. This column can be modified.

The `setup_timers.TIMER_NAME` value can be changed to select a different timer. The value can be any of the values in the `performance_timers.TIMER_NAME` column. For an explanation of how event timing occurs, see Section 19.2.3.1, "Performance Schema Event Timing".

Modifications to the `setup_timers` table affect monitoring immediately. Events already in progress use the original timer for the begin time and the new timer for the end time, which leads to unpredictable results. If you make timer changes, you may want to use `TRUNCATE TABLE` to reset Performance Schema statistics.

19.7.2. Performance Schema Instance Tables

Instance tables document what types of objects are instrumented. They provide event names and explanatory notes or status information:

- `cond_instances`: Condition synchronization object instances
- `file_instances`: File instances
- `mutex_instances`: Mutex synchronization object instances
- `rwlock_instances`: Lock synchronization object instances

These tables list instrumented synchronization objects and files. There are three types of synchronization objects: `cond`, `mutex`, and `rwlock`. Each instance table has an `EVENT_NAME` or `NAME` column to indicate the instrument associated with each row. Instrument names have multiple parts and form a hierarchy, as discussed in Section 19.4, "Performance Schema Instrument Naming Conventions".

The `mutex_instances.LOCKED_BY_THREAD_ID` and `rwlock_instances.WRITE_LOCKED_BY_THREAD_ID` columns are extremely important for investigating performance bottlenecks or deadlocks. For examples of how to use them for this purpose, see Section 19.11, "Using the Performance Schema to Diagnose Problems"

19.7.2.1. The `cond_instances` Table

The `cond_instances` table lists all the conditions seen by the Performance Schema while the server executes. A condition is a synchronization mechanism used in the code to signal that a specific event has happened, so that a thread waiting for this condition can resume work.

When a thread is waiting for something to happen, the condition name is an indication of what the thread is waiting for, but there is no immediate way to tell which other thread, or threads, will cause the condition to happen.

The `cond_instances` table has these columns:

- `NAME`

  The instrument name associated with the condition.

- `OBJECT_INSTANCE_BEGIN`

  The address in memory of the condition that was instrumented.

19.7.2.2. The `file_instances` Table

The `file_instances` table lists all the files seen by the Performance Schema when executing file I/O instrumentation. If a file on disk has never been opened, it will not be in `file_instances`. When a file is deleted from the disk, it is also removed from the `file_instances` table.

The `file_instances` table has these columns:

- `FILE_NAME`

  The file name.

- `EVENT_NAME`

  The instrument name associated with the file.

- `OPEN_COUNT`

  The count of open handles on the file. If a file was opened and then closed, it was opened 1 time, but `OPEN_COUNT` will be 0. To list all the files currently opened by the server, use `WHERE OPEN_COUNT > 0`.

19.7.2.3. The `mutex_instances` Table

The `mutex_instances` table lists all the mutexes seen by the Performance Schema while the server executes. A mutex is a synchronization mechanism used in the code to enforce that only one thread at a given time can have access to some common resource. The resource is said to be “protected” by the mutex.

When two threads executing in the server (for example, two user sessions executing a query simultaneously) do need to access the same resource (a file, a buffer, or some piece of data), these two threads will compete against each other, so that the first query to obtain a lock on the mutex will cause the other query to wait until the first is done and unlocks the mutex.

The work performed while holding a mutex is said to be in a “critical section,” and multiple queries do execute this critical section in a serialized way (one at a time), which is a potential bottleneck.

The `mutex_instances` table has these columns:

- `NAME`

  The instrument name associated with the mutex.

- `OBJECT_INSTANCE_BEGIN`

  The address in memory of the mutex that was instrumented.

- `LOCKED_BY_THREAD_ID`

  When a thread currently has a mutex locked, `LOCKED_BY_THREAD_ID` is the `THREAD_ID` of the locking thread, otherwise it is `NULL`.

For every mutex instrumented in the code, the Performance Schema provides the following information.

- The `setup_instruments` table lists the name of the instrumentation point, with the prefix `wait/synch/mutex/`.
- When some code creates a mutex, a row is added to the `mutex_instances` table. The `OBJECT_INSTANCE_BEGIN` column is a property that uniquely identifies the mutex.
- When a thread attempts to lock a mutex, the `events_waits_current` table shows a row for that thread, indicating that it is waiting on a mutex (in the `EVENT_NAME` column), and indicating which mutex is waited on (in the `OBJECT_INSTANCE_BEGIN` column).
- When a thread succeeds in locking a mutex:
  - `events_waits_current` shows that the wait on the mutex is completed (in the `TIMER_END` and `TIMER_WAIT` columns)
  - The completed wait event is added to the `events_waits_history` and `events_waits_history_long` tables
  - `mutex_instances` shows that the mutex is now owned by the thread (in the `THREAD_ID` column).
- When a thread unlocks a mutex, `mutex_instances` shows that the mutex now has no owner (the `THREAD_ID` column is `NULL`).
- When a mutex object is destroyed, the corresponding row is removed from `mutex_instances`.

By performing queries on both of the following tables, a monitoring application or a DBA can detect bottlenecks or deadlocks between threads that involve mutexes:

- `events_waits_current`, to see what mutex a thread is waiting for

- `mutex_instances`, to see which other thread currently owns a mutex

19.7.2.4. The `rwlock_instances` Table

The `rwlock_instances` table lists all the `rwlock` instances (read write locks) seen by the Performance Schema while the server executes. An `rwlock` is a synchronization mechanism used in the code to enforce that threads at a given time can have access to some common resource following certain rules. The resource is said to be “protected” by the `rwlock`. The access is either shared (many threads can have a read lock at the same time) or exclusive (only one thread can have a write lock at a given time).

Depending on how many threads are requesting a lock, and the nature of the locks requested, access can be either granted in shared mode, granted in exclusive mode, or not granted at all, waiting for other threads to finish first.

The `rwlock_instances` table has these columns:

- `NAME`

  The instrument name associated with the lock.

- `OBJECT_INSTANCE_BEGIN`

  The address in memory of the lock that was instrumented.

- `WRITE_LOCKED_BY_THREAD_ID`

  When a thread currently has an `rwlock` locked in exclusive (write) mode, `WRITE_LOCKED_BY_THREAD_ID` is the `THREAD_ID` of the locking thread, otherwise it is `NULL`.

- `READ_LOCKED_BY_COUNT`

  When a thread currently has an `rwlock` locked in shared (read) mode, `READ_LOCKED_BY_COUNT` is incremented by 1. This is a counter only, so it cannot be used directly to find which thread holds a read lock, but it can be used to see whether there is a read contention on an `rwlock`, and see how many readers are currently active.

By performing queries on both of the following tables, a monitoring application or a DBA may detect some bottlenecks or deadlocks between threads that involve locks:

- `events_waits_current`, to see what `rwlock` a thread is waiting for
- `rwlock_instances`, to see which other thread currently owns an `rwlock`

There is a limitation: The `rwlock_instances` can be used only to identify the thread holding a write lock, but not the threads holding a read lock.

19.7.3. Performance Schema Wait Event Tables

These tables store wait events:

- `events_waits_current`: Current wait events
- `events_waits_history`: The most recent wait events for each thread
- `events_waits_history_long`: The most recent wait events overall

19.7.3.1. The `events_waits_current` Table

The `events_waits_current` table contains current wait events, one row per thread showing the current status of the thread's most recent monitored wait event.

The `events_waits_current` table can be truncated with `TRUNCATE TABLE`.

Of the tables that contain wait event rows, `events_waits_current` is the most fundamental. Other tables that contain wait event rows are logically derived from the current events. For example, the `events_waits_history` and `events_waits_history_long` tables are collections of the most recent wait events, up to a fixed number of rows.

The `events_waits_current` table has these columns:

- `THREAD_ID`, `EVENT_ID`

  The thread associated with the event and the event number. These two values taken together form a primary key that uniquely identifies the row. No two rows will have the same pair of values.

- `EVENT_NAME`

  The name of the instrument that produced the event. This is a `setup_instruments.NAME` value. Instrument names have multiple parts and form a hierarchy, as discussed in Section 19.4, “Performance Schema Instrument Naming Conventions”.

- `SOURCE`

  The name of the source file containing the instrumented code that produced the event and the line number in the file at which the instrumentation occurs. This enables you to check the source to determine exactly what code is involved. For example, if a mutex or lock is being blocked, you can check the context in which this occurs.

- `TIMER_START`, `TIMER_END`, `TIMER_WAIT`

  Timing information for the event. The unit for these values is picoseconds (trillionths of a second). The `TIMER_START` and `TIMER_END` values indicate when event timing started and ended. `TIMER_WAIT` is the event elapsed time (duration).

  If an event has not finished, `TIMER_END` and `TIMER_WAIT` are `NULL`.

  If an event is produced from an instrument that has `TIMED = NO`, timing information is not collected, and `TIMER_START`, `TIMER_END`, and `TIMER_WAIT` are all `NULL`.

  For discussion of picoseconds as the unit for event times and factors that affect time values, see Section 19.2.3.1, “Performance Schema Event Timing”.

- `SPINS`

  For a mutex, the number of spin rounds. If the value is `NULL`, the code does not use spin rounds or spinning is not instrumented.

- `OBJECT_SCHEMA`, `OBJECT_NAME`, `OBJECT_TYPE`, `OBJECT_INSTANCE_BEGIN`

  These columns identify the object “being acted on.” What that means depends on the object type.

  For a synchronization object (`cond`, `mutex`, `rwlock`):

  - `OBJECT_SCHEMA`, `OBJECT_NAME`, and `OBJECT_TYPE` are `NULL`.
  - `OBJECT_INSTANCE_BEGIN` is the address of the synchronization object in memory.

  For a file I/O object:

  - `OBJECT_SCHEMA` is `NULL`.
  - `OBJECT_NAME` is the file name.
  - `OBJECT_TYPE` is `FILE`.
  - `OBJECT_INSTANCE_BEGIN` is an address in memory.

  An `OBJECT_INSTANCE_BEGIN` value itself has no meaning, except that different values indicate different objects. `OBJECT_INSTANCE_BEGIN` can be used for debugging. For example, it can be used with `GROUP BY OBJECT_INSTANCE_BEGIN` to see whether the load on 1,000 mutexes (that protect, say, 1,000 pages or blocks of data) is spread evenly or just hitting a few bottlenecks. This can help you correlate with other sources of information if you see the same object address in a log file or another debugging or performance tool.

- `NESTING_EVENT_ID`

  Currently `NULL`.

- `OPERATION`

  The type of operation performed, such as `lock`, `read`, or `write`.

- `NUMBER_OF_BYTES`

The number of bytes read or written by the operation.

- `FLAGS`

  Reserved for future use.

19.7.3.2. The `events_waits_history` Table

The `events_waits_history` table contains the most recent 10 wait events per thread. The table size may be changed by modifying the `performance_schema_events_waits_history_size` system variable at server startup. As new events are added to the table, older events are discarded if the table is full. Events are not added to the table until they have ended.

The `events_waits_history` table has the same structure as `events_waits_current`. See Section 19.7.3.1, "The `events_waits_current` Table".

The `events_waits_history` table can be truncated with `TRUNCATE TABLE`.

19.7.3.3. The `events_waits_history_long` Table

The `events_waits_history_long` table contains the most recent 10,000 wait events. The table size may be changed by modifying the `performance_schema_events_waits_history_long_size` system variable at server startup. As new events are added to the table, older events are discarded if the table is full. Events are not added to the table until they have ended.

The `events_waits_history_long` table has the same structure as `events_waits_current`. See Section 19.7.3.1, "The `events_waits_current` Table".

The `events_waits_history_long` table can be truncated with `TRUNCATE TABLE`.

19.7.4. Performance Schema Summary Tables

Summary tables provide aggregate information for terminated events over time. The tables in this group summarize event data in different ways.

Event Wait Summaries:

- `events_waits_summary_global_by_event_name`: Wait events summarized per event name
- `events_waits_summary_by_instance`: Wait events summarized per instance
- `events_waits_summary_by_thread_by_event_name`: Wait events summarized per thread and event name

File I/O Summaries:

- `file_summary_by_event_name`: File events summarized per event name
- `file_summary_by_instance`: File events summarized per instance

The `events_waits_summary_global_by_event_name` table was named `EVENTS_WAITS_SUMMARY_BY_EVENT_NAME` before MySQL 5.5.7.

Each summary table has grouping columns that determine how to group the data to be aggregated, and summary columns that contain the aggregated values. Tables that summarize events in similar ways often have similar sets of summary columns and differ only in the grouping columns used to determine how events are aggregated.

Summary tables can be truncated with `TRUNCATE TABLE`. The effect is to reset the summary columns to 0 or `NULL`, not to remove rows. This enables you to clear collected values and restart aggregation. That might be useful, for example, after you have made a runtime configuration change.

19.7.4.1. Event Wait Summary Tables

The event waits summary tables aggregate general information about event waits:

- `events_waits_summary_global_by_event_name`: Wait events summarized per event name

- `events_waits_summary_by_instance`: Wait events summarized per instance
- `events_waits_summary_by_thread_by_event_name`: Wait events summarized per thread and event name

For example:

```
mysql> SELECT * FROM events_waits_summary_global_by_event_name\G
...
*************************** 6. row ***************************
    EVENT_NAME: wait/synch/mutex/sql/MYSQL_BIN_LOG::LOCK_index
    COUNT_STAR: 8
SUM_TIMER_WAIT: 2119302
MIN_TIMER_WAIT: 196092
AVG_TIMER_WAIT: 264912
MAX_TIMER_WAIT: 569421
...
*************************** 9. row ***************************
    EVENT_NAME: wait/synch/mutex/sql/hash_filo::lock
    COUNT_STAR: 69
SUM_TIMER_WAIT: 16848828
MIN_TIMER_WAIT: 0
AVG_TIMER_WAIT: 244185
MAX_TIMER_WAIT: 735345
...
```

`TRUNCATE TABLE` is permitted for summary tables. It resets the counters to zero rather than removing rows.

The event wait summary tables have these grouping columns to indicate how events are aggregated:

- `events_waits_summary_global_by_event_name` has an `EVENT_NAME` column. Each row summarizes events for a given instrument. An instrument might be used to create multiple instances of the instrumented object. For example, if there is an instrument for a mutex that is created for each connection, there are as many instances as there are connections. The summary row for the instrument summarizes over all these instances.
- `events_waits_summary_by_instance` has `EVENT_NAME` and `OBJECT_INSTANCE_BEGIN` columns. Each row summarizes events for a given instrument instance. If an instrument is used to create multiple instances, each instance has a unique `OBJECT_INSTANCE_BEGIN` value, so these instances are summarized separately in this table.
- `events_waits_summary_by_thread_by_event_name` has `THREAD_ID` and `EVENT_NAME` columns. Each row summarizes events for a given thread and instrument.

The event waits summary tables have these summary columns containing aggregated values:

- `COUNT_STAR`

  The number of summarized events. This value includes all events, whether timed or not.
- `SUM_TIMER_WAIT`

  The total wait time of the summarized timed events. This value is calculated only for timed events because nontimed events have a wait time of `NULL`. The same is true for the other `*xxx*_TIMER_WAIT` values.
- `MIN_TIMER_WAIT`

  The minimum wait time of the summarized timed events.
- `AVG_TIMER_WAIT`

  The average wait time of the summarized timed events.
- `MAX_TIMER_WAIT`

  The maximum wait time of the summarized timed events.

19.7.4.2. File I/O Summary Tables

The file I/O summary tables aggregate information about I/O operations:

- `file_summary_by_event_name`: File events summarized per event name

- `file_summary_by_instance`: File events summarized per instance

For example:

```
mysql> SELECT * FROM file_summary_by_instance\G
...
*************************** 2. row ***************************
                FILE_NAME: /private/var/mysql/50514/share/english/errmsg.sys
               EVENT_NAME: wait/io/file/sql/ERRMSG
               COUNT_READ: 3
              COUNT_WRITE: 0
 SUM_NUMBER_OF_BYTES_READ: 42211
SUM_NUMBER_OF_BYTES_WRITE: 0
...
*************************** 6. row ***************************
                FILE_NAME: /private/var/mysql/50514/data/binlog.000001
               EVENT_NAME: wait/io/file/sql/binlog
               COUNT_READ: 0
              COUNT_WRITE: 0
 SUM_NUMBER_OF_BYTES_READ: 0
SUM_NUMBER_OF_BYTES_WRITE: 0
...
```

`TRUNCATE TABLE` is permitted for summary tables. It resets the counters to zero rather than removing rows.

The file I/O summary tables have these grouping columns to indicate how events are aggregated:

- `file_summary_by_event_name` has an `EVENT_NAME` column. Each row summarizes events for a given instrument.
- `file_summary_by_instance` has `FILE_NAME` and `EVENT_NAME` columns. Each row summarizes events for a given file instrument instance.

The file I/O summary tables have these summary columns containing aggregated values:

- `COUNT_READ`

  The number of read operations in the summarized events.

- `COUNT_WRITE`

  The number of write operations in the summarized events.

- `SUM_NUMBER_OF_BYTES_READ`

  The number of bytes read in the summarized events.

- `SUM_NUMBER_OF_BYTES_WRITE`

  The number of bytes written in the summarized events.

19.7.5. Performance Schema Miscellaneous Tables

The following sections describe tables that do not fall into the table categories discussed in the preceding sections:

- `performance_timers`: Which event timers are available.
- `threads`: Information about server threads.

19.7.5.1. The `performance_timers` Table

The `performance_timers` table shows which event timers are available:

```
mysql> SELECT * FROM performance_timers;
+-------------+-----------------+------------------+----------------+
| TIMER_NAME  | TIMER_FREQUENCY | TIMER_RESOLUTION | TIMER_OVERHEAD |
+-------------+-----------------+------------------+----------------+
| CYCLE       |      2389029850 |                1 |             72 |
| NANOSECOND  |            NULL |             NULL |           NULL |
| MICROSECOND |         1000000 |                1 |            585 |
| MILLISECOND |            1035 |                1 |            738 |
| TICK        |             101 |                1 |            630 |
+-------------+-----------------+------------------+----------------+
```

If the values associated with a given timer name are `NULL`, that timer is not supported on your platform. The rows that do not contain `NULL` indicate which timers you can use in `setup_timers`.

The `performance_timers` table has these columns:

- `TIMER_NAME`

  The name by which to refer to the timer when configuring the `setup_timers` table.

- `TIMER_FREQUENCY`

  The number of timer units per second. For a cycle timer, the frequency is generally related to the CPU speed. For example, on a system with a 2.4GHz processor, the `CYCLE` may be close to 2400000000.

- `TIMER_RESOLUTION`

  Indicates the number of timer units by which timer values increase. If a timer has a resolution of 10, its value increases by 10 each time.

- `TIMER_OVERHEAD`

  The minimal number of cycles of overhead to obtain one timing with the given timer. The Performance Schema determines this value by invoking the timer 20 times during initialization and picking the smallest value. The total overhead really is twice this amount because the instrumentation invokes the timer at the start and end of each event. The timer code is called only for timed events, so this overhead does not apply for nontimed events.

19.7.5.2. The `threads` Table

The `threads` table contains a row for each server thread:

```
mysql> SELECT * FROM threads;
+-----------+----------------+----------------------------------------+
| THREAD_ID | PROCESSLIST_ID | NAME                                   |
+-----------+----------------+----------------------------------------+
|         0 |              0 | thread/sql/main                        |
|         1 |              0 | thread/innodb/io_handler_thread        |
|        16 |              0 | thread/sql/signal_handler              |
|        23 |              7 | thread/sql/one_connection              |
|         5 |              0 | thread/innodb/io_handler_thread        |
|        12 |              0 | thread/innodb/srv_lock_timeout_thread  |
|        22 |              6 | thread/sql/one_connection              |
...
```

If you have the `PROCESS` privilege, you can see all threads. Otherwise, you can see only your own threads (that is, threads associated with the MySQL account that you are using).

The `threads` table has these columns:

- `THREAD_ID`

  This is the unique identifier of an instrumented thread.

- `PROCESSLIST_ID`

  For threads that are displayed in `INFORMATION_SCHEMA.PROCESSLIST`, this is the `INFORMATION_SCHEMA.ID` value, which is also the value that `CONNECTION_ID()` would return within that thread. For background threads (threads not associated with a user connection), `PROCESSLIST_ID` is 0, so the values are not unique.

  This column was named `ID` before MySQL 5.5.8.

- `NAME`

  `NAME` is the name associated with the instrumentation of the code in the server. For example, `thread/sql/one_connection` corresponds to the thread function in the code responsible for handling a user connection, and `thread/sql/main` stands for the `main()` function of the server.

The `threads` table was named `PROCESSLIST` before MySQL 5.5.6.

19.8. Performance Schema System Variables

The Performance Schema implements several system variables that provide configuration information:

```
mysql> SHOW VARIABLES LIKE 'perf%';
+---------------------------------------------------+---------+
| Variable_name                                     | Value   |
+---------------------------------------------------+---------+
| performance_schema                                | ON      |
| performance_schema_events_waits_history_long_size | 10000   |
| performance_schema_events_waits_history_size      | 10      |
| performance_schema_max_cond_classes               | 80      |
| performance_schema_max_cond_instances             | 1000    |
| performance_schema_max_file_classes               | 50      |
| performance_schema_max_file_handles               | 32768   |
| performance_schema_max_file_instances             | 10000   |
| performance_schema_max_mutex_classes              | 200     |
| performance_schema_max_mutex_instances            | 1000000 |
| performance_schema_max_rwlock_classes             | 30      |
| performance_schema_max_rwlock_instances           | 1000000 |
| performance_schema_max_table_handles              | 100000  |
| performance_schema_max_table_instances            | 50000   |
| performance_schema_max_thread_classes             | 50      |
| performance_schema_max_thread_instances           | 1000    |
+---------------------------------------------------+---------+
```

Table 19.1. Performance Schema Variable Reference

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
performance_schema	Yes	Yes	Yes		Global	No
Performance_schema_cond_classes_lost				Yes	Global	No
Performance_schema_cond_instances_lost				Yes	Global	No
performance_schema_events_waits_history_long_size	Yes	Yes	Yes		Global	No
performance_schema_events_waits_history_size	Yes	Yes	Yes		Global	No
Performance_schema_file_classes_lost				Yes	Global	No
Performance_schema_file_handles_lost				Yes	Global	No
Performance_schema_file_instances_lost				Yes	Global	No
Performance_schema_locker_lost				Yes	Global	No
performance_schema_max_cond_classes	Yes	Yes	Yes		Global	No
performance_schema_max_cond_instances	Yes	Yes	Yes		Global	No
performance_schema_max_file_classes	Yes	Yes	Yes		Global	No
performance_schema_max_file_handles	Yes	Yes	Yes		Global	No
perform-	Yes	Yes	Yes		Global	No

Name	Cmd-Line	Option file	System Var	Status Var	Var Scope	Dynamic
ance_schema_max_file_instances						
performance_schema_max_mutex_classes	Yes	Yes	Yes		Global	No
performance_schema_max_mutex_instances	Yes	Yes	Yes		Global	No
performance_schema_max_rwlock_classes	Yes	Yes	Yes		Global	No
performance_schema_max_rwlock_instances	Yes	Yes	Yes		Global	No
performance_schema_max_table_handles	Yes	Yes	Yes		Global	No
performance_schema_max_table_instances	Yes	Yes	Yes		Global	No
performance_schema_max_thread_classes	Yes	Yes	Yes		Global	No
performance_schema_max_thread_instances	Yes	Yes	Yes		Global	No
Performance_schema_mutex_classes_lost				Yes	Global	No
Performance_schema_mutex_instances_lost				Yes	Global	No
Performance_schema_rwlock_classes_lost				Yes	Global	No
Performance_schema_rwlock_instances_lost				Yes	Global	No
Performance_schema_table_handles_lost				Yes	Global	No
Performance_schema_table_instances_lost				Yes	Global	No
Performance_schema_thread_classes_lost				Yes	Global	No
Performance_schema_thread_instances_lost				Yes	Global	No

The variables have the following meanings:

- `performance_schema`

  The value of this variable is `ON` or `OFF` to indicate whether the Performance Schema is enabled. By default, the value is `OFF`. At server startup, you can specify this variable with no value or a value of 1 to enable it, or with a value of 0 to disable it.

- `performance_schema_events_waits_history_long_size`

The number of rows in the `events_waits_history_long` table.

- `performance_schema_events_waits_history_size`

  The number of rows per thread in the `events_waits_history` table.

- `performance_schema_max_cond_classes`

  The maximum number of condition instruments.

- `performance_schema_max_cond_instances`

  The maximum number of instrumented condition objects.

- `performance_schema_max_file_classes`

  The maximum number of file instruments.

- `performance_schema_max_file_handles`

  The maximum number of opened file objects.

  The value of `performance_schema_max_file_handles` should be greater than the value of `open_files_limit`: `open_files_limit` affects the maximum number of open file handles the server can support and `performance_schema_max_file_handles` affects how many of these file handles can be instrumented.

- `performance_schema_max_file_instances`

  The maximum number of instrumented file objects.

- `performance_schema_max_mutex_classes`

  The maximum number of mutex instruments.

- `performance_schema_max_mutex_instances`

  The maximum number of instrumented mutex objects.

- `performance_schema_max_rwlock_classes`

  The maximum number of rwlock instruments.

- `performance_schema_max_rwlock_instances`

  The maximum number of instrumented rwlock objects.

- `performance_schema_max_table_handles`

  The maximum number of opened table objects.

- `performance_schema_max_table_instances`

  The maximum number of instrumented table objects.

- `performance_schema_max_thread_classes`

  The maximum number of thread instruments.

- `performance_schema_max_thread_instances`

  The maximum number of instrumented thread objects.

  The `max_connections` and `max_delayed_threads` system variables affect how many threads are run in the server. `performance_schema_max_thread_instances` affects how many of these running threads can be instrumented. If you increase `max_connections` or `max_delayed_threads`, you should consider increasing `performance_schema_max_thread_instances` so that `performance_schema_max_thread_instances` is greater than the sum of `max_connections` and `max_delayed_threads`.

19.9. Performance Schema Status Variables

The Performance Schema implements several status variables that provide information about instrumentation that could not be loaded or created due to memory constraints:

```
mysql> SHOW STATUS LIKE 'perf%';
+------------------------------------------+-------+
| Variable_name                            | Value |
+------------------------------------------+-------+
| Performance_schema_cond_classes_lost     | 0     |
| Performance_schema_cond_instances_lost   | 0     |
| Performance_schema_file_classes_lost     | 0     |
| Performance_schema_file_handles_lost     | 0     |
| Performance_schema_file_instances_lost   | 0     |
| Performance_schema_locker_lost           | 0     |
| Performance_schema_mutex_classes_lost    | 0     |
| Performance_schema_mutex_instances_lost  | 0     |
| Performance_schema_rwlock_classes_lost   | 0     |
| Performance_schema_rwlock_instances_lost | 0     |
| Performance_schema_table_handles_lost    | 0     |
| Performance_schema_table_instances_lost  | 0     |
| Performance_schema_thread_classes_lost   | 0     |
| Performance_schema_thread_instances_lost | 0     |
+------------------------------------------+-------+
```

Names for these variables have several forms:

- `Performance_schema_xxx_classes_lost`

  How many instruments of type *`xxx`* could not be loaded.

- `Performance_schema_xxx_instances_lost`

  How many instances of object type *`xxx`* could not be created.

- `Performance_schema_xxx_handles_lost`

  How many instances of object type *`xxx`* could not be opened.

- `Performance_schema_locker_lost`

  How many events are “lost” or not recorded, due to the following conditions:

  - Events are recursive (for example, waiting for A caused a wait on B, which caused a wait on C).
  - The depth of the nested events stack is greater than the limit imposed by the implementation.

  Currently, events recorded by the Performance Schema are not recursive, so this variable should always be 0.

For information on using these variables to check Performance Schema status, see Section 19.5, “Performance Schema Status Monitoring”.

19.10. Performance Schema and Plugins

Removing a plugin with `UNINSTALL PLUGIN` does not affect information already collected for code in that plugin. Time spent executing the code while the plugin was loaded was still spent even if the plugin is unloaded later. The associated event information, including aggregate information, remains readable in `performance_schema` database tables. For additional information about the effect of plugin installation and removal, see Section 19.5, “Performance Schema Status Monitoring”.

A plugin implementor who instruments plugin code should document its instrumentation characteristics to enable those who load the plugin to account for its requirements. For example, a third-party storage engine should include in its documentation how much memory the engine needs for mutex and other instruments.

19.11. Using the Performance Schema to Diagnose Problems

The Performance Schema is a tool to help a DBA do performance tuning by taking real measurements instead of “wild guesses.” This section demonstrates some ways to use the Performance Schema for this purpose. The discussion here relies on the use of event filtering, which is described in Section 19.2.3.2, “Performance Schema Event Filtering”.

The following example provides one methodology that you can use to analyze a repeatable problem, such as investigating a performance bottleneck. To begin, you should have a repeatable use case where performance is deemed “too slow” and needs optimization, and you should enable all instrumentation (no pre-filtering at all).

1. Run the use case.
2. Using the Performance Schema tables, analyze the root cause of the performance problem. This analysis will rely heavily on post-filtering.
3. For problem areas that are ruled out, disable the corresponding instruments. For example, if analysis shows that the issue is not related to file I/O in a particular storage engine, disable the file I/O instruments for that engine. Then truncate the history and summary tables to remove previously collected events.
4. Repeat the process at step 1.

   At each iteration, the Performance Schema output, particularly the `events_waits_history_long` table, will contain less and less "noise" caused by nonsignificant instruments, and given that this table has a fixed size, will contain more and more data relevant to the analysis of the problem at hand.

   At each iteration, investigation should lead closer and closer to the root cause of the problem, as the "signal/noise" ratio will improve, making analysis easier.
5. Once a root cause of performance bottleneck is identified, take the appropriate corrective action, such as:
   - Tune the server parameters (cache sizes, memory, and so forth).
   - Tune a query by writing it differently,
   - Tune the database schema (tables, indexes, and so forth).
   - Tune the code (this applies to storage engine or server developers only).
6. Start again at step 1, to see the effects of the changes on performance.

The `mutex_instances.LOCKED_BY_THREAD_ID` and `rwlock_instances.WRITE_LOCKED_BY_THREAD_ID` columns are extremely important for investigating performance bottlenecks or deadlocks. This is made possible by Performance Schema instrumentation as follows:

1. Suppose that thread 1 is stuck waiting for a mutex.
2. You can determine what the thread is waiting for:

   ```
   SELECT * FROM events_waits_current WHERE THREAD_ID = thread_1;
   ```

   Say the query result identifies that the thread is waiting for mutex A, found in `events_waits_current.OBJECT_INSTANCE_BEGIN`.
3. You can determine which thread is holding mutex A:

   ```
   SELECT * FROM mutex_instances WHERE OBJECT_INSTANCE_BEGIN = mutex_A;
   ```

   Say the query result identifies that it is thread 2 holding mutex A, as found in `mutex_instances.LOCKED_BY_THREAD_ID`.
4. You can see what thread 2 is doing:

   ```
   SELECT * FROM events_waits_current WHERE THREAD_ID = thread_2;
   ```

Chapter 20. Connectors and APIs

MySQL Connectors provide connectivity to the MySQL server for client programs. APIs provide low-level access to the MySQL protocol and MySQL resources. Both Connectors and the APIs enable you to connect and execute MySQL statements from another language or environment, including Java (JDBC), ODBC, Perl, Python, PHP, Ruby, and native C and embedded MySQL instances.

> **Note**
>
> Connector version numbers do not correlate with MySQL Server version numbers. See also Table 20.2, “MySQL Connector Versions and MySQL Server Versions”.

A number of connectors are developed by MySQL:

- Connector/ODBC provides driver support for connecting to a MySQL server using the Open Database Connectivity (ODBC) API. Support is available for ODBC connectivity from Windows, Unix and Mac OS X platforms.
- Connector/Net enables developers to create .NET applications that use data stored in a MySQL database. Connector/Net implement a fully functional ADO.NET interface and provides support for use with ADO.NET aware tools. Applications that want to use Connector/Net can be written in any of the supported .NET languages.

  The MySQL Visual Studio Plugin works with Connector/Net and Visual Studio 2005. The plugin is a MySQL DDEX Provider, which means that you can use the schema and data manipulation tools within Visual Studio to create and edit objects within a MySQL database.
- Connector/J provides driver support for connecting to MySQL from a Java application using the standard Java Database Connectivity (JDBC) API.
- Connector/MXJ is a tool that enables easy deployment and management of MySQL server and database through your Java application.
- Connector/C++ is a tool that enables easy deployment and management of MySQL server and database through your C++ application.
- Connector/C is a standalone replacement for the MySQL Client Library (`libmysql`).
- Connector/OpenOffice.org is a tool that enables OpenOffice.org applications to connect to MySQL server.

There are two direct access methods for using MySQL natively within a C application:

- The C API provides low-level access to the MySQL protocol through the `libmysql` client library; this is the primary method used to connect to an instance of the MySQL server, and is used both by MySQL command line clients and many of the APIs also detailed in this section. MySQL Connector/C can now also be used for this purpose.
- `libmysqld` is an embedded MySQL server library that enables you to embed an instance of the MySQL server into your C applications.

If you need to access MySQL from a C application, or build an interface to MySQL for a language not supported by the Connectors or APIs in this chapter, the C API is where you would start. A number of programmers utilities are available to help with the process, and also covered in this section.

The remaining APIs provide an interface to MySQL from specific application languages. These solutions are not developed or supported by MySQL. Basic information on their usage and abilities is provided here for reference purposes only.

All the language APIs are developed using one of two methods, using `libmysql` or by building a *native driver*. The two solutions offer different benefits:

- Using *`libmysql`* offers complete compatibility with MySQL as it uses the same libraries as the MySQL client applications. However, the feature set is limited to the implementation and interfaces exposed through `libmysql` and the performance may be lower as data is copied between the native language, and the MySQL API components. MySQL Connector/C is a possible alternative to using `libmysql`.
- *Native drivers* are an implementation of the MySQL network protocol entirely within the host language or environment. Native drivers are fast, as there is less copying of data between components, and they can offer advanced functionality not available through the standard MySQL API. Native drivers are also easier to build and deploy, as you do not need a copy of the MySQL client libraries to build the native driver components.

A list of many of the libraries and interfaces available for MySQL are shown in the table. See Table 20.1, “MySQL APIs and Interfaces”.

Table 20.1. MySQL APIs and Interfaces

Environment	API	Type	Notes
Ada	MySQL Bindings for GNU Ada	`libmysql`	See MySQL Bindings for GNU Ada
C	Connector/C	Replacement for `libmysql`	See Section 20.6, “MySQL Connector/C”.
C++	Connector/C++	`libmysql`	See Section 20.5, “MySQL Connector/C++”.
	MySQL++	`libmysql`	See MySQL++ Web site.
	MySQL wrapped	`libmysql`	See MySQL wrapped.
Cocoa	MySQL-Cocoa	`libmysql`	Compatible with the Objective-C Cocoa environment. See http://mysql-cocoa.sourceforge.net/
D	MySQL for D	`libmysql`	See MySQL for D.
Eiffel	Eiffel MySQL	`libmysql`	See Section 20.15, “MySQL Eiffel Wrapper”.
Erlang	`erlang-mysql-driver`	`libmysql`	See `erlang-mysql-driver`.
Haskell	Haskell MySQL Bindings	Native Driver	See Brian O'Sullivan's pure Haskell MySQL bindings.
	`hsql-mysql`	`libmysql`	See MySQL driver for Haskell .
Java/JDBC	Connector/J	Native Driver	See Section 20.3, “MySQL Connector/J”.
Kaya	MyDB	`libmysql`	See MyDB.
Lua	LuaSQL	`libmysql`	See LuaSQL.
.NET/Mono	Connector/Net	Native Driver	See Section 20.2, “MySQL Connector/Net”.
Objective Caml	MySQL Bindings for OBjective Caml	`libmysql`	See MySQL Bindings for Objective Caml.
Octave	Database bindings for GNU Octave	`libmysql`	See Database bindings for GNU Octave.
ODBC	Connector/ODBC	`libmysql`	See Section 20.1, “MySQL Connector/ODBC”.
OpenOffice	MySQL Connector/OpenOffice.org	`libmysql`	Direct connectivity, without using JDBC/ODBC. See Section 20.7, “MySQL Connector/OpenOffice.org”.
Perl	`DBI`/`DBD::mysql`	`libmysql`	See Section 20.11, “MySQL Perl API”.
	`Net::MySQL`	Native Driver	See `Net::MySQL` at CPAN
PHP	`mysql`, `ext/mysql` interface (deprecated)	`libmysql`	See Section 20.10.1, “MySQL”.
	`mysqli`, `ext/mysqli` interface	`libmysql`	See Section 20.10.2, “MySQL Improved Extension (`Mysqli`)”.
	`PDO_MYSQL`	`libmysql`	See Section 20.10.4, “MySQL Functions (PDO_MYSQL)”.
	PDO mysqlnd	Native Driver	See PHP PDO `mysqlnd`.
Python	MySQLdb	`libmysql`	See Section 20.12, “MySQL Python API”.
Ruby	MySQL/Ruby	`libmysql`	Uses `libmysql`. See Section 20.13.1, “The MySQL/Ruby API”.
	Ruby/MySQL	Native Driver	See Section 20.13.2, “The Ruby/MySQL API”.
Scheme	`Myscsh`	`libmysql`	See `Myscsh`.
SPL	`sql_mysql`	`libmysql`	See `sql_mysql` for SPL.
Tcl	MySQLtcl	`libmysql`	See Section 20.14, “MySQL Tcl API”.

Table 20.2. MySQL Connector Versions and MySQL Server Versions

Connector	Connector version	MySQL Server version
Connector/C++	1.0.5 GA	5.1, 5.4, 5.5, 5.6

Connector	Connector version	MySQL Server version
Connector/OpenOffice.org	1.0 GA	5.0, 5.1, 5.4, 5.5, 5.6
Connector/J	5.1.8	4.1, 5.0, 5.1, 5.4, 5.5, 5.6
Connector/Net	1.0 (No longer supported)	4.0, 5.0
Connector/Net	5.2	5.0, 5.1, 5.4, 5.5, 5.6
Connector/Net	6.0	5.0, 5.1, 5.4, 5.5, 5.6
Connector/Net	6.1	5.0, 5.1, 5.4, 5.5, 5.6
Connector/ODBC	3.51 (Unicode not supported)	4.1, 5.0, 5.1, 5.4, 5.5, 5.6
Connector/ODBC	5.1	4.1.1+, 5.0, 5.1, 5.4, 5.5, 5.6

20.1. MySQL Connector/ODBC

The MySQL Connector/ODBC is the name for the family of MySQL ODBC drivers (previously called MyODBC drivers) that provide access to a MySQL database using the industry standard Open Database Connectivity (ODBC) API. This reference covers Connector/ODBC 3.51 and Connector/ODBC 5.1. Both releases provide an ODBC compliant interface to MySQL Server.

MySQL Connector/ODBC provides both driver-manager based and native interfaces to the MySQL database, which full support for MySQL functionality, including stored procedures, transactions and, with Connector/ODBC 5.1, full Unicode compliance.

For more information on the ODBC API standard and how to use it, refer to http://support.microsoft.com/kb/110093.

The application development part of this reference assumes a good working knowledge of C, general DBMS knowledge, and finally, but not least, familiarity with MySQL. For more information about MySQL functionality and its syntax, refer to http://dev.mysql.com/doc/.

Typically, you need to install Connector/ODBC only on Windows machines. For Unix and Mac OS X you can use the native MySQL network or named pipe to communicate with your MySQL database. You may need Connector/ODBC for Unix or Mac OS X if you have an application that requires an ODBC interface to communicate with the database. Applications that require ODBC to communicate with MySQL include ColdFusion, Microsoft Office, and Filemaker Pro.

Key topics:

- For help installing Connector/ODBC see Section 20.1.3, “Connector/ODBC Installation”.
- For information on the configuration options, see Section 20.1.4.2, “Connector/ODBC Connection Parameters”.
- For more information on connecting to a MySQL database from a Windows host using Connector/ODBC see Section 20.1.5.2, “Step-by-step Guide to Connecting to a MySQL Database through Connector/ODBC”.
- If you want to use Microsoft Access as an interface to a MySQL database using Connector/ODBC see Section 20.1.5.4, “Using Connector/ODBC with Microsoft Access”.
- General tips on using Connector/ODBC, including obtaining the last auto-increment ID see Section 20.1.7.1, “Connector/ODBC General Functionality”.
- For tips and common questions on using Connector/ODBC with specific application see Section 20.1.7.2, “Connector/ODBC Application Specific Tips”.
- For a general list of Frequently Asked Questions see Section 20.1.7.3, “Connector/ODBC Errors and Resolutions (FAQ)”.
- Additional support when using Connector/ODBC is available, see Section 20.1.8, “Connector/ODBC Support”.

20.1.1. Connector/ODBC Versions

There are currently two version of Connector/ODBC available:

- Connector/ODBC 5.1, currently in GA status, is a partial rewrite of the of the 3.51 code base and is designed to work with all versions of MySQL from 4.1.1. It does not work with versions of MySQL Server prior to 4.1.1.

  Connector/ODBC 5.1 also includes the following changes and improvements over the 3.51 release:

  - Improved support on Windows 64-bit platforms.

  - Full Unicode support at the driver level. This includes support for the `SQL_WCHAR` data type, and support for Unicode login, password and DSN configurations. For more information,. see Microsoft Knowledgebase Article #716246.
  - Support for the `SQL_NUMERIC_STRUCT` data type, which provides easier access to the precise definition of numeric values. For more information, see Microsoft Knowledgebase Article #714556
  - Native Windows setup library. This replaces the Qt library based interface for configuring DSN information within the ODBC Data Sources application.
  - Support for the ODBC descriptor, which improves the handling and metadata of columns and parameter data. For more information, see Microsoft Knowledgebase Article #716339.
- Connector/ODBC 3.51 is the current release of the 32-bit ODBC driver, also known as the MySQL ODBC 3.51 driver. Connector/ODBC 3.51 has support for ODBC 3.5x specification level 1 (complete core API + level 2 features) to continue to provide all functionality of ODBC for accessing MySQL.

The manual for versions of Connector/ODBC older than 3.51 can be located in the corresponding binary or source distribution. Please note that versions of Connector/ODBC earlier than the 3.51 revision were not fully compliant with the ODBC specification.

> **Note**
>
> From this section onward, the primary focus of this guide is the Connector/ODBC 3.51 and Connector/ODBC 5.1 drivers.

> **Note**
>
> Version numbers for MySQL products are formatted as X.X.X. However, Windows tools (Control Panel, properties display) may show the version numbers as XX.XX.XX. For example, the official MySQL formatted version number 5.0.9 may be displayed by Windows tools as 5.00.09. The two versions are the same; only the number display format is different.

20.1.2. Connector/ODBC Introduction

ODBC (Open Database Connectivity) provides a way for client programs to access a wide range of databases or data sources. ODBC is a standardized API that enables connections to SQL database servers. It was developed according to the specifications of the SQL Access Group and defines a set of function calls, error codes, and data types that can be used to develop database-independent applications. ODBC usually is used when database independence or simultaneous access to different data sources is required.

For more information about ODBC, refer to http://support.microsoft.com/kb/110093.

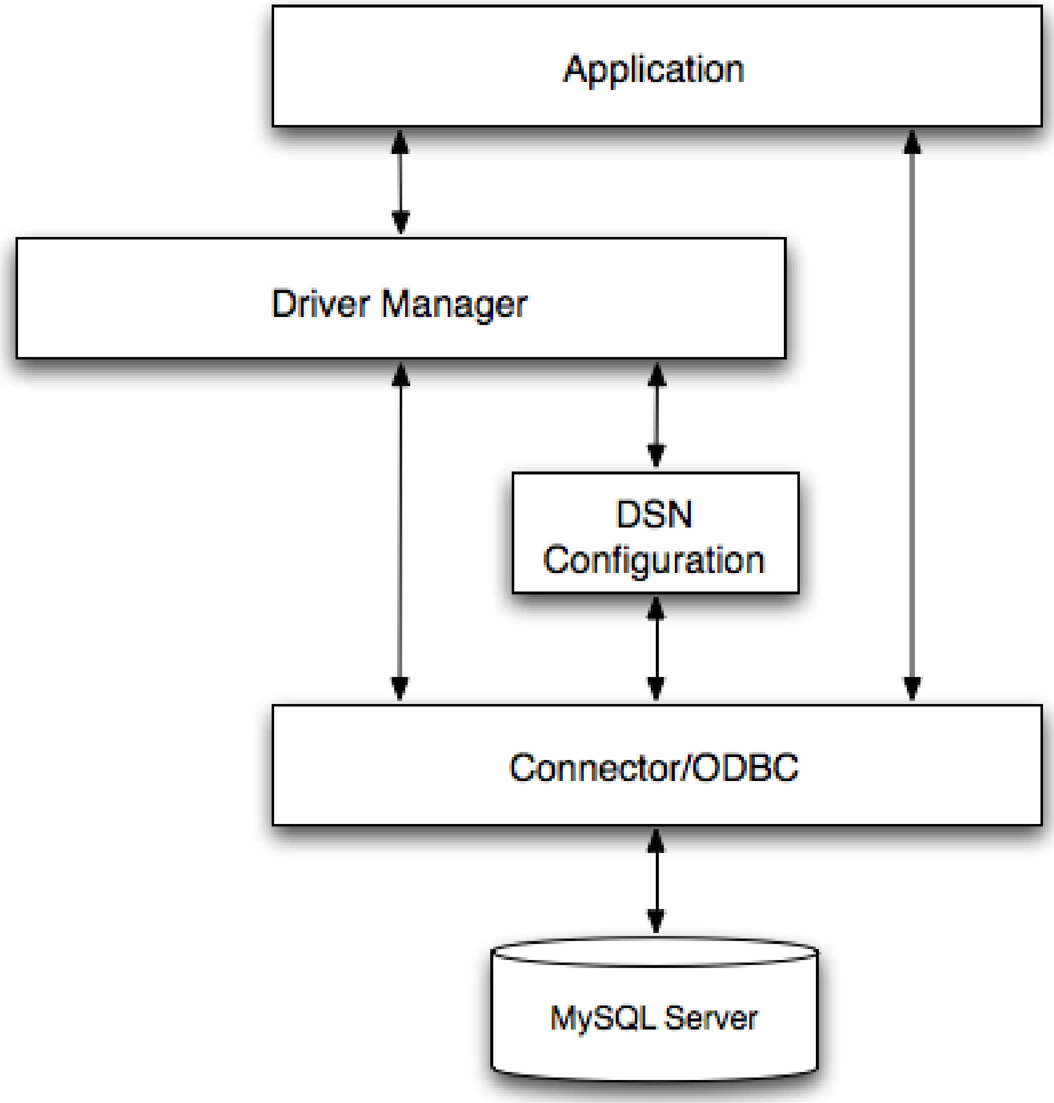
20.1.2.1. General Information About ODBC and Connector/ODBC

Open Database Connectivity (ODBC) is a widely accepted application-programming interface (API) for database access. It is based on the Call-Level Interface (CLI) specifications from X/Open and ISO/IEC for database APIs and uses Structured Query Language (SQL) as its database access language.

A survey of ODBC functions supported by Connector/ODBC is given at Section 20.1.6.1, “Connector/ODBC API Reference”. For general information about ODBC, see http://support.microsoft.com/kb/110093.

20.1.2.1.1. Connector/ODBC Architecture

The Connector/ODBC architecture is based on five components, as shown in the following diagram:



- **Application:**

  The Application uses the ODBC API to access the data from the MySQL server. The ODBC API in turn uses the communicates with the Driver Manager. The Application communicates with the Driver Manager using the standard ODBC calls. The Application does not care where the data is stored, how it is stored, or even how the system is configured to access the data. It needs to know only the Data Source Name (DSN).

  A number of tasks are common to all applications, no matter how they use ODBC. These tasks are:

  - Selecting the MySQL server and connecting to it
  - Submitting SQL statements for execution
  - Retrieving results (if any)
  - Processing errors
  - Committing or rolling back the transaction enclosing the SQL statement
  - Disconnecting from the MySQL server

  Because most data access work is done with SQL, the primary tasks for applications that use ODBC are submitting SQL statements and retrieving any results generated by those statements.

- **Driver manager:**

  The Driver Manager is a library that manages communication between application and driver or drivers. It performs the following tasks:

  - Resolves Data Source Names (DSN). The DSN is a configuration string that identifies a given database driver, database, database host and optionally authentication information that enables an ODBC application to connect to a database using a standardized reference.

    Because the database connectivity information is identified by the DSN, any ODBC compliant application can connect to the data source using the same DSN reference. This eliminates the need to separately configure each application that needs access to a given database; instead you instruct the application to use a pre-configured DSN.

  - Loading and unloading of the driver required to access a specific database as defined within the DSN. For example, if you have configured a DSN that connects to a MySQL database then the driver manager will load the Connector/ODBC driver to enable the ODBC API to communicate with the MySQL host.

  - Processes ODBC function calls or passes them to the driver for processing.

- **Connector/ODBC Driver:**

  The Connector/ODBC driver is a library that implements the functions supported by the ODBC API. It processes ODBC function calls, submits SQL requests to MySQL server, and returns results back to the application. If necessary, the driver modifies an application's request so that the request conforms to syntax supported by MySQL.

- **DSN Configuration:**

  The ODBC configuration file stores the driver and database information required to connect to the server. It is used by the Driver Manager to determine which driver to be loaded according to the definition in the DSN. The driver uses this to read connection parameters based on the DSN specified. For more information, Section 20.1.4, “Connector/ODBC Configuration”.

- **MySQL Server:**

  The MySQL database where the information is stored. The database is used as the source of the data (during queries) and the destination for data (during inserts and updates).

20.1.2.1.2. ODBC Driver Managers

An ODBC Driver Manager is a library that manages communication between the ODBC-aware application and any drivers. Its main functionality includes:

- Resolving Data Source Names (DSN).
- Driver loading and unloading.
- Processing ODBC function calls or passing them to the driver.

Both Windows and Mac OS X include ODBC driver managers with the operating system. Most ODBC Driver Manager implementations also include an administration application that makes the configuration of DSN and drivers easier. Examples and information on these managers, including Unix ODBC driver managers are listed below:

- Microsoft Windows ODBC Driver Manager (`odbc32.dll`), http://support.microsoft.com/kb/110093.
- Mac OS X includes `ODBC Administrator`, a GUI application that provides a simpler configuration mechanism for the Unix iODBC Driver Manager. You can configure DSN and driver information either through ODBC Administrator or through the iODBC configuration files. This also means that you can test ODBC Administrator configurations using the `iodbctest` command. http://www.apple.com.
- `unixODBC` Driver Manager for Unix (`libodbc.so`). See http://www.unixodbc.org, for more information. The `unixODBC` Driver Manager includes the Connector/ODBC driver 3.51 in the installation package, starting with version `unixODBC` 2.1.2.
- `iODBC` ODBC Driver Manager for Unix (`libiodbc.so`), see http://www.iodbc.org, for more information.

20.1.3. Connector/ODBC Installation

You can install the Connector/ODBC drivers using two different methods, a binary installation and a source installation. The binary installation is the easiest and most straightforward method of installation. Using the source installation methods should only be necessary on platforms where a binary installation package is not available, or in situations where you want to customize or modify the installation process or Connector/ODBC drivers before installation.

Where to Get Connector/ODBC

You can get a copy of the latest version of Connector/ODBC binaries and sources from our Web site at http://dev.mysql.com/downloads/connector/odbc/.

For more information about Connector/ODBC, visit http://www.mysql.com/products/myodbc/.

For more information about licensing, visit http://www.mysql.com/company/legal/licensing/.

Supported Platforms

Connector/ODBC can be used on all major platforms supported by MySQL. You can install it on:

- Windows 95, 98, Me, NT, 2000, XP, 2003, Vista and 7
- All Unix-like Operating Systems, including: AIX, Amiga, BSDI, DEC, FreeBSD, HP-UX 10/11, Linux, NetBSD, OpenBSD, OS/2, SGI Irix, Solaris, SunOS, SCO OpenServer, SCO UnixWare, Tru64 Unix
- Mac OS X and Mac OS X Server

Using a binary distribution offers the most straightforward method for installing Connector/ODBC. If you want more control over the driver, the installation location and or to customize elements of the driver you will need to build and install from the source.

If a binary distribution is not available for a particular platform build the driver from the original source code. You can contribute the binaries you create to MySQL by sending a mail message to `<myodbc@lists.mysql.com>`, so that it becomes available for other users.

> **Note**
>
> On all non-Windows platforms except Mac OS X, the driver is built against `unixODBC` and is expecting a 2-byte `SQLWCHAR`, not 4 bytes as `iODBC` is using. For this reason, the binaries are **only** compatible with `unixODBC` and you will need to recompile the driver against `iODBC` if you wish to use them together. For further information see Section 20.1.2.1.2, “ODBC Driver Managers”.

For further instructions:

Platform	Binary	Source
Windows	Installation Instructions	Build Instructions
Unix/Linux	Installation Instructions	Build Instructions
Mac OS X	Installation Instructions	

20.1.3.1. Installing Connector/ODBC from a Binary Distribution on Windows

Before installing the Connector/ODBC drivers on Windows you should ensure that your Microsoft Data Access Components (MDAC) are up to date. You can obtain the latest version from the Microsoft Data Access and Storage Web site.

There are three available distribution types to use when installing for Windows. The contents in each case are identical, it is only the installation method which is different.

- Zipped installer consists of a Zipped package containing a standalone installation application. To install from this package, you must unzip the installer, and then run the installation application. See Section 20.1.3.1.1, “Installing the Windows Connector/ODBC Driver using an installer” to complete the installation.
- MSI installer, an installation file that can be used with the installer included in Windows 2000, Windows XP and Windows Server 2003. See Section 20.1.3.1.1, “Installing the Windows Connector/ODBC Driver using an installer” to complete the installation.
- Zipped DLL package, containing the DLL files that need must be manually installed. See Section 20.1.3.1.2, “Installing the Windows Connector/ODBC Driver using the Zipped DLL package” to complete the installation.

Note

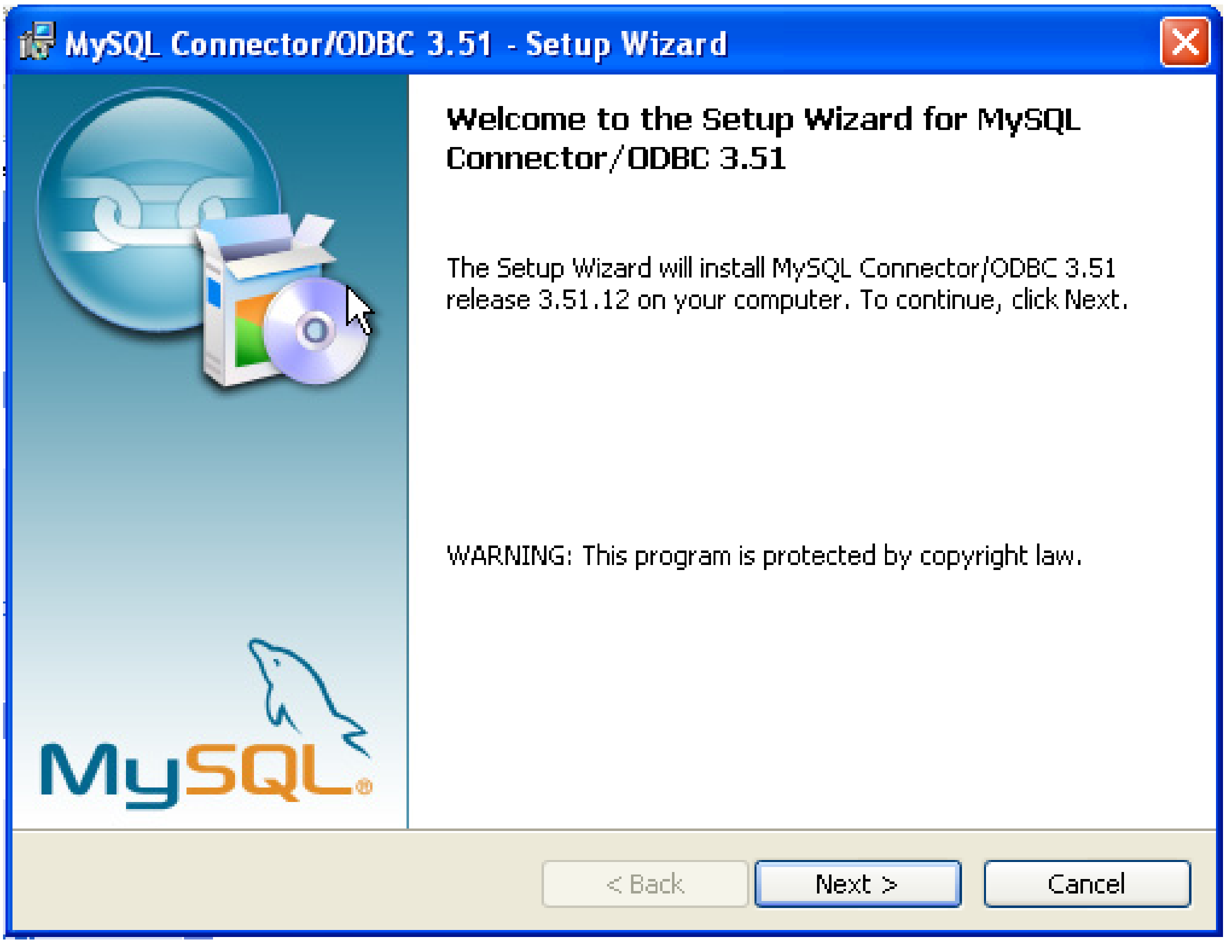
An OLEDB/ODBC driver for Windows 64-bit is available from Microsoft Downloads.

20.1.3.1.1. Installing the Windows Connector/ODBC Driver using an installer

The installer packages offer a very simple method for installing the Connector/ODBC drivers. If you have downloaded the zipped installer then you must extract the installer application. The basic installation process is identical for both installers.

You should follow these steps to complete the installation:

1. Double-click the standalone installer that you extracted, or the MSI file you downloaded.
2. The MySQL Connector/ODBC 3.51 - Setup Wizard will start. Click the NEXT button to begin the installation process.



MySQL Connector/ODBC 3.51 - Setup Wizard

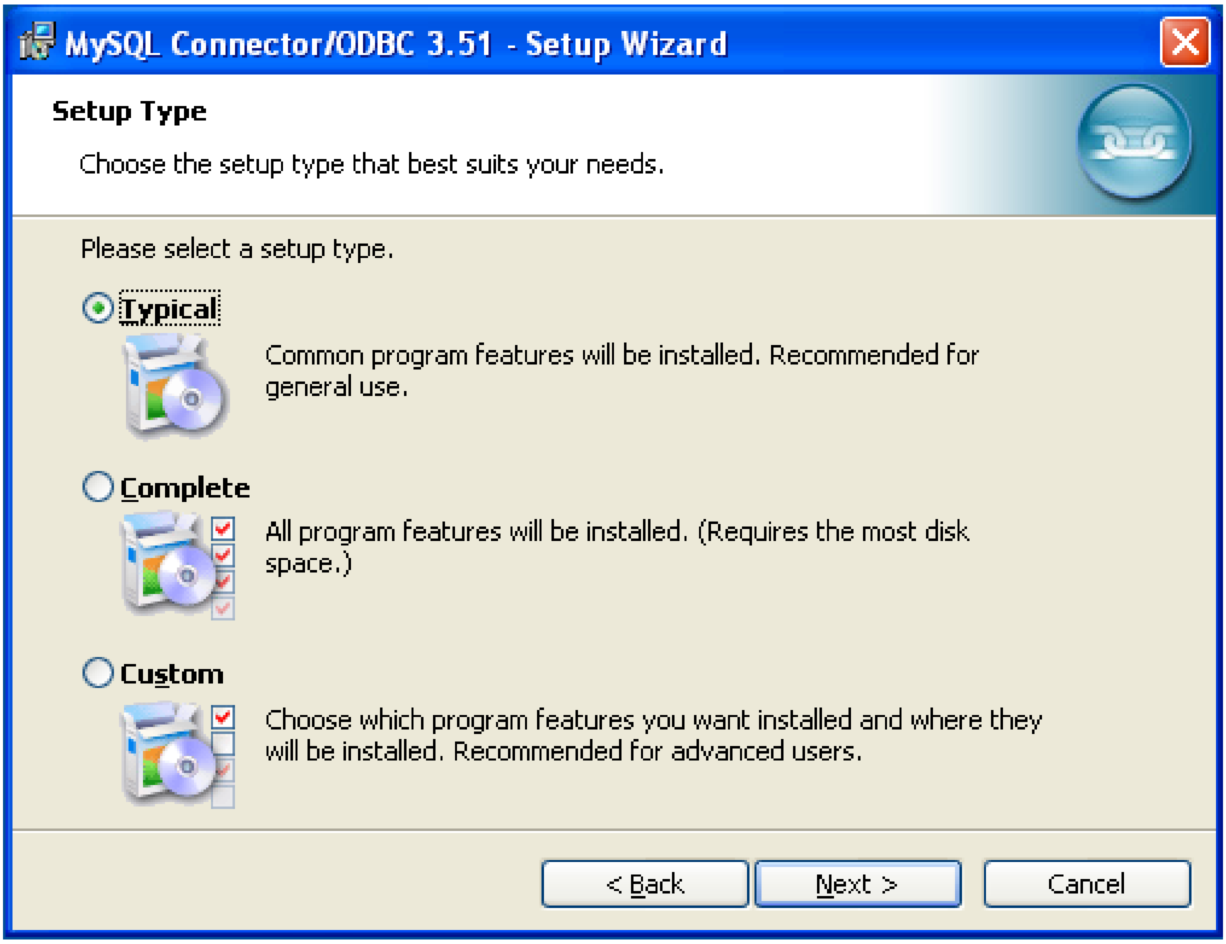
Welcome to the Setup Wizard for MySQL Connector/ODBC 3.51

The Setup Wizard will install MySQL Connector/ODBC 3.51 release 3.51.12 on your computer. To continue, click Next.

WARNING: This program is protected by copyright law.

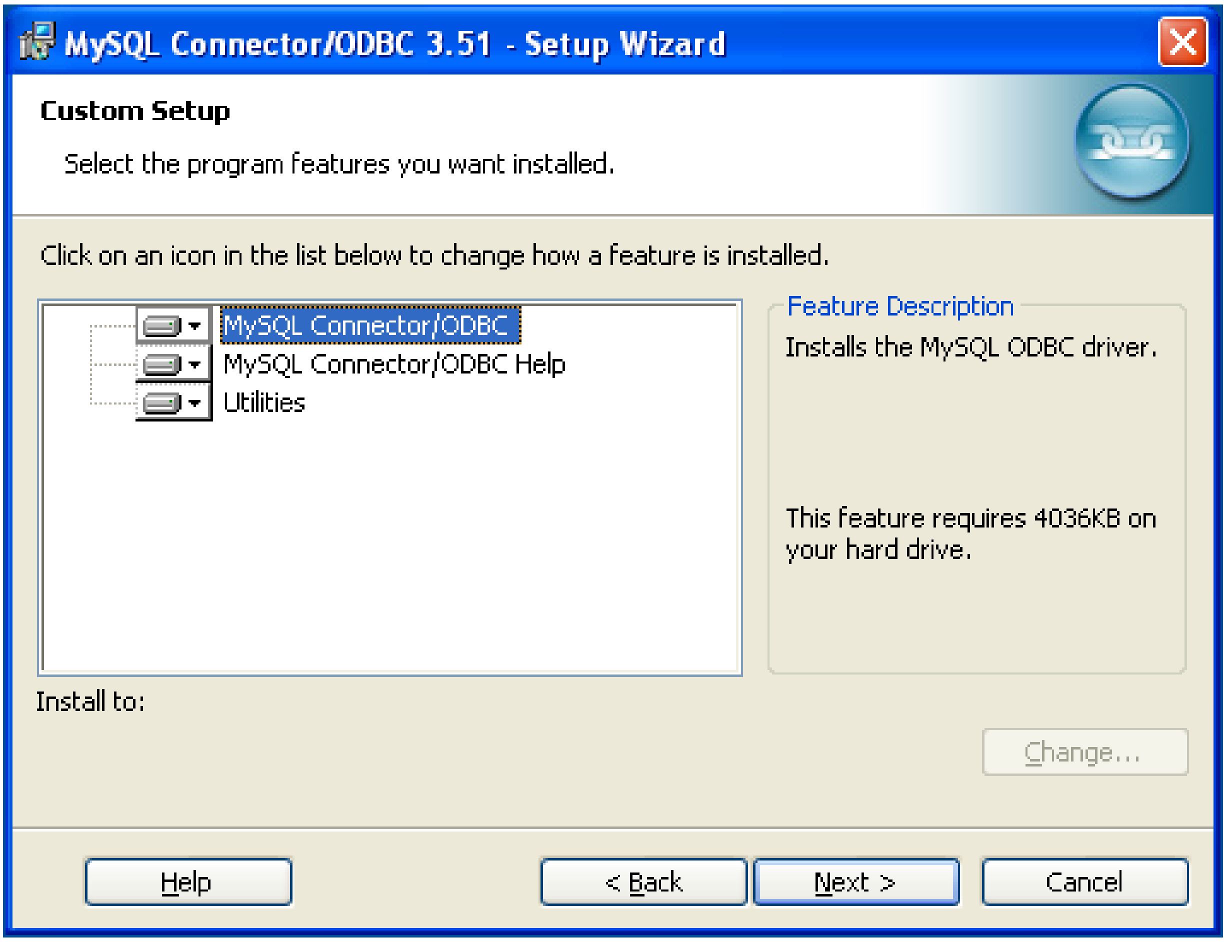
3. You will need to choose the installation type. The Typical installation provides the standard files you will need to connect to a MySQL database using ODBC. The Complete option installs all the available files, including debug and utility components. It is recommended you choose one of these two options to complete the installation. If choose one of these methods, click NEXT and then proceed to step 5.

   You may also choose a Custom installation, which enables you to select the individual components that you want to install. You have chosen this method, click NEXT and then proceed to step 4.

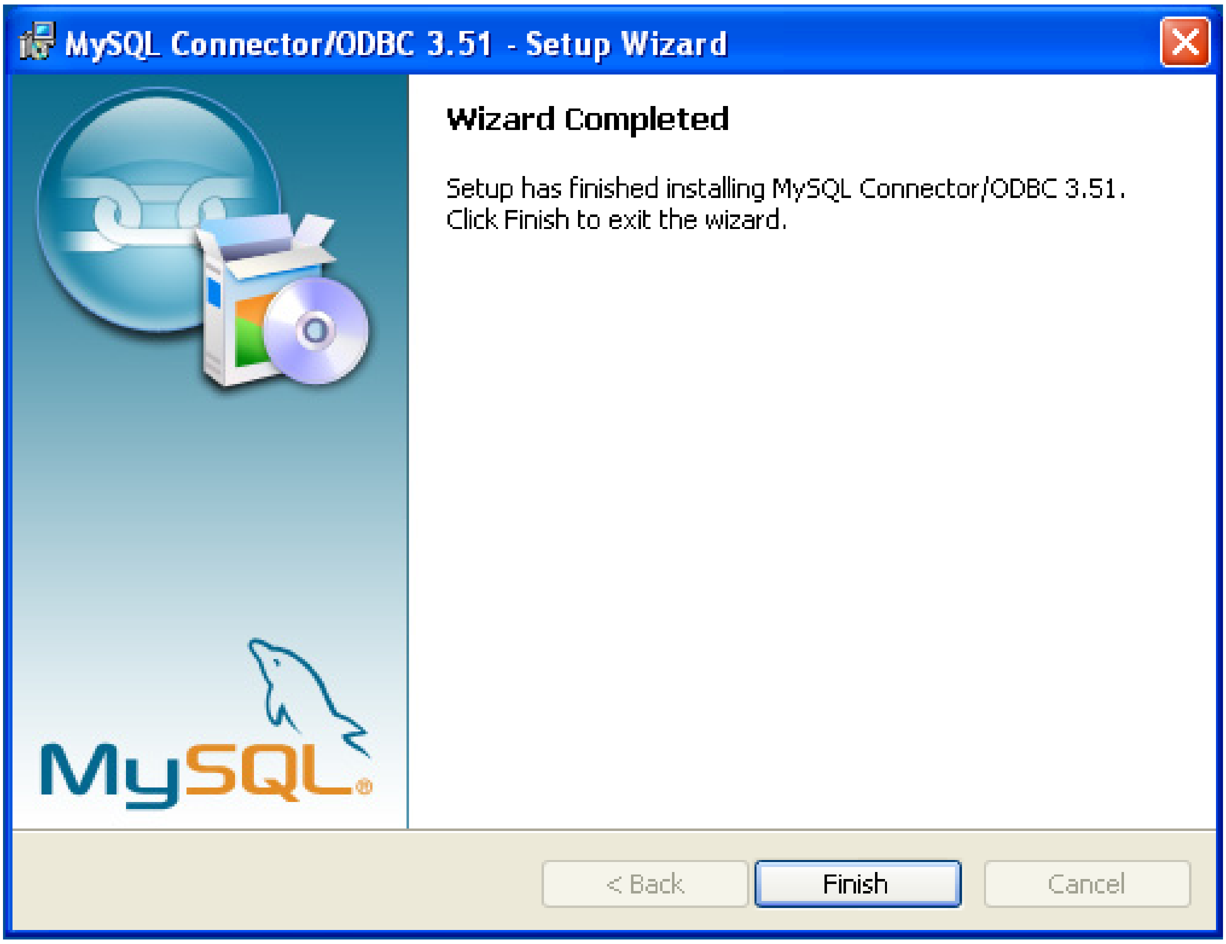


MySQL Connector/ODBC 3.51 - Setup Wizard
Setup Type
Choose the setup type that best suits your needs.
Please select a setup type.
● Typical
Common program features will be installed. Recommended for general use.
○ Complete
All program features will be installed. (Requires the most disk space.)
○ Custom
Choose which program features you want installed and where they will be installed. Recommended for advanced users.
< Back
Next >
Cancel

4. If you have chosen a custom installation, use the pop-ups to select which components to install and then click NEXT to install the necessary files.


MySQL Connector/ODBC 3.51 - Setup Wizard
Custom Setup
Select the program features you want installed.
Click on an icon in the list below to change how a feature is installed.
MySQL Connector/ODBC
MySQL Connector/ODBC Help
Utilities
Feature Description
Installs the MySQL ODBC driver.
This feature requires 4036KB on your hard drive.
Install to:
Change...
Help
< Back
Next >
Cancel

5. Once the files have copied to your machine, the installation is complete. Click FINISH to exit the installer.



Wizard Completed

Setup has finished installing MySQL Connector/ODBC 3.51.
Click Finish to exit the wizard.

Now the installation is complete, you can continue to configure your ODBC connections using Section 20.1.4, "Connector/ODBC Configuration".

20.1.3.1.2. Installing the Windows Connector/ODBC Driver using the Zipped DLL package

If you have downloaded the Zipped DLL package then you must install the individual files required for Connector/ODBC operation manually. Once you have unzipped the installation files, you can either perform this operation by hand, executing each statement individually, or you can use the included Batch file to perform an installation to the default locations.

> **Note**
>
> The following instructions will only work for 32-bit Windows systems. If you have a 64-bit Windows system you are advised to use the MSI installer, which will install both the 32-bit and 64-bit drivers to the correct locations.

To install using the Batch file:

1. Unzip the Connector/ODBC Zipped DLL package.
2. Open a Command Prompt.
3. Change to the directory created when you unzipped the Connector/ODBC Zipped DLL package.
4. Run `Install.bat:`

   ```
   C:\> Install.bat
   ```

   This will copy the necessary files into the default location, and then register the Connector/ODBC driver with the Windows ODBC manager.

If you want to copy the files to an alternative location - for example, to run or test different versions of the Connector/ODBC driver on the same machine, then you must copy the files by hand. It is however not recommended to install these files in a nonstandard location. To copy the files by hand to the default installation location use the following steps:

1. Unzip the Connector/ODBC Zipped DLL package.
2. Open a Command Prompt.
3. Change to the directory created when you unzipped the Connector/ODBC Zipped DLL package.
4. Copy the library files to a suitable directory. The default is to copy them into the default Windows system directory `\Windows\System32`:

   ```
   C:\> copy lib\myodbc3S.dll \Windows\System32
   C:\> copy lib\myodbc3S.lib \Windows\System32
   C:\> copy lib\myodbc3.dll \Windows\System32
   C:\> copy lib\myodbc3.lib \Windows\System32
   ```

5. Copy the Connector/ODBC tools. These must be placed into a directory that is in the system `PATH`. The default is to install these into the Windows system directory `\Windows\System32`:

   ```
   C:\> copy bin\myodbc3i.exe \Windows\System32
   C:\> copy bin\myodbc3m.exe \Windows\System32
   C:\> copy bin\myodbc3c.exe \Windows\System32
   ```

6. Optionally copy the help files. For these files to be accessible through the help system, they must be installed in the Windows system directory:

   ```
   C:\> copy doc\*.hlp \Windows\System32
   ```

7. Finally, you must register the Connector/ODBC driver with the ODBC manager:

   ```
   C:\> myodbc3i -a -d -t"MySQL ODBC 3.51 Driver;\
     DRIVER=myodbc3.dll;SETUP=myodbc3S.dll"
   ```

   You must change the references to the DLL files and command location in the above statement if you have not installed these files into the default location.

20.1.3.2. Installing Connector/ODBC from a Binary Distribution on Unix

There are two methods available for installing Connector/ODBC on Unix from a binary distribution. For most Unix environments you will need to use the tarball distribution. For Linux systems, there is also an RPM distribution available.

> **Note**
>
> To install Connector/ODBC 5.1 on Unix you require unixODBC 2.2.12 or later to be installed.

20.1.3.2.1. Installing Connector/ODBC from a Binary Tarball Distribution

To install the driver from a tarball distribution (`.tar.gz` file), download the latest version of the driver for your operating system and follow these steps that demonstrate the process using the Linux version of the tarball:

```
shell> su root
shell> gunzip mysql-connector-odbc-3.51.11-i686-pc-linux.tar.gz
shell> tar xvf mysql-connector-odbc-3.51.11-i686-pc-linux.tar
shell> cd mysql-connector-odbc-3.51.11-i686-pc-linux
```

Read the installation instructions in the `INSTALL` file and execute these commands.

Then proceed on to Section 20.1.4.5, “Configuring a Connector/ODBC DSN on Unix”, to configure the DSN for Connector/ODBC. For more information, refer to the `INSTALL` file that comes with your distribution.

20.1.3.2.2. Installing Connector/ODBC from an RPM Distribution

To install or upgrade Connector/ODBC from an RPM distribution on Linux, simply download the RPM distribution of the latest version of Connector/ODBC and follow the instructions below. Use `su root` to become `root`, then install the RPM file.

If you are installing for the first time:

```
shell> su root
```

```
shell> rpm -ivh mysql-connector-odbc-3.51.12.i386.rpm
```

If the driver exists, upgrade it like this:

```
shell> su root
shell> rpm -Uvh mysql-connector-odbc-3.51.12.i386.rpm
```

If there is any dependency error for MySQL client library, `libmysqlclient`, simply ignore it by supplying the `--nodeps` option, and then make sure the MySQL client shared library is in the path or set through `LD_LIBRARY_PATH`.

This installs the driver libraries and related documents to `/usr/local/lib` and `/usr/share/doc/MyODBC`, respectively. Proceed onto Section 20.1.4.5, “Configuring a Connector/ODBC DSN on Unix”.

To **uninstall** the driver, become `root` and execute an `rpm` command:

```
shell> su root
shell> rpm -e mysql-connector-odbc
```

20.1.3.3. Installing Connector/ODBC from a Binary Distribution on Mac OS X

Mac OS X is based on the FreeBSD operating system, and you can normally use the MySQL network port for connecting to MySQL servers on other hosts. Installing the Connector/ODBC driver enables you to connect to MySQL databases on any platform through the ODBC interface. You should only need to install the Connector/ODBC driver when your application requires an ODBC interface. Applications that require or can use ODBC (and therefore the Connector/ODBC driver) include ColdFusion, Filemaker Pro, 4th Dimension and many other applications.

Mac OS X includes its own ODBC manager, based on the `iODBC` manager. Mac OS X includes an administration tool that provides easier administration of ODBC drivers and configuration, updating the underlying `iODBC` configuration files.

The method for installing Connector/ODBC on Mac OS X depends on the version on Connector/ODBC you are using. For Connector/ODBC 3.51.14 and later, the package is provided as a compressed tar archive that you must manually install. For Connector/ODBC 3.51.13 and earlier the software was provided on a compressed disk image (`.dmg`) file and included an installer.

In either case, the driver is designed to work with the iODBC driver manager included with Mac OS X.

To install Connector/ODBC 3.51.14 and later:

1. Download the installation file. Note that versions are available for both PowerPC and Intel platforms.
2. Extract the archive:

   ```
   shell> tar zxf mysql-connector-odbc-3.51.16-osx10.4-x86-32bit.tar.gz
   ```

3. The directory created will contain two subdirectories, `lib` and `bin`. You need to copy these to a suitable location such as `/usr/local`:

   ```
   shell> cp bin/* /usr/local/bin
   shell> cp lib/* /usr/local/lib
   ```

4. Finally, you must register the driver with iODBC using the `myodbc3i` tool you just installed:

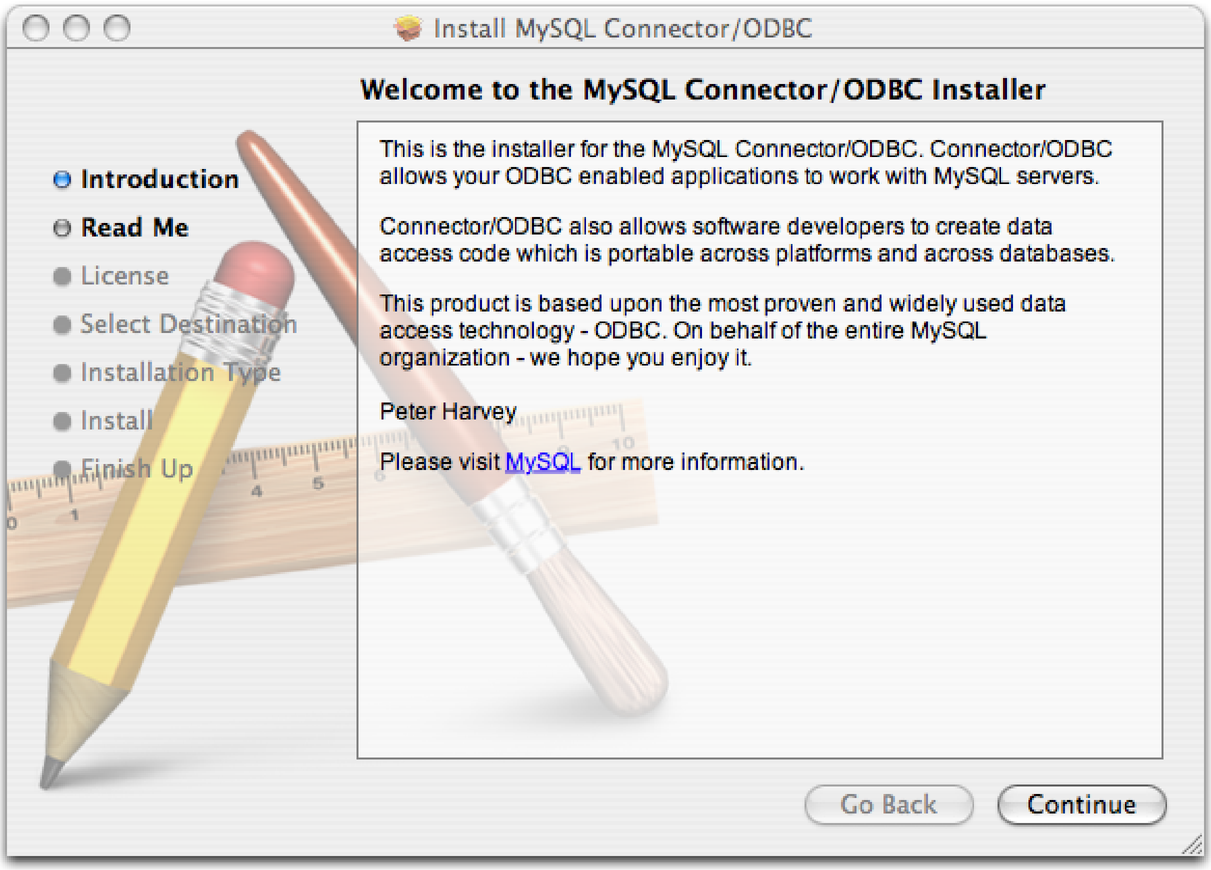
   ```
   shell> myodbc3i -a -d -t"MySQL ODBC 3.51 Driver;Driver=/usr/local/lib/libmyodbc3.so;Setup=/usr/local/lib/libmyodbc
   ```

You can verify the installed drivers either by using the ODBC Administrator application or the `myodbc3i` utility:

```
shell> myodbc3i -q -d
```

To install Connector/ODBC 3.51.13 and earlier, follow these steps:

1. Download the file to your computer and double-click the downloaded image file.
2. Within the disk image you will find an installer package (with the `.pkg` extension). Double-click on this file to start the Mac OS X installer.
3. You will be presented with the installer welcome message. Click the CONTINUE button to begin the installation process.


Install MySQL Connector/ODBC
Introduction
Read Me
License
Select Destination
Installation Type
Install
Finish Up
Go Back
Continue

Welcome to the MySQL Connector/ODBC Installer

This is the installer for the MySQL Connector/ODBC. Connector/ODBC allows your ODBC enabled applications to work with MySQL servers.

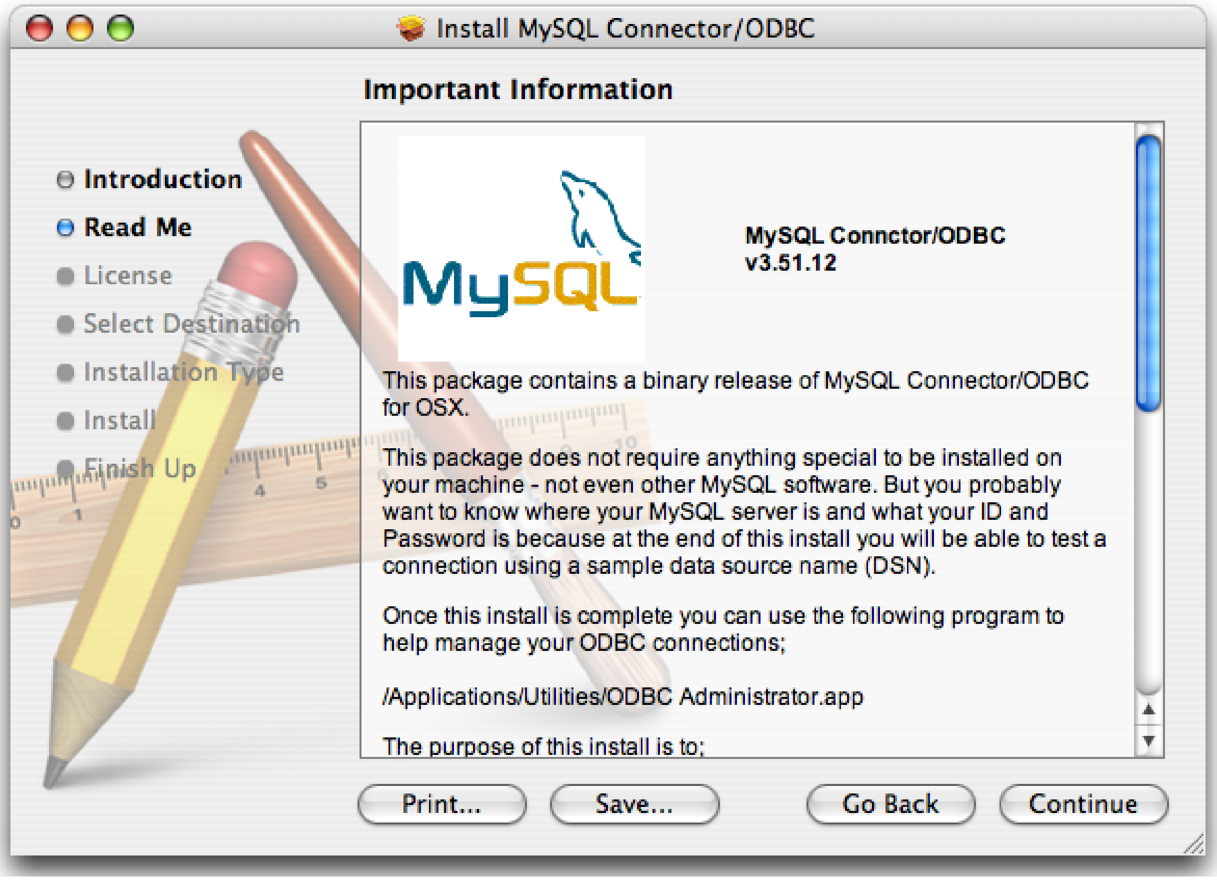
Connector/ODBC also allows software developers to create data access code which is portable across platforms and across databases.

This product is based upon the most proven and widely used data access technology - ODBC. On behalf of the entire MySQL organization - we hope you enjoy it.

Peter Harvey

Please visit MySQL for more information.

4. Please take the time to read the Important Information as it contains guidance on how to complete the installation process. Once you have read the notice and collected the necessary information, click CONTINUE.


Install MySQL Connector/ODBC
Introduction
Read Me
License
Select Destination
Installation Type
Install
Finish Up
Print...
Save...
Go Back
Continue

Important Information

MySQL Connctor/ODBC v3.51.12

This package contains a binary release of MySQL Connector/ODBC for OSX.

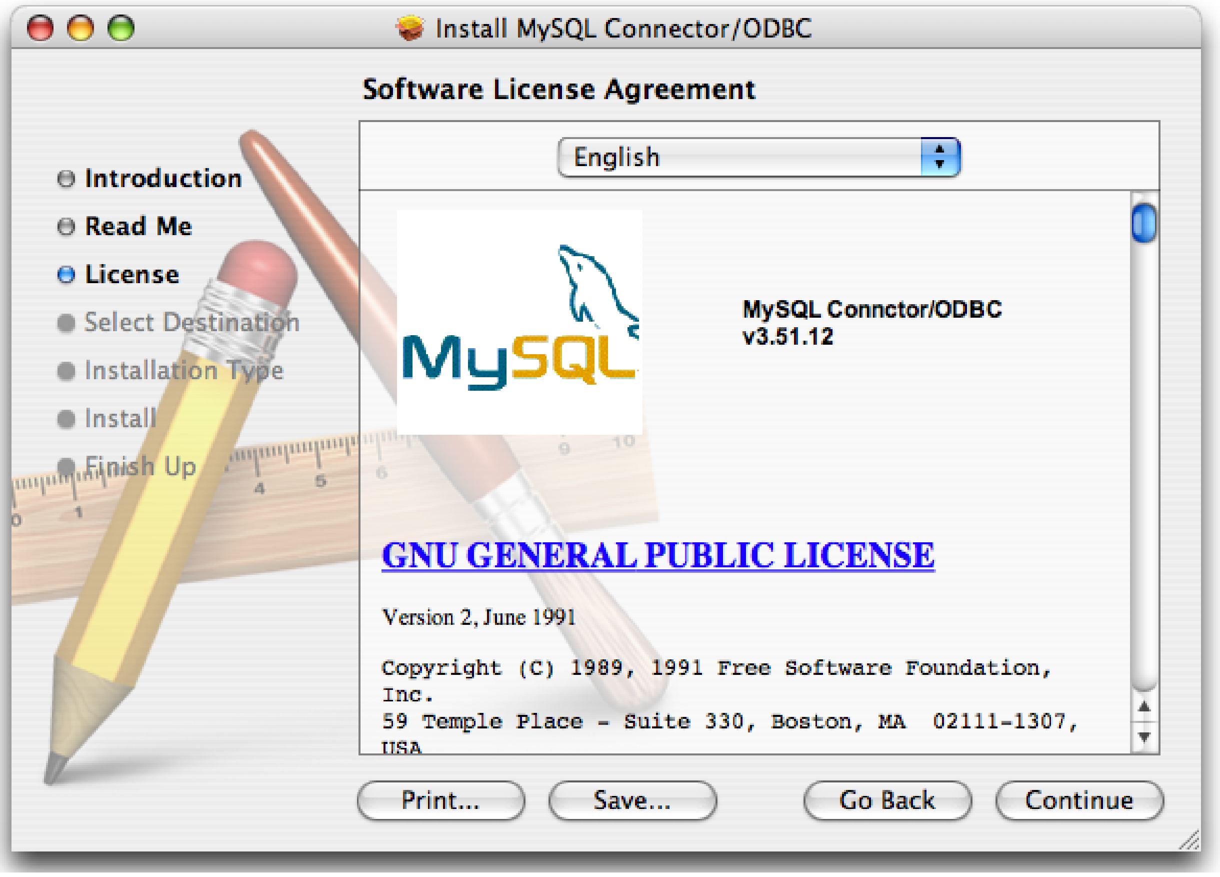
This package does not require anything special to be installed on your machine - not even other MySQL software. But you probably want to know where your MySQL server is and what your ID and Password is because at the end of this install you will be able to test a connection using a sample data source name (DSN).

Once this install is complete you can use the following program to help manage your ODBC connections;

/Applications/Utilities/ODBC Administrator.app

The purpose of this install is to;

5. Connector/ODBC drivers are made available under the GNU General Public License. Please read the license if you are not familiar with it before continuing installation. Click CONTINUE to approve the license (you will be asked to confirm that decision) and continue the installation.


Install MySQL Connector/ODBC
Software License Agreement
Introduction
Read Me
License
Select Destination
Installation Type
Install
Finish Up
English
Print...
Save...
Go Back
Continue

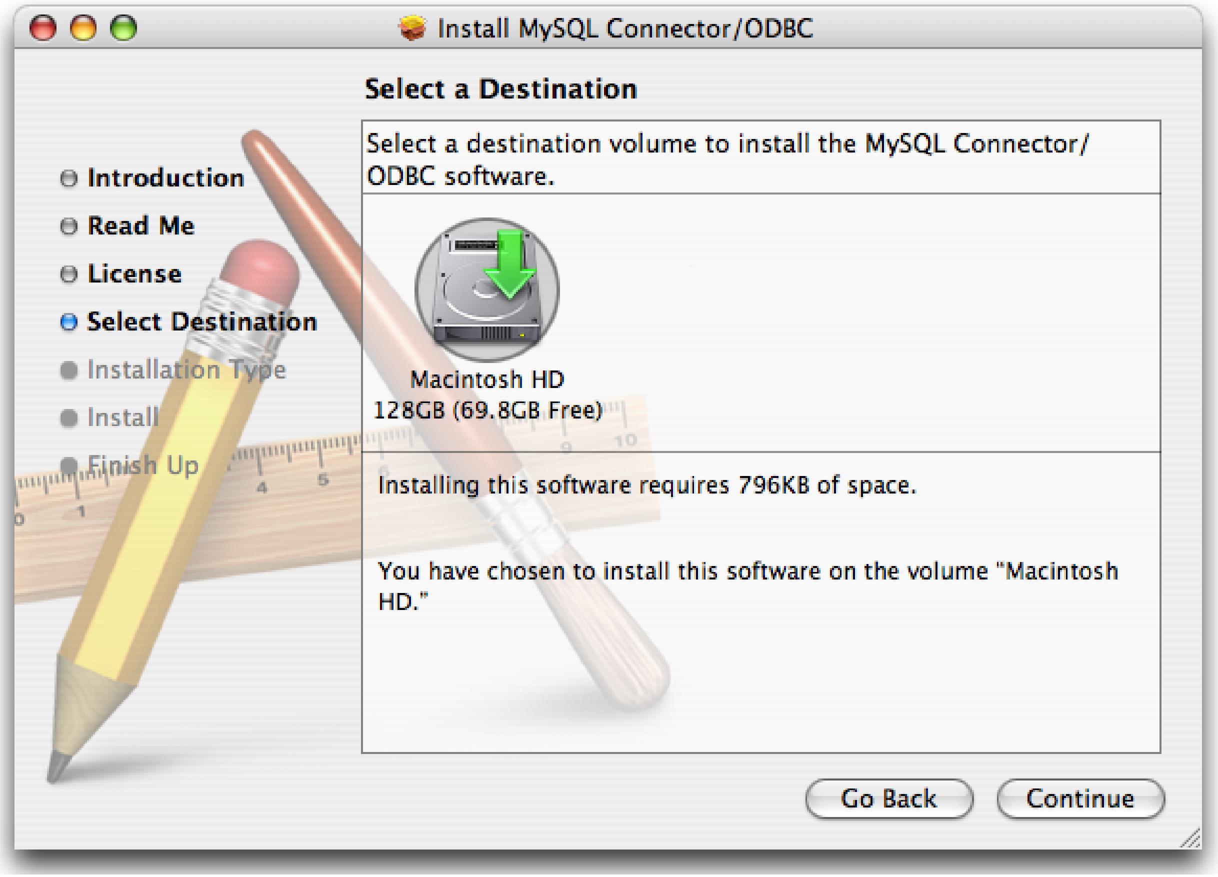
MySQL Connctor/ODBC
v3.51.12

GNU GENERAL PUBLIC LICENSE

Version 2, June 1991

Copyright (C) 1989, 1991 Free Software Foundation, Inc.
59 Temple Place - Suite 330, Boston, MA 02111-1307, USA

6. Choose a location to install the Connector/ODBC drivers and the ODBC Administrator application. You must install the files onto a drive with an operating system and you may be limited in the choices available. Select the drive you want to use, and then click CONTINUE.


Install MySQL Connector/ODBC
Introduction
Read Me
License
Select Destination
Installation Type
Install
Finish Up
Go Back
Continue

Select a Destination

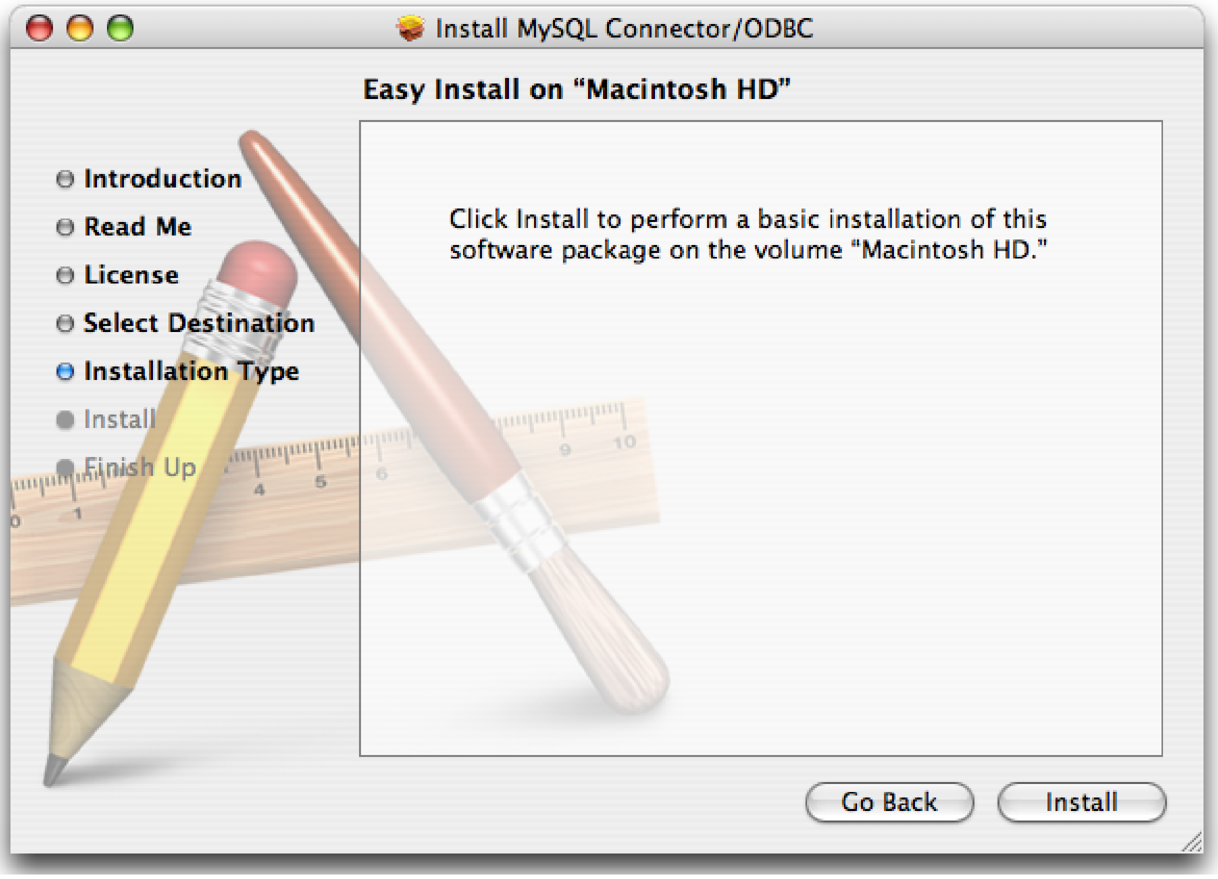
Select a destination volume to install the MySQL Connector/ODBC software.

Macintosh HD
128GB (69.8GB Free)

Installing this software requires 796KB of space.

You have chosen to install this software on the volume "Macintosh HD."

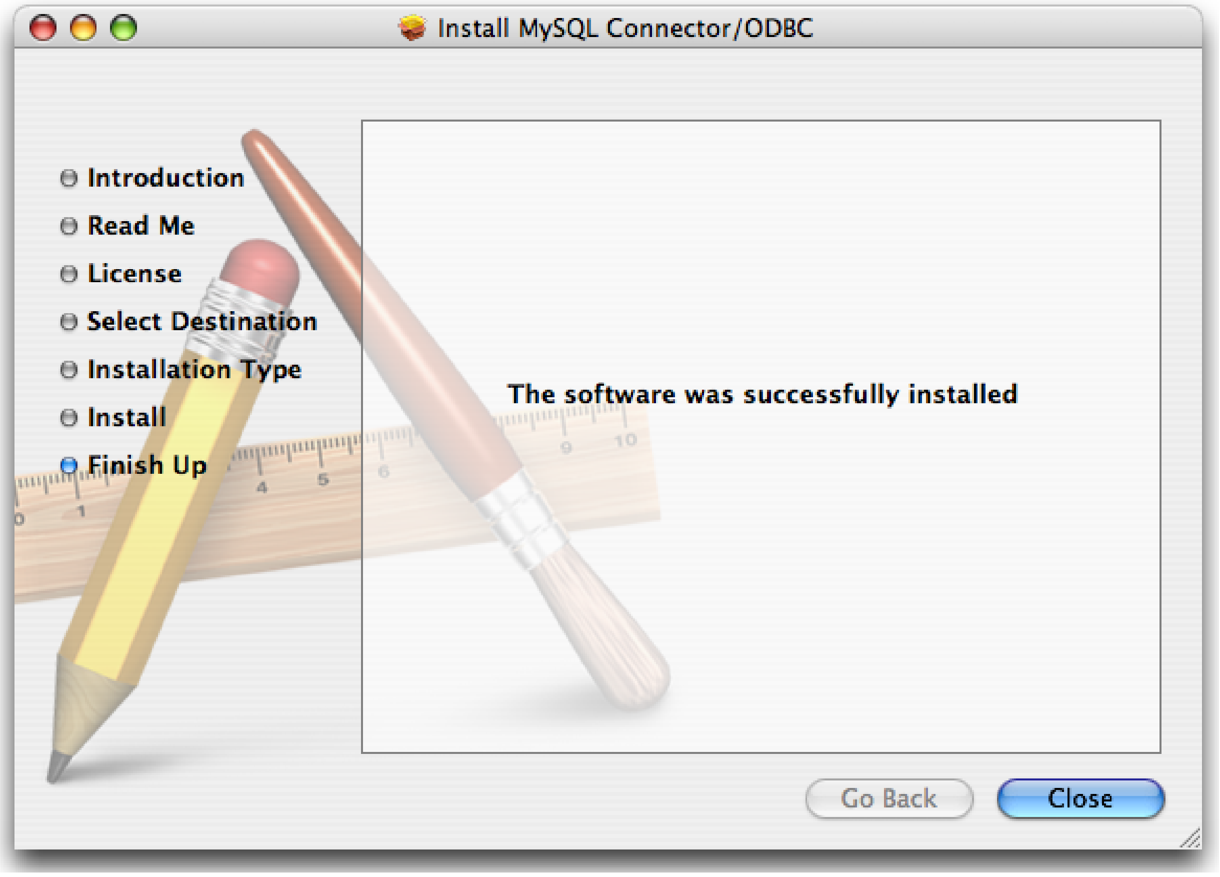
7. The installer will automatically select the files that need to be installed on your machine. Click INSTALL to continue. The installer will copy the necessary files to your machine. A progress bar will be shown indicating the installation progress.


Install MySQL Connector/ODBC
Introduction
Read Me
License
Select Destination
Installation Type
Install
Finish Up
Go Back
Install

Easy Install on "Macintosh HD"

Click Install to perform a basic installation of this software package on the volume "Macintosh HD."

8. When installation has been completed you will get a window like the one shown below. Click CLOSE to close and quit the installer.



The software was successfully installed

20.1.3.4. Installing Connector/ODBC from a Source Distribution on Windows

You should only need to install Connector/ODBC from source on Windows if you want to change or modify the source or installation. If you are unsure whether to install from source, please use the binary installation detailed in Section 20.1.3.1, “Installing Connector/ODBC from a Binary Distribution on Windows”.

Installing Connector/ODBC from source on Windows requires a number of different tools and packages:

- MDAC, Microsoft Data Access SDK from http://support.microsoft.com/kb/110093.
- Suitable C compiler, such as Microsoft Visual C++ or the C compiler included with Microsoft Visual Studio.
- Compatible `make` tool. Microsoft's `nmake` is used in the examples in this section.
- MySQL client libraries and include files from MySQL 4.0.0 or higher. (Preferably MySQL 4.0.16 or higher). This is required because Connector/ODBC uses new calls and structures that exist only starting from this version of the library. To get the client libraries and include files, visit http://dev.mysql.com/downloads/.

20.1.3.4.1. Building Connector/ODBC 3.51

Connector/ODBC source distributions include `Makefiles` that require the `nmake` or other `make` utility. In the distribution, you can find `Makefile` for building the release version and `Makefile_debug` for building debugging versions of the driver libraries and DLLs.

To build the driver, use this procedure:

1. Download and extract the sources to a folder, then change directory into that folder. The following command assumes the folder is named `myodbc3-src`:

```
C:\> cd myodbc3-src
```

2. Edit `Makefile` to specify the correct path for the MySQL client libraries and header files. Then use the following commands to build and install the release version:

   ```
   C:\> nmake -f Makefile
   C:\> nmake -f Makefile install
   ```

   `nmake -f Makefile` builds the release version of the driver and places the binaries in subdirectory called `Release`.

   `nmake -f Makefile install` installs (copies) the driver DLLs and libraries (`myodbc3.dll`, `myodbc3.lib`) to your system directory.

3. To build the debug version, use `Makefile_Debug` rather than `Makefile`, as shown below:

   ```
   C:\> nmake -f Makefile_debug
   C:\> nmake -f Makefile_debug install
   ```

4. You can clean and rebuild the driver by using:

   ```
   C:\> nmake -f Makefile clean
   C:\> nmake -f Makefile install
   ```

> **Note**
>
> - Make sure to specify the correct MySQL client libraries and header files path in the Makefiles (set the `MYSQL_LIB_PATH` and `MYSQL_INCLUDE_PATH` variables). The default header file path is assumed to be `C:\mysql\include`. The default library path is assumed to be `C:\mysql\lib\opt` for release DLLs and `C:\mysql\lib\debug` for debug versions.
> - For the complete usage of `nmake`, visit http://msdn.microsoft.com/library/default.asp?url=/library/en-us/dv_vcce4/html/evgrfRunningNMAKE.asp.
> - If you are using the Subversion tree for compiling, all Windows-specific `Makefiles` are named as `Win_Makefile*`.

20.1.3.4.2. Testing

After the driver libraries are copied/installed to the system directory, you can test whether the libraries are properly built by using the samples provided in the `samples` subdirectory:

```
C:\> cd samples
C:\> nmake -f Makefile all
```

20.1.3.5. Installing Connector/ODBC from a Source Distribution on Unix

You need the following tools to build MySQL from source on Unix:

- A working ANSI C++ compiler. `gcc` 2.95.2 or later, SGI C++, and SunPro C++ are some of the compilers that are known to work.
- A good `make` program. GNU `make` is always recommended and is sometimes required.
- MySQL client libraries and include files from MySQL 4.0.0 or higher. (Preferably MySQL 4.0.16 or higher). This is required because Connector/ODBC uses new calls and structures that exist only starting from this version of the library. To get the client libraries and include files, visit http://dev.mysql.com/downloads/.

  If you have built your own MySQL server or client libraries from source using the GNU autotools, you must use the `--enable-thread-safe-client` option to `configure` when the libraries were built. No special option is needed if you configure with `CMake`.

  You should also ensure that the `libmysqlclient` library were built and installed as a shared library.
- A compatible ODBC manager must be installed. Connector/ODBC is known to work with the `iODBC` and `unixODBC` managers. See Section 20.1.2.1.2, “ODBC Driver Managers”, for more information.

- If you are using a character set that isn't compiled into the MySQL client library then you need to install the MySQL character definitions from the `charsets` directory into `SHAREDIR` (by default, `/usr/local/mysql/share/mysql/charsets`). These should be in place if you have installed the MySQL server on the same machine. See Section 9.1, "Character Set Support", for more information on character set support.

Once you have all the required files, unpack the source files to a separate directory, you then have to run `configure` and build the library using `make`.

20.1.3.5.1. Typical `configure` Options

The `configure` script gives you a great deal of control over how you configure your Connector/ODBC build. Typically you do this using options on the `configure` command line. You can also affect `configure` using certain environment variables. For a list of options and environment variables supported by `configure`, run this command:

```
shell> ./configure --help
```

Some of the more commonly used `configure` options are described here:

1. To compile Connector/ODBC, you need to supply the MySQL client include and library files path using the `--with-mysql-path=DIR` option, where `DIR` is the directory where MySQL is installed.

   MySQL compile options can be determined by running `DIR/bin/mysql_config`.

2. Supply the standard header and library files path for your ODBC Driver Manager (`iODBC` or `unixODBC`).

   - If you are using `iODBC` and `iODBC` is not installed in its default location (`/usr/local`), you might have to use the `--with-iodbc=DIR` option, where `DIR` is the directory where `iODBC` is installed.

     If the `iODBC` headers do not reside in `DIR/include`, you can use the `--with-iodbc-includes=INCDIR` option to specify their location.

     The applies to libraries. If they are not in `DIR/lib`, you can use the `--with-iodbc-libs=LIBDIR` option.

   - If you are using `unixODBC`, use the `--with-unixODBC=DIR` option (case sensitive) to make `configure` look for `unixODBC` instead of `iODBC` by default, `DIR` is the directory where `unixODBC` is installed.

     If the `unixODBC` headers and libraries aren't located in `DIR/include` and `DIR/lib`, use the `--with-unixODBC-includes=INCDIR` and `--with-unixODBC-libs=LIBDIR` options.

3. You might want to specify an installation prefix other than `/usr/local`. For example, to install the Connector/ODBC drivers in `/usr/local/odbc/lib`, use the `--prefix=/usr/local/odbc` option.

The final configuration command looks something like this:

```
shell> ./configure --prefix=/usr/local \
         --with-iodbc=/usr/local \
         --with-mysql-path=/usr/local/mysql
```

20.1.3.5.2. Additional configure Options

There are a number of other options that you need, or want, to set when configuring the Connector/ODBC driver before it is built.

- To link the driver with MySQL thread safe client libraries `libmysqlclient_r.so` or `libmysqlclient_r.a`, you must specify the following `configure` option:

  ```
  --enable-thread-safe
  ```

  and can be disabled (default) using

  ```
  --disable-thread-safe
  ```

  This option enables the building of the driver thread-safe library `libmyodbc3_r.so` from by linking with MySQL thread-safe client library `libmysqlclient_r.so` (The extensions are OS dependent).

  If the compilation with the thread-safe option fails, it may be because the correct thread-libraries on the system could not be located. You should set the value of `LIBS` to point to the correct thread library for your system.

```
LIBS="-lpthread" ./configure ..
```

- You can enable or disable the shared and static versions of Connector/ODBC using these options:

  ```
  --enable-shared[=yes/no]
  --disable-shared
  --enable-static[=yes/no]
  --disable-static
  ```

- By default, all the binary distributions are built as nondebugging versions (configured with `--without-debug`).

  To enable debugging information, build the driver from a source distribution with the proper configuration option to enable debugging support. See Section 2.9.4, “MySQL Source-Configuration Options”.

- This option is available only for source trees that have been obtained from the Subversion repository. This option does not apply to the packaged source distributions.

  By default, the driver is built with the `--without-docs` option. If you would like the documentation to be built, then execute `configure` with:

  ```
  --with-docs
  ```

20.1.3.5.3. Building and Compilation

To build the driver libraries, you have to just execute `make`.

```
shell> make
```

If any errors occur, correct them and continue the build process. If you aren't able to build, then send a detailed email to `<myodbc@lists.mysql.com>` for further assistance.

20.1.3.5.4. Building Shared Libraries

On most platforms, MySQL does not build or support `.so` (shared) client libraries by default. This is based on our experience of problems when building shared libraries.

In cases like this, you have to download the MySQL distribution and configure it with these options:

```
--without-server --enable-shared
```

To build shared driver libraries, you must specify the `--enable-shared` option for `configure`. By default, `configure` does not enable this option.

If you have configured with the `--disable-shared` option, you can build the `.so` file from the static libraries using the following commands:

```
shell> cd mysql-connector-odbc-3.51.01
shell> make
shell> cd driver
shell> CC=/usr/bin/gcc \
          $CC -bundle -flat_namespace -undefined error \
          -o .libs/libmyodbc3-3.51.01.so \
          catalog.o connect.o cursor.o dll.o error.o execute.o \
          handle.o info.o misc.o myodbc3.o options.o prepare.o \
          results.o transact.o utility.o \
          -L/usr/local/mysql/lib/mysql/ \
          -L/usr/local/iodbc/lib/ \
          -lz -lc -lmysqlclient -liodbcinst
```

Make sure to change `-liodbcinst` to `-lodbcinst` if you are using `unixODBC` instead of `iODBC`, and configure the library paths accordingly.

This builds and places the `libmyodbc3-3.51.01.so` file in the `.libs` directory. Copy this file to the Connector/ODBC library installation directory (`/usr/local/lib` (or the `lib` directory under the installation directory that you supplied with the `--prefix`).

```
shell> cd .libs
shell> cp libmyodbc3-3.51.01.so /usr/local/lib
shell> cd /usr/local/lib
shell> ln -s libmyodbc3-3.51.01.so libmyodbc3.so
```

To build the thread-safe driver library:

```
shell> CC=/usr/bin/gcc \
          $CC -bundle -flat_namespace -undefined error
          -o .libs/libmyodbc3_r-3.51.01.so
          catalog.o connect.o cursor.o dll.o error.o execute.o
          handle.o info.o misc.o myodbc3.o options.o prepare.o
          results.o transact.o utility.o
          -L/usr/local/mysql/lib/mysql/
          -L/usr/local/iodbc/lib/
          -lz -lc -lmysqlclient_r -liodbcinst
```

20.1.3.5.5. Installing Driver Libraries

To install the driver libraries, execute the following command:

```
shell> make install
```

That command installs one of the following sets of libraries:

For Connector/ODBC 3.51:

- `libmyodbc3.so`
- `libmyodbc3-3.51.01.so`, where 3.51.01 is the version of the driver
- `libmyodbc3.a`

For thread-safe Connector/ODBC 3.51:

- `libmyodbc3_r.so`
- `libmyodbc3-3_r.51.01.so`
- `libmyodbc3_r.a`

For more information on build process, refer to the `INSTALL` file that comes with the source distribution. Note that if you are trying to use the `make` from Sun, you may end up with errors. On the other hand, GNU `gmake` should work fine on all platforms.

20.1.3.5.6. Testing Connector/ODBC on Unix

To run the basic samples provided in the distribution with the libraries that you built, use the following command:

```
shell> make test
```

Before running the tests, create the DSN 'myodbc3' in `odbc.ini` and set the environment variable `ODBCINI` to the correct `odbc.ini` file; and MySQL server is running. You can find a sample `odbc.ini` with the driver distribution.

You can even modify the `samples/run-samples` script to pass the desired DSN, UID, and PASSWORD values as the command-line arguments to each sample.

20.1.3.5.7. Building Connector/ODBC from Source on Mac OS X

To build the driver on Mac OS X (Darwin), make use of the following `configure` example:

```
shell> ./configure --prefix=/usr/local
          --with-unixODBC=/usr/local
          --with-mysql-path=/usr/local/mysql
          --disable-shared
          --enable-gui=no
          --host=powerpc-apple
```

The command assumes that the `unixODBC` and MySQL are installed in the default locations. If not, configure accordingly.

On Mac OS X, `--enable-shared` builds `.dylib` files by default. You can build `.so` files like this:

```
shell> make
shell> cd driver
shell> CC=/usr/bin/gcc \
          $CC -bundle -flat_namespace -undefined error
          -o .libs/libmyodbc3-3.51.01.so *.o
          -L/usr/local/mysql/lib/
          -L/usr/local/iodbc/lib
          -liodbcinst -lmysqlclient -lz -lc
```

To build the thread-safe driver library:

```
shell> CC=/usr/bin/gcc \
          $CC -bundle -flat_namespace -undefined error
          -o .libs/libmyodbc3-3.51.01.so *.o
          -L/usr/local/mysql/lib/
          -L/usr/local/iodbc/lib
          -liodbcinst -lmysqlclienti_r -lz -lc -lpthread
```

Make sure to change the `-liodbcinst` to `-lodbcinst` in case of using `unixODBC` instead of `iODBC` and configure the libraries path accordingly.

In Apple's version of GCC, both `cc` and `gcc` are actually symbolic links to `gcc3`.

Copy this library to the `$prefix/lib` directory and symlink to `libmyodbc3.so`.

You can cross-check the output shared-library properties using this command:

```
shell> otool -LD .libs/libmyodbc3-3.51.01.so
```

20.1.3.5.8. Building Connector/ODBC from Source on HP-UX

To build the driver on HP-UX 10.x or 11.x, make use of the following `configure` example:

If using `cc`:

```
shell> CC="cc" \
          CFLAGS="+z" \
          LDFLAGS="-Wl,+b:-Wl,+s" \
          ./configure --prefix=/usr/local
          --with-unixodbc=/usr/local
          --with-mysql-path=/usr/local/mysql/lib/mysql
          --enable-shared
          --enable-thread-safe
```

If using `gcc`:

```
shell> CC="gcc" \
          LDFLAGS="-Wl,+b:-Wl,+s" \
          ./configure --prefix=/usr/local
          --with-unixodbc=/usr/local
          --with-mysql-path=/usr/local/mysql
          --enable-shared
          --enable-thread-safe
```

Once the driver is built, cross-check its attributes using `chatr .libs/libmyodbc3.sl` to determine whether you need to have set the MySQL client library path using the `SHLIB_PATH` environment variable. For static versions, ignore all shared-library options and run `configure` with the `--disable-shared` option.

20.1.3.5.9. Building Connector/ODBC from Source on AIX

To build the driver on AIX, make use of the following `configure` example:

```
shell> ./configure --prefix=/usr/local
          --with-unixodbc=/usr/local
          --with-mysql-path=/usr/local/mysql
          --disable-shared
          --enable-thread-safe
```

> **Note**
>
> For more information about how to build and set up the static and shared libraries across the different platforms refer to ' Using static and shared libraries across platforms'.

20.1.3.6. Installing Connector/ODBC from the Development Source Tree

> **Caution**
>
> You should read this section only if you are interested in helping us test our new code. If you just want to get MySQL Connector/ODBC up and running on your system, you should use a standard release distribution.

To obtain the most recent development source tree, you first need to download and install Bazaar. You can obtain Bazaar from the Bazaar VCS Web site. Bazaar is supported by any platform that supports Python, and is therefore compatible with any Linux, Unix, Windows or Mac OS X host. Instructions for downloading and installing Bazaar on the different platforms are available on the Bazaar Web site.

To build from the source trees, you need the following tools:

- autoconf 2.52 (or newer)
- automake 1.4 (or newer)
- libtool 1.4 (or newer)
- m4

The most recent development source tree is available from our public Subversion trees at http://dev.mysql.com/tech-resources/sources.html.

To check out out the Connector/ODBC sources, change to the directory where you want the copy of the Connector/ODBC tree to be stored, then use the following command:

```
shell> bzr branch lp:myodbc
```

You should now have a copy of the entire Connector/ODBC source tree in the directory `connector-odbc3`. To build from this source tree on Unix or Linux follow these steps:

```
shell> cd myodbc
shell> aclocal
shell> autoheader
shell> libtoolize -c -f
shell> autoconf
shell> automake;
shell> ./configure  # Add your favorite options here
shell> make
```

For more information on how to build, refer to the `INSTALL` file located in the same directory. For more information on options to `configure`, see Section 20.1.3.5.1, “Typical `configure` Options”

When the build is done, run `make install` to install the Connector/ODBC 3.51 driver on your system.

If you have gotten to the `make` stage and the distribution does not compile, please report it to `<myodbc@lists.mysql.com>`.

On Windows, make use of Windows Makefiles `WIN-Makefile` and `WIN-Makefile_debug` in building the driver. For more information, see Section 20.1.3.4, “Installing Connector/ODBC from a Source Distribution on Windows”.

After the initial checkout operation to get the source tree, you should run `bzr pull` periodically to update your source according to the latest version.

20.1.4. Connector/ODBC Configuration

Before you connect to a MySQL database using the Connector/ODBC driver you must configure an ODBC *Data Source Name*. The DSN associates the various configuration parameters required to communicate with a database to a specific name. You use the DSN in an application to communicate with the database, rather than specifying individual parameters within the application itself. DSN information can be user specific, system specific, or provided in a special file. ODBC data source names are configured in different ways, depending on your platform and ODBC driver.

20.1.4.1. Data Source Names

A Data Source Name associates the configuration parameters for communicating with a specific database. Generally a DSN consists of the following parameters:

- Name
- Host Name
- Database Name
- Login

- Password

In addition, different ODBC drivers, including Connector/ODBC, may accept additional driver-specific options and parameters.

There are three types of DSN:

- A *System DSN* is a global DSN definition that is available to any user and application on a particular system. A System DSN can normally only be configured by a systems administrator, or by a user who has specific permissions that let them create System DSNs.
- A *User DSN* is specific to an individual user, and can be used to store database connectivity information that the user regularly uses.
- A *File DSN* uses a simple file to define the DSN configuration. File DSNs can be shared between users and machines and are therefore more practical when installing or deploying DSN information as part of an application across many machines.

DSN information is stored in different locations depending on your platform and environment.

20.1.4.2. Connector/ODBC Connection Parameters

You can specify the parameters in the following tables for Connector/ODBC when configuring a DSN. Users on Windows can use the Options and Advanced panels when configuring a DSN to set these parameters; see the table for information on which options relate to which fields and check boxes. On Unix and Mac OS X, use the parameter name and value as the keyword/value pair in the DSN configuration. Alternatively, you can set these parameters within the `InConnectionString` argument in the `SQLDriverConnect()` call.

Parameter	Default Value	Comment
`user`	ODBC	The user name used to connect to MySQL.
`uid`	ODBC	Synonymous with `user`. Added in 3.51.16.
`server`	`localhost`	The host name of the MySQL server.
`database`		The default database.
`option`	0	Options that specify how Connector/ODBC should work. See below.
`port`	3306	The TCP/IP port to use if `server` is not `localhost`.
`initstmt`		Initial statement. A statement to execute when connecting to MySQL. In version 3.51 the parameter is called `stmt`. Note, the driver supports the initial statement being executed only at the time of the initial connection.
`password`		The password for the `user` account on `server`.
`pwd`		Synonymous with `password`. Added in 3.51.16.
`socket`		The Unix socket file or Windows named pipe to connect to if `server` is `localhost`.
`sslca`		The path to a file with a list of trust SSL CAs. Added in 3.51.16.
`sslcapath`		The path to a directory that contains trusted SSL CA certificates in PEM format. Added in 3.51.16.
`sslcert`		The name of the SSL certificate file to use for establishing a secure connection. Added in 3.51.16.
`sslcipher`		A list of permissible ciphers to use for SSL encryption. The cipher list has the same format as the `openssl ciphers` command Added in 3.51.16.
`sslkey`		The name of the SSL key file to use for establishing a secure connection. Added in 3.51.16.
`charset`		The character set to use for the connection. Added in 3.51.17.
`sslverify`		If set to 1, the SSL certificate will be verified when used with the MySQL connection. If not set, then the default behavior is to ignore SSL certificate verification.
`readtimeout`		The timeout in seconds for attempts to read from the server. Each attempt uses this timeout value and there are retries if necessary, so the total effective timeout value is three times the option value. You can set the value so that a lost connection can be detected earlier than the TCP/IP `Close_Wait_Timeout` value of 10 minutes. This option works only for TCP/IP connections, and only for Windows prior to MySQL 5.1.12. Corresponds to the `MYSQL_OPT_READ_TIMEOUT` option of the MySQL Client Library. This option was added in Connector/ODBC 3.51.27.

Parameter	Default Value	Comment
`writetimeout`		The timeout in seconds for attempts to write to the server. Each attempt uses this timeout value and there are `net_retry_count` retries if necessary, so the total effective timeout value is `net_retry_count` times the option value. This option works only for TCP/IP connections, and only for Windows prior to MySQL 5.1.12. Corresponds to the `MYSQL_OPT_WRITE_TIMEOUT` option of the MySQL Client Library. This option was added in Connector/ODBC 3.51.27.
`interactive`		Enables the `CLIENT_INTERACTIVE` connection option of `mysql_real_connect`.

> **Note**
>
> The SSL configuration parameters can also be automatically loaded from a `my.ini` or `my.cnf` file.

The `option` argument is used to tell Connector/ODBC that the client isn't 100% ODBC compliant. On Windows, you normally select options by toggling the check boxes in the connection screen, but you can also select them in the `option` argument. The following options are listed in the order in which they appear in the Connector/ODBC connect screen.

Flagname	GUI Option	Description
`FLAG_FIELD_LENGTH`	Do not Optimize Column Width	The client cannot handle that Connector/ODBC returns the real width of a column. This option was removed in 3.51.18.
`FLAG_FOUND_ROWS`	Return Matching Rows	The client cannot handle that MySQL returns the true value of affected rows. If this flag is set, MySQL returns “found rows” instead. You must have MySQL 3.21.14 or newer to get this to work.
`FLAG_DEBUG`	Trace Driver Calls To myodbc.log	Make a debug log in `C:\myodbc.log` on Windows, or `/tmp/myodbc.log` on Unix variants. This option was removed in Connector/ODBC 3.51.18.
`FLAG_BIG_PACKETS`	Allow Big Results	Do not set any packet limit for results and bind parameters. Without this option, parameter binding will be truncated to 255 characters.
`FLAG_NO_PROMPT`	Do not Prompt Upon Connect	Do not prompt for questions even if driver would like to prompt.
`FLAG_DYNAMIC_CURSOR`	Enable Dynamic Cursor	Enable or disable the dynamic cursor support.
`FLAG_NO_SCHEMA`	Ignore # in Table Name	Ignore use of database name in *`db_name.tbl_name.col_name`*.
`FLAG_NO_DEFAULT_CURSOR`	User Manager Cursors	Force use of ODBC manager cursors (experimental).
`FLAG_NO_LOCALE`	Do not Use Set Locale	Disable the use of extended fetch (experimental).
`FLAG_PAD_SPACE`	Pad Char To Full Length	Pad `CHAR` columns to full column length.
`FLAG_FULL_COLUMN_NAMES`	Return Table Names for SQLDescribeCol	`SQLDescribeCol()` returns fully qualified column names.
`FLAG_COMPRESSED_PROTO`	Use Compressed Protocol	Use the compressed client/server protocol.
`FLAG_IGNORE_SPACE`	Ignore Space After Function Names	Tell server to ignore space after function name and before “`(`” (needed by PowerBuilder). This makes all function names keywords.
`FLAG_NAMED_PIPE`	Force Use of Named Pipes	Connect with named pipes to a `mysqld` server running on NT.
`FLAG_NO_BIGINT`	Change BIGINT Columns to Int	Change `BIGINT` columns to `INT` columns (some applications cannot handle `BIGINT`).
`FLAG_NO_CATALOG`	No Catalog	Forces results from the catalog functions, such as `SQLTables`, to always return `NULL` and the driver to report that catalogs are not supported.
`FLAG_USE_MYCNF`	Read Options From `my.cnf`	Read parameters from the `[client]` and `[odbc]` groups from `my.cnf`.
`FLAG_SAFE`	Safe	Add some extra safety checks.
`FLAG_NO_TRANSACTIONS`	Disable transactions	Disable transactions.
`FLAG_LOG_QUERY`	Save queries to `myodbc.sql`	Enable query logging to `c:\myodbc.sql`(`/tmp/myodbc.sql`) file. (Enabled only in debug mode.)
`FLAG_NO_CACHE`	Do not Cache Result	Do not cache the results locally in the driver, instead read from server

Flagname	GUI Option	Description
	(forward only cursors)	`mysql_use_result()`). This works only for forward-only cursors. This option is very important in dealing with large tables when you do not want the driver to cache the entire result set.
`FLAG_FORWARD_CURSOR`	Force Use Of Forward Only Cursors	Force the use of `Forward-only` cursor type. In case of applications setting the default static/dynamic cursor type, and one wants the driver to use non-cache result sets, then this option ensures the forward-only cursor behavior.
`FLAG_AUTO_RECONNECT`	Enable auto-reconnect.	Enables auto-reconnection functionality. You should not use this option with transactions, since a auto reconnection during a incomplete transaction may cause corruption. Note that an auto-reconnected connection will not inherit the same settings and environment as the original. This option was added in Connector/ODBC 3.51.13.
`FLAG_AUTO_IS_NULL`	Flag Auto Is Null	When `FLAG_AUTO_IS_NULL` is set, the driver does not change the default value of `sql_auto_is_null`, leaving it at 1, so you get the MySQL default, not the SQL standard behavior. When `FLAG_AUTO_IS_NULL` is not set, the driver changes the default value of `SQL_AUTO_IS_NULL` to 0 after connecting, so you get the SQL standard, not the MySQL default behavior. Thus, omitting the flag disables the compatibility option and forces SQL standard behavior. See `IS NULL`. This option was added in Connector/ODBC 3.51.13.
`FLAG_ZERO_DATE_TO_MIN`	Return SQL_NULL_DATA for zero date	Translates zero dates (`XXXX-00-00`) into the minimum date values supported by ODBC, `XXXX-01-01`. This resolves an issue where some statements will not work because the date returned and the minimum ODBC date value are incompatible. This option was added in Connector/ODBC 3.51.17.
`FLAG_MIN_DATE_TO_ZERO`	Bind minimal date as zero date	Translates the minimum ODBC date value (`XXXX-01-01`) to the zero date format supported by MySQL (`XXXX-00-00`). This resolves an issue where some statements will not work because the date returned and the minimum ODBC date value are incompatible. This option was added in Connector/ODBC 3.51.17.
`FLAG_MULTI_STATEMENTS`	Allow multiple statements	Enables support for batched statements. This option was added in Connector/ODBC 3.51.18.
`FLAG_COLUMN_SIZE_S32`	Limit column size to 32-bit value	Limits the column size to a signed 32-bit value to prevent problems with larger column sizes in applications that do not support them. This option is automatically enabled when working with ADO applications. This option was added in Connector/ODBC 3.51.22.
`FLAG_NO_BINARY_RESULT`	Always handle binary function results as character data	When set this option disables charset 63 for columns with an empty `org_table`. This option was added in Connector/ODBC 3.51.26.
`FLAG_NO_INFORMATION_SCHEMA`		Tells catalog functions not to use `INFORMATION_SCHEMA`, but rather use legacy algorithms. The trade-off here is usually speed for information quality. Using `INFORMATION_SCHEMA` is often slow, but the information obtained is more complete.
`FLAG_DFLT_BIGINT_BIND_STR`		Causes `BIGINT` parameters to be bound as strings. Microsoft Access treats `BIGINT` as a string on linked tables. The value is read correctly, but bound as a string. This option is used automatically if the driver is used by Microsoft Access.

To select multiple options, add together their values.

> **Note**
>
> From version of MySQL Connector/ODBC 5.1.6 onwards, it is possible to use the flag name directly as a parameter in the connection string, by using the flag name without the FLAG_ prefix. So, in addition to using the `options` parameter with various flags set, it is now possible to use the flags directly as parameters. For example, `FIELD_LENGTH`, `FOUND_ROWS` and `DEBUG` could all be used as parameters.

The following table shows some recommended `option` values for various configurations.

Configuration	Option Value
Microsoft Access, Visual Basic	3
Driver trace generation (Debug mode)	4
Microsoft Access (with improved DELETE queries)	35
Large tables with too many rows	2049
Sybase PowerBuilder	135168
Query log generation (Debug mode)	524288
Generate driver trace as well as query log (Debug mode)	524292
Large tables with no-cache results	3145731

20.1.4.3. Configuring a Connector/ODBC DSN on Windows

The `ODBC Data Source Administrator` within Windows enables you to create DSNs, check driver installation and configure ODBC systems such as tracing (used for debugging) and connection pooling.

Different editions and versions of Windows store the `ODBC Data Source Administrator` in different locations depending on the version of Windows that you are using.

To open the `ODBC Data Source Administrator` in Windows Server 2003:

> **Tip**
>
> Because it is possible to create DSN using either the 32-bit or 64-bit driver, but using the same DNS identifier, it is advisable to include the driver being used within the DSN identifier. This will help you to identify the DSN when using it from applications such as Excel that are only compatible with the 32-bit driver. For example, you might add `Using32bitCODBC` to the DSN identifier for the 32-bit interface and `Using64bitCODBC` for those using the 64-bit Connector/ODBC driver.

1. On the `Start` menu, choose `Administrative Tools`, and then click `Data Sources (ODBC)`.

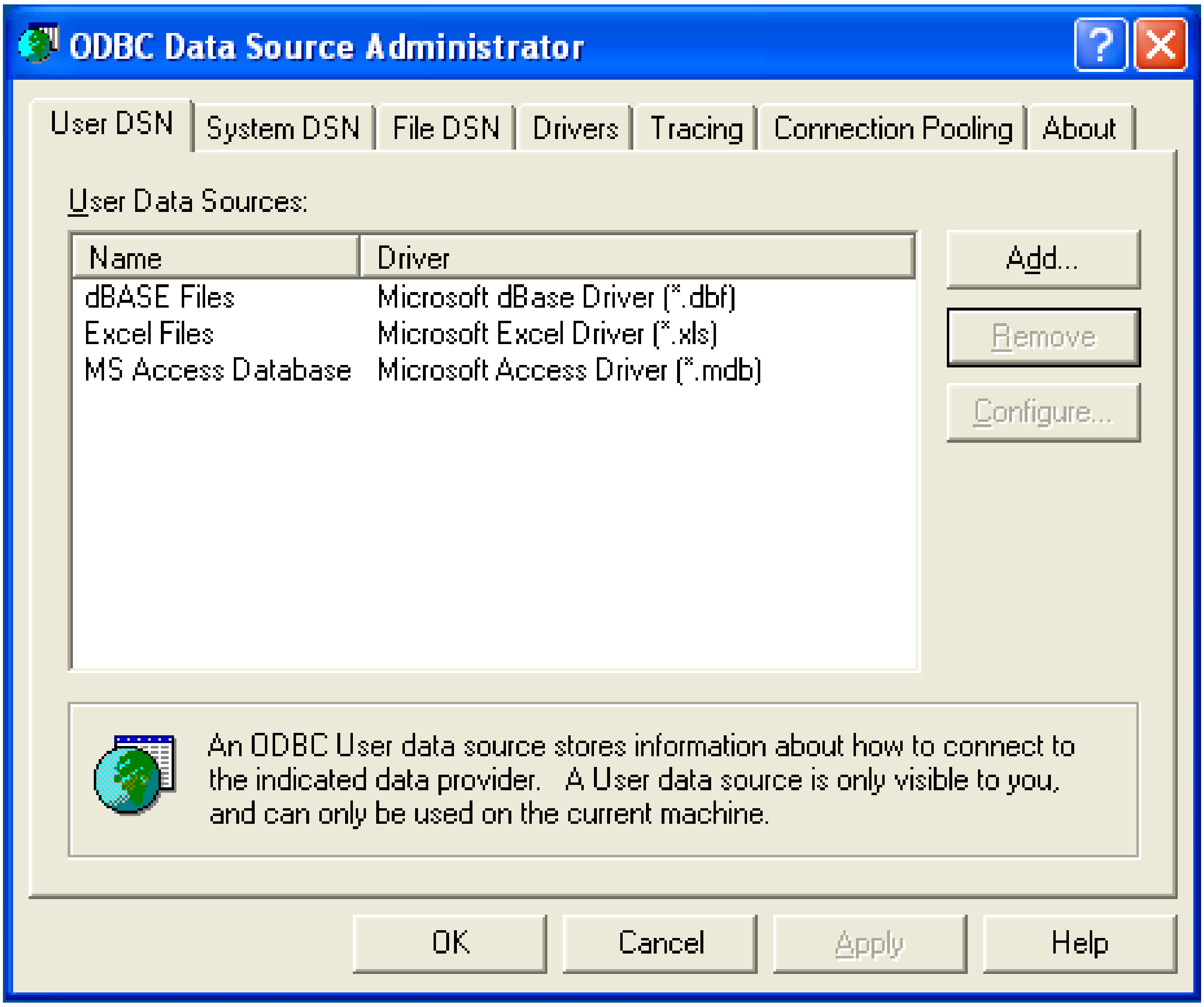
To open the `ODBC Data Source Administrator` in Windows 2000 Server or Windows 2000 Professional:

1. On the `Start` menu, choose `Settings`, and then click `Control Panel`.
2. In `Control Panel`, click `Administrative Tools`.
3. In `Administrative Tools`, click `Data Sources (ODBC)`.

To open the `ODBC Data Source Administrator` on Windows XP:

1. On the `Start` menu, click `Control Panel`.
2. In the `Control Panel` when in `Category View` click `Performance and Maintenance` and then click `Administrative Tools.`. If you are viewing the `Control Panel` in `Classic View`, click `Administrative Tools`.
3. In `Administrative Tools`, click `Data Sources (ODBC)`.

Irrespective of your Windows version, you should be presented the `ODBC Data Source Administrator` window:


ODBC Data Source Administrator
User DSN
System DSN
File DSN
Drivers
Tracing
Connection Pooling
About
User Data Sources:
Add...
Remove
Configure...
OK
Cancel
Apply
Help

Name	Driver
dBASE Files	Microsoft dBase Driver (*.dbf)
Excel Files	Microsoft Excel Driver (*.xls)
MS Access Database	Microsoft Access Driver (*.mdb)

An ODBC User data source stores information about how to connect to the indicated data provider. A User data source is only visible to you, and can only be used on the current machine.

Within Windows XP, you can add the `Administrative Tools` folder to your Start menu to make it easier to locate the ODBC Data Source Administrator. To do this:

1. Right-click the Start menu.
2. Select `Properties`.
3. Click Customize....
4. Select the Advanced tab.
5. Within `Start menu items`, within the `System Administrative Tools` section, select `Display on the All Programs menu`.

Within both Windows Server 2003 and Windows XP you may want to permanently add the `ODBC Data Source Administrator` to your Start menu. To do this, locate the `Data Sources (ODBC)` icon using the methods shown, then right-click on the icon and then choose Pin to Start Menu.

The interfaces for the 3.51 and 5.1 versions of the Connector/ODBC driver are different, although the fields and information that you need to enter remain the same.

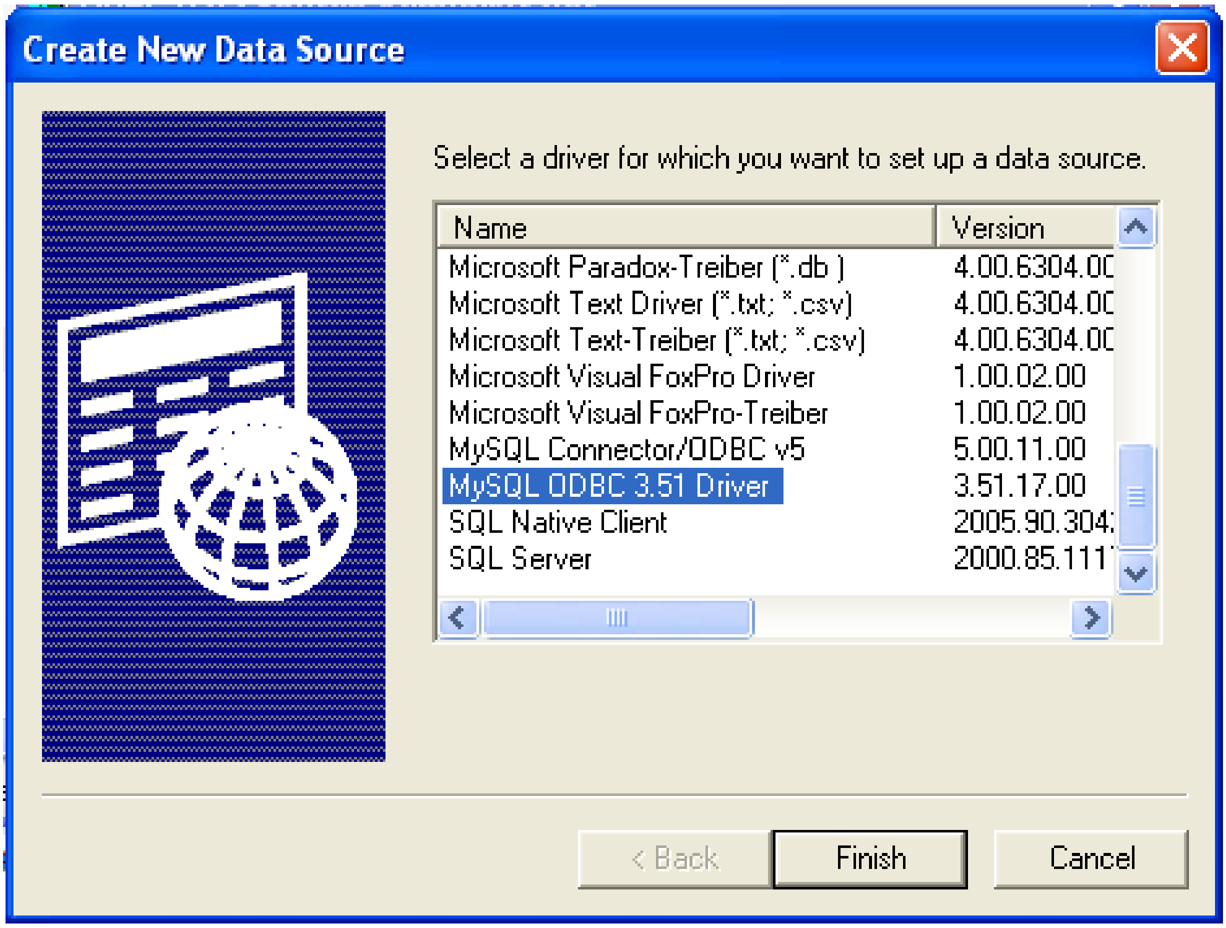
To configure a DSN using Connector/ODBC 3.51.x or Connector/ODBC 5.1.0, see Section 20.1.4.3.1, “Configuring a Connector/ODBC 3.51 DSN on Windows”.

To configure a DSN using Connector/ODBC 5.1.1 or later, see Section 20.1.4.3.2, “Configuring a Connector/ODBC 5.1 DSN on Windows”.

20.1.4.3.1. Configuring a Connector/ODBC 3.51 DSN on Windows

To add and configure a new Connector/ODBC data source on Windows, use the `ODBC Data Source Administrator`:

1. Open the `ODBC Data Source Administrator`.
2. To create a System DSN (which will be available to all users) , select the `System DSN` tab. To create a User DSN, which will be unique only to the current user, click the ADD... button.
3. You will need to select the ODBC driver for this DSN.



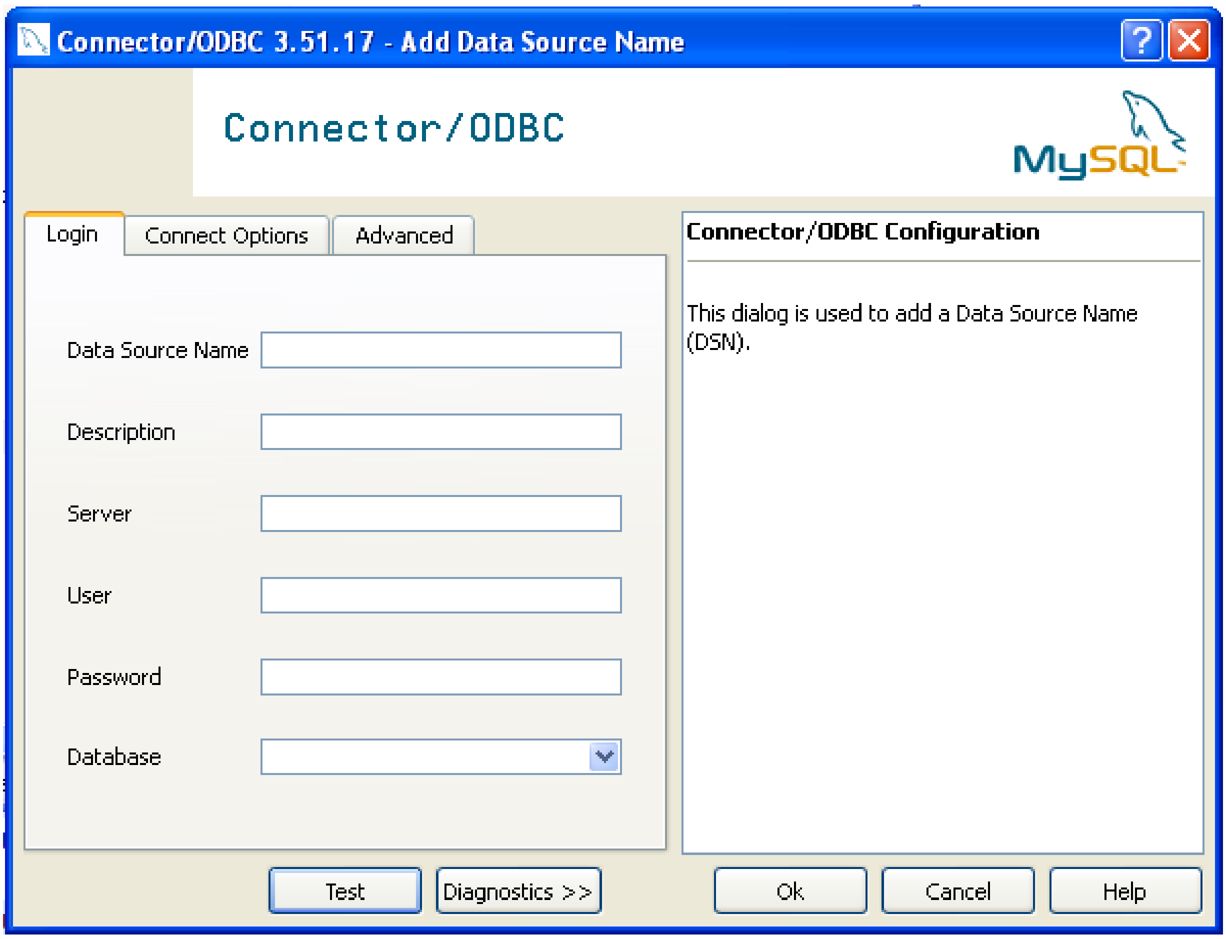
Create New Data Source

Select a driver for which you want to set up a data source.

Name	Version
Microsoft Paradox-Treiber (*.db)	4.00.6304.0
Microsoft Text Driver (*.txt; *.csv)	4.00.6304.0
Microsoft Text-Treiber (*.txt; *.csv)	4.00.6304.0
Microsoft Visual FoxPro Driver	1.00.02.00
Microsoft Visual FoxPro-Treiber	1.00.02.00
MySQL Connector/ODBC v5	5.00.11.00
MySQL ODBC 3.51 Driver	3.51.17.00
SQL Native Client	2005.90.304
SQL Server	2000.85.111

   Select `MySQL ODBC 3.51 Driver`, then click FINISH.

4. You now need to configure the specific fields for the DSN you are creating through the `Add Data Source Name` dialog.


Connector/ODBC 3.51.17 - Add Data Source Name
Connector/ODBC
MySQL
Login
Connect Options
Advanced
Data Source Name
Description
Server
User
Password
Database
Test
Diagnostics >>
Ok
Cancel
Help

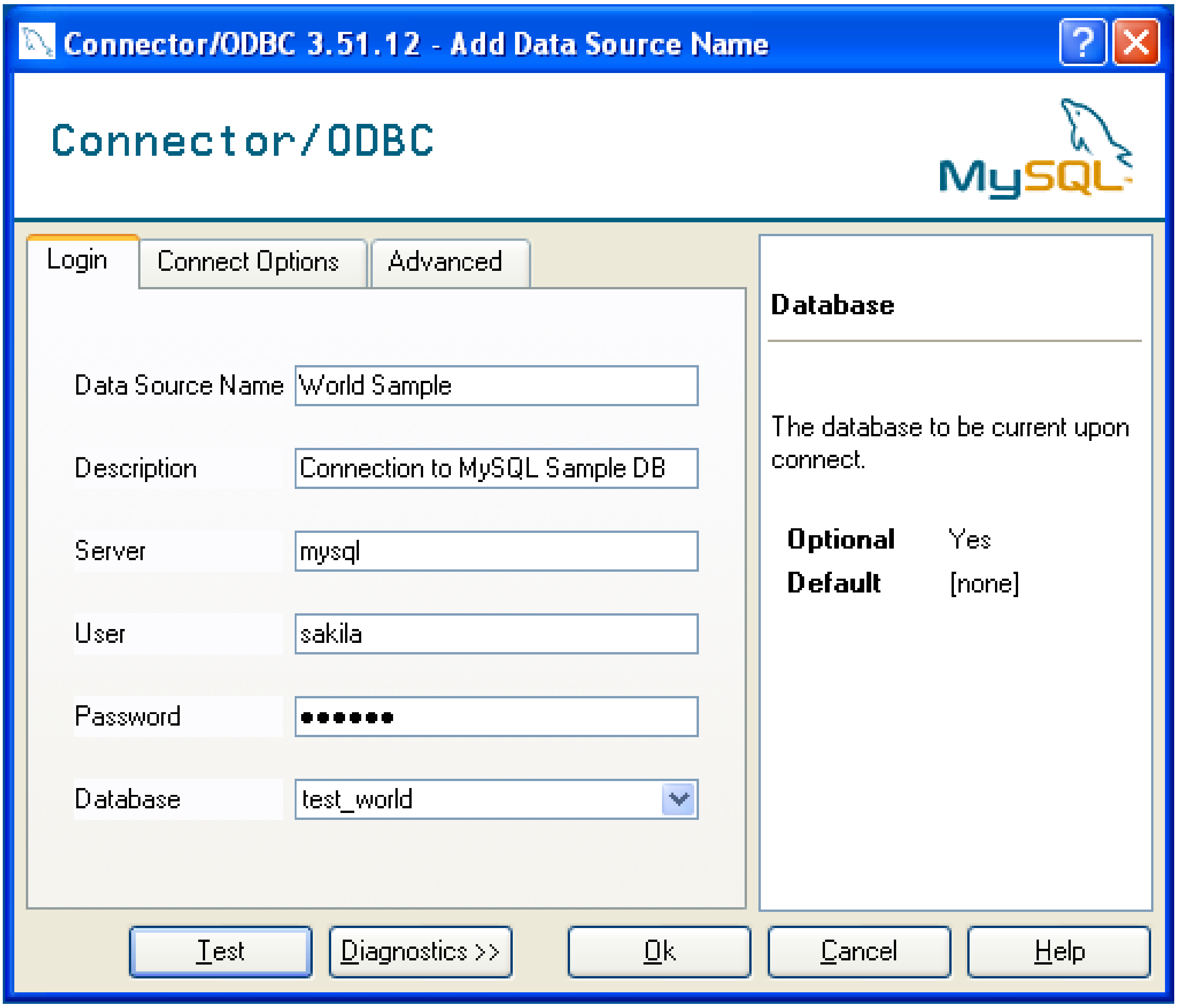
Connector/ODBC Configuration

This dialog is used to add a Data Source Name (DSN).

In the **Data Source Name** box, enter the name of the data source you want to access. It can be any valid name that you choose.

5. In the **Description** box, enter some text to help identify the connection.
6. In the **Server** field, enter the name of the MySQL server host that you want to access. By default, it is `localhost`.
7. In the **User** field, enter the user name to use for this connection.
8. In the **Password** field, enter the corresponding password for this connection.
9. The **Database** pop-up should automatically populate with the list of databases that the user has permissions to access.
10. Click OK to save the DSN.

A completed DSN configuration may look like this:


Connector/ODBC 3.51.12 - Add Data Source Name
Connector/ODBC
MySQL
Login
Connect Options
Advanced
Test
Diagnostics >>
Ok
Cancel
Help

Data Source Name: World Sample

Description: Connection to MySQL Sample DB

Server: mysql

User: sakila

Password: ●●●●●●

Database: test_world

Database

The database to be current upon connect.

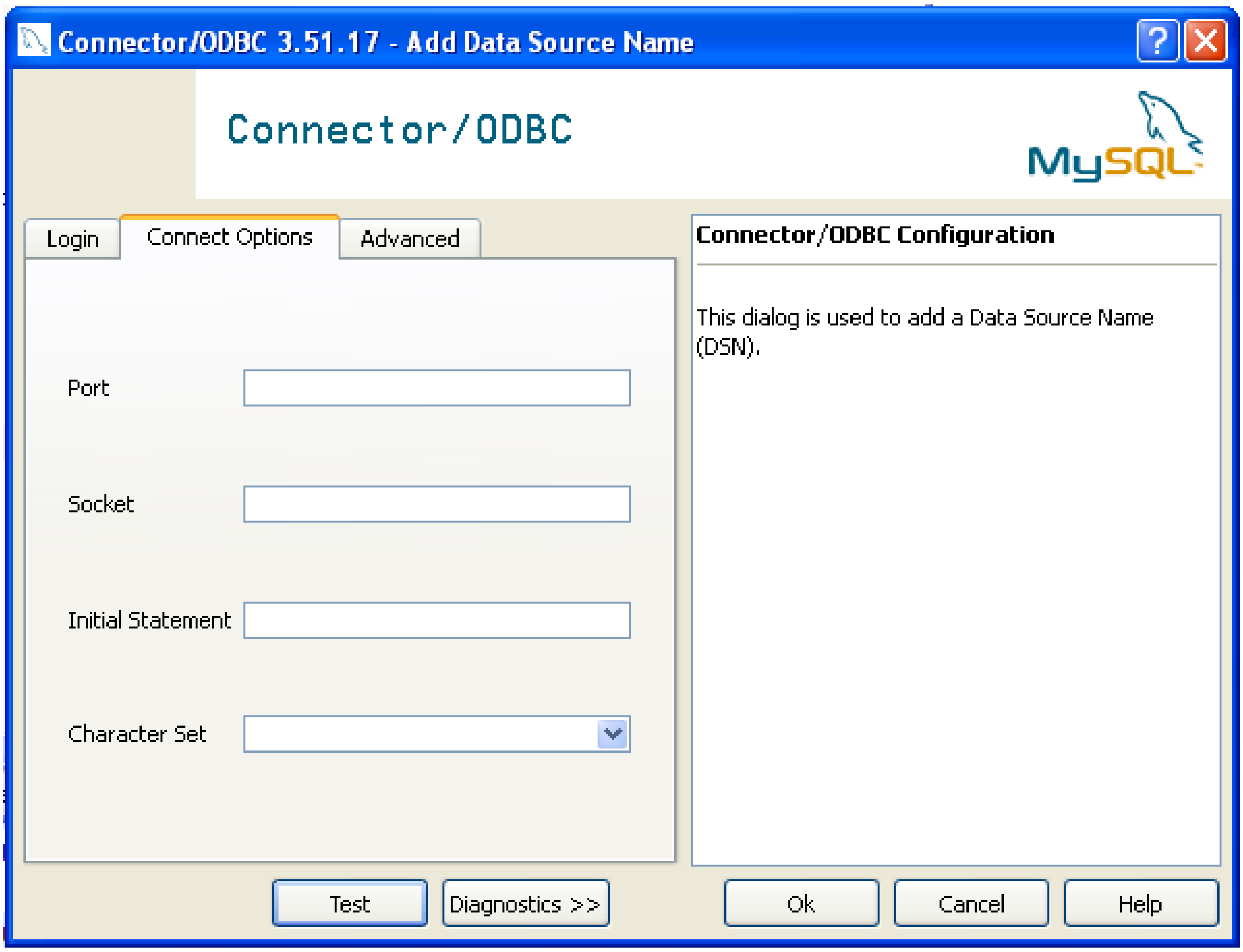
Optional Yes

Default [none]

You can verify the connection using the parameters you have entered by clicking the TEST button. If the connection could be made successfully, you will be notified with a `Success; connection was made!` dialog.

If the connection failed, you can obtain more information on the test and why it may have failed by clicking the DIAGNOSTICS... button to show additional error messages.

You can configure a number of options for a specific DSN by using either the CONNECT OPTIONS or ADVANCED tabs in the DSN configuration dialog.

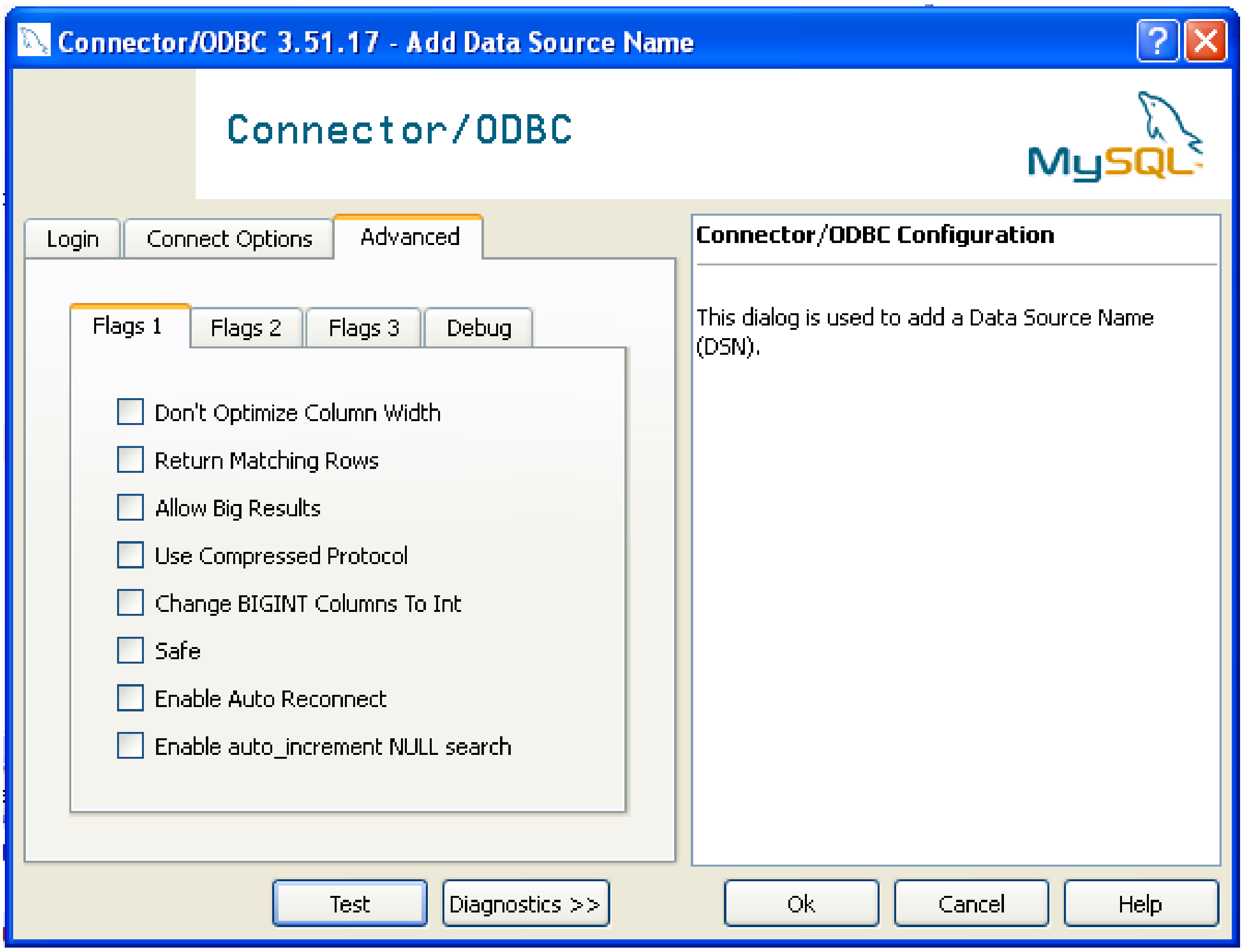

Connector/ODBC 3.51.17 - Add Data Source Name
Connector/ODBC
MySQL
Login
Connect Options
Advanced
Port
Socket
Initial Statement
Character Set
Connector/ODBC Configuration
Test
Diagnostics >>
Ok
Cancel
Help

This dialog is used to add a Data Source Name (DSN).

The three options you can configure are:

- **PORT** sets the TCP/IP port number to use when communicating with MySQL. Communication with MySQL uses port 3306 by default. If your server is configured to use a different TCP/IP port, you must specify that port number here.
- **SOCKET** sets the name or location of a specific socket or Windows pipe to use when communicating with MySQL.
- **INITIAL STATEMENT** defines an SQL statement that will be executed when the connection to MySQL is opened. You can use this to set MySQL options for your connection, such as disabling autocommit.
- **CHARACTER SET** is a pop-up list from which you can select the default character set to be used with this connection. The Character Set option was added in 3.5.17.

The ADVANCED tab enables you to configure Connector/ODBC connection parameters. Refer to Section 20.1.4.2, “Connector/ODBC Connection Parameters”, for information about the meaning of these options.


Connector/ODBC 3.51.17 - Add Data Source Name
Connector/ODBC
MySQL
Login
Connect Options
Advanced
Flags 1
Flags 2
Flags 3
Debug
Test
Diagnostics >>
Ok
Cancel
Help

☐ Don't Optimize Column Width
☐ Return Matching Rows
☐ Allow Big Results
☐ Use Compressed Protocol
☐ Change BIGINT Columns To Int
☐ Safe
☐ Enable Auto Reconnect
☐ Enable auto_increment NULL search

Connector/ODBC Configuration

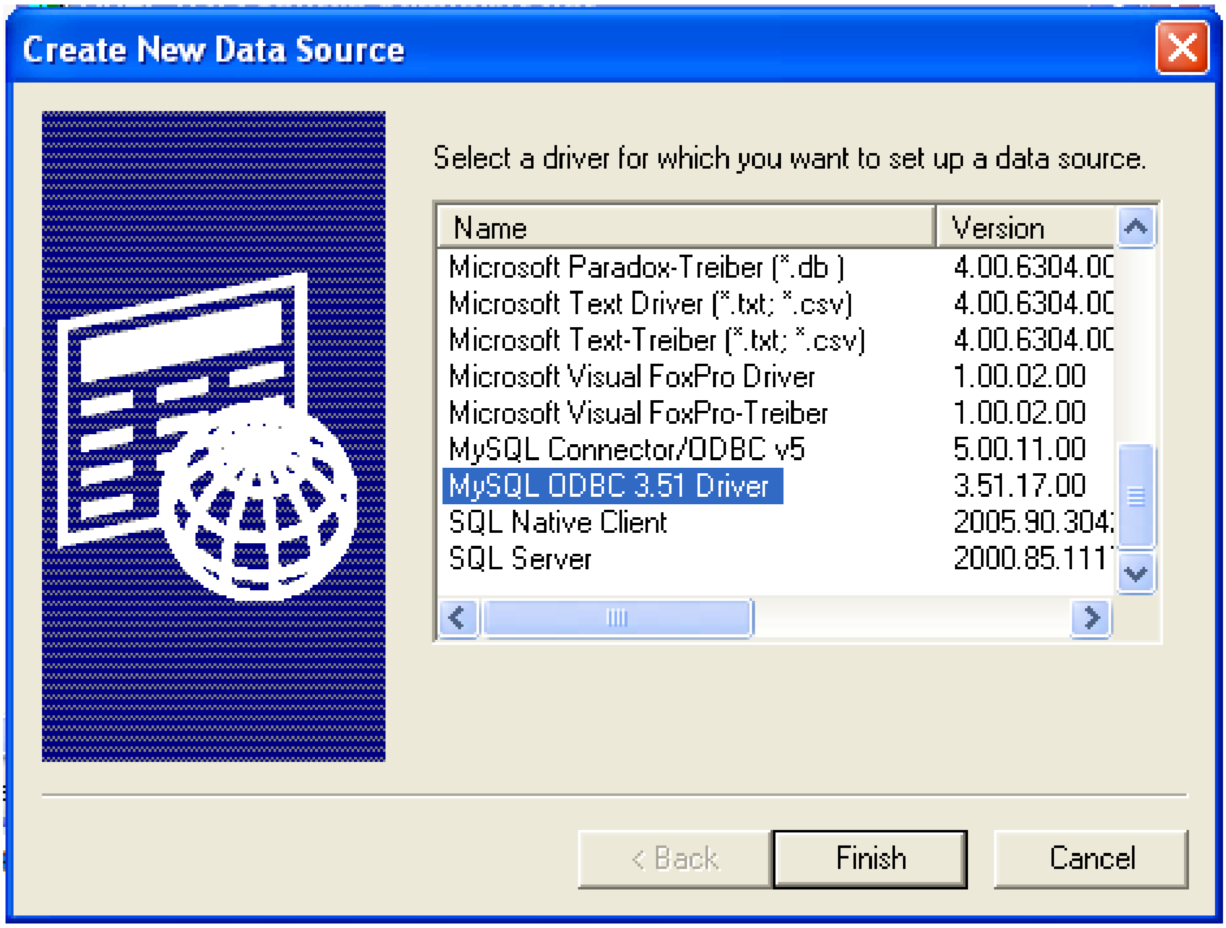
This dialog is used to add a Data Source Name (DSN).

20.1.4.3.2. Configuring a Connector/ODBC 5.1 DSN on Windows

The DSN configuration when using Connector/ODBC 5.1.1 and later has a slightly different layout. Also, due to the native Unicode support within Connector/ODBC 5.1, you no longer need to specify the initial character set to be used with your connection.

To configure a DSN using the Connector/ODBC 5.1.1 or later driver:

1. Open the `ODBC Data Source Administrator`.
2. To create a System DSN (which will be available to all users) , select the **SYSTEM DSN** tab. To create a User DSN, which will be unique only to the current user, click the ADD... button.
3. You will need to select the ODBC driver for this DSN.

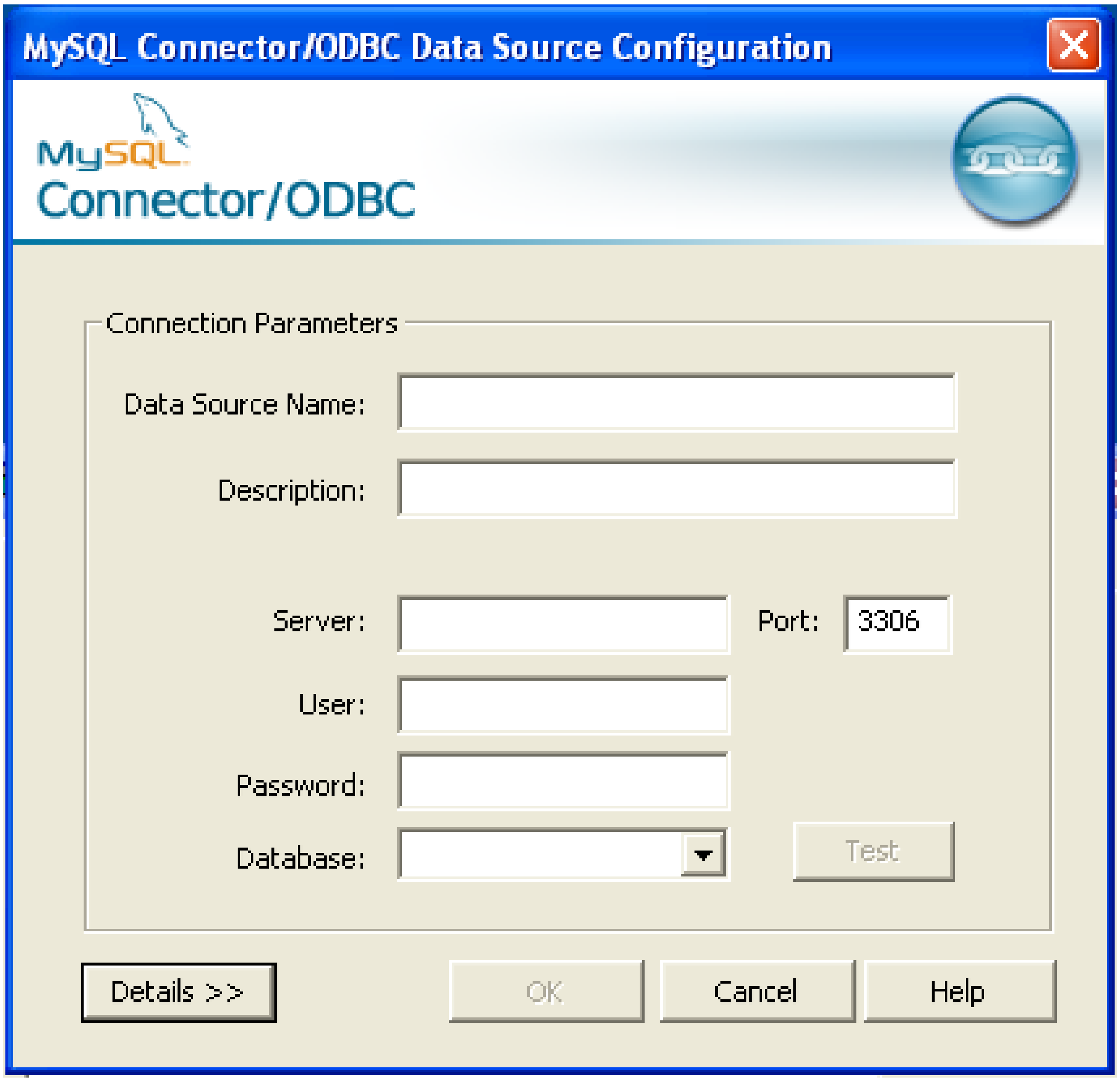


Select a driver for which you want to set up a data source.

Name	Version
Microsoft Paradox-Treiber (*.db)	4.00.6304.00
Microsoft Text Driver (*.txt; *.csv)	4.00.6304.00
Microsoft Text-Treiber (*.txt; *.csv)	4.00.6304.00
Microsoft Visual FoxPro Driver	1.00.02.00
Microsoft Visual FoxPro-Treiber	1.00.02.00
MySQL Connector/ODBC v5	5.00.11.00
MySQL ODBC 3.51 Driver	3.51.17.00
SQL Native Client	2005.90.304
SQL Server	2000.85.111

Select `MySQL ODBC 5.1 Driver`, then click FINISH.

4. You now need to configure the specific fields for the DSN you are creating through the `Connection Parameters` dialog.


MySQL Connector/ODBC Data Source Configuration
MySQL
Connector/ODBC
Connection Parameters
Data Source Name:
Description:
Server:
Port:
User:
Password:
Database:
Test
Details >>
OK
Cancel
Help

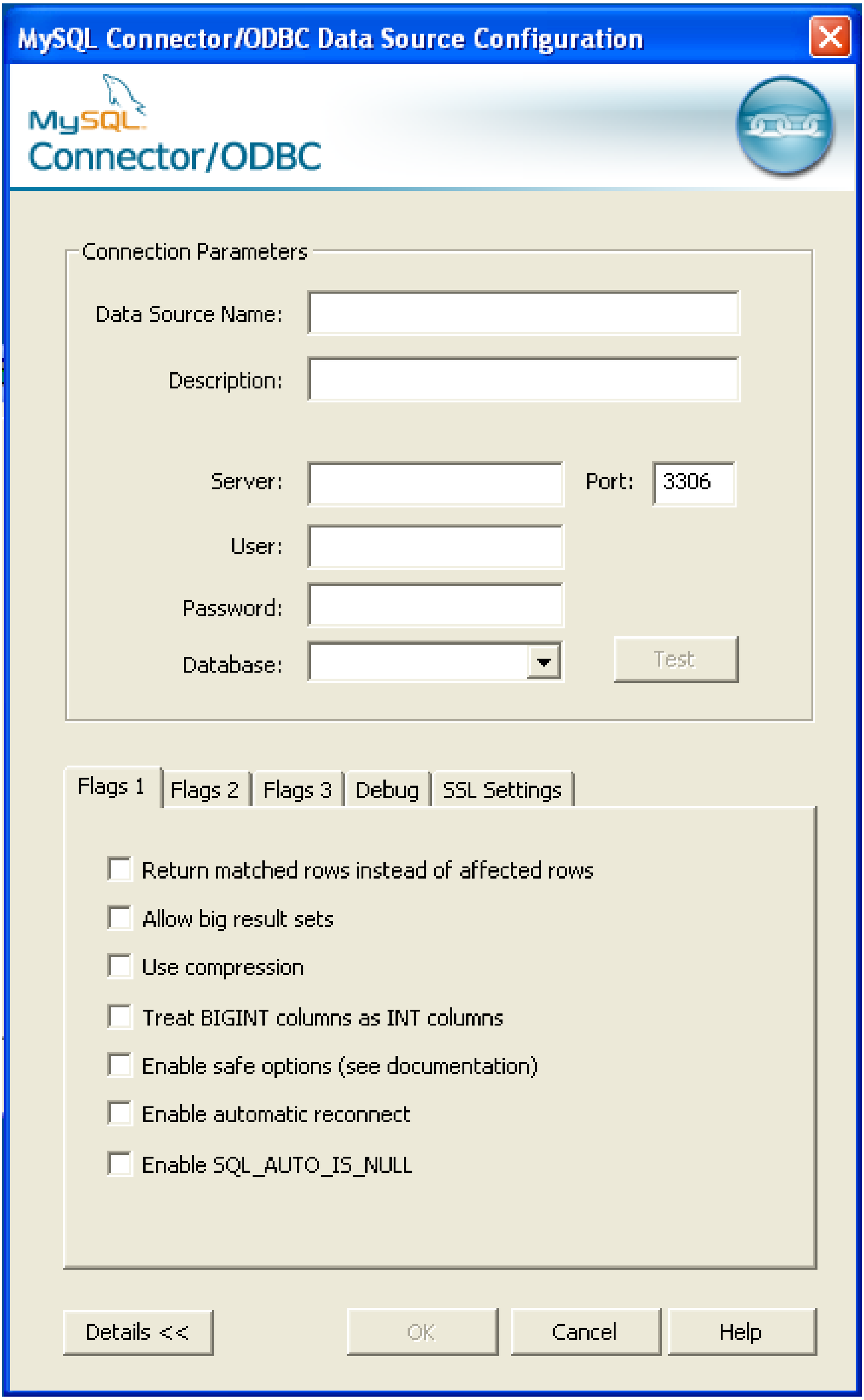
Port: 3306

In the **DATA SOURCE NAME** box, enter the name of the data source you want to access. It can be any valid name that you choose.

5. In the **DESCRIPTION** box, enter some text to help identify the connection.
6. In the **SERVER** field, enter the name of the MySQL server host that you want to access. By default, it is `localhost`.
7. In the **USER** field, enter the user name to use for this connection.
8. In the **PASSWORD** field, enter the corresponding password for this connection.
9. The **DATABASE** pop-up should automatically populate with the list of databases that the user has permissions to access.
10. To communicate over a different TCP/IP port than the default (3306), change the value of the **PORT**.
11. Click OK to save the DSN.

You can verify the connection using the parameters you have entered by clicking the TEST button. If the connection could be made successfully, you will be notified with a `Success; connection was made!` dialog.

You can configure a number of options for a specific DSN by using the DETAILS button.


MySQL Connector/ODBC Data Source Configuration
MySQL
Connector/ODBC
Test
Flags 1
Flags 2
Flags 3
Debug
SSL Settings
Details <<
OK
Cancel
Help

Connection Parameters

Data Source Name:

Description:

Server:

Port: 3306

User:

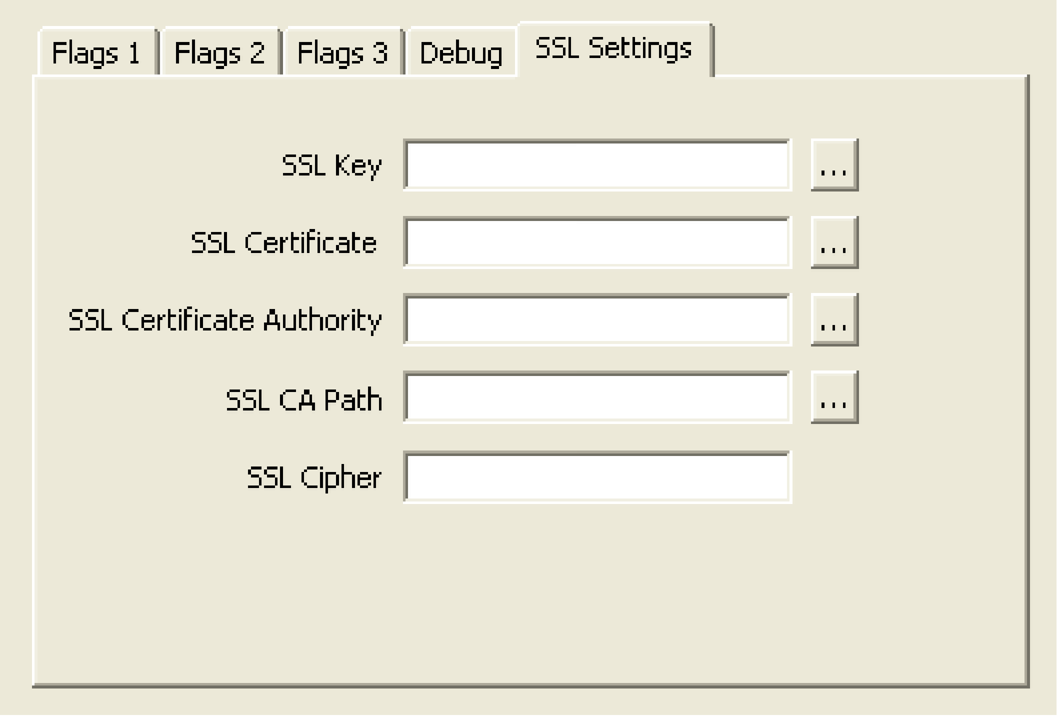
Password:

Database:

☐ Return matched rows instead of affected rows
☐ Allow big result sets
☐ Use compression
☐ Treat BIGINT columns as INT columns
☐ Enable safe options (see documentation)
☐ Enable automatic reconnect
☐ Enable SQL_AUTO_IS_NULL

The **DETAILS** button opens a tabbed display which enables you to set additional options:

- **FLAGS 1**, **FLAGS 2**, and **FLAGS 3** enable you to select the additional flags for the DSN connection. For more information on these flags, see Section 20.1.4.2, “Connector/ODBC Connection Parameters”.
- **DEBUG** enables you to enable ODBC debugging to record the queries you execute through the DSN to the `myodbc.sql` file. For more information, see Section 20.1.4.8, “Getting an ODBC Trace File”.
- **SSL SETTINGS** configures the additional options required for using the Secure Sockets Layer (SSL) when communicating with MySQL server. Note that you must have enabled SSL and configured the MySQL server with suitable certificates to communicate over SSL.



The ADVANCED tab enables you to configure Connector/ODBC connection parameters. Refer to Section 20.1.4.2, “Connector/ODBC Connection Parameters”, for information about the meaning of these options.

20.1.4.3.3. Errors and Debugging

This section answers Connector/ODBC connection-related questions.

- **While configuring a Connector/ODBC DSN, a `Could Not Load Translator or Setup Library` error occurs**

  For more information, refer to MS KnowledgeBase Article(Q260558). Also, make sure you have the latest valid `ctl3d32.dll` in your system directory.

- On Windows, the default `myodbc3.dll` is compiled for optimal performance. If you want to debug Connector/ODBC 3.51 (for example, to enable tracing), you should instead use `myodbc3d.dll`. To install this file, copy `myodbc3d.dll` over the installed `myodbc3.dll` file. Make sure to revert back to the release version of the driver DLL once you are done with the debugging because the debug version may cause performance issues. Note that the `myodbc3d.dll` isn't included in Connector/ODBC 3.51.07 through 3.51.11. If you are using one of these versions, you should copy that DLL from a previous version (for example, 3.51.06).

20.1.4.4. Configuring a Connector/ODBC DSN on Mac OS X

To configure a DSN on Mac OS X you can either use the `myodbc3i` utility, edit the `odbc.ini` file within the `Library/ODBC` directory of the user or the should use the ODBC Administrator. If you have Mac OS X 10.2 or earlier, refer to Section 20.1.4.5, “Configuring a Connector/ODBC DSN on Unix”. Select whether you want to create a User DSN or a System DSN. If you want to add a System DSN, you may need to authenticate with the system. You must click the padlock and enter a user and password with administrator privileges.

For correct operation of ODBC Administrator, you should ensure that the `/Library/ODBC/odbc.ini` file used to set up ODBC connectivity and DSNs are writable by the `admin` group. If this file is not writable by this group then the ODBC Administrator may fail, or may appear to have worked but not generated the correct entry.

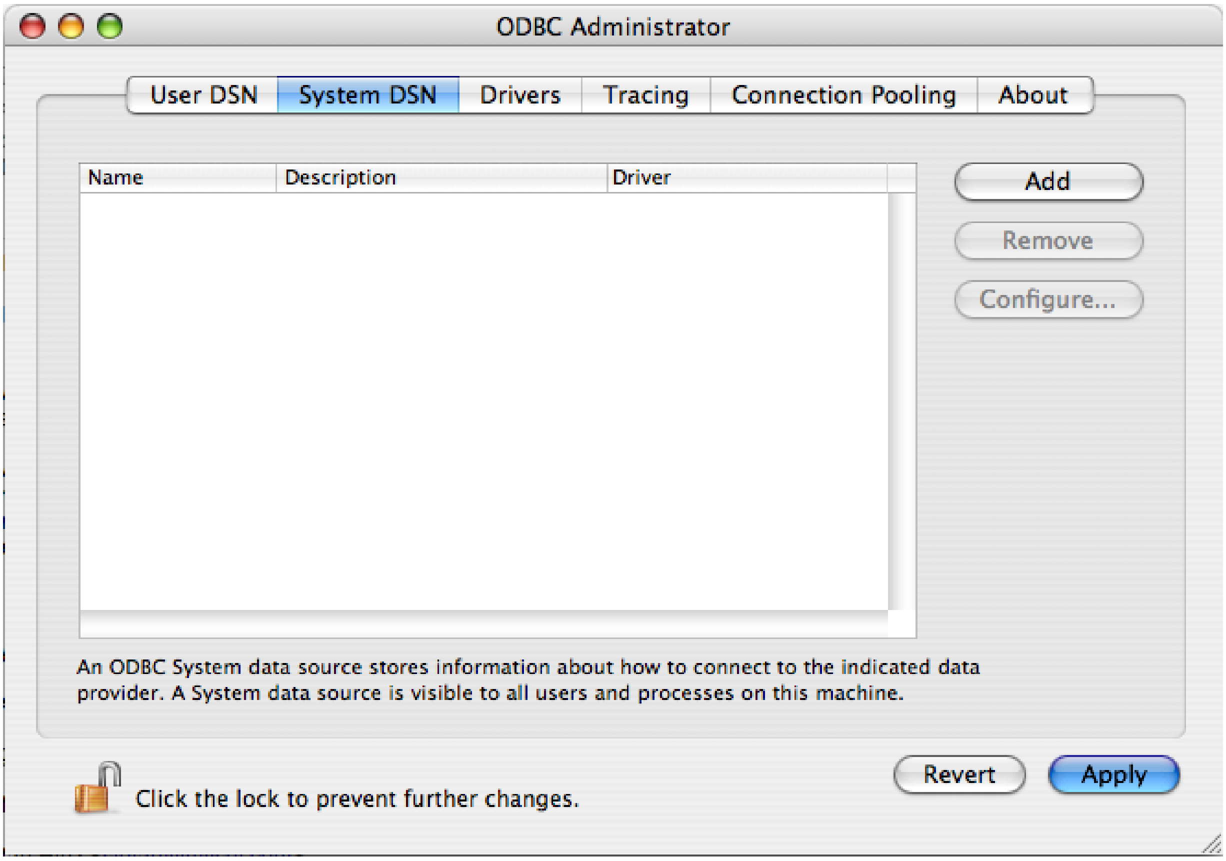
> **Warning**
>
> There are known issues with the OS X ODBC Administrator and Connector/ODBC that may prevent you from creating a DSN using this method. In this case you should use the command-line or edit the `odbc.ini` file directly. Note that existing DSNs or those that you create using the `myodbc3i` or `myodbc-installer` tool can still be checked and edited using ODBC Administrator.

To create a DSN using the `myodbc3i` utility, you need only specify the DSN type and the DSN connection string. For example:

```
shell> myodbc3i -a -s -t"DSN=mydb;DRIVER=MySQL ODBC 3.51 Driver;SERVER=mysql;USER=username;PASSWORD=pass"
```

To use ODBC Administrator:

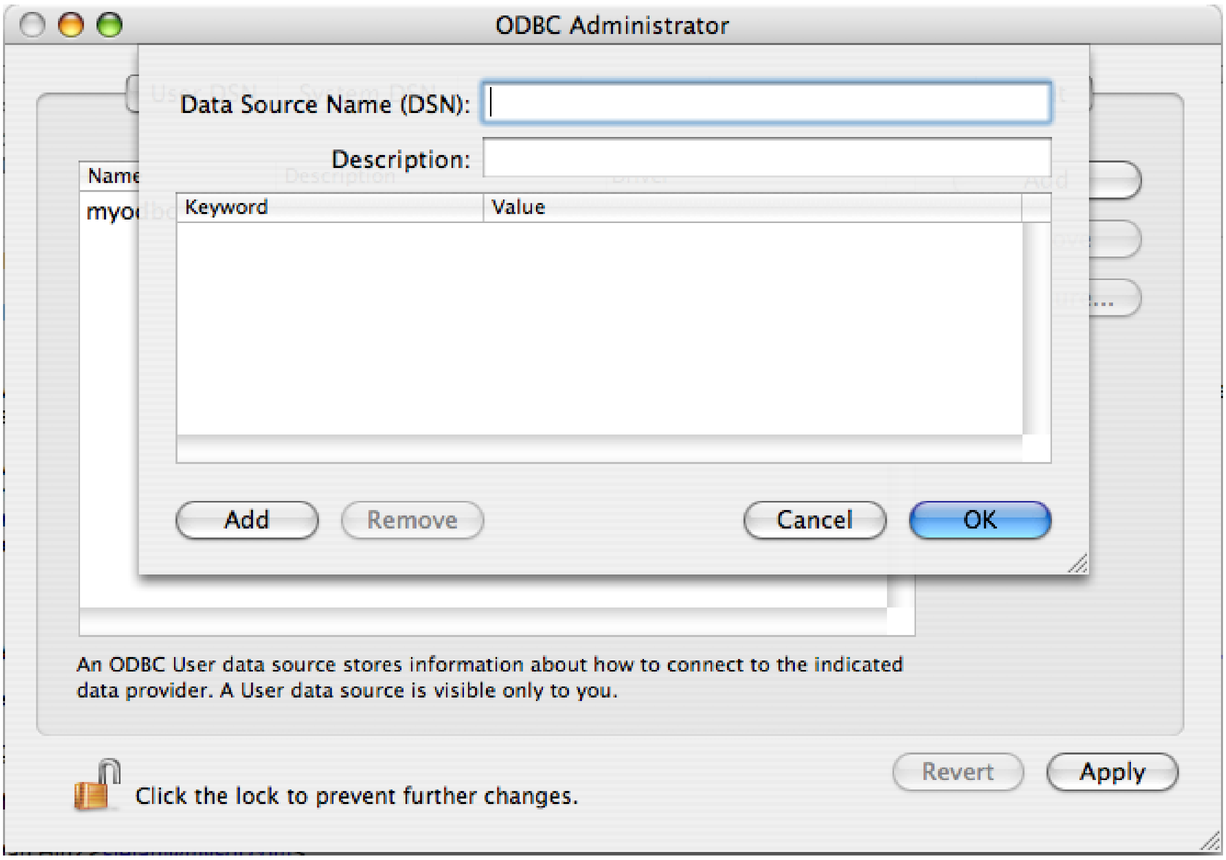
1. Open the ODBC Administrator from the `Utilities` folder in the `Applications` folder.



An ODBC System data source stores information about how to connect to the indicated data provider. A System data source is visible to all users and processes on this machine.

Click the lock to prevent further changes.

2. On the User DSN or System DSN panel, click ADD.
3. Select the Connector/ODBC driver and click OK.
4. You will be presented with the `Data Source Name` dialog. Enter The `Data Source Name` and an optional `Description` for the DSN.


ODBC Administrator
Data Source Name (DSN):
Description:
Keyword
Value
Name
myo
Add
Remove
Cancel
OK
Revert
Apply

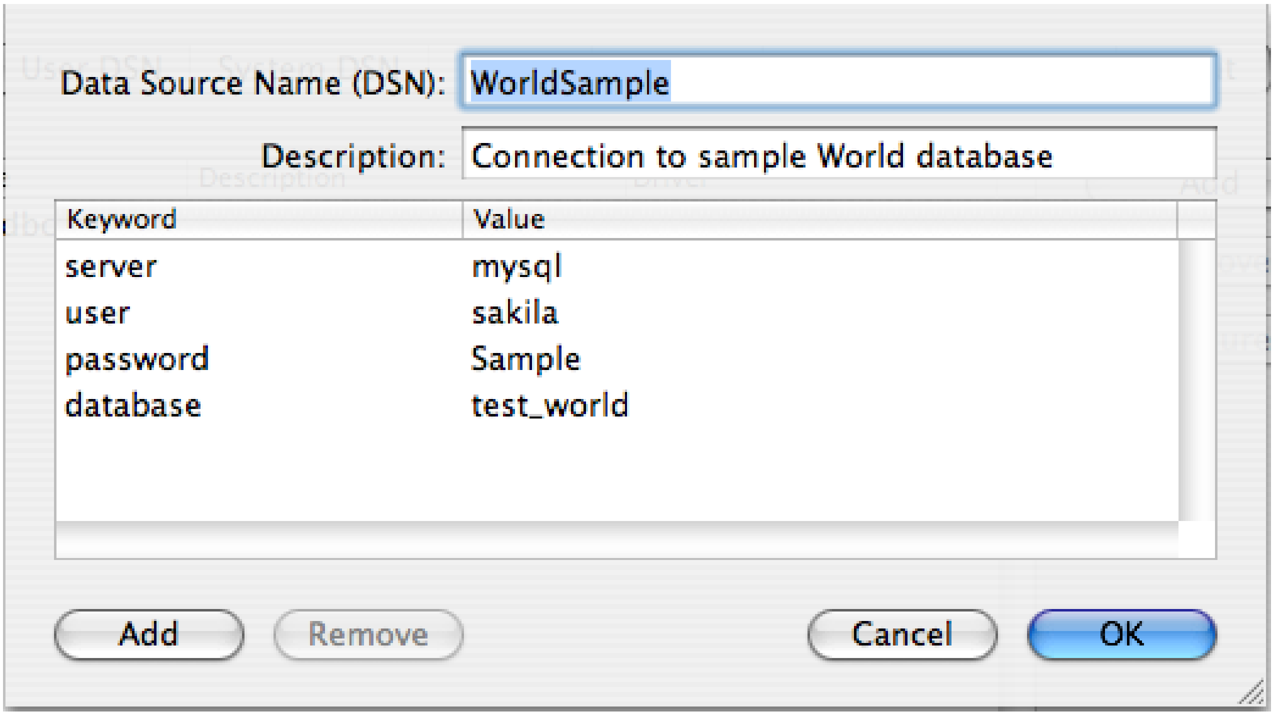
An ODBC User data source stores information about how to connect to the indicated data provider. A User data source is visible only to you.

Click the lock to prevent further changes.

5. Click Add to add a new keyword/value pair to the panel. You should configure at least four pairs to specify the `server`, `username`, `password` and `database` connection parameters. See Section 20.1.4.2, “Connector/ODBC Connection Parameters”.

6. Click OK to add the DSN to the list of configured data source names.

A completed DSN configuration may look like this:


Add
Remove
Cancel
OK

Data Source Name (DSN): WorldSample

Description: Connection to sample World database

Keyword	Value
server	mysql
user	sakila
password	Sample
database	test_world

You can configure other ODBC options in your DSN by adding further keyword/value pairs and setting the corresponding values. See Section 20.1.4.2, “Connector/ODBC Connection Parameters”.

20.1.4.5. Configuring a Connector/ODBC DSN on Unix

On `Unix`, you configure DSN entries directly in the `odbc.ini` file. Here is a typical `odbc.ini` file that configures `myodbc3` as the DSN name for Connector/ODBC 3.51:

```
;
;  odbc.ini configuration for Connector/ODBC and Connector/ODBC 3.51 drivers
;

[ODBC Data Sources]
myodbc3     = MyODBC 3.51 Driver DSN

[myodbc3]
Driver       = /usr/local/lib/libmyodbc3.so
Description  = Connector/ODBC 3.51 Driver DSN
SERVER       = localhost
PORT         =
USER         = root
Password     =
Database     = test
OPTION       = 3
SOCKET       =

[Default]
Driver       = /usr/local/lib/libmyodbc3.so
Description  = Connector/ODBC 3.51 Driver DSN
SERVER       = localhost
PORT         =
USER         = root
Password     =
Database     = test
OPTION       = 3
SOCKET       =
```

Refer to the Section 20.1.4.2, “Connector/ODBC Connection Parameters”, for the list of connection parameters that can be supplied.

> **Note**
>
> If you are using `unixODBC`, you can use the following tools to set up the DSN:

- ODBCConfig GUI tool(HOWTO: ODBCConfig)
- odbcinst

In some cases when using `unixODBC`, you might get this error:

```
Data source name not found and no default driver specified
```

If this happens, make sure the `ODBCINI` and `ODBCSYSINI` environment variables are pointing to the right `odbc.ini` file. For example, if your `odbc.ini` file is located in `/usr/local/etc`, set the environment variables like this:

```
export ODBCINI=/usr/local/etc/odbc.ini
export ODBCSYSINI=/usr/local/etc
```

20.1.4.6. Connecting Without a Predefined DSN

You can connect to the MySQL server using SQLDriverConnect, by specifying the `DRIVER` name field. Here are the connection strings for Connector/ODBC using DSN-Less connections:

For Connector/ODBC 3.51:

```
ConnectionString = "DRIVER={MySQL ODBC 3.51 Driver};\
                   SERVER=localhost;\
                   DATABASE=test;\
                   USER=venu;\
                   PASSWORD=venu;\
                   OPTION=3;"
```

If your programming language converts backslash followed by whitespace to a space, it is preferable to specify the connection string as a single long string, or to use a concatenation of multiple strings that does not add spaces in between. For example:

```
ConnectionString = "DRIVER={MySQL ODBC 3.51 Driver};"
```

```
                    "SERVER=localhost;"
                    "DATABASE=test;"
                    "USER=venu;"
                    "PASSWORD=venu;"
                    "OPTION=3;"
```

Note. Note that on Mac OS X you may need to specify the full path to the Connector/ODBC driver library.

Refer to the Section 20.1.4.2, “Connector/ODBC Connection Parameters”, for the list of connection parameters that can be supplied.

20.1.4.7. ODBC Connection Pooling

Connection pooling enables the ODBC driver to re-use existing connections to a given database from a pool of connections, instead of opening a new connection each time the database is accessed. By enabling connection pooling you can improve the overall performance of your application by lowering the time taken to open a connection to a database in the connection pool.

For more information about connection pooling: http://support.microsoft.com/default.aspx?scid=kb;EN-US;q169470.

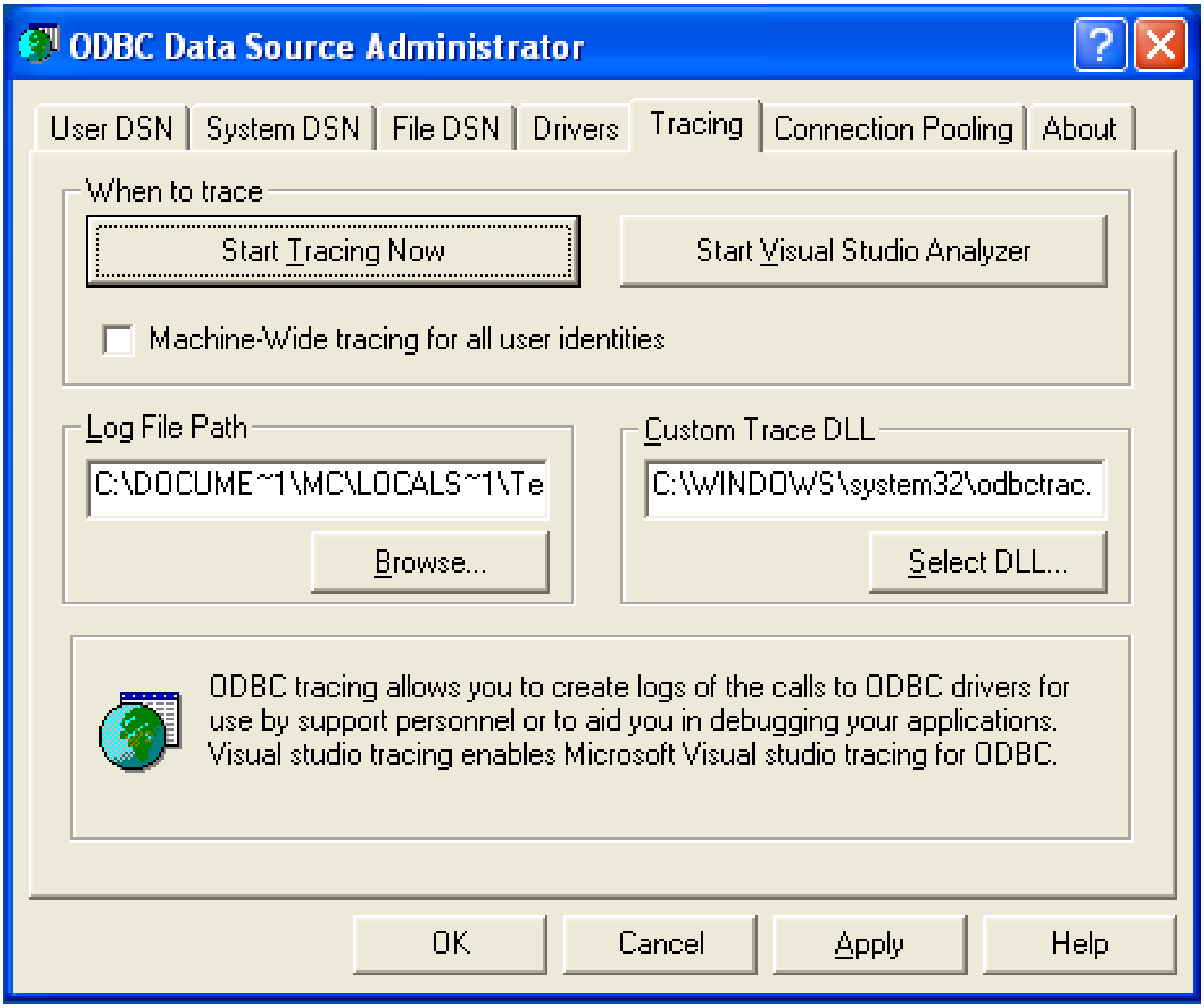
20.1.4.8. Getting an ODBC Trace File

If you encounter difficulties or problems with Connector/ODBC, you should start by making a log file from the `ODBC Manager` and Connector/ODBC. This is called *tracing*, and is enabled through the ODBC Manager. The procedure for this differs for Windows, Mac OS X and Unix.

20.1.4.8.1. Enabling ODBC Tracing on Windows

To enable the trace option on Windows:

1. The `Tracing` tab of the ODBC Data Source Administrator dialog box enables you to configure the way ODBC function calls are traced.


ODBC Data Source Administrator
User DSN
System DSN
File DSN
Drivers
Tracing
Connection Pooling
About
When to trace
Start Tracing Now
Start Visual Studio Analyzer
☐ Machine-Wide tracing for all user identities
Log File Path
C:\DOCUME~1\MC\LOCALS~1\Te
Browse...
Custom Trace DLL
C:\WINDOWS\system32\odbctrac.
Select DLL...
OK
Cancel
Apply
Help

ODBC tracing allows you to create logs of the calls to ODBC drivers for use by support personnel or to aid you in debugging your applications. Visual studio tracing enables Microsoft Visual studio tracing for ODBC.

2. When you activate tracing from the `Tracing` tab, the `Driver Manager` logs all ODBC function calls for all subsequently run applications.

3. ODBC function calls from applications running before tracing is activated are not logged. ODBC function calls are recorded in a log file you specify.

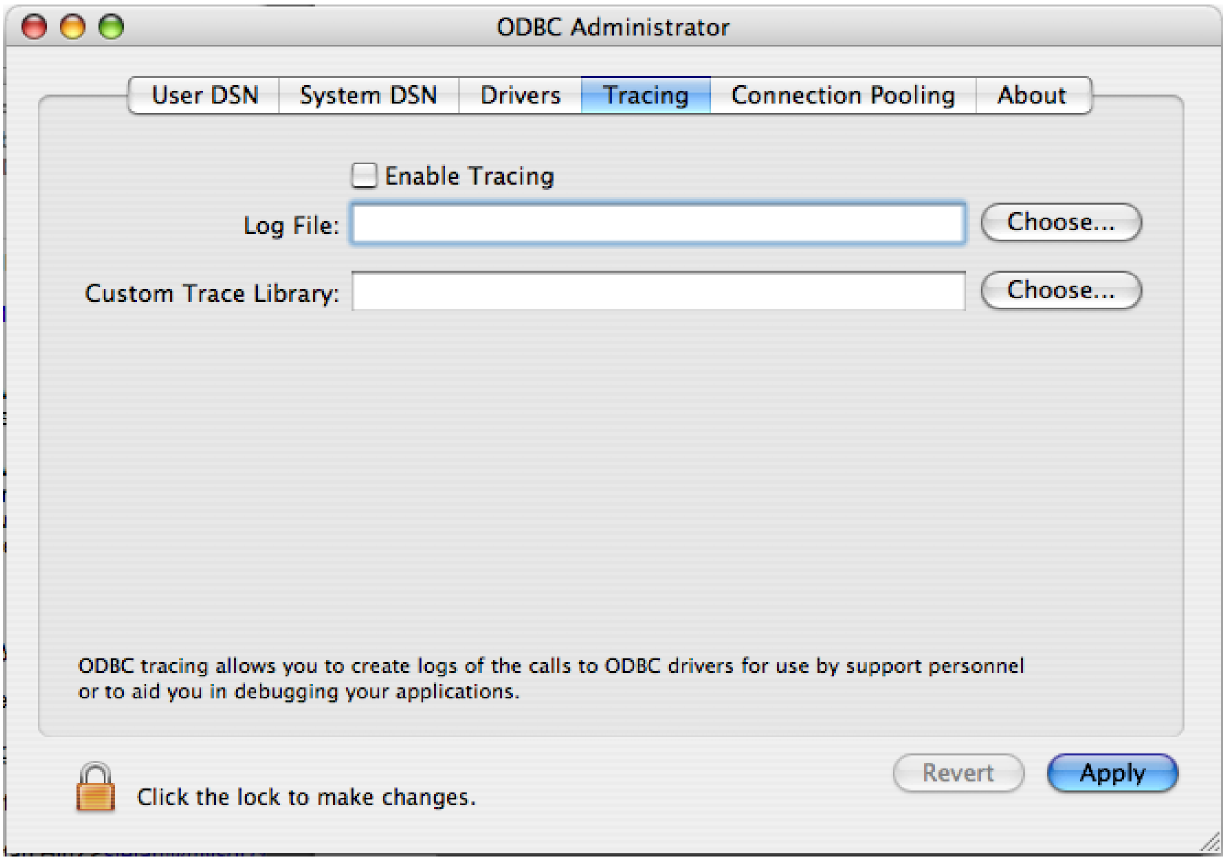
4. Tracing ceases only after you click `Stop Tracing Now`. Remember that while tracing is on, the log file continues to increase in size and that tracing affects the performance of all your ODBC applications.

20.1.4.8.2. Enabling ODBC Tracing on Mac OS X

To enable the trace option on Mac OS X 10.3 or later you should use the `Tracing` tab within ODBC Administrator .

1. Open the ODBC Administrator.

2. Select the `Tracing` tab.



ODBC tracing allows you to create logs of the calls to ODBC drivers for use by support personnel or to aid you in debugging your applications.

Click the lock to make changes.

3. Select the `Enable Tracing` check box.
4. Enter the location where you want to save the Tracing log. If you want to append information to an existing log file, click the CHOOSE... button.

20.1.4.8.3. Enabling ODBC Tracing on Unix

To enable the trace option on Mac OS X 10.2 (or earlier) or Unix you must add the `trace` option to the ODBC configuration:

1. On Unix, you need to explicitly set the `Trace` option in the `ODBC.INI` file.

   Set the tracing `ON` or `OFF` by using `TraceFile` and `Trace` parameters in `odbc.ini` as shown below:

   ```
   TraceFile  = /tmp/odbc.trace
   Trace      = 1
   ```

   `TraceFile` specifies the name and full path of the trace file and `Trace` is set to `ON` or `OFF`. You can also use `1` or `YES` for `ON` and `0` or `NO` for `OFF`. If you are using `ODBCConfig` from `unixODBC`, then follow the instructions for tracing `unixODBC` calls at HOWTO-ODBCConfig.

20.1.4.8.4. Enabling a Connector/ODBC Log

To generate a Connector/ODBC log, do the following:

1. Within Windows, enable the `Trace Connector/ODBC` option flag in the Connector/ODBC connect/configure screen. The log is written to file `C:\myodbc.log`. If the trace option is not remembered when you are going back to the above screen, it means that you are not using the `myodbcd.dll` driver, see Section 20.1.4.3.3, “Errors and Debugging”.

   On Mac OS X, Unix, or if you are using DSN-Less connection, then you need to supply `OPTION=4` in the connection string or set the corresponding keyword/value pair in the DSN.
2. Start your application and try to get it to fail. Then check the Connector/ODBC trace file to find out what could be wrong.

If you need help determining what is wrong, see Section 20.1.8.1, “Connector/ODBC Community Support”.

20.1.5. Connector/ODBC Examples

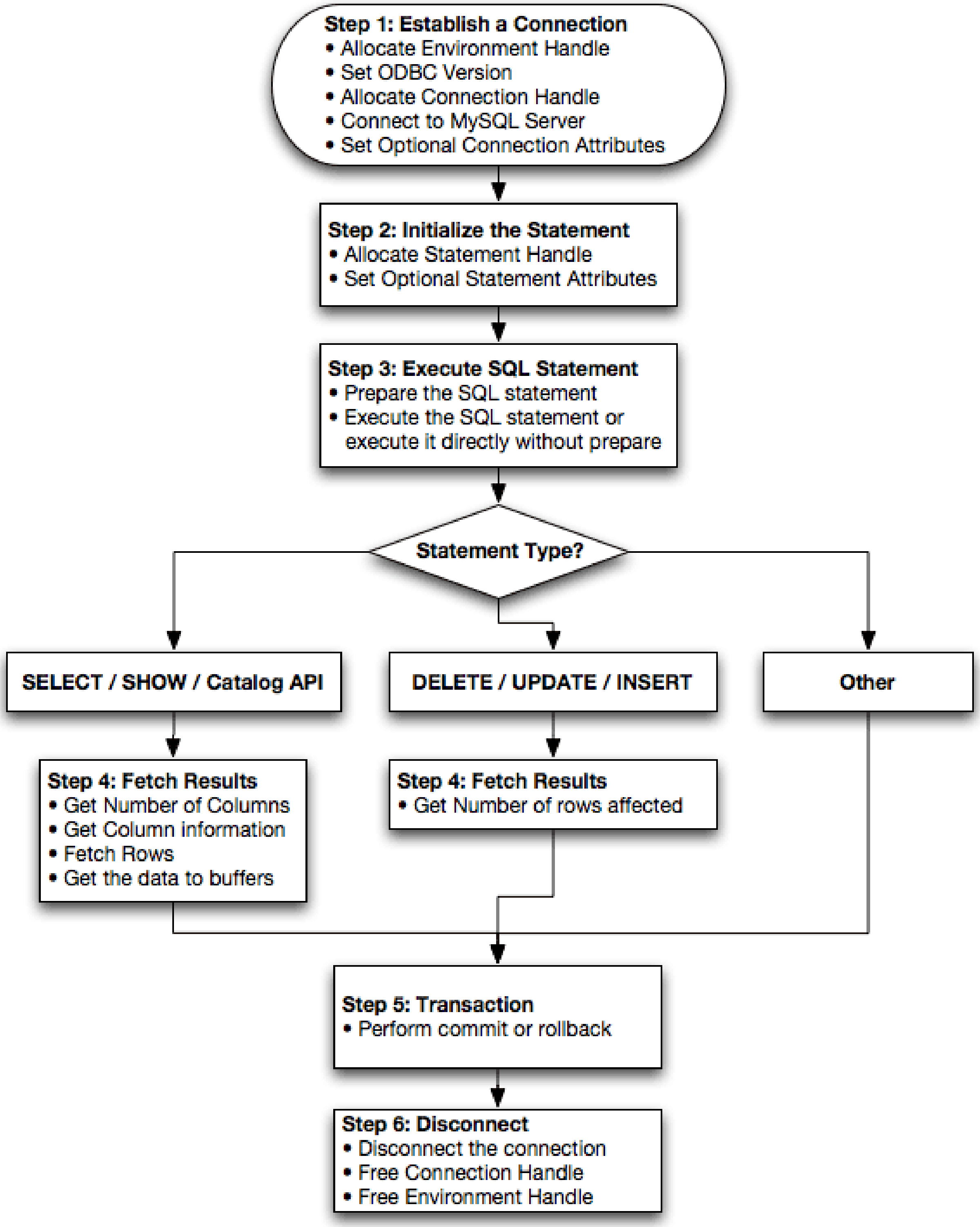
Once you have configured a DSN to provide access to a database, how you access and use that connection is dependent on the application or programming language. As ODBC is a standardized interface, any application or language that supports ODBC can use the DSN and connect to the configured database.

20.1.5.1. Basic Connector/ODBC Application Steps

Interacting with a MySQL server from an applications using the Connector/ODBC typically involves the following operations:

- Configure the Connector/ODBC DSN
- Connect to MySQL server
- Initialization operations
- Execute SQL statements
- Retrieve results
- Perform Transactions
- Disconnect from the server

Most applications use some variation of these steps. The basic application steps are shown in the following diagram:


Step 1: Establish a Connection
• Allocate Environment Handle
• Set ODBC Version
• Allocate Connection Handle
• Connect to MySQL Server
• Set Optional Connection Attributes
Step 2: Initialize the Statement
• Allocate Statement Handle
• Set Optional Statement Attributes
Step 3: Execute SQL Statement
• Prepare the SQL statement
• Execute the SQL statement or execute it directly without prepare
Statement Type?
SELECT / SHOW / Catalog API
DELETE / UPDATE / INSERT
Other
Step 4: Fetch Results
• Get Number of Columns
• Get Column information
• Fetch Rows
• Get the data to buffers
Step 4: Fetch Results
• Get Number of rows affected
Step 5: Transaction
• Perform commit or rollback
Step 6: Disconnect
• Disconnect the connection
• Free Connection Handle
• Free Environment Handle

20.1.5.2. Step-by-step Guide to Connecting to a MySQL Database through Connector/ODBC

A typical installation situation where you would install Connector/ODBC is when you want to access a database on a Linux or Unix host from a Windows machine.

As an example of the process required to set up access between two machines, the steps below take you through the basic steps. These instructions assume that you want to connect to system ALPHA from system BETA with a user name and password of `myuser` and `mypassword`.

On system ALPHA (the MySQL server) follow these steps:

1. Start the MySQL server.
2. Use `GRANT` to set up an account with a user name of `myuser` that can connect from system BETA using a password of `myuser` to the database `test`:

   ```
   GRANT ALL ON test.* to 'myuser'@'BETA' IDENTIFIED BY 'mypassword';
   ```

   For more information about MySQL privileges, refer to Section 5.5, “MySQL User Account Management”.

On system BETA (the Connector/ODBC client), follow these steps:

1. Configure a Connector/ODBC DSN using parameters that match the server, database and authentication information that you have just configured on system ALPHA.

Parameter	Value	Comment
DSN	remote_test	A name to identify the connection.
SERVER	ALPHA	The address of the remote server.
DATABASE	test	The name of the default database.
USER	myuser	The user name configured for access to this database.
PASSWORD	mypassword	The password for `myuser`.

2. Using an ODBC-capable application, such as Microsoft Office, connect to the MySQL server using the DSN you have just created. If the connection fails, use tracing to examine the connection process. See Section 20.1.4.8, “Getting an ODBC Trace File”, for more information.

20.1.5.3. Connector/ODBC and Third-Party ODBC Tools

Once you have configured your Connector/ODBC DSN, you can access your MySQL database through any application that supports the ODBC interface, including programming languages and third-party applications. This section contains guides and help on using Connector/ODBC with various ODBC-compatible tools and applications, including Microsoft Word, Microsoft Excel and Adobe/Macromedia ColdFusion.

Connector/ODBC has been tested with the following applications.

Publisher	Application	Notes
Adobe	ColdFusion	Formerly Macromedia ColdFusion
Borland	C++ Builder	
	Builder 4	
	Delphi	
Business Objects	Crystal Reports	
Claris	Filemaker Pro	
Corel	Paradox	
Computer Associates	Visual Objects	Also known as CAVO
	AllFusion ERwin Data Modeler	
Gupta	Team Developer	Previously known as Centura Team Developer; Gupta SQL/Windows
Gensym	G2-ODBC Bridge	
Inline	iHTML	
Lotus	Notes	Versions 4.5 and 4.6
Microsoft	Access	
	Excel	
	Visio Enterprise	
	Visual C++	
	Visual Basic	

Publisher	**Application**	**Notes**
	ODBC.NET	Using C#, Visual Basic, C++
	FoxPro	
	Visual Interdev	
OpenOffice.org	OpenOffice.org	
Perl	DBD::ODBC	
Pervasive Software	DataJunction	
Sambar Technologies	Sambar Server	
SPSS	SPSS	
SoftVelocity	Clarion	
SQLExpress	SQLExpress for Xbase++	
Sun	StarOffice	
SunSystems	Vision	
Sybase	PowerBuilder	
	PowerDesigner	
theKompany.com	Data Architect	

If you know of any other applications that work with Connector/ODBC, please send mail to `<myodbc@lists.mysql.com>` about them.

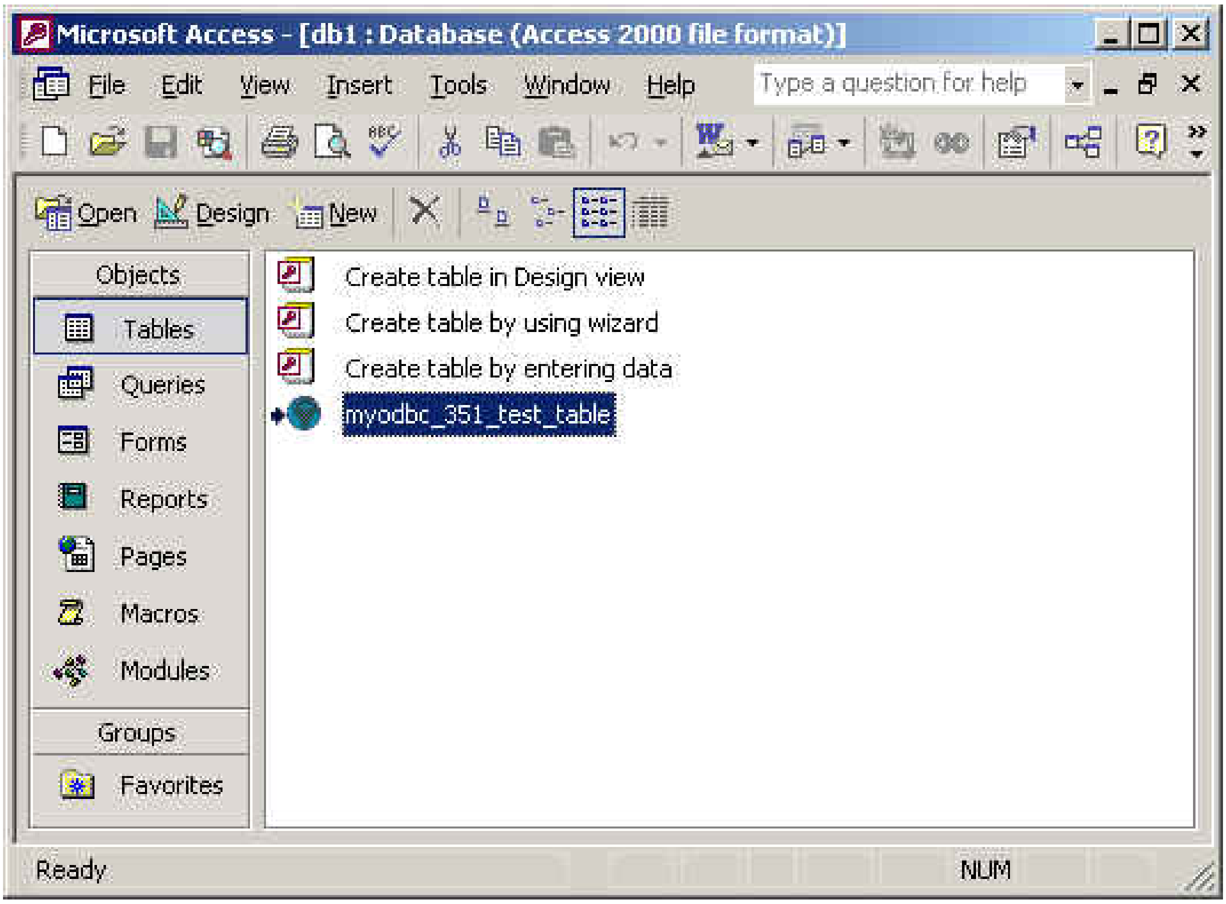
20.1.5.4. Using Connector/ODBC with Microsoft Access

You can use MySQL database with Microsoft Access using Connector/ODBC. The MySQL database can be used as an import source, an export source, or as a linked table for direct use within an Access application, so you can use Access as the front-end interface to a MySQL database.

20.1.5.4.1. Exporting Access Data to MySQL

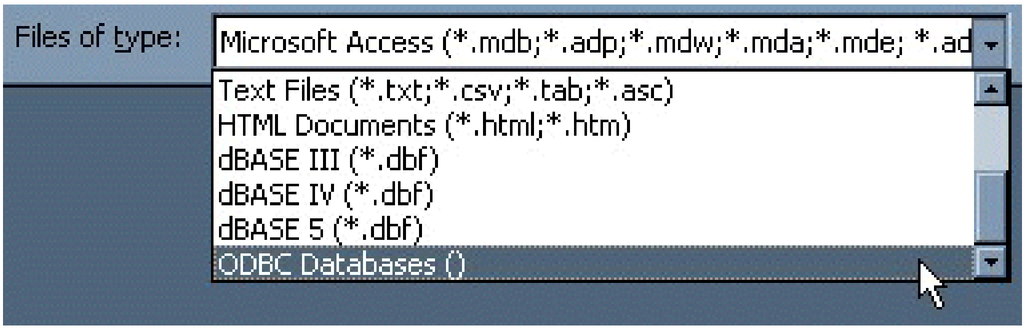
To export a table of data from an Access database to MySQL, follow these instructions:

1. When you open an Access database or an Access project, a Database window appears. It displays shortcuts for creating new database objects and opening existing objects.


Microsoft Access - [db1 : Database (Access 2000 file format)]
File
Edit
View
Insert
Tools
Window
Help
Type a question for help
Open
Design
New
Objects
Tables
Queries
Forms
Reports
Pages
Macros
Modules
Groups
Favorites
Create table in Design view
Create table by using wizard
Create table by entering data
myodbc_351_test_table
Ready
NUM

2. Click the name of the `table` or `query` you want to export, and then in the `File` menu, select `Export`.

3. In the `Export Object Type` *`Object name`* `To` dialog box, in the `Save As Type` box, select `ODBC Databases ()` as shown here:


Files of type:
Microsoft Access (*.mdb;*.adp;*.mdw;*.mda;*.mde; *.ad
Text Files (*.txt;*.csv;*.tab;*.asc)
HTML Documents (*.html;*.htm)
dBASE III (*.dbf)
dBASE IV (*.dbf)
dBASE 5 (*.dbf)
ODBC Databases ()

4. In the `Export` dialog box, enter a name for the file (or use the suggested name), and then select `OK`.

5. The Select Data Source dialog box is displayed; it lists the defined data sources for any ODBC drivers installed on your computer. Click either the File Data Source or Machine Data Source tab, and then double-click the Connector/ODBC or Connector/ODBC 3.51 data source that you want to export to. To define a new data source for Connector/ODBC, please Section 20.1.4.3, “Configuring a Connector/ODBC DSN on Windows”.

> **Note**
>
> Ensure that the information that you are exporting to the MySQL table is valid for the corresponding MySQL data types. Values that are outside of the supported range of the MySQL data type but valid within Access may trigger an “overflow” error during the export.

Microsoft Access connects to the MySQL Server through this data source and exports new tables and or data.

20.1.5.4.2. Importing MySQL Data to Access

To import a table or tables from MySQL to Access, follow these instructions:

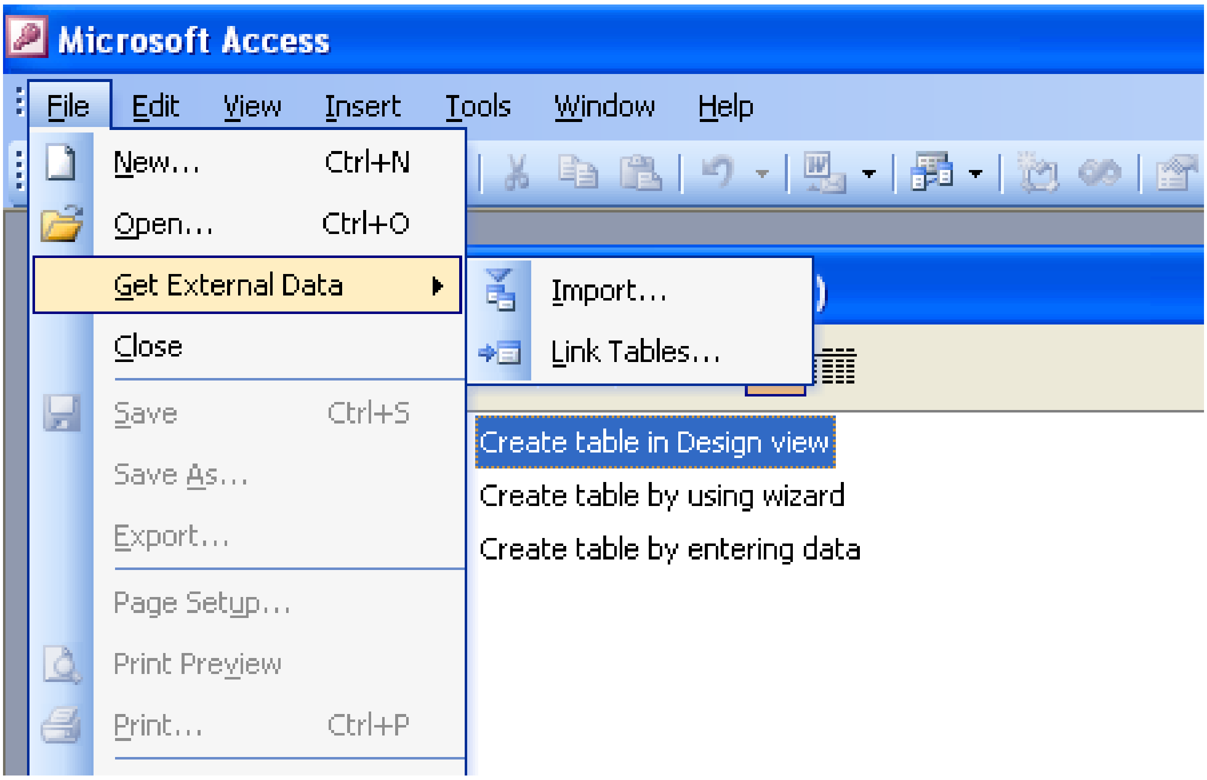
1. Open a database, or switch to the Database window for the open database.
2. To import tables, on the `File` menu, point to `Get External Data`, and then click `Import`.
3. In the `Import` dialog box, in the Files Of Type box, select **ODBC DATABASES ()**. The Select Data Source dialog box lists the defined data sources **THE SELECT DATA SOURCE** dialog box is displayed; it lists the defined data source names.
4. If the ODBC data source that you selected requires you to log on, enter your login ID and password (additional information might also be required), and then click `OK`.
5. Microsoft Access connects to the MySQL server through `ODBC data source` and displays the list of tables that you can `import`.
6. Click each table that you want to `import`, and then click `OK`.

20.1.5.4.3. Using Microsoft Access as a Front-end to MySQL

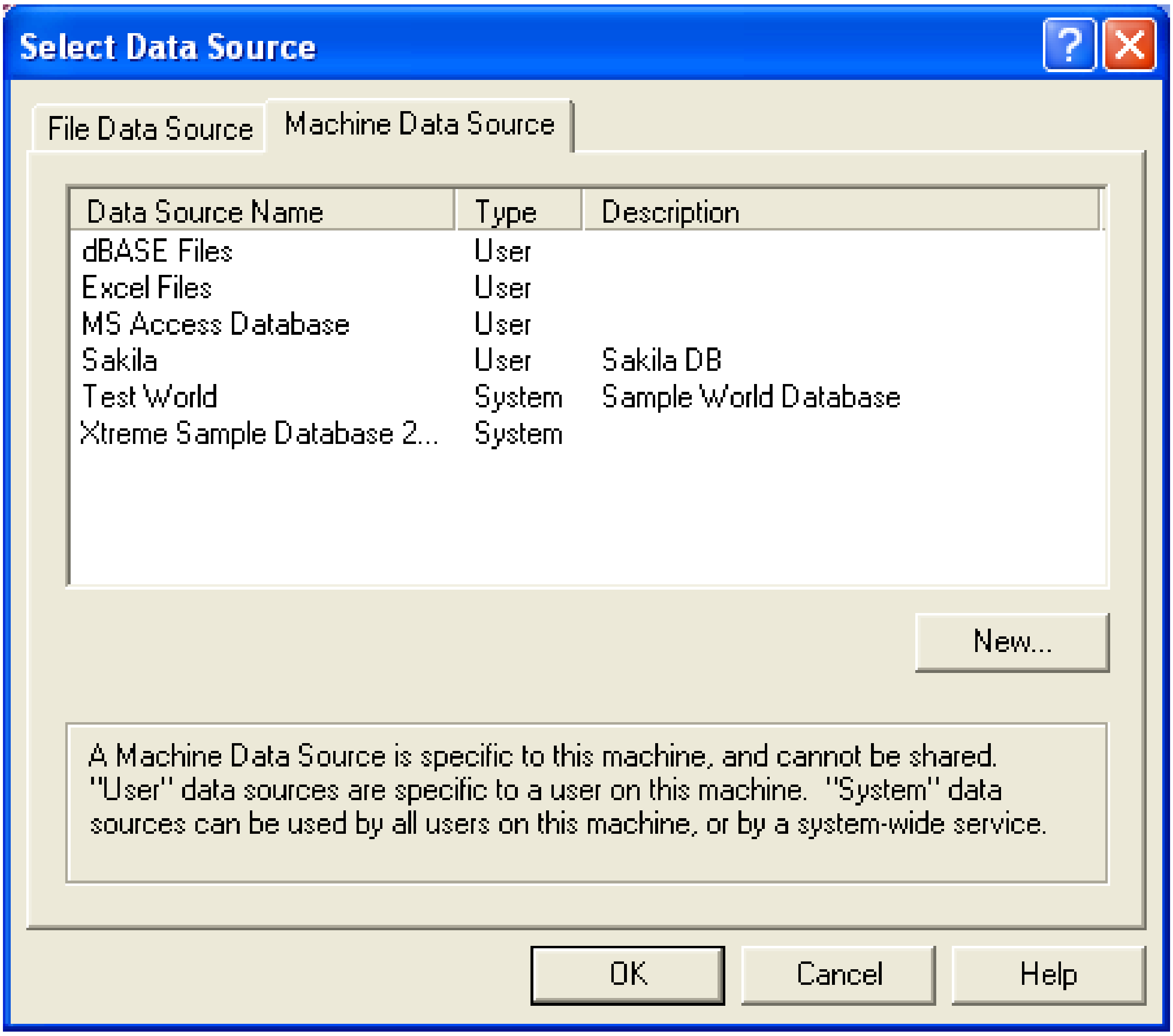
You can use Microsoft Access as a front end to a MySQL database by linking tables within your Microsoft Access database to tables that exist within your MySQL database. When a query is requested on a table within Access, ODBC is used to execute the queries on the MySQL database instead.

To create a linked table:

1. Open the Access database that you want to link to MySQL.
2. From the FILE, choose GET EXTERNAL DATA->LINK TABLES.


Microsoft Access
File
Edit
View
Insert
Tools
Window
Help
New... Ctrl+N
Open... Ctrl+O
Get External Data
Close
Save Ctrl+S
Save As...
Export...
Page Setup...
Print Preview
Print... Ctrl+P
Import...
Link Tables...
Create table in Design view
Create table by using wizard
Create table by entering data

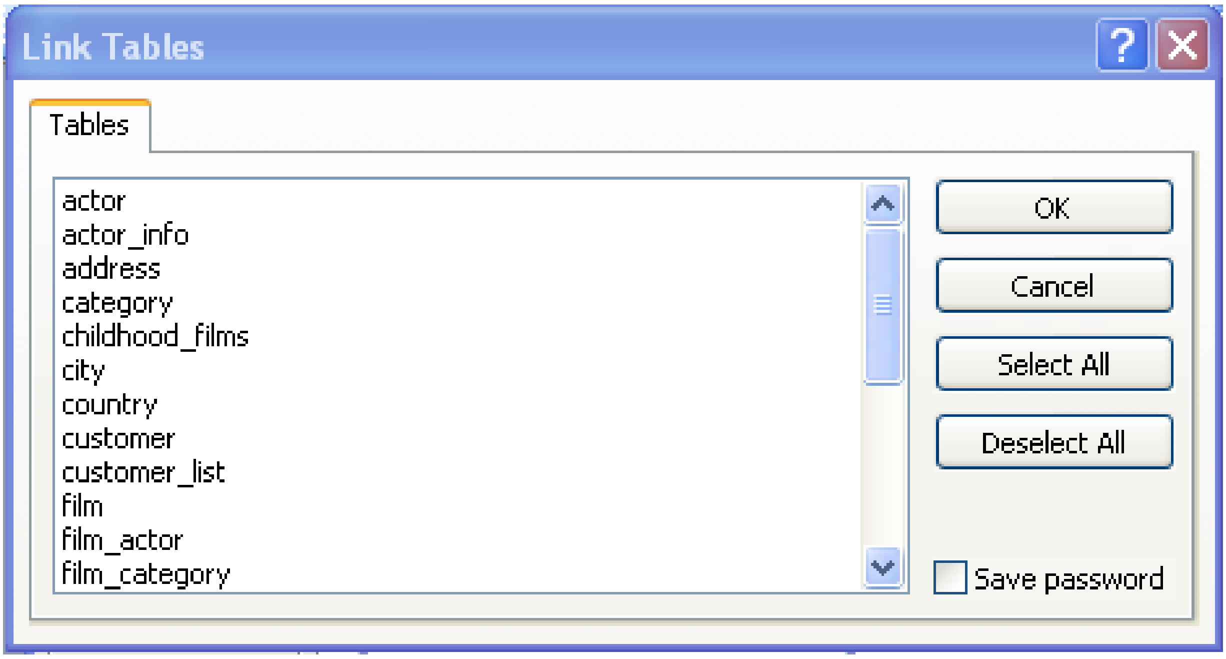
3. From the browser, choose **ODBC DATABASES ()** from the **FILES OF TYPE** pop-up.
4. In the **SELECT DATA SOURCE** window, choose an existing DSN, either from a **FILE DATA SOURCE** or **MACHINE DATA SOURCE**.You can also create a new DSN using the NEW... button. For more information on creating a DSN see Section 20.1.4.3, “Configuring a Connector/ODBC DSN on Windows”.


Select Data Source
?
File Data Source
Machine Data Source
New...
OK
Cancel
Help

Data Source Name	Type	Description
dBASE Files	User	
Excel Files	User	
MS Access Database	User	
Sakila	User	Sakila DB
Test World	System	Sample World Database
Xtreme Sample Database 2...	System	

A Machine Data Source is specific to this machine, and cannot be shared. "User" data sources are specific to a user on this machine. "System" data sources can be used by all users on this machine, or by a system-wide service.

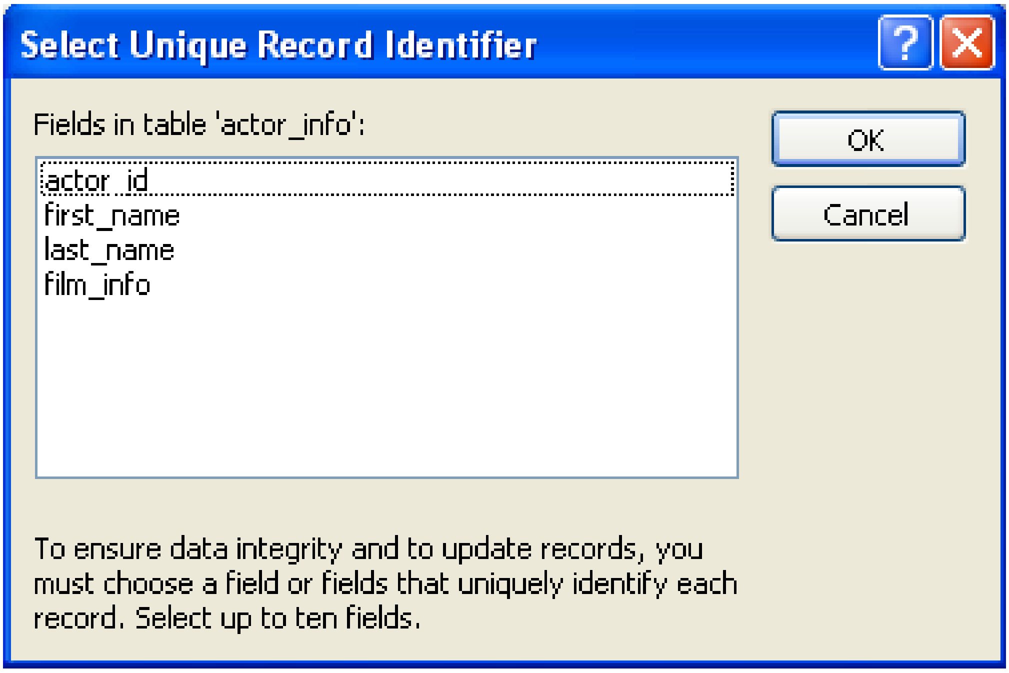
5. In the **Link Tables** dialog, select one or more tables from the MySQL database. A link will be created to each table that you select from this list.


Link Tables
?
Tables
OK
Cancel
Select All
Deselect All

actor
actor_info
address
category
childhood_films
city
country
customer
customer_list
film
film_actor
film_category

☐ Save password

6. If Microsoft Access is unable to determine the unique record identifier for a table automatically then it may ask you to confirm the column, or combination of columns, to be used to uniquely identify each row from the source table. Select the columns you want to use and click OK.


Select Unique Record Identifier
Fields in table 'actor_info':
actor_id
first_name
last_name
film_info
OK
Cancel

To ensure data integrity and to update records, you must choose a field or fields that uniquely identify each record. Select up to ten fields.

Once the process has been completed, you can now build interfaces and queries to the linked tables just as you would for any Access database.

Use the following procedure to view or to refresh links when the structure or location of a linked table has changed. The Linked Table Manager lists the paths to all currently linked tables.

To view or refresh links:

1. Open the database that contains links to MySQL tables.
2. On the `Tools` menu, point to `Add-ins` (`Database Utilities` in Access 2000 or newer), and then click `Linked Table Manager`.
3. Select the check box for the tables whose links you want to refresh.
4. Click OK to refresh the links.

Microsoft Access confirms a successful refresh or, if the table wasn't found, displays the `Select New Location of` <table name> dialog box in which you can specify its the table's new location. If several selected tables have moved to the new location that you specify, the Linked Table Manager searches that location for all selected tables, and updates all links in one step.

To change the path for a set of linked tables:

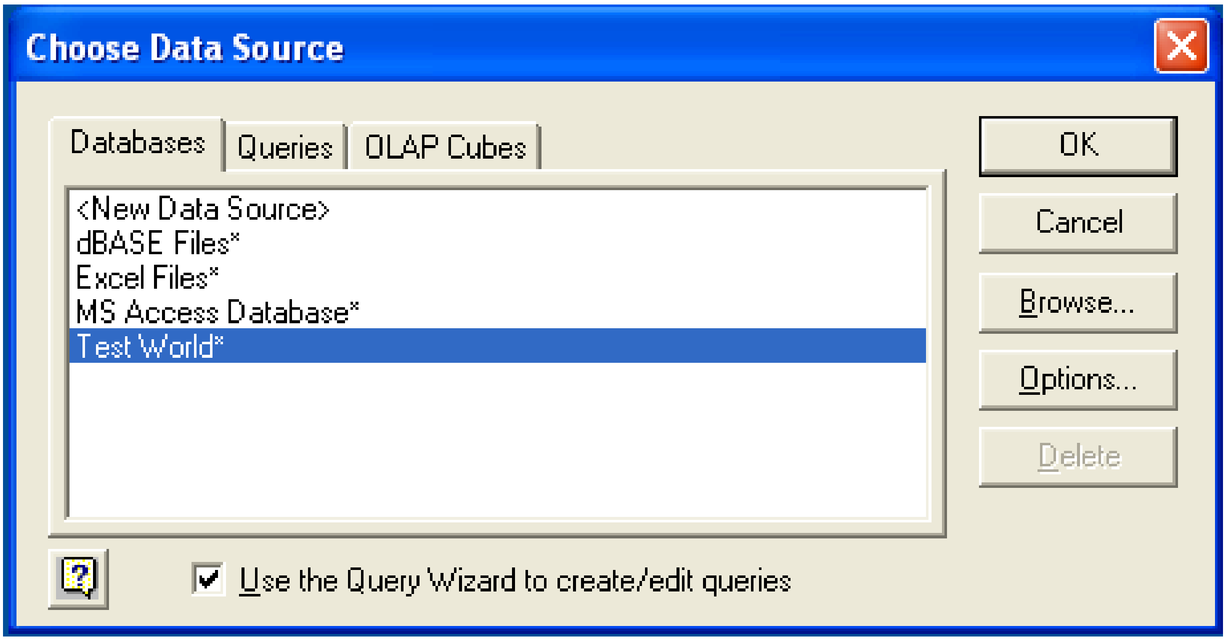
1. Open the database that contains links to tables.
2. On the `Tools` menu, point to `Add-ins` (`Database Utilities` in Access 2000 or newer), and then click `Linked Table Manager`.
3. Select the `Always Prompt For A New Location` check box.
4. Select the check box for the tables whose links you want to change, and then click `OK`.
5. In the `Select New Location of` <table name> dialog box, specify the new location, click `Open`, and then click `OK`.

20.1.5.5. Using Connector/ODBC with Microsoft Word or Excel

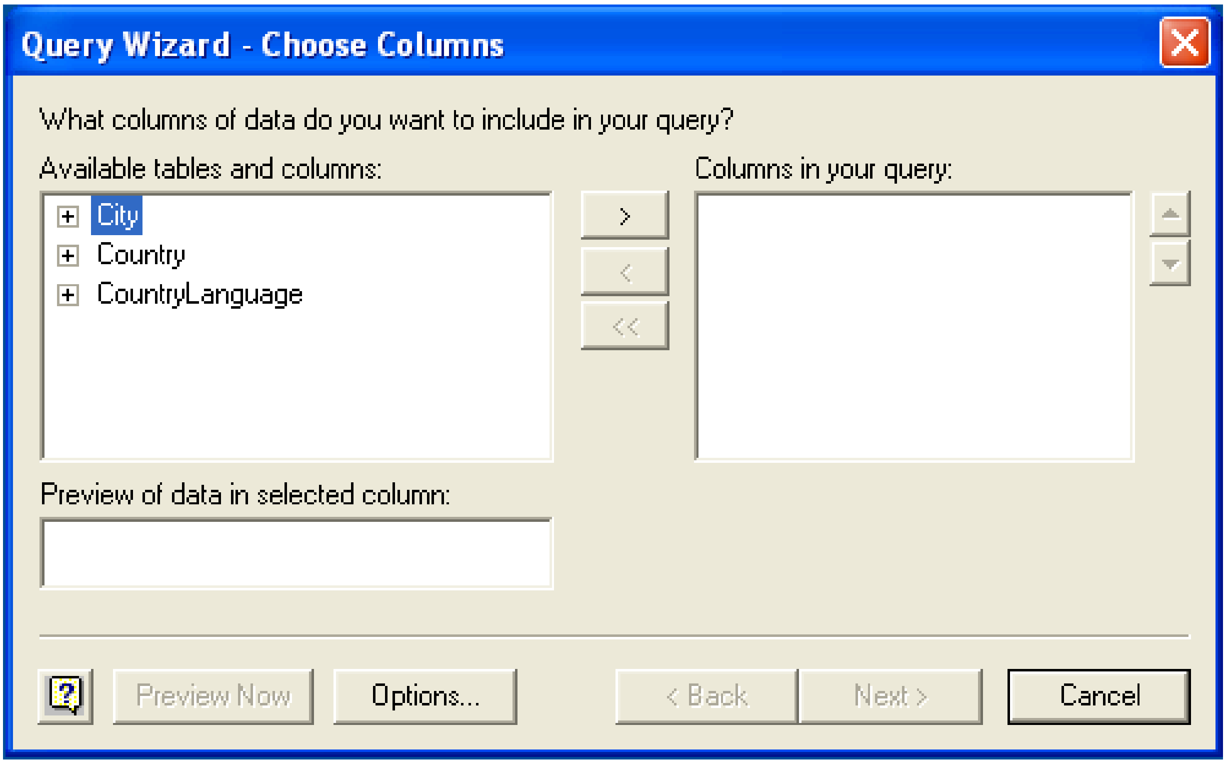
You can use Microsoft Word and Microsoft Excel to access information from a MySQL database using Connector/ODBC. Within Microsoft Word, this facility is most useful when importing data for mailmerge, or for tables and data to be included in reports. Within Microsoft Excel, you can execute queries on your MySQL server and import the data directly into an Excel Worksheet, presenting the data as a series of rows and columns.

With both applications, data is accessed and imported into the application using Microsoft Query , which enables you to execute a query though an ODBC source. You use Microsoft Query to build the SQL statement to be executed, selecting the tables, fields, selection criteria and sort order. For example, to insert information from a table in the World test database into an Excel spreadsheet, using the DSN samples shown in Section 20.1.4, “Connector/ODBC Configuration”:

1. Create a new Worksheet.
2. From the `Data` menu, choose `Import External Data`, and then select `New Database Query`.
3. Microsoft Query will start. First, you need to choose the data source, by selecting an existing Data Source Name.

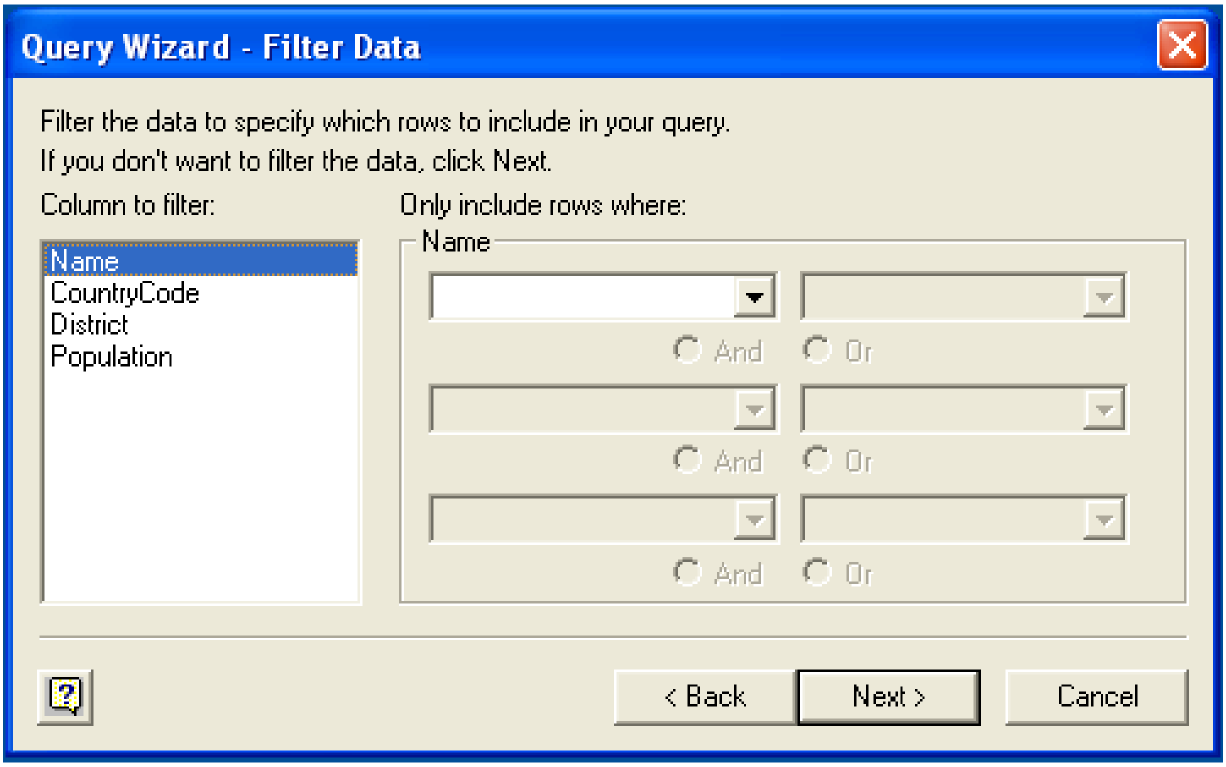

Choose Data Source
Databases
Queries
OLAP Cubes
<New Data Source>
dBASE Files*
Excel Files*
MS Access Database*
Test World*
OK
Cancel
Browse...
Options...
Delete
☑ Use the Query Wizard to create/edit queries

4. Within the `Query Wizard`, you must choose the columns that you want to import. The list of tables available to the user configured through the DSN is shown on the left, the columns that will be added to your query are shown on the right. The columns you choose are equivalent to those in the first section of a `SELECT` query. Click NEXT to continue.


Query Wizard - Choose Columns
Available tables and columns:
City
Country
CountryLanguage
>
<
<<
Columns in your query:
Preview of data in selected column:
Preview Now
Options...
< Back
Next >
Cancel

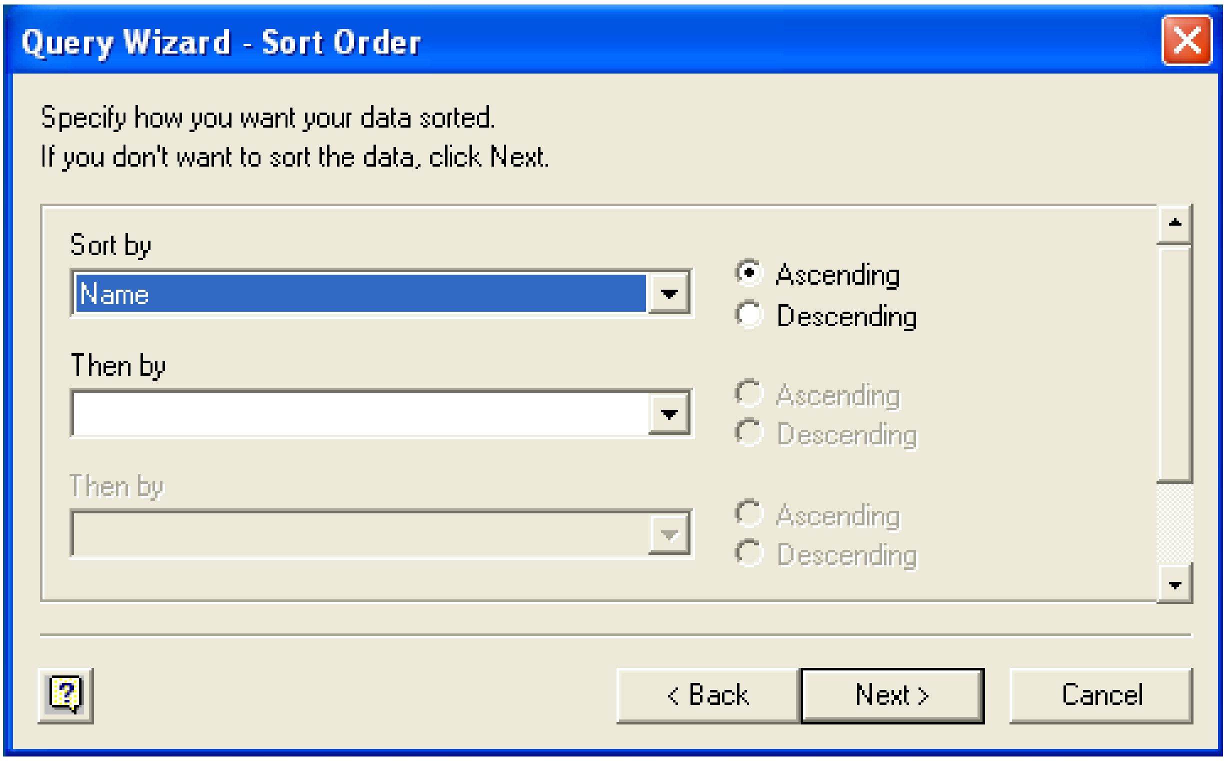
What columns of data do you want to include in your query?

5. You can filter rows from the query (the equivalent of a `WHERE` clause) using the `Filter Data` dialog. Click NEXT to continue.

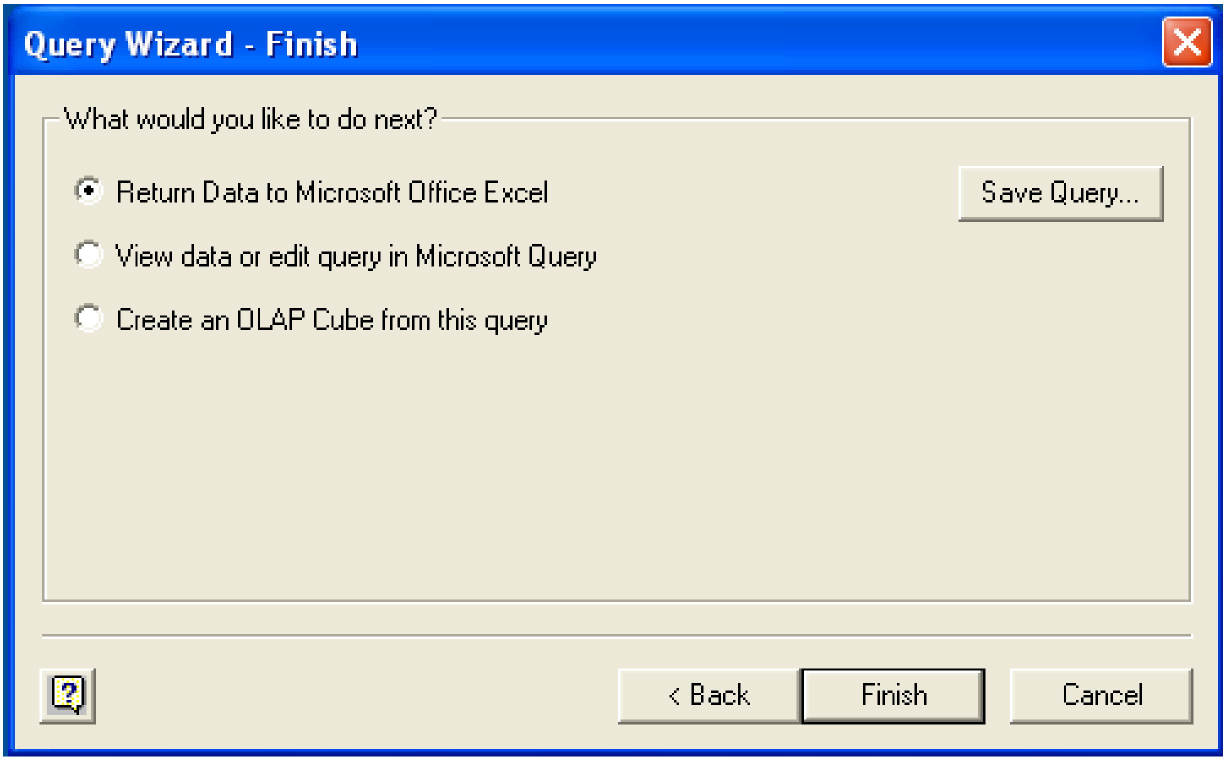

Query Wizard - Filter Data
Column to filter:
Name
CountryCode
District
Population
Only include rows where:
Name
○ And ○ Or
○ And ○ Or
○ And ○ Or
< Back
Next >
Cancel

Filter the data to specify which rows to include in your query.
If you don't want to filter the data, click Next.

6. Select an (optional) sort order for the data. This is equivalent to using a `ORDER BY` clause in your SQL query. You can select up to three fields for sorting the information returned by the query. Click NEXT to continue.


Query Wizard - Sort Order
Specify how you want your data sorted.
If you don't want to sort the data, click Next.
Sort by
Name
● Ascending
○ Descending
Then by
○ Ascending
○ Descending
Then by
○ Ascending
○ Descending
< Back
Next >
Cancel

7. Select the destination for your query. You can select to return the data Microsoft Excel, where you can choose a worksheet and cell where the data will be inserted; you can continue to view the query and results within Microsoft Query, where you can edit the SQL query and further filter and sort the information returned; or you can create an OLAP Cube from the query, which can then be used directly within Microsoft Excel. Click FINISH.


Query Wizard - Finish
What would you like to do next?
● Return Data to Microsoft Office Excel
○ View data or edit query in Microsoft Query
○ Create an OLAP Cube from this query
Save Query...
< Back
Finish
Cancel

The same process can be used to import data into a Word document, where the data will be inserted as a table. This can be used for mail merge purposes (where the field data is read from a Word table), or where you want to include data and reports within a report or other document.

20.1.5.6. Using Connector/ODBC with Crystal Reports

Crystal Reports can use an ODBC DSN to connect to a database from which you to extract data and information for reporting purposes.

> **Note**
>
> There is a known issue with certain versions of Crystal Reports where the application is unable to open and browse tables and fields through an ODBC connection. Before using Crystal Reports with MySQL, please ensure that you have update to the latest version, including any outstanding service packs and hotfixes. For more information on this issue, see the Business) Objects Knowledgebase for more information.

For example, to create a simple crosstab report within Crystal Reports XI, you should follow these steps:

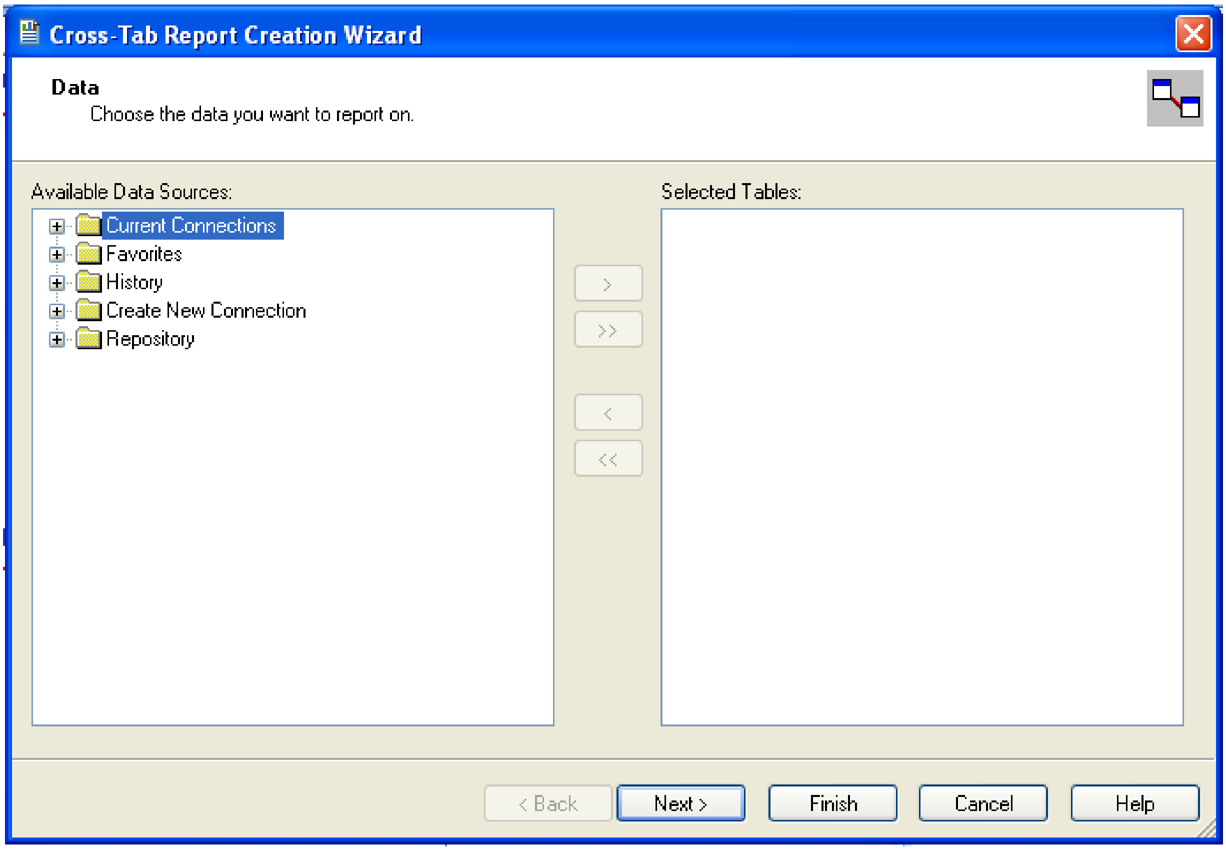
1. Create a DSN using the `Data Sources (ODBC)` tool. You can either specify a complete database, including user name and password, or you can build a basic DSN and use Crystal Reports to set the user name and password.

   For the purposes of this example, a DSN that provides a connection to an instance of the MySQL Sakila sample database has been created.

2. Open Crystal Reports and create a new project, or an open an existing reporting project into which you want to insert data from your MySQL data source.

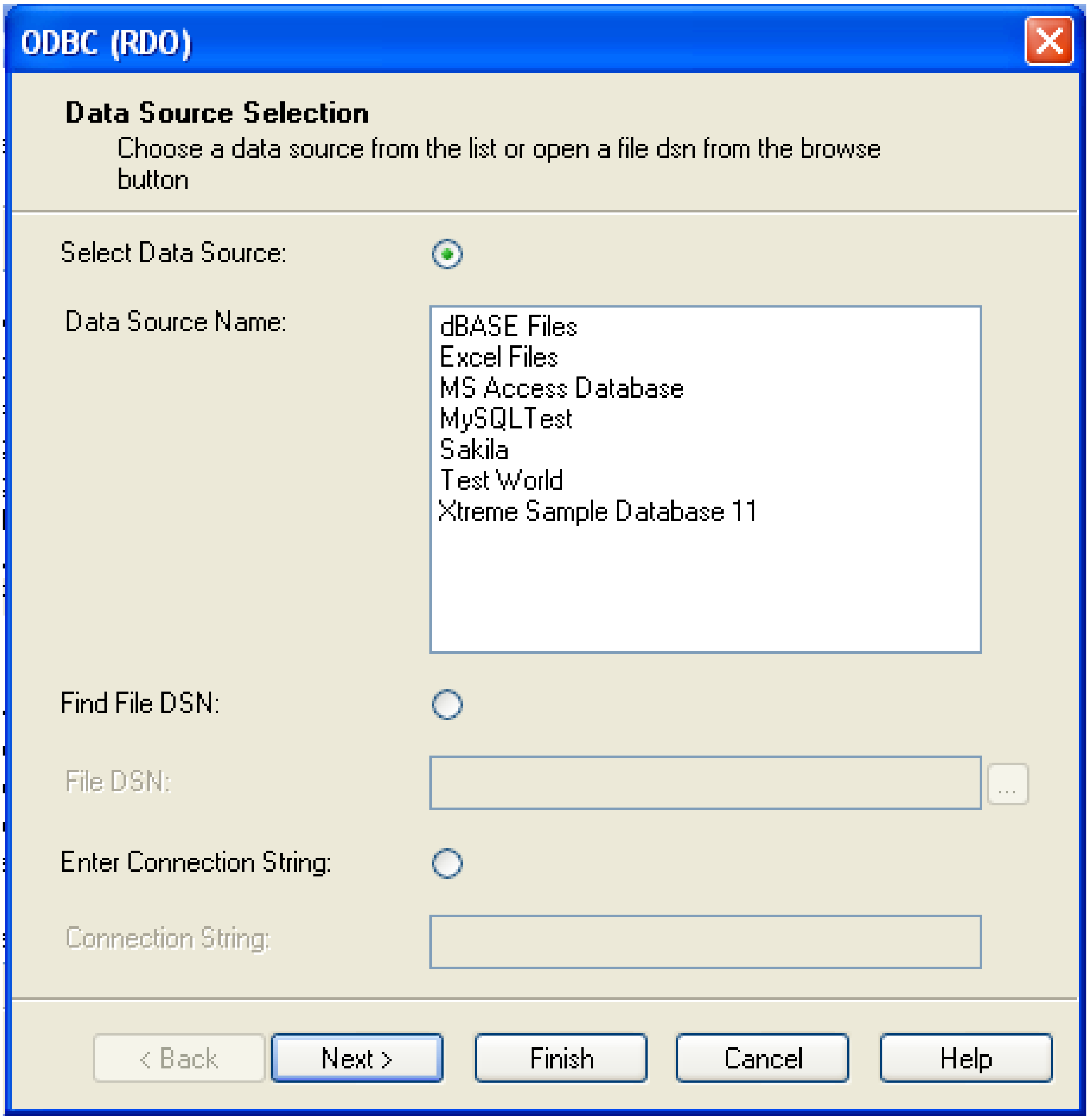
3. Start the Cross-Tab Report Wizard, either by clicking the option on the Start Page. Expand the **CREATE NEW CONNECTION** folder, then expand the **ODBC (RDO)** folder to obtain a list of ODBC data sources.

   You will be asked to select a data source.


Cross-Tab Report Creation Wizard
Data
Choose the data you want to report on.
Available Data Sources:
Current Connections
Favorites
History
Create New Connection
Repository
Selected Tables:
>
>>
<
<<
< Back
Next >
Finish
Cancel
Help

4. When you first expand the **ODBC (RDO)** folder you will be presented the Data Source Selection screen. From here you can select either a pre-configured DSN, open a file-based DSN or enter and manual connection string. For this example, the **SAKILA** DSN will be used.

   If the DSN contains a user name/password combination, or you want to use different authentication credentials, click NEXT to enter the user name and password that you want to use. Otherwise, click FINISH to continue the data source selection wizard.



Data Source Selection

Choose a data source from the list or open a file dsn from the browse button

Select Data Source: ●

Data Source Name:
dBASE Files
Excel Files
MS Access Database
MySQLTest
Sakila
Test World
Xtreme Sample Database 11

Find File DSN: ○

File DSN:

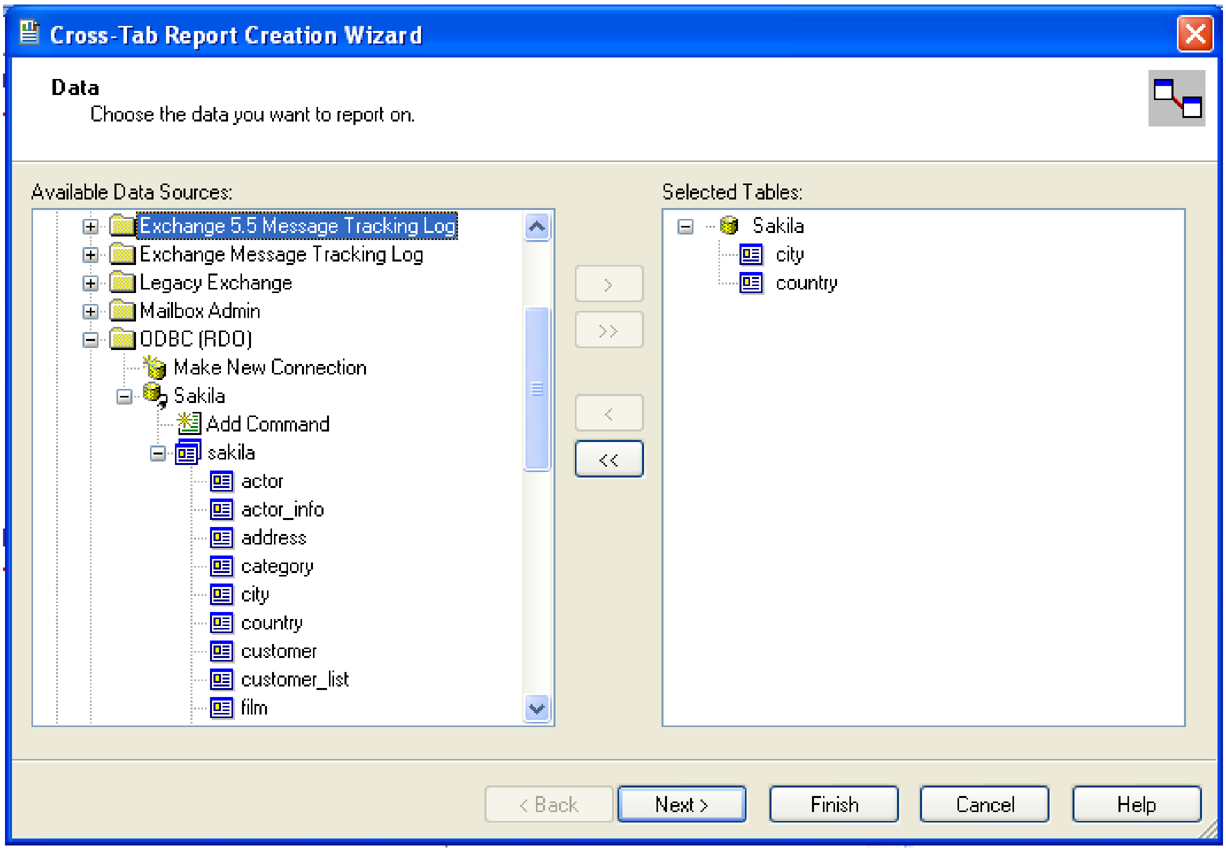
Enter Connection String: ○

Connection String:

5. You will be returned the Cross-Tab Report Creation Wizard. You now need to select the database and tables that you want to include in your report. For our example, we will expand the selected Sakila database. Click the `city` table and use the > button to add the table to the report. Then repeat the action with the `country` table. Alternatively you can select multiple tables and add them to the report.

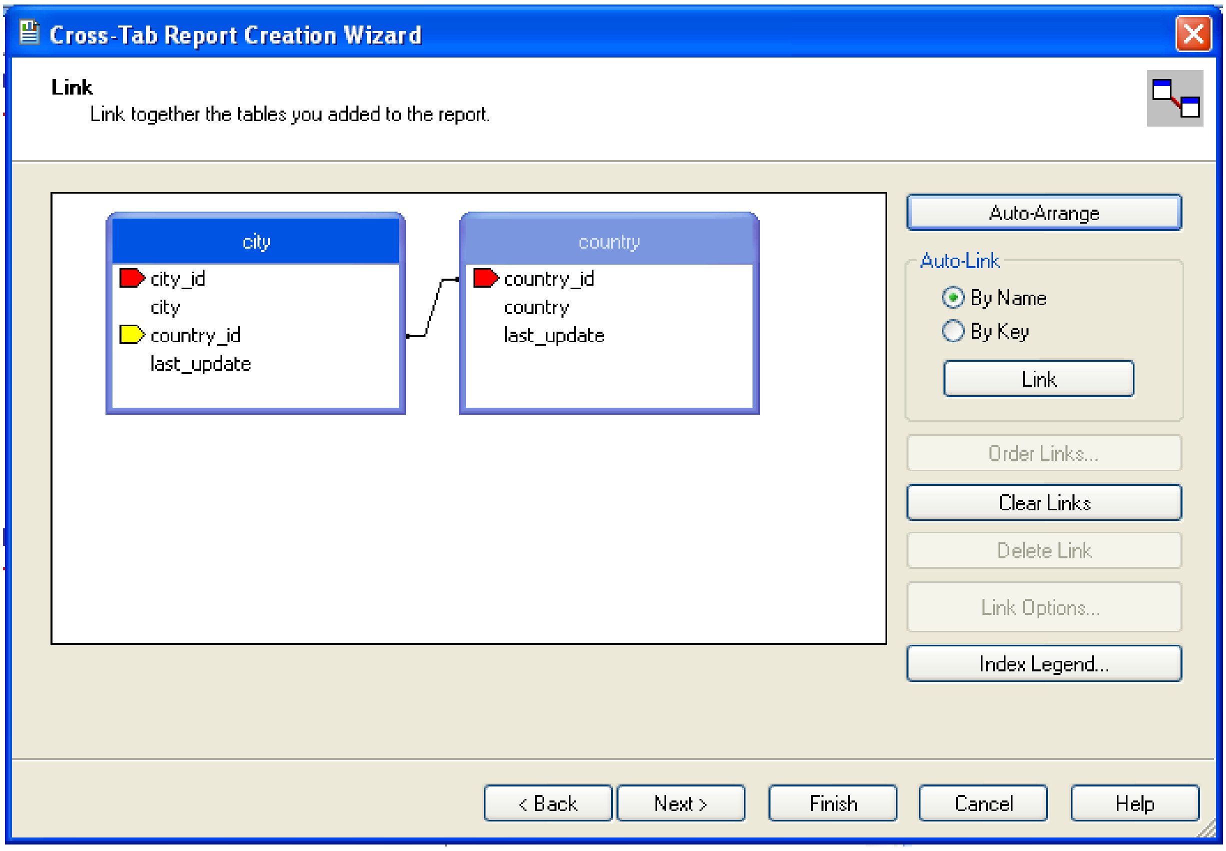
   Finally, you can select the parent **SAKILA** resource and add of the tables to the report.

   Once you have selected the tables you want to include, click NEXT to continue.


Cross-Tab Report Creation Wizard
Data
Choose the data you want to report on.
Available Data Sources:
Exchange 5.5 Message Tracking Log
Exchange Message Tracking Log
Legacy Exchange
Mailbox Admin
ODBC (RDO)
Make New Connection
Sakila
Add Command
sakila
actor
actor_info
address
category
city
country
customer
customer_list
film
Selected Tables:
Sakila
city
country
>
>>
<
<<
< Back
Next >
Finish
Cancel
Help

6. Crystal Reports will now read the table definitions and automatically identify the links between the tables. The identification of links between tables enables Crystal Reports to automatically lookup and summarize information based on all the tables in the database according to your query. If Crystal Reports is unable to perform the linking itself, you can manually create the links between fields in the tables you have selected.

   Click NEXT to continue the process.



Cross-Tab Report Creation Wizard

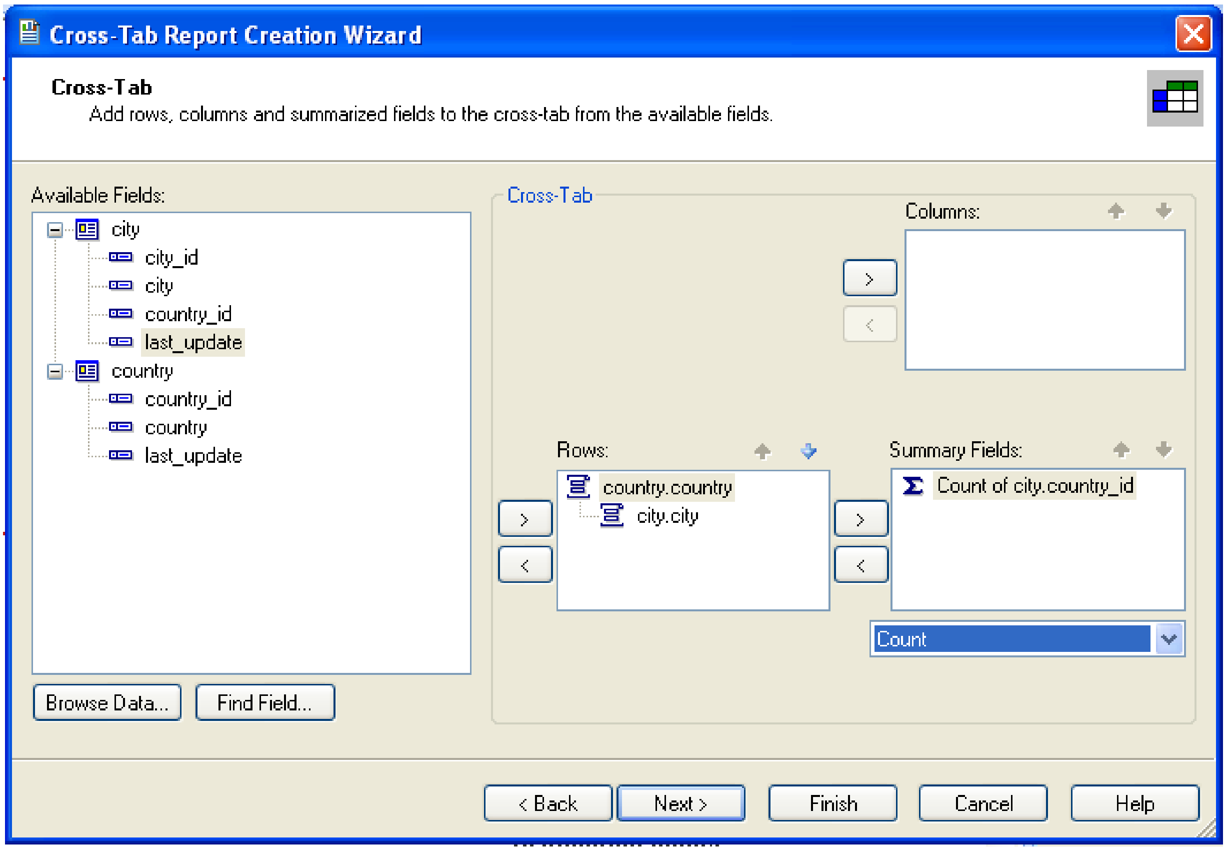
Link

Link together the tables you added to the report.

city
city_id
city
country_id
last_update
country
country_id
country
last_update
Auto-Arrange
Auto-Link
● By Name
○ By Key
Link
Order Links...
Clear Links
Delete Link
Link Options...
Index Legend...
< Back
Next >
Finish
Cancel
Help

7. You can now select the columns and rows that you wish to include within the Cross-Tab report. Drag and drop or use the > buttons to add fields to each area of the report. In the example shown, we will report on cities, organized by country, incorporating a count of the number of cities within each country. If you want to browse the data, select a field and click the BROWSE DATA... button.

   Click NEXT to create a graph of the results. Since we are not creating a graph from this data, click FINISH to generate the report.



Cross-Tab Report Creation Wizard

Cross-Tab

Add rows, columns and summarized fields to the cross-tab from the available fields.

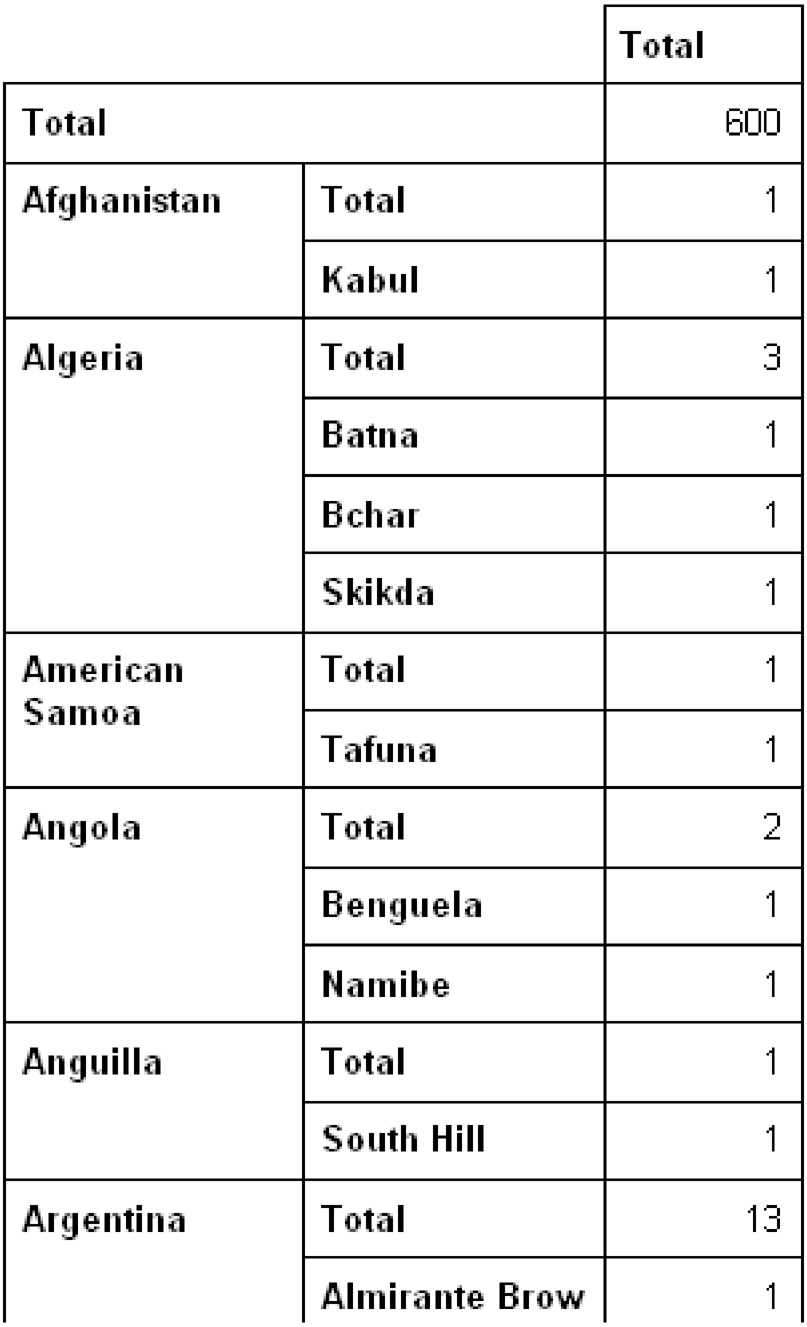
Rows:
- country.country
  - city.city

Summary Fields:
- Count of city.country_id

Count

Available Fields:
city
city_id
city
country_id
last_update
country
country_id
country
last_update
Browse Data...
Find Field...
Cross-Tab
Columns:
Rows:
Summary Fields:
< Back
Next >
Finish
Cancel
Help

8. The finished report will be shown, a sample of the output from the Sakila sample database is shown below.



		Total
Total		600
Afghanistan	Total	1
	Kabul	1
Algeria	Total	3
	Batna	1
	Bchar	1
	Skikda	1
American Samoa	Total	1
	Tafuna	1
Angola	Total	2
	Benguela	1
	Namibe	1
Anguilla	Total	1
	South Hill	1
Argentina	Total	13
	Almirante Brow	1

Once the ODBC connection has been opened within Crystal Reports, you can browse and add any fields within the available tables into your reports.

20.1.5.7. Connector/ODBC Programming

With a suitable ODBC Manager and the Connector/ODBC driver installed, any programming language or environment that can support ODBC should be able to connect to a MySQL database through Connector/ODBC.

This includes, but is certainly not limited to, Microsoft support languages (including Visual Basic, C# and interfaces such as ODBC.NET), Perl (through the DBI module, and the DBD::ODBC driver).

20.1.5.7.1. Using Connector/ODBC with Visual Basic Using ADO, DAO and RDO

This section contains simple examples of the use of MySQL ODBC 3.51 Driver with ADO, DAO and RDO.

20.1.5.7.1.1. ADO: `rs.addNew`, `rs.delete`, and `rs.update`

The following ADO (ActiveX Data Objects) example creates a table `my_ado` and demonstrates the use of `rs.addNew`, `rs.delete`, and `rs.update`.

```
Private Sub myodbc_ado_Click()

Dim conn As ADODB.Connection
Dim rs As ADODB.Recordset
Dim fld As ADODB.Field
Dim sql As String

'connect to MySQL server using MySQL ODBC 3.51 Driver
Set conn = New ADODB.Connection
conn.ConnectionString = "DRIVER={MySQL ODBC 3.51 Driver};"_
& "SERVER=localhost;"_
& " DATABASE=test;"_
& "UID=venu;PWD=venu; OPTION=3"

conn.Open

'create table
conn.Execute "DROP TABLE IF EXISTS my_ado"
conn.Execute "CREATE TABLE my_ado(id int not null primary key, name varchar(20)," _
& "txt text, dt date, tm time, ts timestamp)"

'direct insert
conn.Execute "INSERT INTO my_ado(id,name,txt) values(1,100,'venu')"
conn.Execute "INSERT INTO my_ado(id,name,txt) values(2,200,'MySQL')"
conn.Execute "INSERT INTO my_ado(id,name,txt) values(3,300,'Delete')"

Set rs = New ADODB.Recordset
rs.CursorLocation = adUseServer

'fetch the initial table ..
rs.Open "SELECT * FROM my_ado", conn
Debug.Print rs.RecordCount
rs.MoveFirst
Debug.Print String(50, "-") & "Initial my_ado Result Set " & String(50, "-")
For Each fld In rs.Fields
Debug.Print fld.Name,
Next
Debug.Print

Do Until rs.EOF
For Each fld In rs.Fields
Debug.Print fld.Value,
Next
rs.MoveNext
Debug.Print
Loop
rs.Close

'rs insert
rs.Open "select * from my_ado", conn, adOpenDynamic, adLockOptimistic
rs.AddNew
rs!Name = "Monty"
rs!txt = "Insert row"
rs.Update
rs.Close

'rs update
rs.Open "SELECT * FROM my_ado"
rs!Name = "update"
rs!txt = "updated-row"
rs.Update
rs.Close

'rs update second time..
rs.Open "SELECT * FROM my_ado"
rs!Name = "update"
rs!txt = "updated-second-time"
rs.Update
rs.Close

'rs delete
rs.Open "SELECT * FROM my_ado"
rs.MoveNext
rs.MoveNext
rs.Delete
rs.Close

'fetch the updated table ..
rs.Open "SELECT * FROM my_ado", conn
Debug.Print rs.RecordCount
rs.MoveFirst
Debug.Print String(50, "-") & "Updated my_ado Result Set " & String(50, "-")
For Each fld In rs.Fields
Debug.Print fld.Name,
Next
Debug.Print

Do Until rs.EOF
For Each fld In rs.Fields
Debug.Print fld.Value,
Next
rs.MoveNext
Debug.Print
Loop
rs.Close
conn.Close
End Sub
```

20.1.5.7.1.2. DAO: `rs.addNew`, `rs.update`, and Scrolling

The following DAO (Data Access Objects) example creates a table `my_dao` and demonstrates the use of `rs.addNew`, `rs.update`, and result set scrolling.

```
Private Sub myodbc_dao_Click()

Dim ws As Workspace
Dim conn As Connection
Dim queryDef As queryDef
Dim str As String

'connect to MySQL using MySQL ODBC 3.51 Driver
Set ws = DBEngine.CreateWorkspace("", "venu", "venu", dbUseODBC)
str = "odbc;DRIVER={MySQL ODBC 3.51 Driver};"_
& "SERVER=localhost;"_
& " DATABASE=test;"_
& "UID=venu;PWD=venu; OPTION=3"
Set conn = ws.OpenConnection("test", dbDriverNoPrompt, False, str)

'Create table my_dao
Set queryDef = conn.CreateQueryDef("", "drop table if exists my_dao")
queryDef.Execute

Set queryDef = conn.CreateQueryDef("", "create table my_dao(Id INT AUTO_INCREMENT PRIMARY KEY, " _
& "Ts TIMESTAMP(14) NOT NULL, Name varchar(20), Id2 INT)")
queryDef.Execute

'Insert new records using rs.addNew
Set rs = conn.OpenRecordset("my_dao")
Dim i As Integer

For i = 10 To 15
rs.AddNew
rs!Name = "insert record" & i
rs!Id2 = i
rs.Update
Next i
rs.Close

'rs update..
Set rs = conn.OpenRecordset("my_dao")
rs.Edit
rs!Name = "updated-string"
rs.Update
rs.Close

'fetch the table back...
Set rs = conn.OpenRecordset("my_dao", dbOpenDynamic)
str = "Results:"
rs.MoveFirst
While Not rs.EOF
str = " " & rs!Id & " , " & rs!Name & ", " & rs!Ts & ", " & rs!Id2
Debug.Print "DATA:" & str
rs.MoveNext
Wend

'rs Scrolling
rs.MoveFirst
str = " FIRST ROW: " & rs!Id & " , " & rs!Name & ", " & rs!Ts & ", " & rs!Id2
Debug.Print str

rs.MoveLast
str = " LAST ROW: " & rs!Id & " , " & rs!Name & ", " & rs!Ts & ", " & rs!Id2
Debug.Print str

rs.MovePrevious
str = " LAST-1 ROW: " & rs!Id & " , " & rs!Name & ", " & rs!Ts & ", " & rs!Id2
Debug.Print str

'free all resources
rs.Close
queryDef.Close
conn.Close
ws.Close

End Sub
```

20.1.5.7.1.3. RDO: `rs.addNew` and `rs.update`

The following RDO (Remote Data Objects) example creates a table `my_rdo` and demonstrates the use of `rs.addNew` and `rs.update`.

```
Dim rs As rdoResultset
Dim cn As New rdoConnection
Dim cl As rdoColumn
Dim SQL As String

'cn.Connect = "DSN=test;"
cn.Connect = "DRIVER={MySQL ODBC 3.51 Driver};"_
& "SERVER=localhost;"_
& " DATABASE=test;"_
& "UID=venu;PWD=venu; OPTION=3"

cn.CursorDriver = rdUseOdbc
cn.EstablishConnection rdDriverPrompt


'drop table my_rdo
SQL = "drop table if exists my_rdo"
cn.Execute SQL, rdExecDirect

'create table my_rdo
SQL = "create table my_rdo(id int, name varchar(20))"
cn.Execute SQL, rdExecDirect

'insert - direct
SQL = "insert into my_rdo values (100,'venu')"
cn.Execute SQL, rdExecDirect

SQL = "insert into my_rdo values (200,'MySQL')"
cn.Execute SQL, rdExecDirect

'rs insert
SQL = "select * from my_rdo"
Set rs = cn.OpenResultset(SQL, rdOpenStatic, rdConcurRowVer, rdExecDirect)
rs.AddNew
rs!id = 300
rs!Name = "Insert1"
rs.Update
rs.Close

'rs insert
SQL = "select * from my_rdo"
Set rs = cn.OpenResultset(SQL, rdOpenStatic, rdConcurRowVer, rdExecDirect)
rs.AddNew
rs!id = 400
rs!Name = "Insert 2"
rs.Update
rs.Close

'rs update
SQL = "select * from my_rdo"
Set rs = cn.OpenResultset(SQL, rdOpenStatic, rdConcurRowVer, rdExecDirect)
rs.Edit
rs!id = 999
rs!Name = "updated"
rs.Update
rs.Close

'fetch back...
SQL = "select * from my_rdo"
Set rs = cn.OpenResultset(SQL, rdOpenStatic, rdConcurRowVer, rdExecDirect)
Do Until rs.EOF
For Each cl In rs.rdoColumns
Debug.Print cl.Value,
Next
rs.MoveNext
Debug.Print
Loop
Debug.Print "Row count="; rs.RowCount

'close
rs.Close
cn.Close

End Sub
```

20.1.5.7.2. Using Connector/ODBC with .NET

This section contains simple examples that demonstrate the use of Connector/ODBC drivers with ODBC.NET.

20.1.5.7.2.1. Using Connector/ODBC with ODBC.NET and C# (C sharp)

The following sample creates a table `my_odbc_net` and demonstrates its use in C#.

```
/**
 * @sample    : mycon.cs
 * @purpose   : Demo sample for ODBC.NET using Connector/ODBC
 * @author    : Venu, <myodbc@lists.mysql.com>
 *
 * (C) Copyright MySQL AB, 1995-2006
 *
 **/
```

```
/* build command
 *
 *  csc /t:exe
 *      /out:mycon.exe mycon.cs
 *      /r:Microsoft.Data.Odbc.dll
 */

using Console = System.Console;
using Microsoft.Data.Odbc;

namespace myodbc3
{
  class mycon
  {
    static void Main(string[] args)
    {
      try
        {
          //Connection string for Connector/ODBC 3.51
          string MyConString = "DRIVER={MySQL ODBC 3.51 Driver};" +
            "SERVER=localhost;" +
            "DATABASE=test;" +
            "UID=venu;" +
            "PASSWORD=venu;" +
            "OPTION=3";

          //Connect to MySQL using Connector/ODBC
          OdbcConnection MyConnection = new OdbcConnection(MyConString);
          MyConnection.Open();

          Console.WriteLine("\n !!! success, connected successfully !!!\n");

          //Display connection information
          Console.WriteLine("Connection Information:");
          Console.WriteLine("\tConnection String:" +
                            MyConnection.ConnectionString);
          Console.WriteLine("\tConnection Timeout:" +
                            MyConnection.ConnectionTimeout);
          Console.WriteLine("\tDatabase:" +
                            MyConnection.Database);
          Console.WriteLine("\tDataSource:" +
                            MyConnection.DataSource);
          Console.WriteLine("\tDriver:" +
                            MyConnection.Driver);
          Console.WriteLine("\tServerVersion:" +
                            MyConnection.ServerVersion);

          //Create a sample table
          OdbcCommand MyCommand =
            new OdbcCommand("DROP TABLE IF EXISTS my_odbc_net",
                            MyConnection);
          MyCommand.ExecuteNonQuery();
          MyCommand.CommandText =
            "CREATE TABLE my_odbc_net(id int, name varchar(20), idb bigint)";
          MyCommand.ExecuteNonQuery();

          //Insert
          MyCommand.CommandText =
            "INSERT INTO my_odbc_net VALUES(10,'venu', 300)";
          Console.WriteLine("INSERT, Total rows affected:" +
                            MyCommand.ExecuteNonQuery());;

          //Insert
          MyCommand.CommandText =
            "INSERT INTO my_odbc_net VALUES(20,'mysql',400)";
          Console.WriteLine("INSERT, Total rows affected:" +
                            MyCommand.ExecuteNonQuery());

          //Insert
          MyCommand.CommandText =
            "INSERT INTO my_odbc_net VALUES(20,'mysql',500)";
          Console.WriteLine("INSERT, Total rows affected:" +
                            MyCommand.ExecuteNonQuery());

          //Update
          MyCommand.CommandText =
            "UPDATE my_odbc_net SET id=999 WHERE id=20";
          Console.WriteLine("Update, Total rows affected:" +
                            MyCommand.ExecuteNonQuery());

          //COUNT(*)
          MyCommand.CommandText =
            "SELECT COUNT(*) as TRows FROM my_odbc_net";
          Console.WriteLine("Total Rows:" +
                            MyCommand.ExecuteScalar());

          //Fetch
          MyCommand.CommandText = "SELECT * FROM my_odbc_net";
          OdbcDataReader MyDataReader;
          MyDataReader =  MyCommand.ExecuteReader();
          while (MyDataReader.Read())
            {
              if(string.Compare(MyConnection.Driver,"myodbc3.dll") == 0) {
                //Supported only by Connector/ODBC 3.51
                Console.WriteLine("Data:" + MyDataReader.GetInt32(0) + " " +
                                  MyDataReader.GetString(1) + " " +
                                  MyDataReader.GetInt64(2));
              }
              else {
                //BIGINTs not supported by Connector/ODBC
                Console.WriteLine("Data:" + MyDataReader.GetInt32(0) + " " +
                                  MyDataReader.GetString(1) + " " +
                                  MyDataReader.GetInt32(2));
              }
            }

          //Close all resources
          MyDataReader.Close();
          MyConnection.Close();
        }
      catch (OdbcException MyOdbcException) //Catch any ODBC exception ..
        {
          for (int i=0; i < MyOdbcException.Errors.Count; i++)
            {
              Console.Write("ERROR #" + i + "\n" +
                            "Message: " +
                            MyOdbcException.Errors[i].Message + "\n" +
                            "Native: " +
                            MyOdbcException.Errors[i].NativeError.ToString() + "\n" +
                            "Source: " +
                            MyOdbcException.Errors[i].Source + "\n" +
                            "SQL: " +
                            MyOdbcException.Errors[i].SQLState + "\n");
            }
        }
    }
  }
}
```

20.1.5.7.2.2. Using Connector/ODBC with ODBC.NET and Visual Basic

The following sample creates a table `my_vb_net` and demonstrates the use in VB.

```
' @sample    : myvb.vb
' @purpose   : Demo sample for ODBC.NET using Connector/ODBC
' @author    : Venu, <myodbc@lists.mysql.com>
'
' (C) Copyright MySQL AB, 1995-2006
'
'

'
' build command
'
' vbc /target:exe
'     /out:myvb.exe
'     /r:Microsoft.Data.Odbc.dll
'     /r:System.dll
'     /r:System.Data.dll
'

Imports Microsoft.Data.Odbc
Imports System

Module myvb
  Sub Main()
    Try

      'Connector/ODBC 3.51 connection string
      Dim MyConString As String = "DRIVER={MySQL ODBC 3.51 Driver};" & _
      "SERVER=localhost;" & _
      "DATABASE=test;" & _
      "UID=venu;" & _
      "PASSWORD=venu;" & _
      "OPTION=3;"

      'Connection
      Dim MyConnection As New OdbcConnection(MyConString)
      MyConnection.Open()

      Console.WriteLine("Connection State::" & MyConnection.State.ToString)

      'Drop
      Console.WriteLine("Dropping table")
      Dim MyCommand As New OdbcCommand()
      MyCommand.Connection = MyConnection
      MyCommand.CommandText = "DROP TABLE IF EXISTS my_vb_net"
      MyCommand.ExecuteNonQuery()

      'Create
      Console.WriteLine("Creating....")
      MyCommand.CommandText = "CREATE TABLE my_vb_net(id int, name varchar(30))"
      MyCommand.ExecuteNonQuery()

      'Insert
      MyCommand.CommandText = "INSERT INTO my_vb_net VALUES(10,'venu')"
      Console.WriteLine("INSERT, Total rows affected:" & _
      MyCommand.ExecuteNonQuery())

      'Insert
      MyCommand.CommandText = "INSERT INTO my_vb_net VALUES(20,'mysql')"
      Console.WriteLine("INSERT, Total rows affected:" & _
      MyCommand.ExecuteNonQuery())
      'Insert
      MyCommand.CommandText = "INSERT INTO my_vb_net VALUES(20,'mysql')"
      Console.WriteLine("INSERT, Total rows affected:" & _
      MyCommand.ExecuteNonQuery())

      'Insert
      MyCommand.CommandText = "INSERT INTO my_vb_net(id) VALUES(30)"
      Console.WriteLine("INSERT, Total rows affected:" & _
                        MyCommand.ExecuteNonQuery())

      'Update
      MyCommand.CommandText = "UPDATE my_vb_net SET id=999 WHERE id=20"
      Console.WriteLine("Update, Total rows affected:" & _
      MyCommand.ExecuteNonQuery())

      'COUNT(*)
      MyCommand.CommandText = "SELECT COUNT(*) as TRows FROM my_vb_net"
      Console.WriteLine("Total Rows:" & MyCommand.ExecuteScalar())

      'Select
      Console.WriteLine("Select * FROM my_vb_net")
      MyCommand.CommandText = "SELECT * FROM my_vb_net"
      Dim MyDataReader As OdbcDataReader
      MyDataReader = MyCommand.ExecuteReader
      While MyDataReader.Read
        If MyDataReader("name") Is DBNull.Value Then
          Console.WriteLine("id = " & _
          CStr(MyDataReader("id")) & "  name = " & _
          "NULL")
        Else
          Console.WriteLine("id = " & _
          CStr(MyDataReader("id")) & "  name = " & _
          CStr(MyDataReader("name")))
        End If
      End While

      'Catch ODBC Exception
    Catch MyOdbcException As OdbcException
      Dim i As Integer
      Console.WriteLine(MyOdbcException.ToString)

      'Catch program exception
    Catch MyException As Exception
      Console.WriteLine(MyException.ToString)
    End Try
  End Sub
```

20.1.6. Connector/ODBC Reference

This section provides reference material for the Connector/ODBC API, showing supported functions and methods, supported MySQL column types and the corresponding native type in Connector/ODBC, and the error codes returned by Connector/ODBC when a fault occurs.

20.1.6.1. Connector/ODBC API Reference

This section summarizes ODBC routines, categorized by functionality.

For the complete ODBC API reference, please refer to the ODBC Programmer's Reference at http://msdn.microsoft.com/en-us/library/ms714177.aspx.

An application can call `SQLGetInfo` function to obtain conformance information about Connector/ODBC. To obtain information about support for a specific function in the driver, an application can call `SQLGetFunctions`.

Note

For backward compatibility, the Connector/ODBC 3.51 driver supports all deprecated functions.

The following tables list Connector/ODBC API calls grouped by task:

Connecting to a data source

Function name	C/ODBC 3.51	Standard	Purpose
`SQLAllocHandle`	Yes	ISO 92	Obtains an environment, connection, statement, or descriptor handle.
`SQLConnect`	Yes	ISO 92	Connects to a specific driver by data source name, user ID, and password.
`SQLDriverConnect`	Yes	ODBC	Connects to a specific driver by connection string or requests that the Driver Manager and driver display connection dialog boxes for the user.

Function name	C/ODBC 3.51	Standard	Purpose
`SQLAllocEnv`	Yes	Deprecated	Obtains an environment handle allocated from driver.
`SQLAllocConnect`	Yes	Deprecated	Obtains a connection handle

Obtaining information about a driver and data source

Function name	C/ODBC 3.51	Standard	Purpose
`SQLDataSources`	No	ISO 92	Returns the list of available data sources, handled by the Driver Manager
`SQLDrivers`	No	ODBC	Returns the list of installed drivers and their attributes, handles by Driver Manager
`SQLGetInfo`	Yes	ISO 92	Returns information about a specific driver and data source.
`SQLGetFunctions`	Yes	ISO 92	Returns supported driver functions.
`SQLGetTypeInfo`	Yes	ISO 92	Returns information about supported data types.

Setting and retrieving driver attributes

Function name	C/ODBC 3.51	Standard	Purpose
`SQLSetConnectAttr`	Yes	ISO 92	Sets a connection attribute.
`SQLGetConnectAttr`	Yes	ISO 92	Returns the value of a connection attribute.
`SQLSetConnectOption`	Yes	Deprecated	Sets a connection option
`SQLGetConnectOption`	Yes	Deprecated	Returns the value of a connection option
`SQLSetEnvAttr`	Yes	ISO 92	Sets an environment attribute.
`SQLGetEnvAttr`	Yes	ISO 92	Returns the value of an environment attribute.
`SQLSetStmtAttr`	Yes	ISO 92	Sets a statement attribute.
`SQLGetStmtAttr`	Yes	ISO 92	Returns the value of a statement attribute.
`SQLSetStmtOption`	Yes	Deprecated	Sets a statement option
`SQLGetStmtOption`	Yes	Deprecated	Returns the value of a statement option

Preparing SQL requests

Function name	C/ODBC 3.51	Standard	Purpose
`SQLAllocStmt`	Yes	Deprecated	Allocates a statement handle
`SQLPrepare`	Yes	ISO 92	Prepares an SQL statement for later execution.
`SQLBindParameter`	Yes	ODBC	Assigns storage for a parameter in an SQL statement.
`SQLGetCursorName`	Yes	ISO 92	Returns the cursor name associated with a statement handle.
`SQLSetCursorName`	Yes	ISO 92	Specifies a cursor name.
`SQLSetScrollOptions`	Yes	ODBC	Sets options that control cursor behavior.

Submitting requests

Function name	C/ODBC 3.51	Standard	Purpose
`SQLExecute`	Yes	ISO 92	Executes a prepared statement.
`SQLExecDirect`	Yes	ISO 92	Executes a statement
`SQLNativeSql`	Yes	ODBC	Returns the text of an SQL statement as translated by the driver.
`SQLDescribeParam`	Yes	ODBC	Returns the description for a specific parameter in a statement.
`SQLNumParams`	Yes	ISO 92	Returns the number of parameters in a statement.

Function name	C/ODBC 3.51	Standard	Purpose
`SQLParamData`	Yes	ISO 92	Used in conjunction with `SQLPutData` to supply parameter data at execution time. (Useful for long data values.)
`SQLPutData`	Yes	ISO 92	Sends part or all of a data value for a parameter. (Useful for long data values.)

Retrieving results and information about results

Function name	C/ODBC 3.51	Standard	Purpose
`SQLRowCount`	Yes	ISO 92	Returns the number of rows affected by an insert, update, or delete request.
`SQLNumResultCols`	Yes	ISO 92	Returns the number of columns in the result set.
`SQLDescribeCol`	Yes	ISO 92	Describes a column in the result set.
`SQLColAttribute`	Yes	ISO 92	Describes attributes of a column in the result set.
`SQLColAttributes`	Yes	Deprecated	Describes attributes of a column in the result set.
`SQLFetch`	Yes	ISO 92	Returns multiple result rows.
`SQLFetchScroll`	Yes	ISO 92	Returns scrollable result rows.
`SQLExtendedFetch`	Yes	Deprecated	Returns scrollable result rows.
`SQLSetPos`	Yes	ODBC	Positions a cursor within a fetched block of data and enables an application to refresh data in the rowset or to update or delete data in the result set.
`SQLBulkOperations`	Yes	ODBC	Performs bulk insertions and bulk bookmark operations, including update, delete, and fetch by bookmark.

Retrieving error or diagnostic information

Function name	C/ODBC 3.51	Standard	Purpose
`SQLError`	Yes	Deprecated	Returns additional error or status information
`SQLGetDiagField`	Yes	ISO 92	Returns additional diagnostic information (a single field of the diagnostic data structure).
`SQLGetDiagRec`	Yes	ISO 92	Returns additional diagnostic information (multiple fields of the diagnostic data structure).

Obtaining information about the data source's system tables (catalog functions) item

Function name	C/ODBC 3.51	Standard	Purpose
`SQLColumnPrivileges`	Yes	ODBC	Returns a list of columns and associated privileges for one or more tables.
`SQLColumns`	Yes	X/Open	Returns the list of column names in specified tables.
`SQLForeignKeys`	Yes	ODBC	Returns a list of column names that make up foreign keys, if they exist for a specified table.
`SQLPrimaryKeys`	Yes	ODBC	Returns the list of column names that make up the primary key for a table.
`SQLSpecialColumns`	Yes	X/Open	Returns information about the optimal set of columns that uniquely identifies a row in a specified table, or the columns that are automatically updated when any value in the row is updated by a transaction.
`SQLStatistics`	Yes	ISO 92	Returns statistics about a single table and the list of indexes associated with the table.
`SQLTablePrivileges`	Yes	ODBC	Returns a list of tables and the privileges associated with each table.
`SQLTables`	Yes	X/Open	Returns the list of table names stored in a specific data source.

Performing transactions

Function name	C/ODBC 3.51	Standard	Purpose
`SQLTransact`	Yes	Deprecated	Commits or rolls back a transaction
`SQLEndTran`	Yes	ISO 92	Commits or rolls back a transaction.

Terminating a statement

Function name	C/ODBC 3.51	Standard	Purpose
`SQLFreeStmt`	Yes	ISO 92	Ends statement processing, discards pending results, and, optionally, frees all resources associated with the statement handle.
`SQLCloseCursor`	Yes	ISO 92	Closes a cursor that has been opened on a statement handle.
`SQLCancel`	Yes	ISO 92	Cancels an SQL statement.

Terminating a connection

Function name	C/ODBC 3.51	Standard	Purpose
`SQLDisconnect`	Yes	ISO 92	Closes the connection.
`SQLFreeHandle`	Yes	ISO 92	Releases an environment, connection, statement, or descriptor handle.
`SQLFreeConnect`	Yes	Deprecated	Releases connection handle
`SQLFreeEnv`	Yes	Deprecated	Releases an environment handle

20.1.6.2. Connector/ODBC Data Types

The following table illustrates how driver maps the server data types to default SQL and C data types.

Native Value	SQL Type	C Type
`bigint unsigned`	`SQL_BIGINT`	`SQL_C_UBIGINT`
`bigint`	`SQL_BIGINT`	`SQL_C_SBIGINT`
`bit`	`SQL_BIT`	`SQL_C_BIT`
`bit`	`SQL_CHAR`	`SQL_C_CHAR`
`blob`	`SQL_LONGVARBINARY`	`SQL_C_BINARY`
`bool`	`SQL_CHAR`	`SQL_C_CHAR`
`char`	`SQL_CHAR`	`SQL_C_CHAR`
`date`	`SQL_DATE`	`SQL_C_DATE`
`datetime`	`SQL_TIMESTAMP`	`SQL_C_TIMESTAMP`
`decimal`	`SQL_DECIMAL`	`SQL_C_CHAR`
`double precision`	`SQL_DOUBLE`	`SQL_C_DOUBLE`
`double`	`SQL_FLOAT`	`SQL_C_DOUBLE`
`enum`	`SQL_VARCHAR`	`SQL_C_CHAR`
`float`	`SQL_REAL`	`SQL_C_FLOAT`
`int unsigned`	`SQL_INTEGER`	`SQL_C_ULONG`
`int`	`SQL_INTEGER`	`SQL_C_SLONG`
`integer unsigned`	`SQL_INTEGER`	`SQL_C_ULONG`
`integer`	`SQL_INTEGER`	`SQL_C_SLONG`
`long varbinary`	`SQL_LONGVARBINARY`	`SQL_C_BINARY`
`long varchar`	`SQL_LONGVARCHAR`	`SQL_C_CHAR`
`longblob`	`SQL_LONGVARBINARY`	`SQL_C_BINARY`

Native Value	SQL Type	C Type
`longtext`	`SQL_LONGVARCHAR`	`SQL_C_CHAR`
`mediumblob`	`SQL_LONGVARBINARY`	`SQL_C_BINARY`
`mediumint unsigned`	`SQL_INTEGER`	`SQL_C_ULONG`
`mediumint`	`SQL_INTEGER`	`SQL_C_SLONG`
`mediumtext`	`SQL_LONGVARCHAR`	`SQL_C_CHAR`
`numeric`	`SQL_NUMERIC`	`SQL_C_CHAR`
`real`	`SQL_FLOAT`	`SQL_C_DOUBLE`
`set`	`SQL_VARCHAR`	`SQL_C_CHAR`
`smallint unsigned`	`SQL_SMALLINT`	`SQL_C_USHORT`
`smallint`	`SQL_SMALLINT`	`SQL_C_SSHORT`
`text`	`SQL_LONGVARCHAR`	`SQL_C_CHAR`
`time`	`SQL_TIME`	`SQL_C_TIME`
`timestamp`	`SQL_TIMESTAMP`	`SQL_C_TIMESTAMP`
`tinyblob`	`SQL_LONGVARBINARY`	`SQL_C_BINARY`
`tinyint unsigned`	`SQL_TINYINT`	`SQL_C_UTINYINT`
`tinyint`	`SQL_TINYINT`	`SQL_C_STINYINT`
`tinytext`	`SQL_LONGVARCHAR`	`SQL_C_CHAR`
`varchar`	`SQL_VARCHAR`	`SQL_C_CHAR`
`year`	`SQL_SMALLINT`	`SQL_C_SHORT`

20.1.6.3. Connector/ODBC Error Codes

The following tables lists the error codes returned by the driver apart from the server errors.

Native Code	SQLSTATE 2	SQLSTATE 3	Error Message
500	01000	01000	General warning
501	01004	01004	String data, right truncated
502	01S02	01S02	Option value changed
503	01S03	01S03	No rows updated/deleted
504	01S04	01S04	More than one row updated/deleted
505	01S06	01S06	Attempt to fetch before the result set returned the first row set
506	07001	07002	`SQLBindParameter` not used for all parameters
507	07005	07005	Prepared statement not a cursor-specification
508	07009	07009	Invalid descriptor index
509	08002	08002	Connection name in use
510	08003	08003	Connection does not exist
511	24000	24000	Invalid cursor state
512	25000	25000	Invalid transaction state
513	25S01	25S01	Transaction state unknown
514	34000	34000	Invalid cursor name
515	S1000	HY000	General driver defined error
516	S1001	HY001	Memory allocation error
517	S1002	HY002	Invalid column number
518	S1003	HY003	Invalid application buffer type
519	S1004	HY004	Invalid SQL data type
520	S1009	HY009	Invalid use of null pointer
521	S1010	HY010	Function sequence error
522	S1011	HY011	Attribute can not be set now

Native Code	SQLSTATE 2	SQLSTATE 3	Error Message
523	S1012	HY012	Invalid transaction operation code
524	S1013	HY013	Memory management error
525	S1015	HY015	No cursor name available
526	S1024	HY024	Invalid attribute value
527	S1090	HY090	Invalid string or buffer length
528	S1091	HY091	Invalid descriptor field identifier
529	S1092	HY092	Invalid attribute/option identifier
530	S1093	HY093	Invalid parameter number
531	S1095	HY095	Function type out of range
532	S1106	HY106	Fetch type out of range
533	S1117	HY117	Row value out of range
534	S1109	HY109	Invalid cursor position
535	S1C00	HYC00	Optional feature not implemented
0	21S01	21S01	Column count does not match value count
0	23000	23000	Integrity constraint violation
0	42000	42000	Syntax error or access violation
0	42S02	42S02	Base table or view not found
0	42S12	42S12	Index not found
0	42S21	42S21	Column already exists
0	42S22	42S22	Column not found
0	08S01	08S01	Communication link failure

20.1.7. Connector/ODBC Notes and Tips

Here are some common notes and tips for using Connector/ODBC within different environments, applications and tools. The notes provided here are based on the experiences of Connector/ODBC developers and users.

20.1.7.1. Connector/ODBC General Functionality

This section provides help with common queries and areas of functionality in MySQL and how to use them with Connector/ODBC.

20.1.7.1.1. Obtaining Auto-Increment Values

Obtaining the value of column that uses `AUTO_INCREMENT` after an `INSERT` statement can be achieved in a number of different ways. To obtain the value immediately after an `INSERT`, use a `SELECT` query with the `LAST_INSERT_ID()` function.

For example, using Connector/ODBC you would execute two separate statements, the `INSERT` statement and the `SELECT` query to obtain the auto-increment value.

```
INSERT INTO tbl (auto,text) VALUES(NULL,'text');
SELECT LAST_INSERT_ID();
```

If you do not require the value within your application, but do require the value as part of another `INSERT`, the entire process can be handled by executing the following statements:

```
INSERT INTO tbl (auto,text) VALUES(NULL,'text');
INSERT INTO tbl2 (id,text) VALUES(LAST_INSERT_ID(),'text');
```

Certain ODBC applications (including Delphi and Access) may have trouble obtaining the auto-increment value using the previous examples. In this case, try the following statement as an alternative:

```
SELECT * FROM tbl WHERE auto IS NULL;
```

This alternative method requires that `sql_auto_is_null` variable is not set to 0. See Section 5.1.3, “Server System Variables”.

See also Section 20.9.11.3, “How to Get the Unique ID for the Last Inserted Row”.

20.1.7.1.2. Dynamic Cursor Support

Support for the `dynamic cursor` is provided in Connector/ODBC 3.51, but dynamic cursors are not enabled by default. You can enable this function within Windows by selecting the `Enable Dynamic Cursor` check box within the ODBC Data Source Administrator.

On other platforms, you can enable the dynamic cursor by adding `32` to the `OPTION` value when creating the DSN.

20.1.7.1.3. Connector/ODBC Performance

The Connector/ODBC driver has been optimized to provide very fast performance. If you experience problems with the performance of Connector/ODBC, or notice a large amount of disk activity for simple queries, there are a number of aspects you should check:

- Ensure that `ODBC Tracing` is not enabled. With tracing enabled, a lot of information is recorded in the tracing file by the ODBC Manager. You can check, and disable, tracing within Windows using the TRACING panel of the ODBC Data Source Administrator. Within Mac OS X, check the TRACING panel of ODBC Administrator. See Section 20.1.4.8, "Getting an ODBC Trace File".
- Make sure you are using the standard version of the driver, and not the debug version. The debug version includes additional checks and reporting measures.
- Disable the Connector/ODBC driver trace and query logs. These options are enabled for each DSN, so make sure to examine only the DSN that you are using in your application. Within Windows, you can disable the Connector/ODBC and query logs by modifying the DSN configuration. Within Mac OS X and Unix, ensure that the driver trace (option value 4) and query logging (option value 524288) are not enabled.

20.1.7.1.4. Setting ODBC Query Timeout in Windows

For more information on how to set the query timeout on Microsoft Windows when executing queries through an ODBC connection, read the Microsoft knowledgebase document at http://support.microsoft.com/default.aspx?scid=kb%3Ben-us%3B153756.

20.1.7.2. Connector/ODBC Application Specific Tips

Most programs should work with Connector/ODBC, but for each of those listed here, there are specific notes and tips to improve or enhance the way you work with Connector/ODBC and these applications.

With all applications you should ensure that you are using the latest Connector/ODBC drivers, ODBC Manager and any supporting libraries and interfaces used by your application. For example, on Windows, using the latest version of Microsoft Data Access Components (MDAC) will improve the compatibility with ODBC in general, and with the Connector/ODBC driver.

20.1.7.2.1. Using Connector/ODBC with Microsoft Applications

The majority of Microsoft applications have been tested with Connector/ODBC, including Microsoft Office, Microsoft Access and the various programming languages supported within ASP and Microsoft Visual Studio.

20.1.7.2.1.1. Microsoft Access

To improve the integration between Microsoft Access and MySQL through Connector/ODBC:

- For all versions of Access, you should enable the Connector/ODBC `Return matching rows` option. For Access 2.0, you should additionally enable the `Simulate ODBC 1.0` option.
- You should have a `TIMESTAMP` column in all tables that you want to be able to update. For maximum portability, do not use a length specification in the column declaration (which is unsupported within MySQL in versions earlier than 4.1).
- You should have a primary key in each MySQL table you want to use with Access. If not, new or updated rows may show up as `#DELETED#`.
- Use only `DOUBLE` float fields. Access fails when comparing with single-precision floats. The symptom usually is that new or updated rows may show up as `#DELETED#` or that you cannot find or update rows.
- If you are using Connector/ODBC to link to a table that has a `BIGINT` column, the results are displayed as `#DELETED#`. The work around solution is:
  - Have one more dummy column with `TIMESTAMP` as the data type.

  - Select the `Change BIGINT columns to INT` option in the connection dialog in ODBC DSN Administrator.
  - Delete the table link from Access and re-create it.

  Old records may still display as `#DELETED#`, but newly added/updated records are displayed properly.

- If you still get the error `Another user has changed your data` after adding a `TIMESTAMP` column, the following trick may help you:

  Do not use a `table` data sheet view. Instead, create a form with the fields you want, and use that `form` data sheet view. You should set the `DefaultValue` property for the `TIMESTAMP` column to `NOW()`. It may be a good idea to hide the `TIMESTAMP` column from view so your users are not confused.

- In some cases, Access may generate SQL statements that MySQL cannot understand. You can fix this by selecting `"Query|SQLSpecific|Pass-Through"` from the Access menu.

- On Windows NT, Access reports `BLOB` columns as `OLE OBJECTS`. If you want to have `MEMO` columns instead, you should change `BLOB` columns to `TEXT` with `ALTER TABLE`.

- Access cannot always handle the MySQL `DATE` column properly. If you have a problem with these, change the columns to `DATETIME`.

- If you have in Access a column defined as `BYTE`, Access tries to export this as `TINYINT` instead of `TINYINT UNSIGNED`. This gives you problems if you have values larger than 127 in the column.

- If you have very large (long) tables in Access, it might take a very long time to open them. Or you might run low on virtual memory and eventually get an `ODBC Query Failed` error and the table cannot open. To deal with this, select the following options:

  - Return Matching Rows (2)
  - Allow BIG Results (8).

  These add up to a value of 10 (`OPTION=10`).

Some external articles and tips that may be useful when using Access, ODBC and Connector/ODBC:

- Read How to Trap ODBC Login Error Messages in Access
- Optimizing Access ODBC Applications
  - Optimizing for Client/Server Performance
  - Tips for Converting Applications to Using ODBCDirect
  - Tips for Optimizing Queries on Attached SQL Tables
- For a list of tools that can be used with Access and ODBC data sources, refer to http://www.mysql.com/portal/software/convertors/ section for list of available tools.

20.1.7.2.1.2. Microsoft Excel and Column Types

If you have problems importing data into Microsoft Excel, particularly numeric, date, and time values, this is probably because of a bug in Excel, where the column type of the source data is used to determine the data type when that data is inserted into a cell within the worksheet. The result is that Excel incorrectly identifies the content and this affects both the display format and the data when it is used within calculations.

To address this issue, use the `CONCAT()` function in your queries. The use of `CONCAT()` forces Excel to treat the value as a string, which Excel will then parse and usually correctly identify the embedded information.

However, even with this option, some data may be incorrectly formatted, even though the source data remains unchanged. Use the `Format Cells` option within Excel to change the format of the displayed information.

20.1.7.2.1.3. Microsoft Visual Basic

To be able to update a table, you must define a primary key for the table.

Visual Basic with ADO cannot handle big integers. This means that some queries like `SHOW PROCESSLIST` do not work properly. The fix is to use `OPTION=16384` in the ODBC connect string or to select the `Change BIGINT columns to INT` option in the Connector/ODBC connect screen. You may also want to select the `Return matching rows` option.

20.1.7.2.1.4. Microsoft Visual InterDev

If you have a `BIGINT` in your result, you may get the error `[Microsoft][ODBC Driver Manager] Driver does not support this parameter`. Try selecting the `Change BIGINT columns to INT` option in the Connector/ODBC connect screen.

20.1.7.2.1.5. Visual Objects

You should select the `Don't optimize column widths` option.

20.1.7.2.1.6. Microsoft ADO

When you are coding with the ADO API and Connector/ODBC, you need to pay attention to some default properties that aren't supported by the MySQL server. For example, using the `CursorLocation Property` as `adUseServer` returns a result of –1 for the `RecordCount Property`. To have the right value, you need to set this property to `adUseClient`, as shown in the VB code here:

```
Dim myconn As New ADODB.Connection
Dim myrs As New Recordset
Dim mySQL As String
Dim myrows As Long

myconn.Open "DSN=MyODBCsample"
mySQL = "SELECT * from user"
myrs.Source = mySQL
Set myrs.ActiveConnection = myconn
myrs.CursorLocation = adUseClient
myrs.Open
myrows = myrs.RecordCount

myrs.Close
myconn.Close
```

Another workaround is to use a `SELECT COUNT(*)` statement for a similar query to get the correct row count.

To find the number of rows affected by a specific SQL statement in ADO, use the `RecordsAffected` property in the ADO execute method. For more information on the usage of execute method, refer to http://msdn.microsoft.com/library/default.asp?url=/library/en-us/ado270/htm/mdmthcnnexecute.asp.

For information, see ActiveX Data Objects(ADO) Frequently Asked Questions.

20.1.7.2.1.7. Using Connector/ODBC with Active Server Pages (ASP)

You should select the `Return matching rows` option in the DSN.

For more information about how to access MySQL through ASP using Connector/ODBC, refer to the following articles:

- Using MyODBC To Access Your MySQL Database Via ASP
- ASP and MySQL at DWAM.NT

A Frequently Asked Questions list for ASP can be found at http://support.microsoft.com/default.aspx?scid=/Support/ActiveServer/faq/data/adofaq.asp.

20.1.7.2.1.8. Using Connector/ODBC with Visual Basic (ADO, DAO and RDO) and ASP

Some articles that may help with Visual Basic and ASP:

- MySQL BLOB columns and Visual Basic 6 by Mike Hillyer (`<mike@openwin.org>`).
- How to map Visual basic data type to MySQL types by Mike Hillyer (`<mike@openwin.org>`).

20.1.7.2.2. Using Connector/ODBC with Borland Applications

With all Borland applications where the Borland Database Engine (BDE) is used, follow these steps to improve compatibility:

- Update to BDE 3.2 or newer.
- Enable the `Don't optimize column widths` option in the DSN.
- Enabled the `Return matching rows` option in the DSN.

20.1.7.2.2.1. Using Connector/ODBC with Borland Builder 4

When you start a query, you can use the `Active` property or the `Open` method. Note that `Active` starts by automatically issuing a `SELECT * FROM ...` query. That may not be a good thing if your tables are large.

20.1.7.2.2.2. Using Connector/ODBC with Delphi

Also, here is some potentially useful Delphi code that sets up both an ODBC entry and a BDE entry for Connector/ODBC. The BDE entry requires a BDE Alias Editor that is free at a Delphi Super Page near you. (Thanks to Bryan Brunton `<bryan@flesherfab.com>` for this):

```
fReg:= TRegistry.Create;
fReg.OpenKey('\Software\ODBC\ODBC.INI\DocumentsFab', True);
fReg.WriteString('Database', 'Documents');
fReg.WriteString('Description', ' ');
fReg.WriteString('Driver', 'C:\WINNT\System32\myodbc.dll');
fReg.WriteString('Flag', '1');
fReg.WriteString('Password', '');
fReg.WriteString('Port', ' ');
fReg.WriteString('Server', 'xmark');
fReg.WriteString('User', 'winuser');
fReg.OpenKey('\Software\ODBC\ODBC.INI\ODBC Data Sources', True);
fReg.WriteString('DocumentsFab', 'MySQL');
fReg.CloseKey;
fReg.Free;

Memo1.Lines.Add('DATABASE NAME=');
Memo1.Lines.Add('USER NAME=');
Memo1.Lines.Add('ODBC DSN=DocumentsFab');
Memo1.Lines.Add('OPEN MODE=READ/WRITE');
Memo1.Lines.Add('BATCH COUNT=200');
Memo1.Lines.Add('LANGDRIVER=');
Memo1.Lines.Add('MAX ROWS=-1');
Memo1.Lines.Add('SCHEMA CACHE DIR=');
Memo1.Lines.Add('SCHEMA CACHE SIZE=8');
Memo1.Lines.Add('SCHEMA CACHE TIME=-1');
Memo1.Lines.Add('SQLPASSTHRU MODE=SHARED AUTOCOMMIT');
Memo1.Lines.Add('SQLQRYMODE=');
Memo1.Lines.Add('ENABLE SCHEMA CACHE=FALSE');
Memo1.Lines.Add('ENABLE BCD=FALSE');
Memo1.Lines.Add('ROWSET SIZE=20');
Memo1.Lines.Add('BLOBS TO CACHE=64');
Memo1.Lines.Add('BLOB SIZE=32');

AliasEditor.Add('DocumentsFab','MySQL',Memo1.Lines);
```

20.1.7.2.2.3. Using Connector/ODBC with C++ Builder

Tested with BDE 3.0. The only known problem is that when the table schema changes, query fields are not updated. BDE, however, does not seem to recognize primary keys, only the index named `PRIMARY`, although this has not been a problem.

20.1.7.2.3. Using Connector/ODBC with ColdFusion

The following information is taken from the ColdFusion documentation:

Use the following information to configure ColdFusion Server for Linux to use the `unixODBC` driver with Connector/ODBC for MySQL data sources. You can download Connector/ODBC at http://dev.mysql.com/downloads/connector/odbc/.

ColdFusion version 4.5.1 enables you to use the ColdFusion Administrator to add the MySQL data source. However, the driver is not included with ColdFusion version 4.5.1. Before the MySQL driver appears in the ODBC data sources drop-down list, you must build and copy the Connector/ODBC driver to `/opt/coldfusion/lib/libmyodbc.so`.

The Contrib directory contains the program `mydsn-xxx.zip` which enables you to build and remove the DSN registry file for the Connector/ODBC driver on ColdFusion applications.

For more information and guides on using ColdFusion and Connector/ODBC, see the following external sites:

- Troubleshooting Data Sources and Database Connectivity for Unix Platforms.

20.1.7.2.4. Using Connector/ODBC with OpenOffice.org

Open Office (http://www.openoffice.org) How-to: MySQL + OpenOffice. How-to: OpenOffice + MyODBC + unixODBC.

20.1.7.2.5. Using Connector/ODBC with Sambar Server

Sambar Server (http://www.sambarserver.info) How-to: MyODBC + SambarServer + MySQL.

20.1.7.2.6. Using Connector/ODBC with Pervasive Software DataJunction

You have to change it to output `VARCHAR` rather than `ENUM`, as it exports the latter in a manner that causes MySQL problems.

20.1.7.2.7. Using Connector/ODBC with SunSystems Vision

You should select the `Return matching rows` option.

20.1.7.3. Connector/ODBC Errors and Resolutions (FAQ)

The following section details some common errors and their suggested fix or alternative solution. If you are still experiencing problems, use the Connector/ODBC mailing list; see Section 20.1.8.1, “Connector/ODBC Community Support”.

Many problems can be resolved by upgrading your Connector/ODBC drivers to the latest available release. On Windows, you should also make sure that you have the latest versions of the Microsoft Data Access Components (MDAC) installed.

Questions

- 21.1.7.3.1: I have installed Connector/ODBC on Windows XP x64 Edition or Windows Server 2003 R2 x64. The installation completed successfully, but the Connector/ODBC driver does not appear in `ODBC Data Source Administrator`.
- 21.1.7.3.2: When connecting or using the TEST button in `ODBC Data Source Administrator` I get error 10061 (Cannot connect to server)
- 21.1.7.3.3: The following error is reported when using transactions: `Transactions are not enabled`
- 21.1.7.3.4: Access reports records as `#DELETED#` when inserting or updating records in linked tables.
- 21.1.7.3.5: How do I handle Write Conflicts or Row Location errors?
- 21.1.7.3.6: Exporting data from Access 97 to MySQL reports a `Syntax Error`.
- 21.1.7.3.7: Exporting data from Microsoft DTS to MySQL reports a `Syntax Error`.
- 21.1.7.3.8: Using ODBC.NET with Connector/ODBC, while fetching empty string (0 length), it starts giving the SQL_NO_DATA exception.
- 21.1.7.3.9: Using `SELECT COUNT(*) FROM` *`tbl_name`* within Visual Basic and ASP returns an error.
- 21.1.7.3.10: Using the `AppendChunk()` or `GetChunk()` ADO methods, the `Multiple-step operation generated errors. Check each status value` error is returned.
- 21.1.7.3.11: Access Returns `Another user had modified the record that you have modified` while editing records on a Linked Table.
- 21.1.7.3.12: When linking an application directly to the Connector/ODBC library under Unix/Linux, the application crashes.
- 21.1.7.3.13: Applications in the Microsoft Office suite are unable to update tables that have `DATE` or `TIMESTAMP` columns.
- 21.1.7.3.14: When connecting Connector/ODBC 5.x (Beta) to a MySQL 4.x server, the error `1044 Access denied for user 'xxx'@'%' to database 'information_schema'` is returned.
- 21.1.7.3.15: When calling `SQLTables`, the error `S1T00` is returned, but I cannot find this in the list of error numbers for Connector/ODBC.
- 21.1.7.3.16: When linking to tables in Access 2000 and generating links to tables programmatically, rather than through the table designer interface, you may get errors about tables not existing.
- 21.1.7.3.17: When I try to use batched statements, the execution of the batched statements fails.
- 21.1.7.3.18: When connecting to a MySQL server using ADODB and Excel, occasionally the application fails to communicate with the server and the error `Got an error reading communication packets` appears in the error log.
- 21.1.7.3.19: When using some applications to access a MySQL server using C/ODBC and outer joins, an error is reported re-

garding the Outer Join Escape Sequence.

- 21.1.7.3.20: I can correctly store extended characters in the database (Hebrew/CJK) using C/ODBC 5.1, but when I retrieve the data, the text is not formatted correctly and I get garbled characters.
- 21.1.7.3.21: I have a duplicate MySQL Connector/ODBC entry within my **INSTALLED PROGRAMS** list, but I cannot delete one of them.
- 21.1.7.3.22: When submitting queries with parameter binding using `UPDATE`, my field values are being truncated to 255 characters.
- 21.1.7.3.23: Is it possible to disable data-at-execution using a flag?
- 21.1.7.3.24: When you call `SQLColumns()` for a table column that is `AUTO_INCREMENT`, the `NULLABLE` column of the result set is always `SQL_NULLABLE (1)`.

Questions and Answers

21.1.7.3.1: I have installed Connector/ODBC on Windows XP x64 Edition or Windows Server 2003 R2 x64. The installation completed successfully, but the Connector/ODBC driver does not appear in `ODBC Data Source Administrator`.

This is not a bug, but is related to the way Windows x64 editions operate with the ODBC driver. On Windows x64 editions, the Connector/ODBC driver is installed in the `%SystemRoot%\SysWOW64` folder. However, the default `ODBC Data Source Administrator` that is available through the `Administrative Tools` or `Control Panel` in Windows x64 Editions is located in the `%SystemRoot%\system32` folder, and only searches this folder for ODBC drivers.

On Windows x64 editions, you should use the ODBC administration tool located at `%SystemRoot%\SysWOW64\odbcad32.exe`, this will correctly locate the installed Connector/ODBC drivers and enable you to create a Connector/ODBC DSN.

This issue was originally reported as Bug #20301.

21.1.7.3.2: When connecting or using the TEST button in `ODBC Data Source Administrator` I get error 10061 (Cannot connect to server)

This error can be raised by a number of different issues, including server problems, network problems, and firewall and port blocking problems. For more information, see Section C.5.2.2, “`Can't connect to [local] MySQL server`”.

21.1.7.3.3: The following error is reported when using transactions: `Transactions are not enabled`

This error indicates that you are trying to use transactions with a MySQL table that does not support transactions. Transactions are supported within MySQL when using the `InnoDB` database engine. In versions of MySQL before Mysql 5.1 you may also use the `BDB` engine.

You should check the following before continuing:

- Verify that your MySQL server supports a transactional database engine. Use `SHOW ENGINES` to obtain a list of the available engine types.
- Verify that the tables you are updating use a transaction database engine.
- Ensure that you have not enabled the `disable transactions` option in your DSN.

21.1.7.3.4: Access reports records as `#DELETED#` when inserting or updating records in linked tables.

If the inserted or updated records are shown as `#DELETED#` in the access, then:

- If you are using Access 2000, you should get and install the newest (version 2.6 or higher) Microsoft MDAC (`Microsoft Data Access Components`) from http://support.microsoft.com/kb/110093. This fixes a bug in Access that when you export data to MySQL, the table and column names aren't specified.

  You should also get and apply the Microsoft Jet 4.0 Service Pack 5 (SP5) which can be found at http://support.microsoft.com/default.aspx?scid=kb;EN-US;q239114. This fixes some cases where columns are marked as `#DELETED#` in Access.
- For all versions of Access, you should enable the Connector/ODBC `Return matching rows` option. For Access 2.0, you should additionally enable the `Simulate ODBC 1.0` option.

- You should have a timestamp in all tables that you want to be able to update.
- You should have a primary key in the table. If not, new or updated rows may show up as `#DELETED#`.
- Use only `DOUBLE` float fields. Access fails when comparing with single-precision floats. The symptom usually is that new or updated rows may show up as `#DELETED#` or that you cannot find or update rows.
- If you are using Connector/ODBC to link to a table that has a `BIGINT` column, the results are displayed as `#DELETED`. The work around solution is:
  - Have one more dummy column with `TIMESTAMP` as the data type.
  - Select the `Change BIGINT columns to INT` option in the connection dialog in ODBC DSN Administrator.
  - Delete the table link from Access and re-create it.

  Old records still display as `#DELETED#`, but newly added/updated records are displayed properly.

21.1.7.3.5: How do I handle Write Conflicts or Row Location errors?

If you see the following errors, select the `Return Matching Rows` option in the DSN configuration dialog, or specify `OPTION=2`, as the connection parameter:

```
Write Conflict. Another user has changed your data.

Row cannot be located for updating. Some values may have been changed
since it was last read.
```

21.1.7.3.6: Exporting data from Access 97 to MySQL reports a `Syntax Error`.

This error is specific to Access 97 and versions of Connector/ODBC earlier than 3.51.02. Update to the latest version of the Connector/ODBC driver to resolve this problem.

21.1.7.3.7: Exporting data from Microsoft DTS to MySQL reports a `Syntax Error`.

This error occurs only with MySQL tables using the `TEXT` or `VARCHAR` data types. You can fix this error by upgrading your Connector/ODBC driver to version 3.51.02 or higher.

21.1.7.3.8: Using ODBC.NET with Connector/ODBC, while fetching empty string (0 length), it starts giving the SQL_NO_DATA exception.

You can get the patch that addresses this problem from http://support.microsoft.com/default.aspx?scid=kb;EN-US;q319243.

21.1.7.3.9: Using `SELECT COUNT(*) FROM tbl_name` within Visual Basic and ASP returns an error.

This error occurs because the `COUNT(*)` expression is returning a `BIGINT`, and ADO cannot make sense of a number this big. Select the `Change BIGINT columns to INT` option (option value 16384).

21.1.7.3.10: Using the `AppendChunk()` or `GetChunk()` ADO methods, the `Multiple-step operation generated errors. Check each status value` error is returned.

The `GetChunk()` and `AppendChunk()` methods from ADO doesn't work as expected when the cursor location is specified as `adUseServer`. On the other hand, you can overcome this error by using `adUseClient`.

A simple example can be found from http://www.dwam.net/iishelp/ado/docs/adomth02_4.htm

21.1.7.3.11: Access Returns `Another user had modified the record that you have modified` while editing records on a Linked Table.

In most cases, this can be solved by doing one of the following things:

- Add a primary key for the table if one doesn't exist.
- Add a timestamp column if one doesn't exist.
- Only use double-precision float fields. Some programs may fail when they compare single-precision floats.

If these strategies do not help, you should start by making a log file from the ODBC manager (the log you get when requesting logs from ODBCADMIN) and a Connector/ODBC log to help you figure out why things go wrong. For instructions, see Section 20.1.4.8, “Getting an ODBC Trace File”.

21.1.7.3.12: When linking an application directly to the Connector/ODBC library under Unix/Linux, the application crashes.

Connector/ODBC 3.51 under Unix/Linux is not compatible with direct application linking. You must use a driver manager, such as iODBC or unixODBC to connect to an ODBC source.

21.1.7.3.13: Applications in the Microsoft Office suite are unable to update tables that have `DATE` or `TIMESTAMP` columns.

This is a known issue with Connector/ODBC. You must ensure that the field has a default value (rather than `NULL` and that the default value is nonzero (that is, the default value is not `0000-00-00 00:00:00`).

21.1.7.3.14: When connecting Connector/ODBC 5.x (Beta) to a MySQL 4.x server, the error `1044 Access denied for user 'xxx'@'%' to database 'information_schema'` is returned.

Connector/ODBC 5.x is designed to work with MySQL 5.0 or later, taking advantage of the `INFORMATION_SCHEMA` database to determine data definition information. Support for MySQL 4.1 is planned for the final release.

21.1.7.3.15: When calling `SQLTables`, the error `S1T00` is returned, but I cannot find this in the list of error numbers for Connector/ODBC.

The `S1T00` error indicates that a general timeout has occurred within the ODBC system and is not a MySQL error. Typically it indicates that the connection you are using is stale, the server is too busy to accept your request or that the server has gone away.

21.1.7.3.16: When linking to tables in Access 2000 and generating links to tables programmatically, rather than through the table designer interface, you may get errors about tables not existing.

There is a known issue with a specific version of the `msjet40.dll` that exhibits this issue. The version affected is 4.0.9025.0. Reverting to an older version will enable you to create the links. If you have recently updated your version, check your `WINDOWS` directory for the older version of the file and copy it to the drivers directory.

21.1.7.3.17: When I try to use batched statements, the execution of the batched statements fails.

Batched statement support was added in 3.51.18. Support for batched statements is not enabled by default. You must enable option `FLAG_MULTI_STATEMENTS`, value 67108864, or select the **ALLOW MULTIPLE STATEMENTS** flag within a GUI configuration.

21.1.7.3.18: When connecting to a MySQL server using ADODB and Excel, occasionally the application fails to communicate with the server and the error `Got an error reading communication packets` appears in the error log.

This error may be related to Keyboard Logger 1.1 from PanteraSoft.com, which is known to interfere with the network communication between MySQL Connector/ODBC and MySQL.

21.1.7.3.19: When using some applications to access a MySQL server using C/ODBC and outer joins, an error is reported regarding the Outer Join Escape Sequence.

This is a known issue with MySQL Connector/ODBC which is not correctly parsing the "Outer Join Escape Sequence", as per the specs at Microsoft ODBC Specs. Currently, Connector/ODBC will return value > 0 when asked for `SQL_OJ_CAPABILITIES` even though no parsing takes place in the driver to handle the outer join escape sequence.

21.1.7.3.20: I can correctly store extended characters in the database (Hebrew/CJK) using C/ODBC 5.1, but when I retrieve the data, the text is not formatted correctly and I get garbled characters.

When using ASP and UTF8 characters you should add the following to your ASP files to ensure that the data returned is correctly encoded:

```
Response.CodePage = 65001
Response.CharSet = "utf-8"
```

21.1.7.3.21: I have a duplicate MySQL Connector/ODBC entry within my INSTALLED PROGRAMS list, but I cannot delete one of them.

This problem can occur when you upgrade an existing Connector/ODBC installation, rather than removing and then installing the updated version.

> **Warning**
>
> To fix the problem you should use any working uninstallers to remove existing installations and then may have to edit the contents of the registry. Make sure you have a backup of your registry information before attempting any editing of the registry contents.

21.1.7.3.22: When submitting queries with parameter binding using `UPDATE`, my field values are being truncated to 255

characters.

You should ensure that the `FLAG_BIG_PACKETS` option is set for your connection. This removes the 255 character limitation on bound parameters.

21.1.7.3.23: Is it possible to disable data-at-execution using a flag?

If you do not wish to use data-at-execution, simply remove the corresponding calls. For example:

```
SQLLEN ylen = SQL_LEN_DATA_AT_EXEC(10);
SQLBindCol(hstmt,2,SQL_C_BINARY, buf, 10, &ylen);
```

Would become:

```
SQLBindCol(hstmt,2,SQL_C_BINARY, buf, 10, NULL);
```

Note that in the call to `SQLBindCol()`, &ylen has been replaced by NULL.

For further information please refer to the MSDN documentation for `SQLBindCol()`.

21.1.7.3.24: When you call `SQLColumns()` for a table column that is `AUTO_INCREMENT`, the `NULLABLE` column of the result set is always `SQL_NULLABLE (1)`.

This is because MySQL reports the `DEFAULT` value for such a column as `NULL`. It means, if you insert a `NULL` value into the column, you will get the next integer value for the table's `auto_increment` counter.

20.1.8. Connector/ODBC Support

There are many different places where you can get support for using Connector/ODBC. You should always try the Connector/ODBC Mailing List or Connector/ODBC Forum. See Section 20.1.8.1, “Connector/ODBC Community Support”, for help before reporting a specific bug or issue to MySQL.

20.1.8.1. Connector/ODBC Community Support

Oracle provides assistance to the user community by means of its mailing lists. For Connector/ODBC-related issues, you can get help from experienced users by using the `<myodbc@lists.mysql.com>` mailing list. Archives are available online at http://lists.mysql.com/myodbc.

For information about subscribing to MySQL mailing lists or to browse list archives, visit http://lists.mysql.com/. See Section 1.6.1, “MySQL Mailing Lists”.

Community support from experienced users is also available through the ODBC Forum. You may also find help from other users in the other MySQL Forums, located at http://forums.mysql.com. See Section 1.6.2, “MySQL Community Support at the MySQL Forums”.

20.1.8.2. How to Report Connector/ODBC Problems or Bugs

If you encounter difficulties or problems with Connector/ODBC, you should start by making a log file from the `ODBC Manager` (the log you get when requesting logs from `ODBC ADMIN`) and Connector/ODBC. The procedure for doing this is described in Section 20.1.4.8, “Getting an ODBC Trace File”.

Check the Connector/ODBC trace file to find out what could be wrong. You should be able to determine what statements were issued by searching for the string `>mysql_real_query` in the `myodbc.log` file.

You should also try issuing the statements from the `mysql` client program or from `admndemo`. This helps you determine whether the error is in Connector/ODBC or MySQL.

If you find out something is wrong, please only send the relevant rows (maximum 40 rows) to the `myodbc` mailing list. See Section 1.6.1, “MySQL Mailing Lists”. Please never send the whole Connector/ODBC or ODBC log file!

You should ideally include the following information with the email:

- Operating system and version
- Connector/ODBC version
- ODBC Driver Manager type and version
- MySQL server version

- ODBC trace from Driver Manager
- Connector/ODBC log file from Connector/ODBC driver
- Simple reproducible sample

Remember that the more information you can supply to us, the more likely it is that we can fix the problem!

Also, before posting the bug, check the MyODBC mailing list archive at http://lists.mysql.com/myodbc.

If you are unable to find out what is wrong, the last option is to create an archive in `tar` or Zip format that contains a Connector/ODBC trace file, the ODBC log file, and a `README` file that explains the problem. You can send this to ftp://ftp.mysql.com/pub/mysql/upload/. Only MySQL engineers have access to the files you upload, and we are very discreet with the data.

If you can create a program that also demonstrates the problem, please include it in the archive as well.

If the program works with another SQL server, you should include an ODBC log file where you perform exactly the same SQL statements so that we can compare the results between the two systems.

Remember that the more information you can supply to us, the more likely it is that we can fix the problem.

20.1.8.3. How to Submit a Connector/ODBC Patch

You can send a patch or suggest a better solution for any existing code or problems by sending a mail message to `<myodbc@lists.mysql.com>`.

20.1.8.4. Connector/ODBC Change History

The Connector/ODBC Change History (Changelog) is located with the main Changelog for MySQL. See Section D.2, “MySQL Connector/ODBC (MyODBC) Change History”.

20.1.8.5. Credits

These are the developers that have worked on the Connector/ODBC and Connector/ODBC 3.51 Drivers from MySQL AB.

- Michael (Monty) Widenius
- Venu Anuganti
- Peter Harvey

20.2. MySQL Connector/Net

Connector/Net enables developers to easily create .NET applications that require secure, high-performance data connectivity with MySQL. It implements the required ADO.NET interfaces and integrates into ADO.NET aware tools. Developers can build applications using their choice of .NET languages. Connector/Net is a fully managed ADO.NET driver written in 100% pure C#.

Connector/Net includes full support for:

- Features provided by MySQL Server up to and including MySQL Server version 5.5.
- Large-packet support for sending and receiving rows and BLOBs up to 2 gigabytes in size.
- Protocol compression which enables compressing the data stream between the client and server.
- Support for connecting using TCP/IP sockets, named pipes, or shared memory on Windows.
- Support for connecting using TCP/IP sockets or Unix sockets on Unix.
- Support for the Open Source Mono framework developed by Novell.
- Fully managed, does not utilize the MySQL client library.

This document is intended as a user's guide to Connector/Net and includes a full syntax reference. Syntax information is also included within the `Documentation.chm` file included with the Connector/Net distribution.

If you are using MySQL 5.0 or later, and Visual Studio as your development environment, you may want also want to use the MySQL Visual Studio Plugin. The plugin acts as a DDEX (Data Designer Extensibility) provider, enabling you to use the data design tools within Visual Studio to manipulate the schema and objects within a MySQL database. For more information, see Section 20.2.3, "Connector/Net Visual Studio Integration".

> **Note**
>
> Connector/Net 5.1.2 and later include the Visual Studio Plugin by default.

MySQL Connector/Net supports full versions of Visual Studio 2005, 2008, and 2010, although certain features are only available in Visual Studio 2010 when using MySQL Connector/Net version 6.3.2 and later. Note that MySQL Connector/Net does not currently support Express versions of Microsoft products, including Microsoft Visual Web Developer.

Key topics:

- For connection string properties when using the `MySqlConnection` class, see Section 20.2.6, "Connector/Net Connection String Options Reference".

20.2.1. Connector/Net Versions

There are several versions of Connector/Net available:

- Connector/Net 1.0 includes support for MySQL Server 4.0, 4.1, and 5.0 features, and full compatibility with the ADO.NET driver interface.

  This version of Connector/Net is no longer supported.

- Connector/Net 5.0 includes support for MySQL Server 4.0, 4.1, 5.0 and 5.1 features. Connector/Net 5.0 also includes full support for the ADO.Net 2.0 interfaces and subclasses, includes support for the usage advisor and performance monitor (PerfMon) hooks.

  This version of Connector/Net is no longer supported.

- Connector/Net 5.1 includes support for MySQL Server 4.0, 4.1, 5.0, 5.1, 5.4 and 5.5 features. Connector/Net 5.1 also includes support for a new membership/role provider, Compact Framework 2.0, a new stored procedure parser and improvements to `GetSchema`. Connector/Net 5.1 also includes the Visual Studio Plugin as a standard installable component.

  This version of Connector/Net is no longer supported.

- Connector/Net 5.2 includes support for MySQL Server 4.1, 5.0, 5.1, 5.4, and 5.5 features. Connector/Net 5.2 also includes support for a new membership/role provider, Compact Framework 2.0, a new stored procedure parser and improvements to `GetSchema`. Connector/Net 5.2 also includes the Visual Studio Plugin as a standard installable component.

  This version of Connector/Net is no longer supported.

- Connector/Net 6.0 includes support for MySQL Server 4.1, 5.0, 5.1, 5.4 and 5.5.

  This version of Connector/Net is no longer supported.

- Connector/Net 6.1 includes support for MySQL Server 4.1, 5.0, 5.1, 5.4, and 5.5. Important new features include the MySQL Website Configuration Tool and a Session State Provider.

- Connector/Net 6.2 includes support for MySQL Server 4.1, 5.0, 5.1, 5.4, and 5.5. Important new features include a new logging system and client SSL certificates. Connector/Net 6.2 is currently available as a Beta release.

- Connector/Net 6.3 includes support for MySQL Server 5.0, 5.1, 5.4, and 5.5. Important new features include integration with Visual Studio 2010, such as availability of DDL T4 template for Entity Framework, and a custom MySQL SQL Editor. Other features include refactored transaction scope: Connector/Net now supports nested transactions in a scope where they use the same connection string. Connector/Net 6.3 is available as a Beta release.

The latest source code for Connector/Net can be downloaded from the MySQL public Subversion server. For further details see Section 20.2.2.3, "Installing Connector/Net from the source code".

The following table shows the .NET Framework version required, and MySQL Server version supported by Connector/Net:

Connector/Net version	ADO.NET version supported	.NET Framework version required	MySQL Server version supported	Currently supported
1.0	1.x	1.x	4.0, 4.1, 5.0	No
5.0	2.x+	2.x+	4.0, 4.1, 5.0	No
5.1	2.x+	2.x+	4.0, 4.1, 5.0, 5.1, 5.4, 5.5	No
5.2	2.x+	2.x+	4.1, 5.0, 5.1, 5.4, 5.5	No
6.0	2.x+	2.x+	4.1, 5.0, 5.1, 5.4, 5.5	Critical issues only
6.1	2.x+	2.x+	4.1, 5.0, 5.1, 5.4, 5.5	Yes
6.2	2.x+	2.x+	4.1, 5.0, 5.1, 5.4, 5.5	Yes
6.3	2.x+	2.x+, 4.x+ for VS 2010 support	5.0, 5.1, 5.4, 5.5	Yes

> **Note**
>
> Version numbers for MySQL products are formatted as X.Y.Z, where Z=0 indicates alpha, Z=1 indicates beta, and Z>=2 indicates GA. However, Windows tools (Control Panel, properties display) may show the version numbers as XX.YY.ZZ. For example, the official MySQL formatted version number 5.0.9 may be displayed by Windows tools as 5.00.09. The two versions are the same; only the number display format is different.

20.2.2. Connector/Net Installation

Connector/Net runs on any platform that supports the .NET framework. The .NET framework is primarily supported on recent versions of Microsoft Windows, and is supported on Linux through the Open Source Mono framework (see http://www.mono-project.com).

Connector/Net is available for download from http://dev.mysql.com/downloads/connector/net/5.2.html.

20.2.2.1. Installing Connector/Net on Windows

On Windows, installation is supported either through a binary installation process or by downloading a Zip file with the Connector/Net components.

Before installing, you should ensure that your system is up to date, including installing the latest version of the .NET Framework.

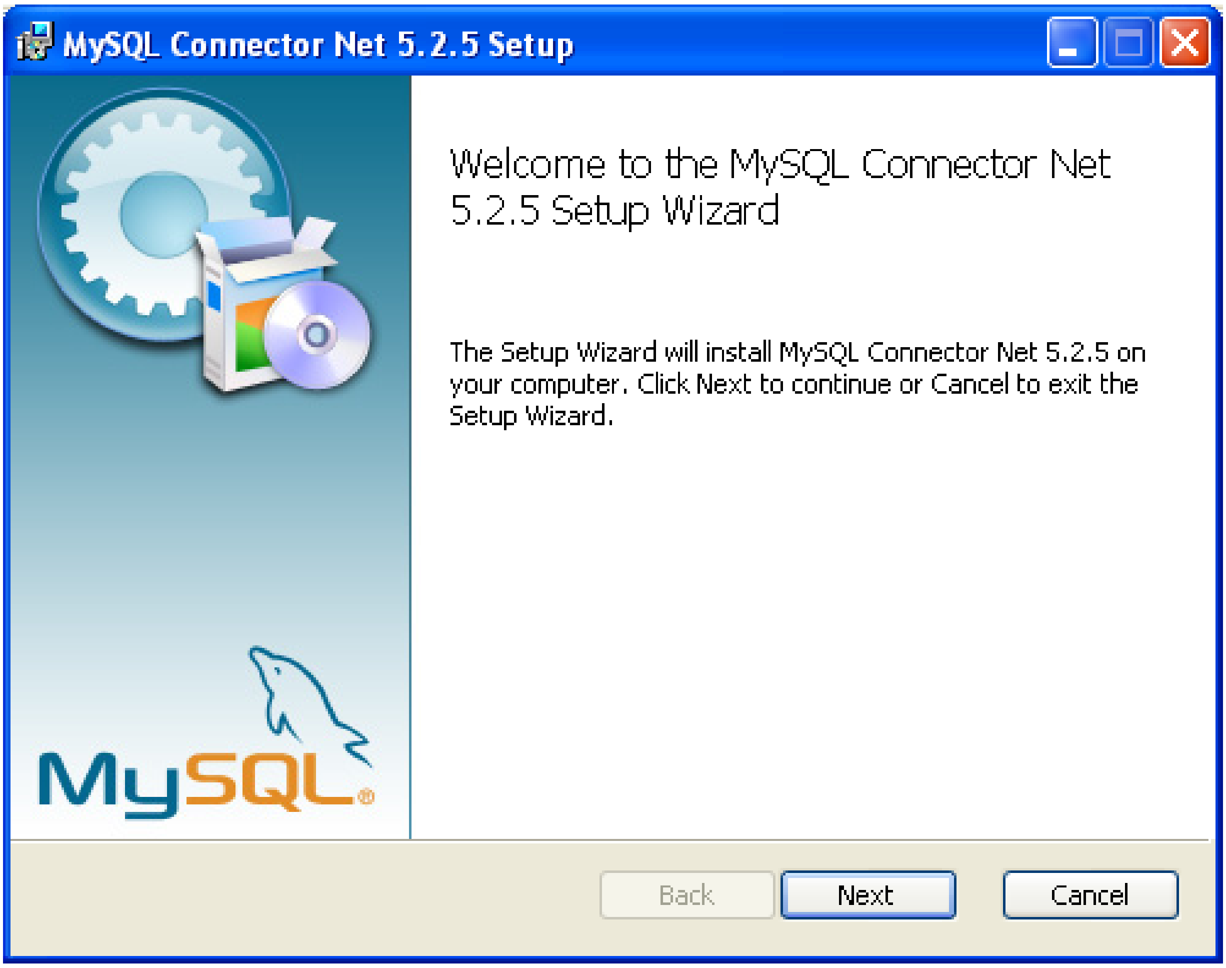
20.2.2.1.1. Installing Connector/Net using the Installer

Using the installer is the most straightforward method of installing Connector/Net on Windows and the installed components include the source code, test code and full reference documentation.

Connector/Net is installed through the use of a Windows Installer (`.msi`) installation package, which can be used to install Connector/Net on all Windows operating systems. The MSI package in contained within a Zip archive named `mysql-connector-net-`*`version`*`.zip`, where *`version`* indicates the Connector/Net version.

To install Connector/Net:

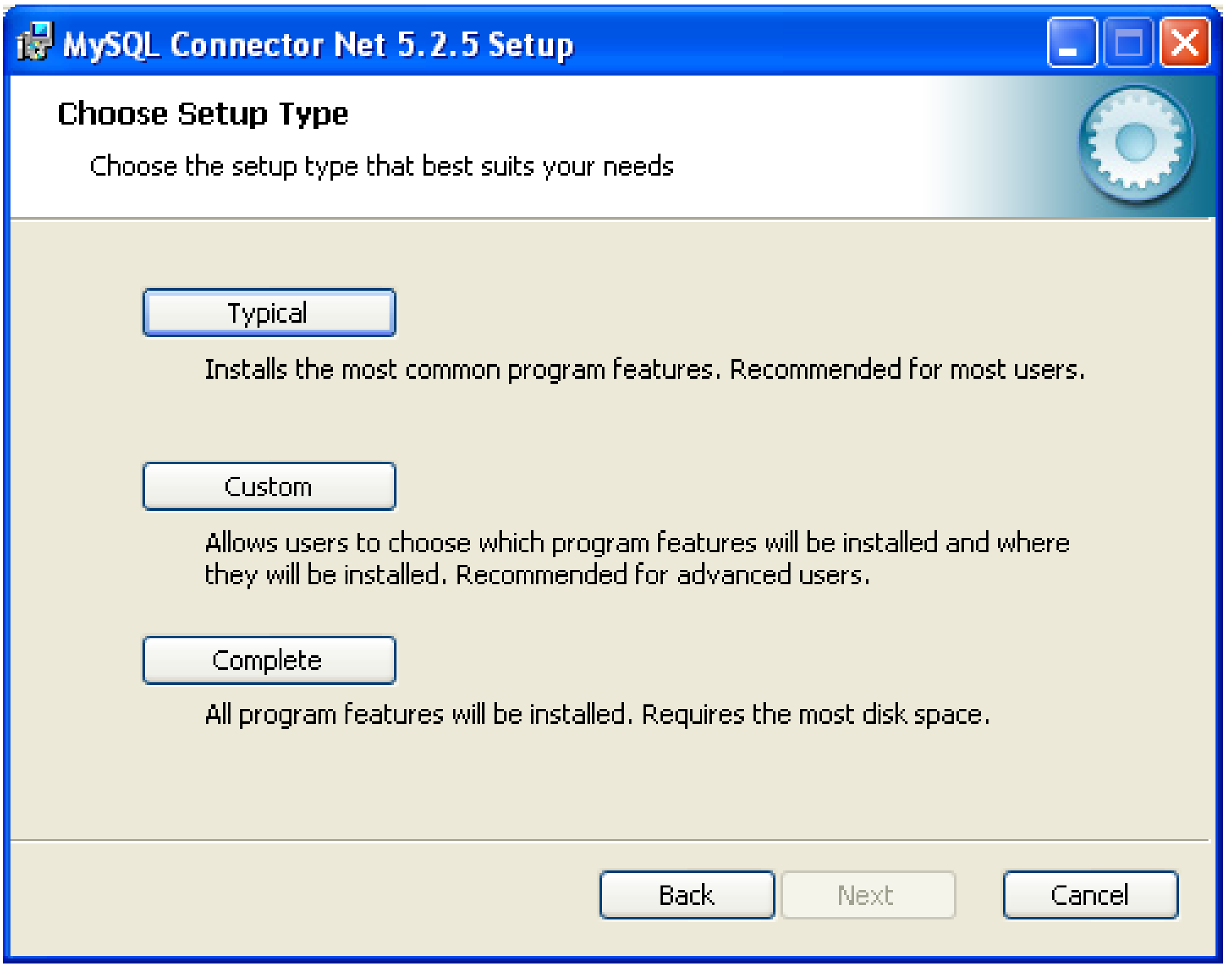
1. Double-click the MSI installer file extracted from the Zip you downloaded. Click NEXT to start the installation.


MySQL Connector Net 5.2.5 Setup
MySQL
Back
Next
Cancel

Welcome to the MySQL Connector Net 5.2.5 Setup Wizard

The Setup Wizard will install MySQL Connector Net 5.2.5 on your computer. Click Next to continue or Cancel to exit the Setup Wizard.

2. You must choose the type of installation that you want to perform.

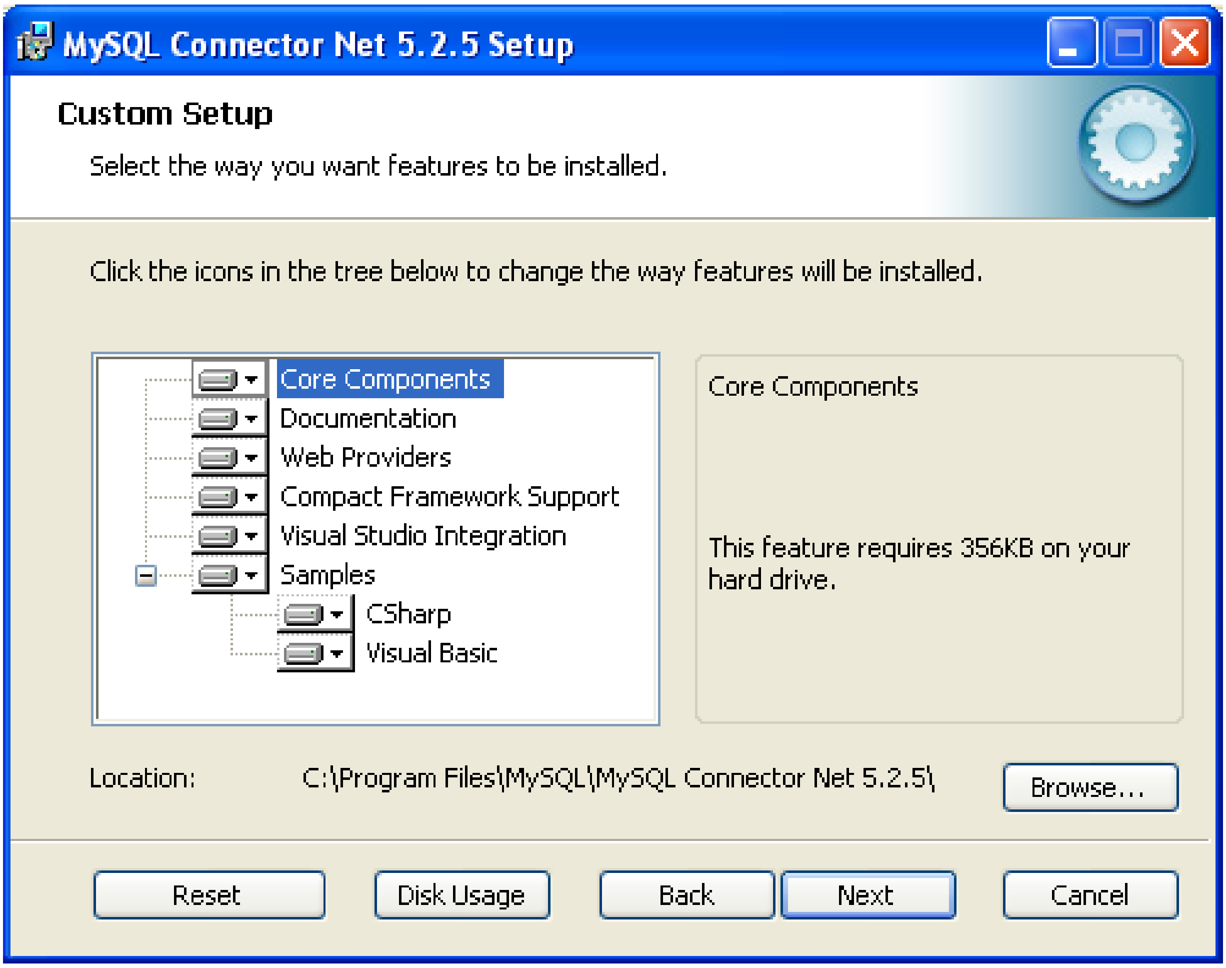

MySQL Connector Net 5.2.5 Setup
Choose Setup Type
Choose the setup type that best suits your needs
Typical
Installs the most common program features. Recommended for most users.
Custom
Allows users to choose which program features will be installed and where they will be installed. Recommended for advanced users.
Complete
All program features will be installed. Requires the most disk space.
Back
Next
Cancel

For most situations, the Typical installation will be suitable. Click the TYPICAL button and proceed to Step 5. A Complete installation installs all the available files. To conduct a Complete installation, click the COMPLETE button and proceed to step 5. If you want to customize your installation, including choosing the components to install and some installation options, click the CUSTOM button and proceed to Step 3.

The Connector/Net installer will register the connector within the Global Assembly Cache (GAC) - this will make the Connector/Net component available to all applications, not just those where you explicitly reference the Connector/Net component. The installer will also create the necessary links in the Start menu to the documentation and release notes.

3. If you have chosen a custom installation, you can select the individual components that you want to install, including the core interface component, supporting documentation (a CHM file) samples and examples and the source code. Select the items, and their installation level, and then click NEXT to continue the installation.

   > **Note**
   >
   > For Connector/Net 1.0.8 or lower and Connector 5.0.4 and lower the installer will attempt to install binaries for both 1.x and 2.x of the .NET Framework. If you only have one version of the framework installed, the connector installation may fail. If this happens, you can choose the framework version to be installed through the custom installation step.



MySQL Connector Net 5.2.5 Setup

Custom Setup

Select the way you want features to be installed.

Click the icons in the tree below to change the way features will be installed.

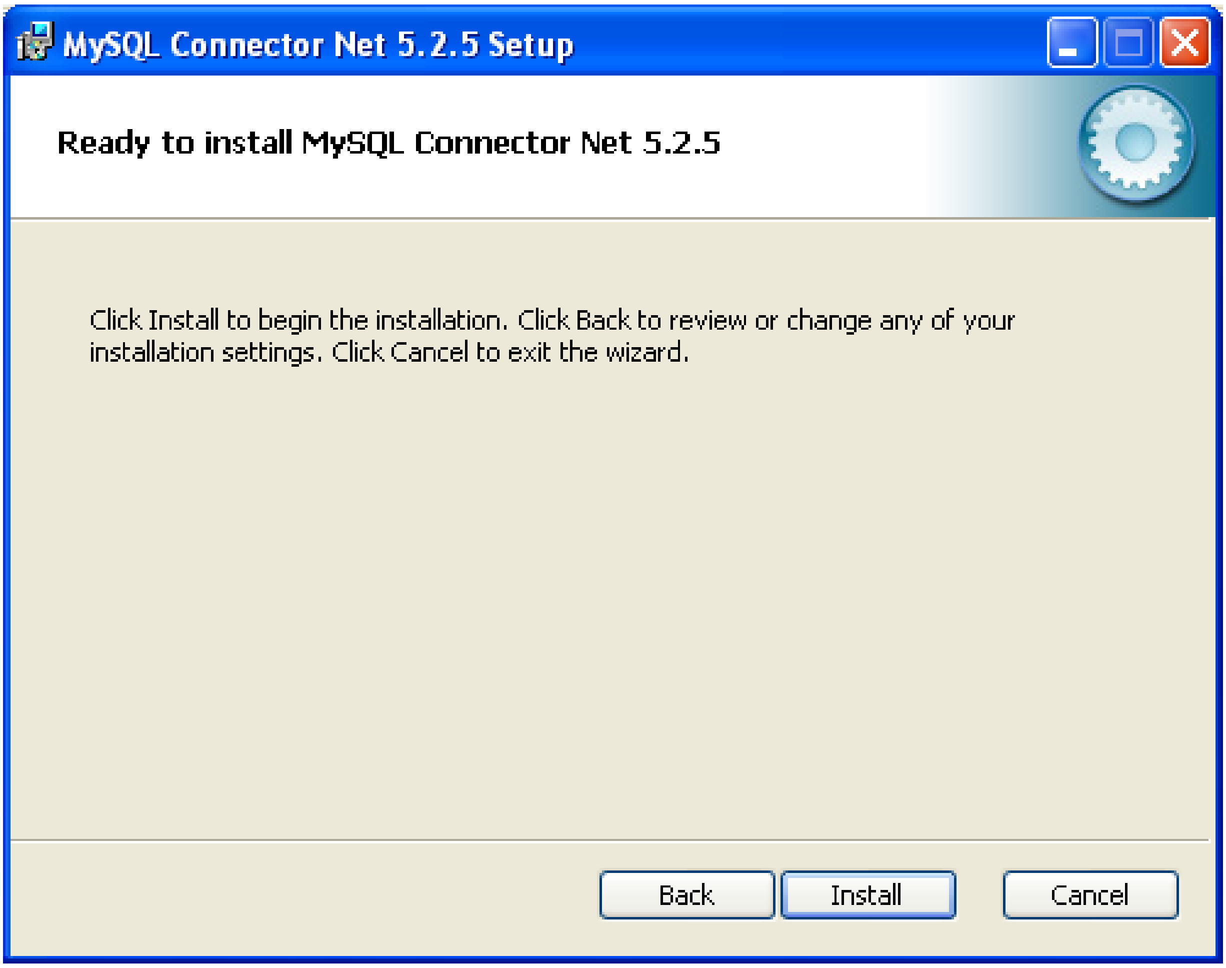
Core Components

This feature requires 356KB on your hard drive.

Location: C:\Program Files\MySQL\MySQL Connector Net 5.2.5\

Core Components
Documentation
Web Providers
Compact Framework Support
Visual Studio Integration
Samples
CSharp
Visual Basic
Browse...
Reset
Disk Usage
Back
Next
Cancel

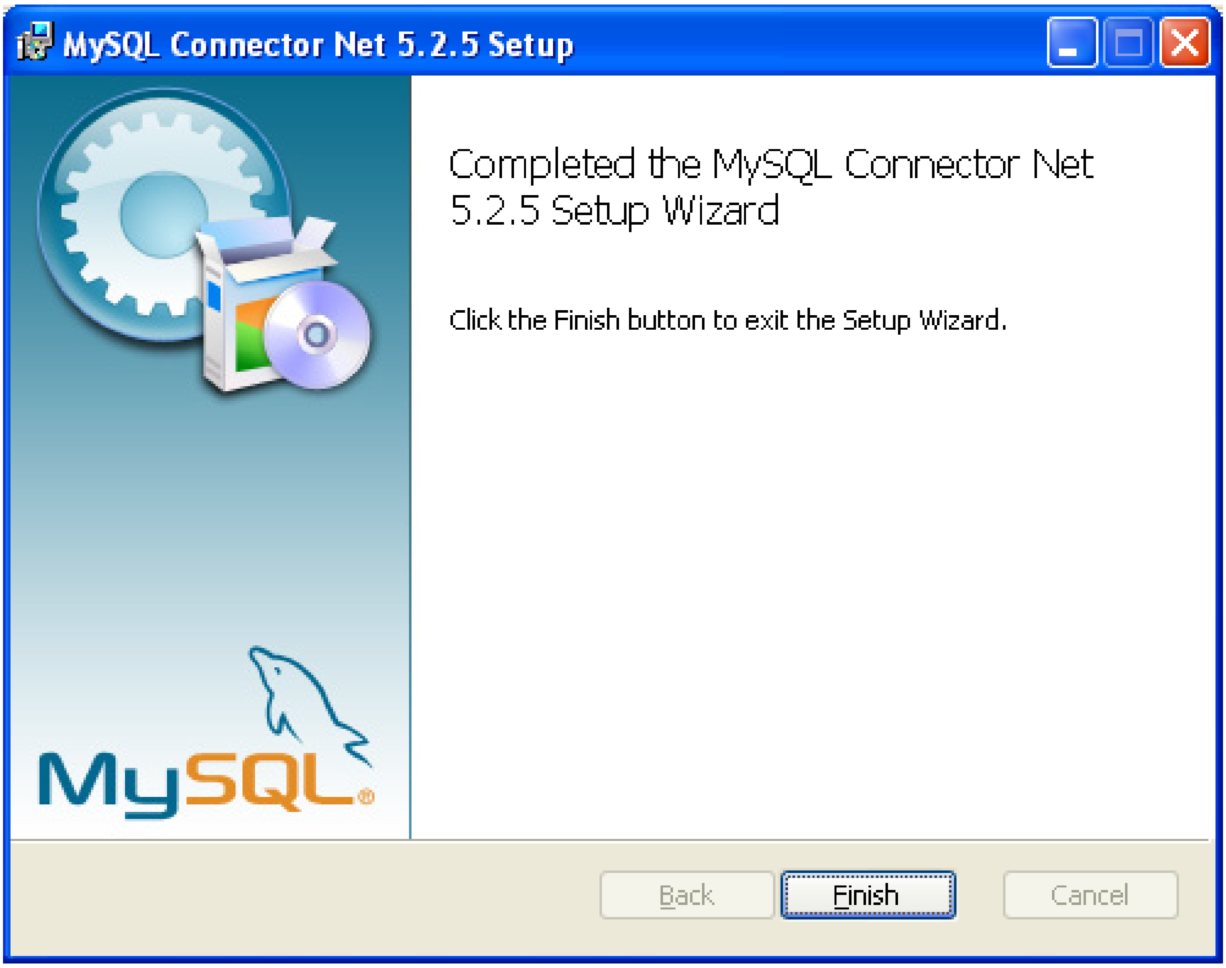
4. You will be given a final opportunity to confirm the installation. Click INSTALL to copy and install the files onto your machine.


MySQL Connector Net 5.2.5 Setup
Ready to install MySQL Connector Net 5.2.5

Click Install to begin the installation. Click Back to review or change any of your installation settings. Click Cancel to exit the wizard.

Back
Install
Cancel

5. Once the installation has been completed, click FINISH to exit the installer.



Completed the MySQL Connector Net 5.2.5 Setup Wizard

Click the Finish button to exit the Setup Wizard.

Unless you choose otherwise, Connector/Net is installed in `C:\Program Files\MySQL\MySQL Connector Net X.X.X`, where *`X.X.X`* is replaced with the version of Connector/Net you are installing. New installations do not overwrite existing versions of Connector/Net.

Depending on your installation type, the installed components will include some or all of the following components:

- `bin`: Connector/Net MySQL libraries for different versions of the .NET environment.
- `docs`: Connector/Net documentation in CHM format.
- `samples`: Sample code and applications that use the Connector/Net component.
- `src`: The source code for the Connector/Net component.

You may also use the `/quiet` or `/q` command-line option with the `msiexec` tool to install the Connector/Net package automatically (using the default options) with no notification to the user. Using this method the user cannot select options. Additionally, no prompts, messages or dialog boxes will be displayed.

```
C:\> msiexec /package connector-net.msi /quiet
```

To provide a progress bar to the user during automatic installation, use the `/passive` option.

20.2.2.1.2. Installing Connector/Net using the Zip packages

If you are having problems running the installer, you can download a Zip file without an installer as an alternative. That file is called `mysql-connector-net-version-noinstall.zip`. Once downloaded, you can extract the files to a location of your choice.

The file contains the following directories:

- `bin`: Connector/Net MySQL libraries for different versions of the .NET environment.
- `Docs`: Connector/Net documentation in CHM format.
- `Samples`: Sample code and applications that use the Connector/Net component.

Connector/Net 6.0.x has a different directory structure:

- `Assemblies`: A collection of DLLs that make up the connector functionality.
- `Documentation`: Connector/Net documentation in CHM format.
- `Samples`: sample code and applications that use the Connector/Net component.

There is also another Zip file available for download called `mysql-connector-net-version-src.zip`. This file contains the source code distribution.

The file contains the following directories:

- `Documentation`: Source files to build the documentation into the compiled HTML (CHM) format.
- `Installer`: Source files to build the Connector/Net installer program.
- `MySql.Data`: Source files for the core data provider.
- `MySql.VisualStudio`: Source files for the Microsoft Visual Studio extensions.
- `MySql.Web`: Source files for the web providers. This includes code for the membership provider, role provider and profile provider. These are used in ASP.NET web sites.
- `Samples`: Source files for several example applications.
- `Tests`: A spreadsheet listing test cases.
- `VisualStudio`: Resources used by the Visual Studio plugin.

Finally, you need to ensure that `MySql.Data.dll` is accessible to your program at build time (and run time). If using Microsoft Visual Studio you will need to add `MySql.Data` as a Reference to your project.

> **Note**
>
> If using MySQL Connector/Net 6.3.5 and above, the `MySql.Data` file provided will work with both .NET Framework 2.x and 4.x.

20.2.2.2. Installing Connector/Net on Unix with Mono

There is no installer available for installing the Connector/Net component on your Unix installation. Before installing, please ensure that you have a working Mono project installation. You can test whether your system has Mono installed by typing:

```
shell> mono --version
```

The version of the Mono JIT compiler will be displayed.

To compile C# source code you will also need to make sure a Mono C# compiler, is installed. Note that there are two Mono C# compilers available, `mcs`, which accesses the 1.0-profile libraries, and `gmcs`, which accesses the 2.0-profile libraries.

To install Connector/Net on Unix/Mono:

1. Download the `mysql-connector-net-version-noinstall.zip` and extract the contents to a directory of your choice, for example: `~/connector-net/`.
2. In the directory where you unzipped the connector to, change into the `bin` directory. Ensure the file `MySql.Data.dll` is present.
3. You must register the Connector/Net component, `MySql.Data`, in the Global Assembly Cache (GAC). In the current direct-

ory enter the `gacutil` command:

```
root-shell> gacutil /i MySql.Data.dll
```

This will register `MySql.Data` into the GAC. You can check this by listing the contents of `/usr/lib/mono/gac`, where you will find `MySql.Data` if the registration has been successful.

You are now ready to compile your application. You must ensure that when you compile your application you include the Connector/Net component using the `-r:` command-line option. For example:

```
shell> gmcs -r:System.dll -r:System.Data.dll -r:MySql.Data.dll HelloWorld.cs
```

Note, the assemblies that need to be referenced will depend on the requirements of the application, but applications using Connector/Net will need to provide `-r:MySql.Data` as a minimum.

You can further check your installation by running the compiled program, for example:

```
shell> mono HelloWorld.exe
```

20.2.2.3. Installing Connector/Net from the source code

> **Caution**
>
> You should read this section only if you are interested in helping us test our new code. If you just want to get Connector/Net up and running on your system, you should use a standard release distribution.

Obtaining the source code

To obtain the most recent development source tree, you first need to download and install Bazaar. You can obtain Bazaar from the Bazaar VCS Website. Bazaar is supported by any platform that supports Python, and is therefore compatible with any Linux, Unix, Windows or Mac OS X host. Instructions for downloading and installing Bazaar on the different platforms are available on the Bazaar Web site.

The most recent development source tree is available from our public Subversion trees at http://dev.mysql.com/tech-resources/sources.html.

To check out out the Connector/Net sources, change to the directory where you want the copy of the Connector/Net tree to be stored, then use the following command:

```
shell> bzr branch lp:connectornet/trunk
```

To download a specific version of Connector/Net, specify the version number instead of `trunk`. For example, to obtain a copy of the 6.0 version of the source tree:

```
shell> bzr branch lp:connectornet/6.0
```

Source packages are also available on the downloads page.

Building the source code on Windows

The following procedure can be used to build the connector on Microsoft Windows.

- Obtain the source code, either from the Subversion server, or through one of the prepared source code packages.
- Navigate to the root of the source code tree.
- A Microsoft Visual Studio 2005 solution file is available to build the connector, this is called `MySQL-VS2005.sln`. Click this file to load the solution into Visual Studio.
- Select BUILD, BUILD SOLUTION from the main menu to build the solution.

Building the source code on Unix

Support for building Connector/Net on Mono/Unix is currently not available.

20.2.3. Connector/Net Visual Studio Integration

When MySQL Connector/Net is installed on Microsoft Windows, Visual Studio integration components are also installed and initialized. This enables the developer to work seamlessly with MySQL Connector/Net in the familiar Visual Studio environment, as described in the following sections of the manual.

MySQL Connector/Net supports Visual Studio versions 2005, 2008, and 2010. However, only MySQL Connector/Net version 6.3 fully integrates with Visual Studio 2010, although applications using earlier versions of the connector can be built with the Visual Studio 2010 environment using .NET 2.x frameworks.

Visual Studio 2010 support was introduced with MySQL Connector/Net 6.3.2. From version 6.3.2 the connector ships with both .NET 2.x and .NET 4.x versions of the entity framework support files, `mysql.data.ef.dll` and `mysql.visualstudio.dll`. The .NET 4.x versions need to be shipped to enable new integration features supported in Visual Studio 2010, including:

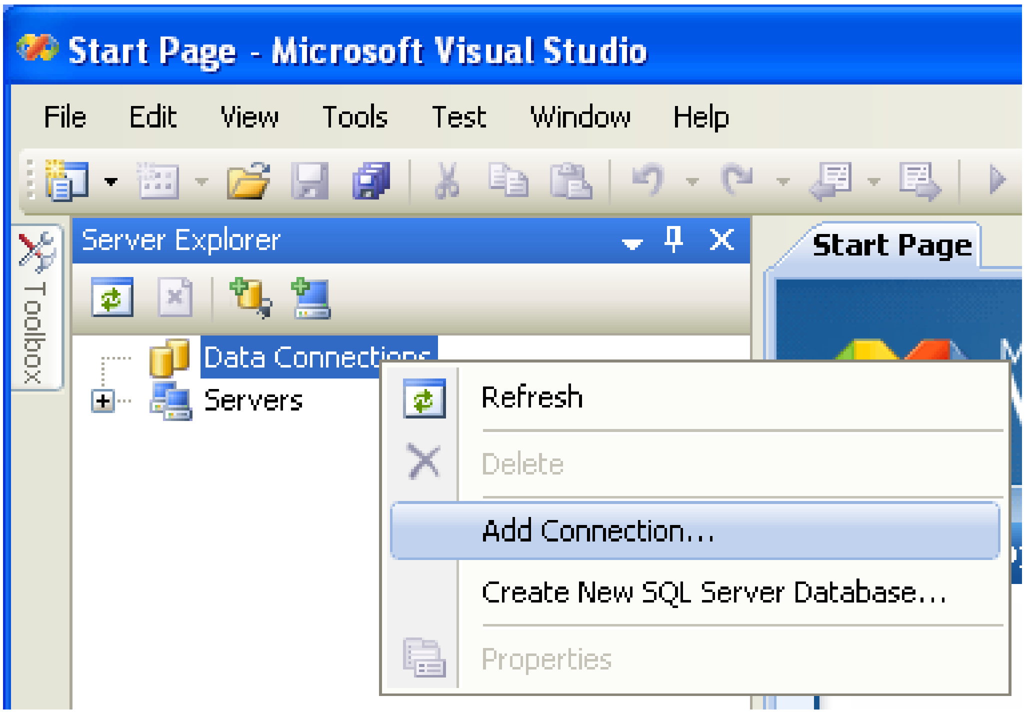
- New DDL T4 template for the Entity Framework (EF) - This enables developers to design an EF model from scratch and use the native Visual Studio 2010 facility to generate MySQL DDL from that model. This is done by creating the model, and with the model open, choosing the SSDLToMySQL template in the properties window. The correct DDL is then generated. The developer can then save this code as a `.mysql` file in their project and execute it against the MySQL server.
- New SQL Editor - A new SQL editor has been included that enables connections to servers to execute SQL. This is activated by creating a new file with a `.mysql` extension. A new template is also included to allow creation of this file type using the Visual Studio 2010 main menu item FILE, NEW. Note that the MySQL SQL Editor is also available in 2005 and 2008.

20.2.3.1. Making a connection

Once the connector is installed, you can use it to create, modify, and delete connections to MySQL databases. To create a connection with a MySQL database, perform the following steps:

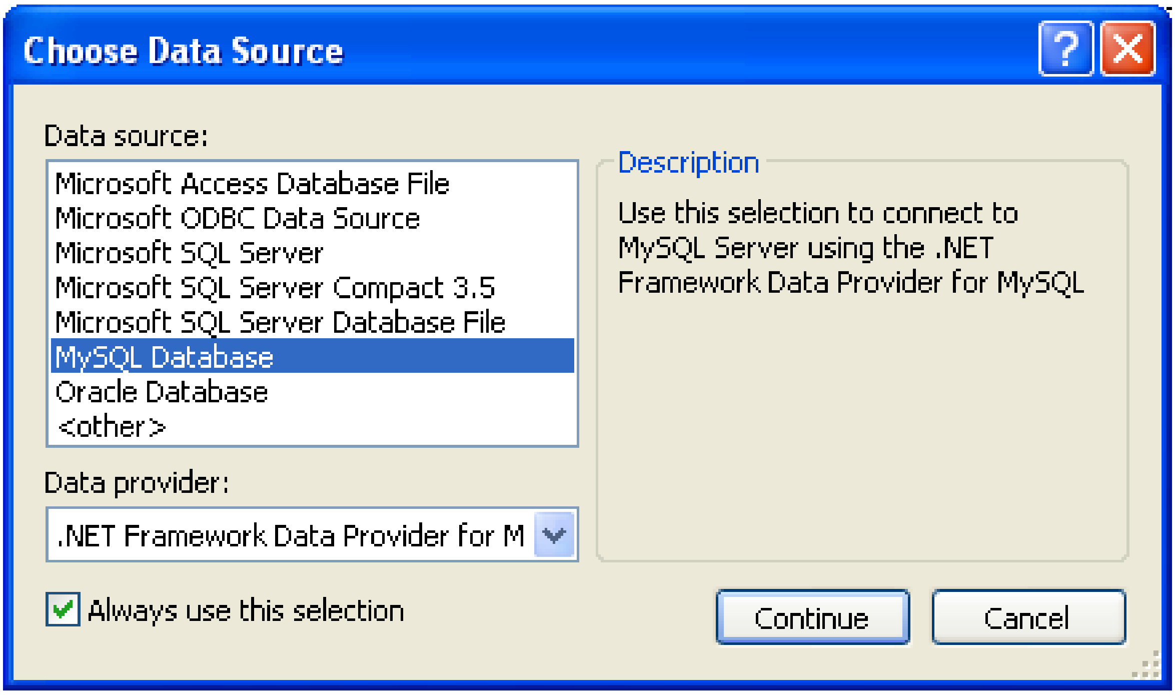
- Start Visual Studio, and open the Server Explorer window (VIEW, SERVER EXPLORER option in the main Visual Studio menu, or **Control+W**, **L** keyboard shortcuts).
- Right-click the Data Connections node, and choose the ADD CONNECTION... menu item.
- Add Connection dialog opens. Press the CHANGE button to choose MySQL Database as a data source.

Figure 20.1. Add Connection Context Menu



- Change Data Source dialog opens. Choose MySQL Database in the list of data sources (or the `<other>` option, if MySQL Database is absent), and then choose .NET Framework Data Provider for MySQL in the combo box of data providers.

Figure 20.2. Choose Data Source



Choose Data Source
?
Data source:
Microsoft Access Database File
Microsoft ODBC Data Source
Microsoft SQL Server
Microsoft SQL Server Compact 3.5
Microsoft SQL Server Database File
MySQL Database
Oracle Database
<other>
Data provider:
Description
Continue
Cancel

Data source: MySQL Database

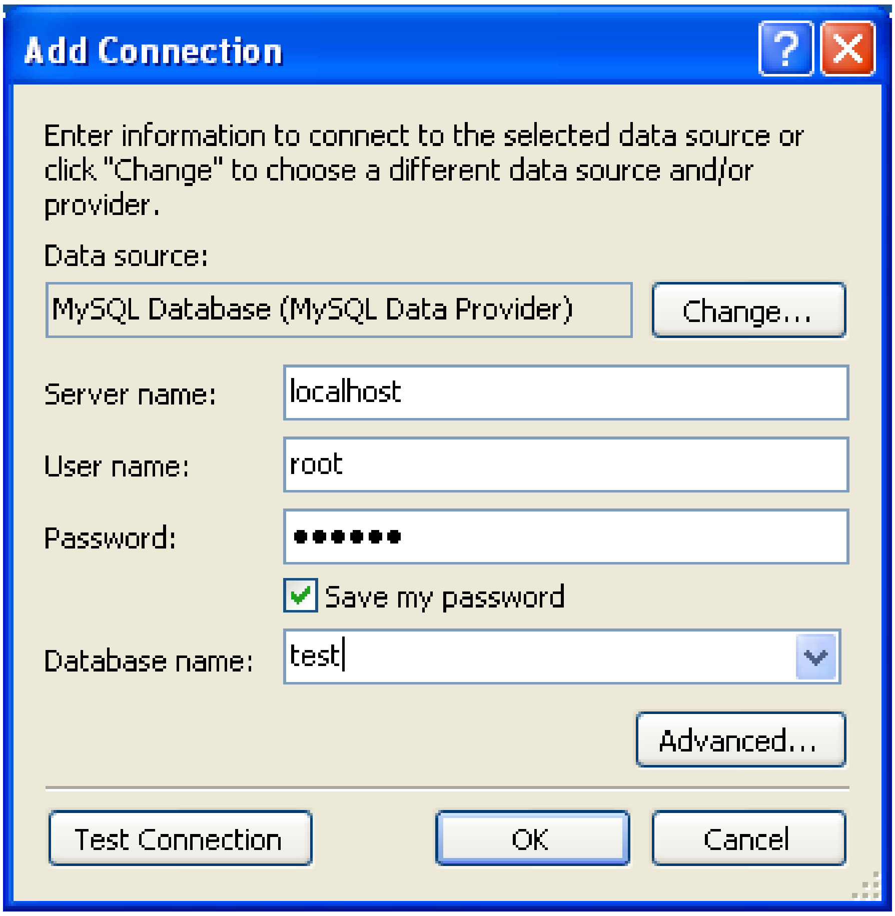
Data provider: .NET Framework Data Provider for M

Use this selection to connect to MySQL Server using the .NET Framework Data Provider for MySQL

☑ Always use this selection

- Input the connection settings: the server host name (for example, localhost if the MySQL server is installed on the local machine), the user name, the password, and the default schema name. Note that you must specify the default schema name to open the connection.

Figure 20.3. Add Connection Dialog


Add Connection
Enter information to connect to the selected data source or click "Change" to choose a different data source and/or provider.
Data source:
Change...
Advanced...
Test Connection
OK
Cancel

Data source: MySQL Database (MySQL Data Provider)

Server name: localhost

User name: root

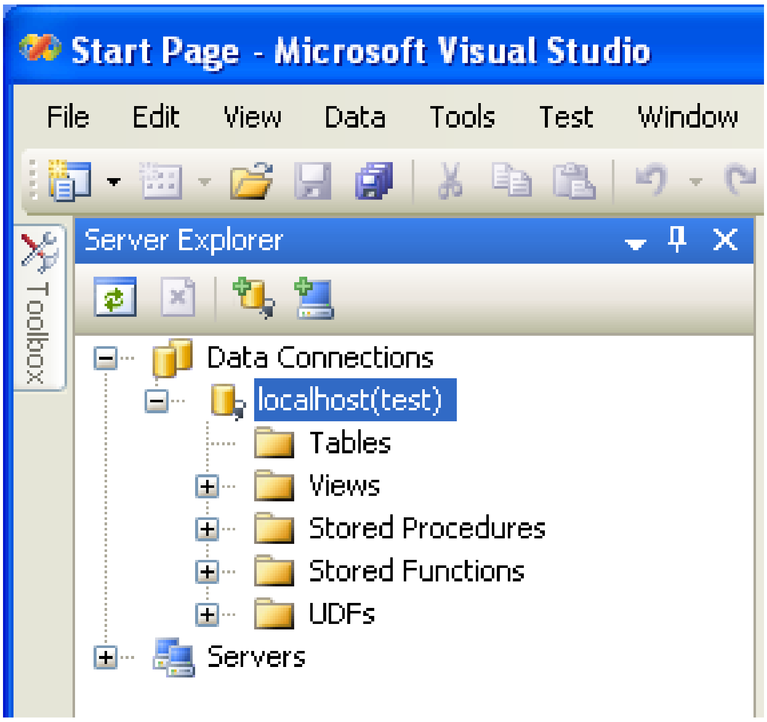
Password: ●●●●●●

☑ Save my password

Database name: test

- You can also set the port to connect with the MySQL server by pressing the ADVANCED button. To test connection with the MySQL server, set the server host name, the user name, and the password, and press the TEST CONNECTION button. If the test succeeds, the success confirmation dialog opens.
- After you set all settings and test the connection, press OK. The newly created connection is displayed in Server Explorer. Now you can work with the MySQL server through standard Server Explorer GUI.

Figure 20.4. New Data Connection


Start Page - Microsoft Visual Studio
File
Edit
View
Data
Tools
Test
Window
Toolbox
Server Explorer
Data Connections
localhost(test)
Tables
Views
Stored Procedures
Stored Functions
UDFs
Servers

After the connection is successfully established, all settings are saved for future use. When you start Visual Studio for the next time, just open the connection node in Server Explorer to establish a connection to the MySQL server again.

To modify and delete a connection, use the Server Explorer context menu for the corresponding node. You can modify any of the settings just by overwriting the existing values with new ones. Note that the connection may be modified or deleted only if no active editor for its objects is opened: otherwise you may loose your data.

20.2.3.2. Editing Tables

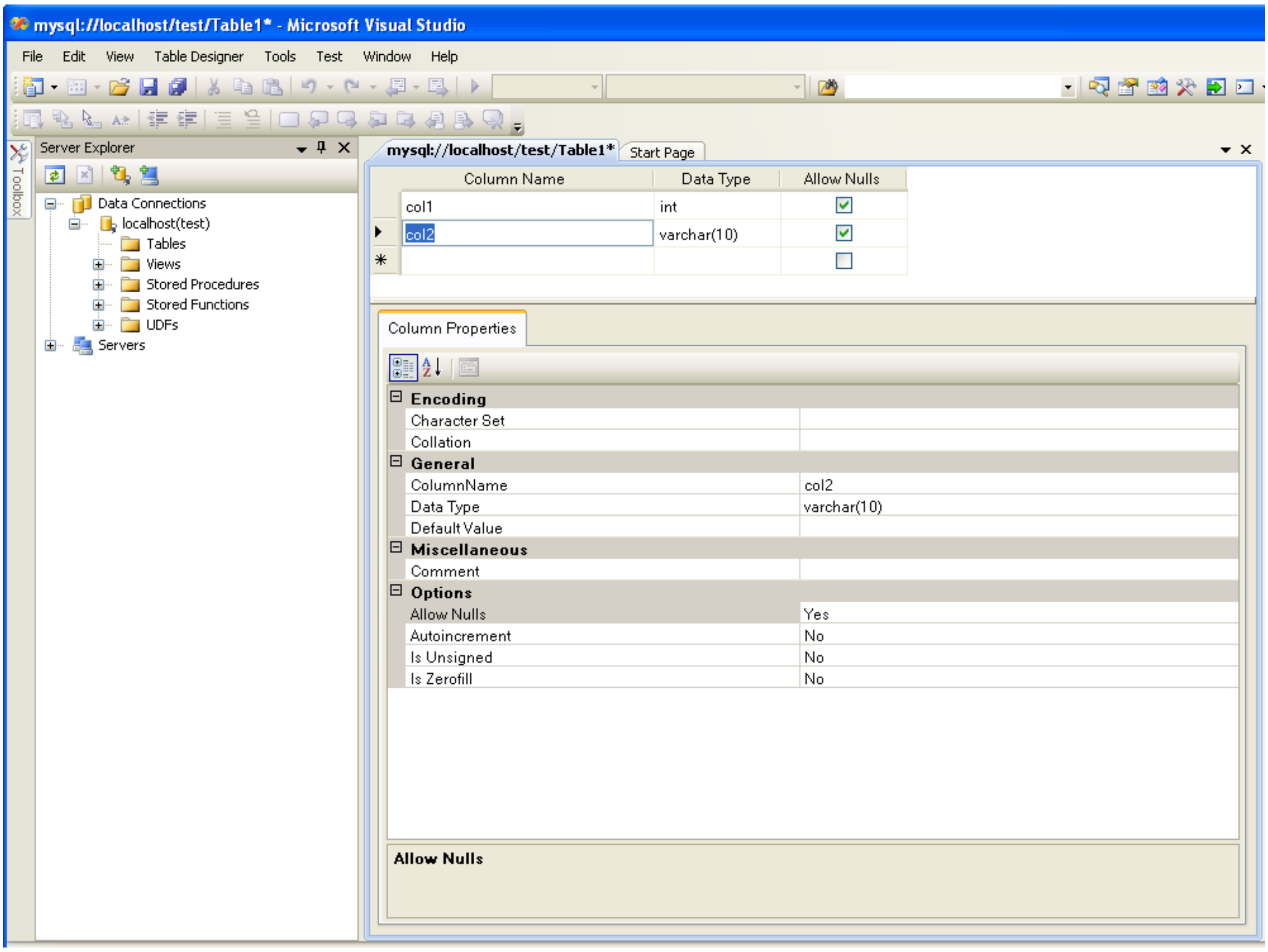
Connector/Net contains a table editor, which enables the visual creation and modification of tables.

The Table Designer can be accessed through a mouse action on table-type node of Server Explorer. To create a new table, right-click the **TABLES** node (under the connection node) and choose the CREATE TABLE command from the context menu.

To modify an existing table, double-click the node of the table you wish to modify, or right-click this node and choose the DESIGN item from the context menu. Either of the commands opens the Table Designer.

The table editor is implemented in the manner of the well-known Query Browser Table Editor, but with minor differences.

Figure 20.5. Editing New Table


mysql://localhost/test/Table1* - Microsoft Visual Studio
File
Edit
View
Table Designer
Tools
Test
Window
Help
Toolbox
Server Explorer
Data Connections
localhost(test)
Tables
Views
Stored Procedures
Stored Functions
UDFs
Servers
mysql://localhost/test/Table1*
Start Page
Column Properties

Column Name	Data Type	Allow Nulls
col1	int	☑
col2	varchar(10)	☑
		☐

Encoding	
Character Set	
Collation	
General	
ColumnName	col2
Data Type	varchar(10)
Default Value	
Miscellaneous	
Comment	
Options	
Allow Nulls	Yes
Autoincrement	No
Is Unsigned	No
Is Zerofill	No

Allow Nulls

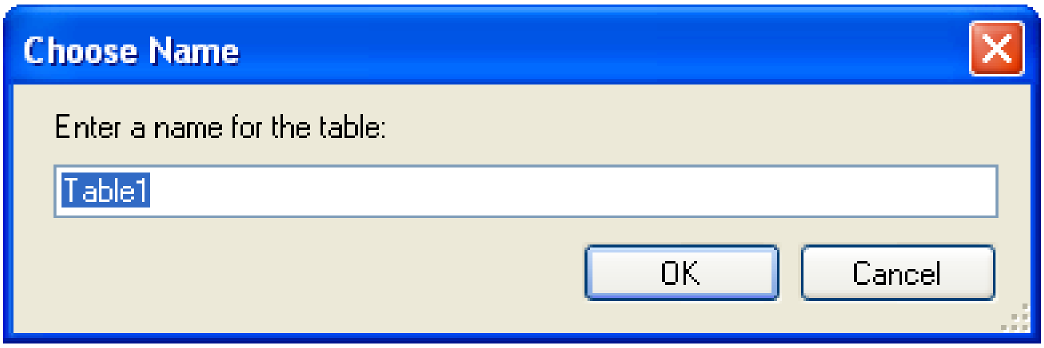
Table Designer consists of the following parts:

- Columns Editor - a data grid on top of the Table Designer. Use the Columns grid for column creation, modification, and deletion.
- Indexes tab - a tab on bottom of the Table Designer. Use the Indexes tab for indexes management.
- Foreign Keys tab - a tab on bottom of the Table Designer. Use the Foreign Keys tab for foreign keys management.
- Column Details tab - a tab on bottom of the Table Designer. Use the Column Details tab to set advanced column options.
- Properties window - a standard Visual Studio Properties window, where the properties of the edited table are displayed. Use the Properties window to set the table properties.

Each of these areas is discussed in more detail in subsequent sections.

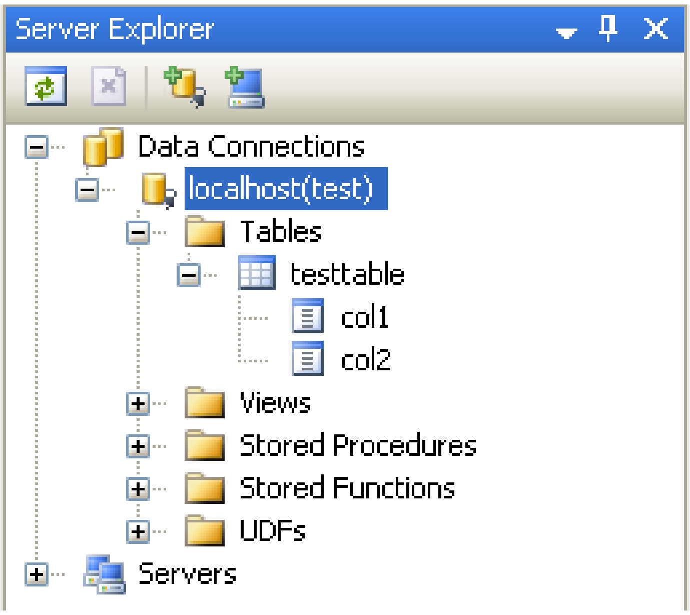
To save changes you have made in the Table Designer, use either SAVE or SAVE ALL button of the Visual Studio main toolbar, or just press **Control+S**. If you have not already named the table you will be prompted to do so.

Figure 20.6. Choose Table Name


Choose Name
Enter a name for the table:
Table1
OK
Cancel

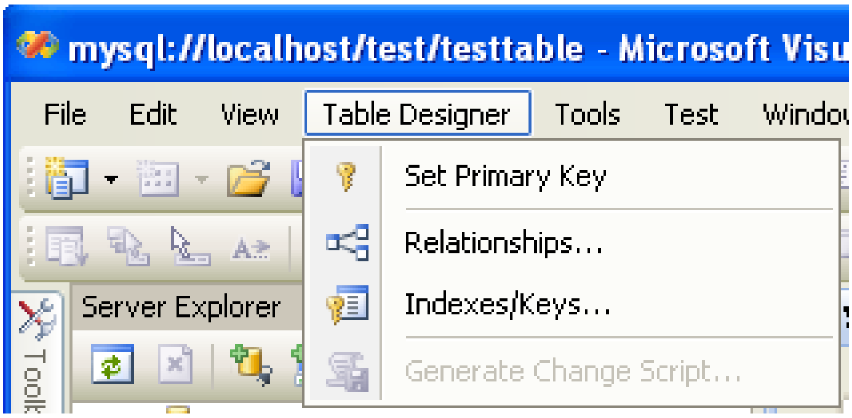
Once created you can view the table in the Server Explorer.

Figure 20.7. Newly Created Table


Server Explorer
Data Connections
localhost(test)
Tables
testtable
col1
col2
Views
Stored Procedures
Stored Functions
UDFs
Servers

The Table Designer main menu enables you to set a Primary Key column, edit Relationships such as Foreign Keys, and create Indexes.

Figure 20.8. Table Designer Main Menu


mysql://localhost/test/testtable - Microsoft Visu
File
Edit
View
Table Designer
Tools
Test
Windo
Set Primary Key
Relationships...
Indexes/Keys...
Generate Change Script...
Server Explorer
Toolb

20.2.3.2.1. Column Editor

You can use the Column Editor to set or change the name, data type, default value, and other properties of a table column. To set the focus to a needed cell of a grid, use the mouse click. Also you can move through the grid using **Tab** and **Shift**+**Tab** keys.

To set or change the name, data type, default value and comment of a column, activate the appropriate cell and type the desired value.

To set or unset flag-type column properties (`NOT NULL`, auto incremented, flags), check or uncheck the corresponding check boxes. Note that the set of column flags depends on its data type.

To reorder columns, index columns or foreign key columns in the Column Editor, select the whole column you wish to reorder by clicking the selector column on the left of the column grid. Then move the column by using **Control+Up** (to move the column up) or **Control+Down** (to move the column down) keys.

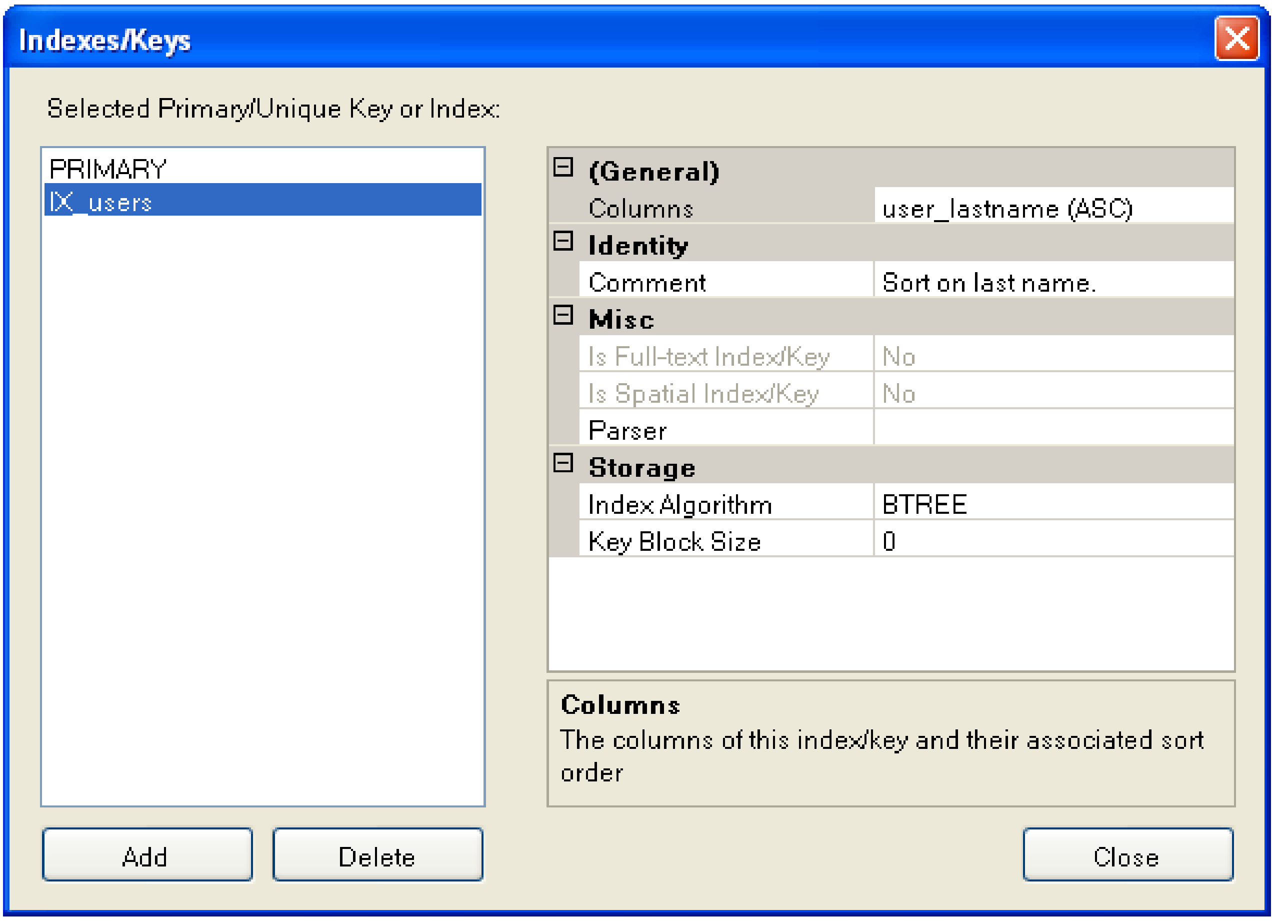
To delete a column, select it by clicking the selector column on the left of the column grid, then press the **Delete** button on a keyboard.

20.2.3.2.2. Editing Indexes

Indexes management is performed using the **Indexes/Keys** dialog.

To add an index, select Table Designer, Indexes/Keys... from the main menu, and click Add to add a new index. You can then set the index name, index kind, index type, and a set of index columns.

Figure 20.9. Indexes Dialog



(General)	
Columns	user_lastname (ASC)
Identity	
Comment	Sort on last name.
Misc	
Is Full-text Index/Key	No
Is Spatial Index/Key	No
Parser	
Storage	
Index Algorithm	BTREE
Key Block Size	0

Columns

The columns of this index/key and their associated sort order

To remove an index, select it in the list box on the left, and click the Delete button.

To change index settings, select the needed index in the list box on the left. The detailed information about the index is displayed in the panel on the right hand side. Change the desired values.

20.2.3.2.3. Editing Foreign Keys

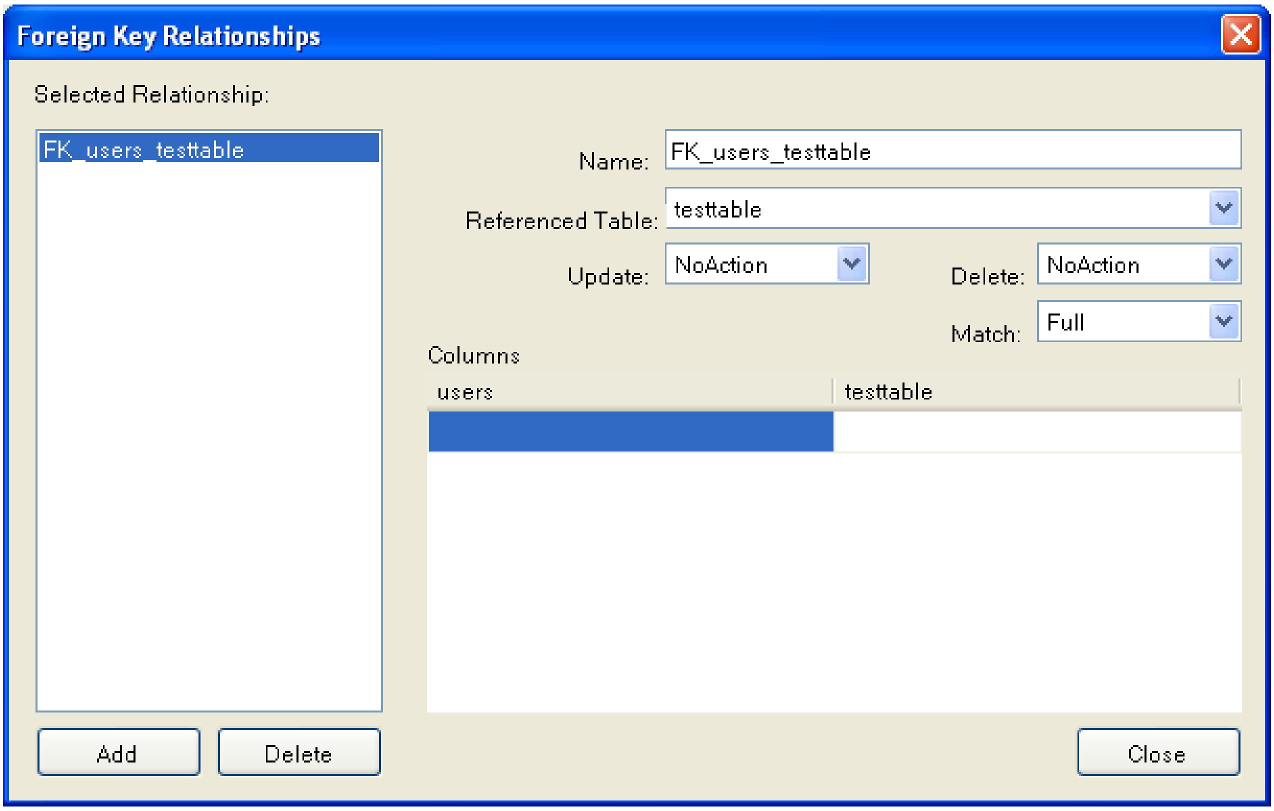
Foreign Keys management is performed using the **Foreign Key Relationships** dialog.

To add a foreign key, select Table Designer, Relationships... from the main menu. This displays the **Foreign Key Relationship** dialog. Click Add. You can then set the foreign key name, referenced table name, foreign key columns, and actions upon update and delete.

To remove a foreign key, select it in the list box on the left, and click the Delete button.

To change foreign key settings, select the required foreign key in the list box on the left. The detailed information about the foreign key is displayed in the right hand panel. Change the desired values.

Figure 20.10. Foreign Key Relationships Dialog



Selected Relationship: FK_users_testtable

Name: FK_users_testtable

Referenced Table: testtable

Update: NoAction

Delete: NoAction

Match: Full

users	testtable

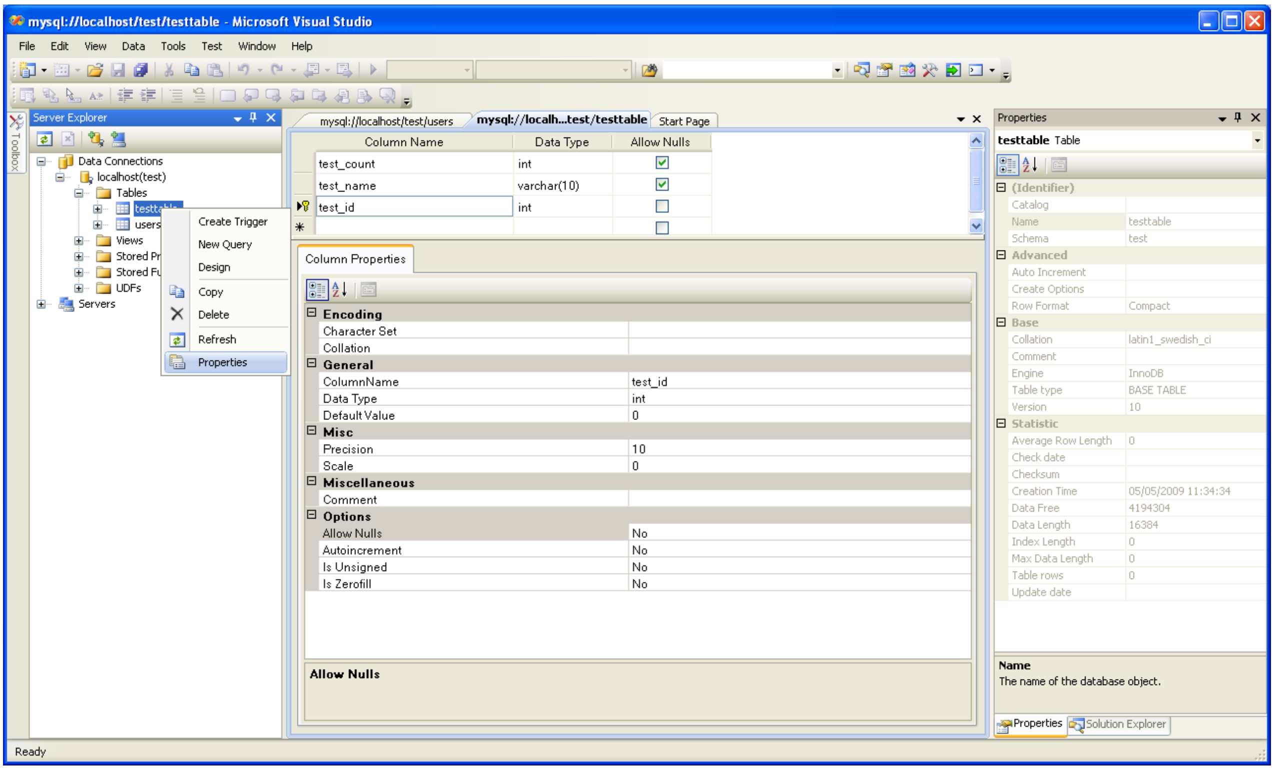
20.2.3.2.4. Column Properties

The **Column Properties** tab can be used to set column options. In addition to the general column properties presented in the Column Editor, in the **Column Properties** tab you can set additional properties such as Character Set, Collation and Precision.

20.2.3.2.5. Table Properties

To bring up Table Properties select the table and right-click to activate the context menu. Select Properties. The **Table Properties** dockable window will be displayed.

Figure 20.11. Table Properties Menu Item


mysql://localhost/test/testtable - Microsoft Visual Studio
File
Edit
View
Data
Tools
Test
Window
Help
Server Explorer
Data Connections
localhost(test)
Tables
testtable
users
Views
Stored Pr
Stored Fu
UDFs
Servers
Create Trigger
New Query
Design
Copy
Delete
Refresh
Properties
mysql://localhost/test/users
mysql://localh...test/testtable
Start Page
Column Properties
Properties
Solution Explorer
Toolbox
Ready

Column Name	Data Type	Allow Nulls
test_count	int	☑
test_name	varchar(10)	☑
test_id	int	☐
		☐

Encoding	
Character Set	
Collation	
General	
ColumnName	test_id
Data Type	int
Default Value	0
Misc	
Precision	10
Scale	0
Miscellaneous	
Comment	
Options	
Allow Nulls	No
Autoincrement	No
Is Unsigned	No
Is Zerofill	No

Allow Nulls

testtable Table

(Identifier)	
Catalog	
Name	testtable
Schema	test
Advanced	
Auto Increment	
Create Options	
Row Format	Compact
Base	
Collation	latin1_swedish_ci
Comment	
Engine	InnoDB
Table type	BASE TABLE
Version	10
Statistic	
Average Row Length	0
Check date	
Checksum	
Creation Time	05/05/2009 11:34:34
Data Free	4194304
Data Length	16384
Index Length	0
Max Data Length	0
Table rows	0
Update date	

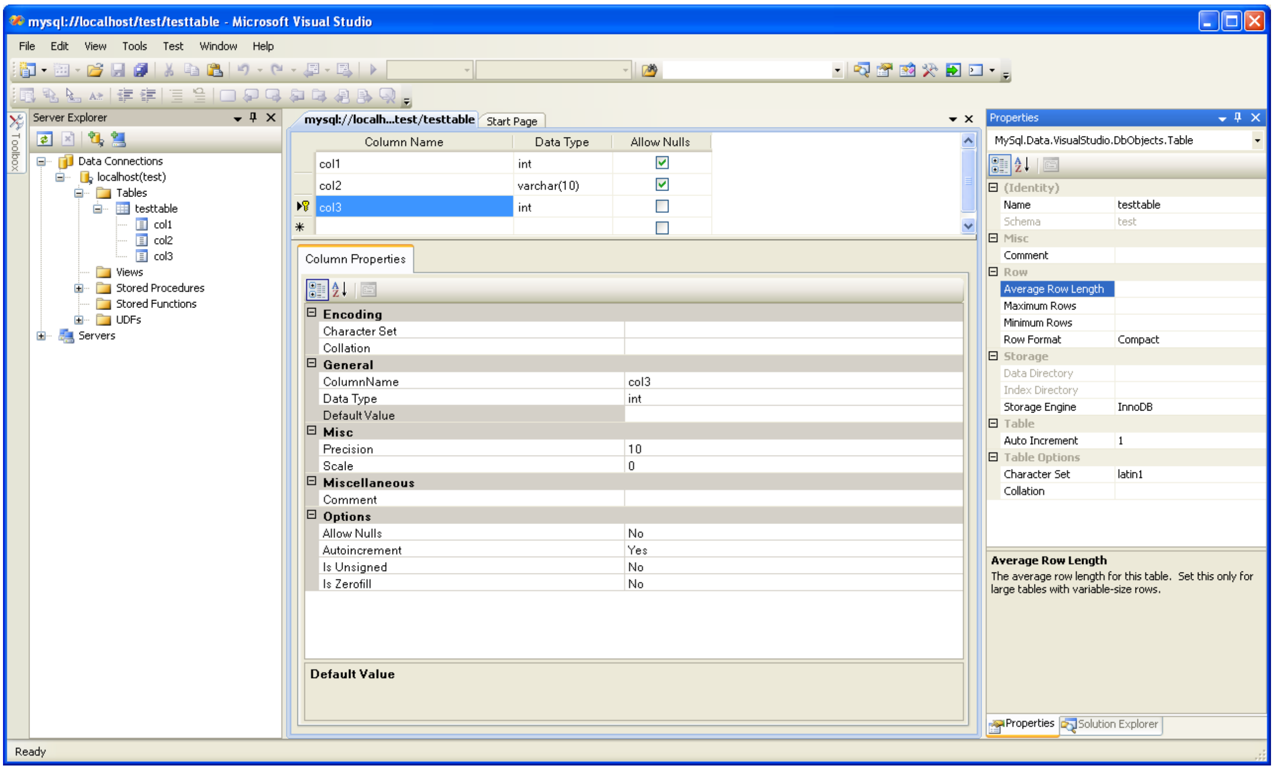
Name
The name of the database object.

The following table properties can be set:

- Auto Increment
- Average Row Length
- Character Set
- Collation
- Comment
- Data Directory
- Index Directory
- Maximum Rows
- Minimum Rows
- Name
- Row Format
- Schema
- Storage Engine

The property `Schema` is read only.

Figure 20.12. Table Properties


mysql://localhost/test/testtable - Microsoft Visual Studio
File Edit View Tools Test Window Help
Server Explorer
Data Connections
localhost(test)
Tables
testtable
col1
col2
col3
Views
Stored Procedures
Stored Functions
UDFs
Servers
mysql://localh...test/testtable
Start Page
Column Properties
Properties
Solution Explorer
Ready

Column Name	Data Type	Allow Nulls
col1	int	☑
col2	varchar(10)	☑
col3	int	☐
		☐

Encoding	
Character Set	
Collation	
General	
ColumnName	col3
Data Type	int
Default Value	
Misc	
Precision	10
Scale	0
Miscellaneous	
Comment	
Options	
Allow Nulls	No
Autoincrement	Yes
Is Unsigned	No
Is Zerofill	No

Default Value

MySql.Data.VisualStudio.DbObjects.Table

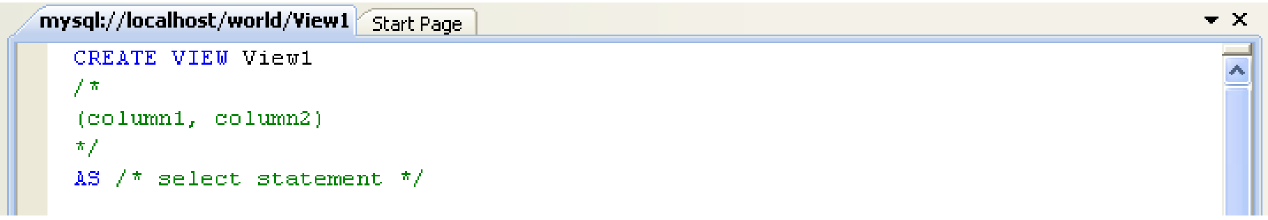
(Identity)	
Name	testtable
Schema	test
Misc	
Comment	
Row	
Average Row Length	
Maximum Rows	
Minimum Rows	
Row Format	Compact
Storage	
Data Directory	
Index Directory	
Storage Engine	InnoDB
Table	
Auto Increment	1
Table Options	
Character Set	latin1
Collation	

Average Row Length
The average row length for this table. Set this only for large tables with variable-size rows.

20.2.3.3. Editing Views

To create a new view, right-click the Views node under the connection node in Server Explorer. From the node's context menu, choose the CREATE VIEW command. This command opens the SQL Editor.

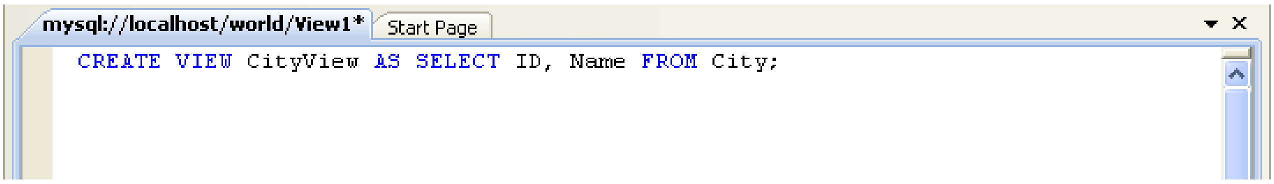
Figure 20.13. Editing View SQL


mysql://localhost/world/View1
Start Page

```
CREATE VIEW View1
/*
(column1, column2)
*/
AS /* select statement */
```

You can then enter the SQL for your view.

Figure 20.14. View SQL Added


mysql://localhost/world/View1*
Start Page

```
CREATE VIEW CityView AS SELECT ID, Name FROM City;
```

To modify an existing view, double-click a node of the view you wish to modify, or right-click this node and choose the ALTER VIEW command from a context menu. Either of the commands opens the SQL Editor.

All other view properties can be set in the Properties window. These properties are:

- Catalog
- Check Option

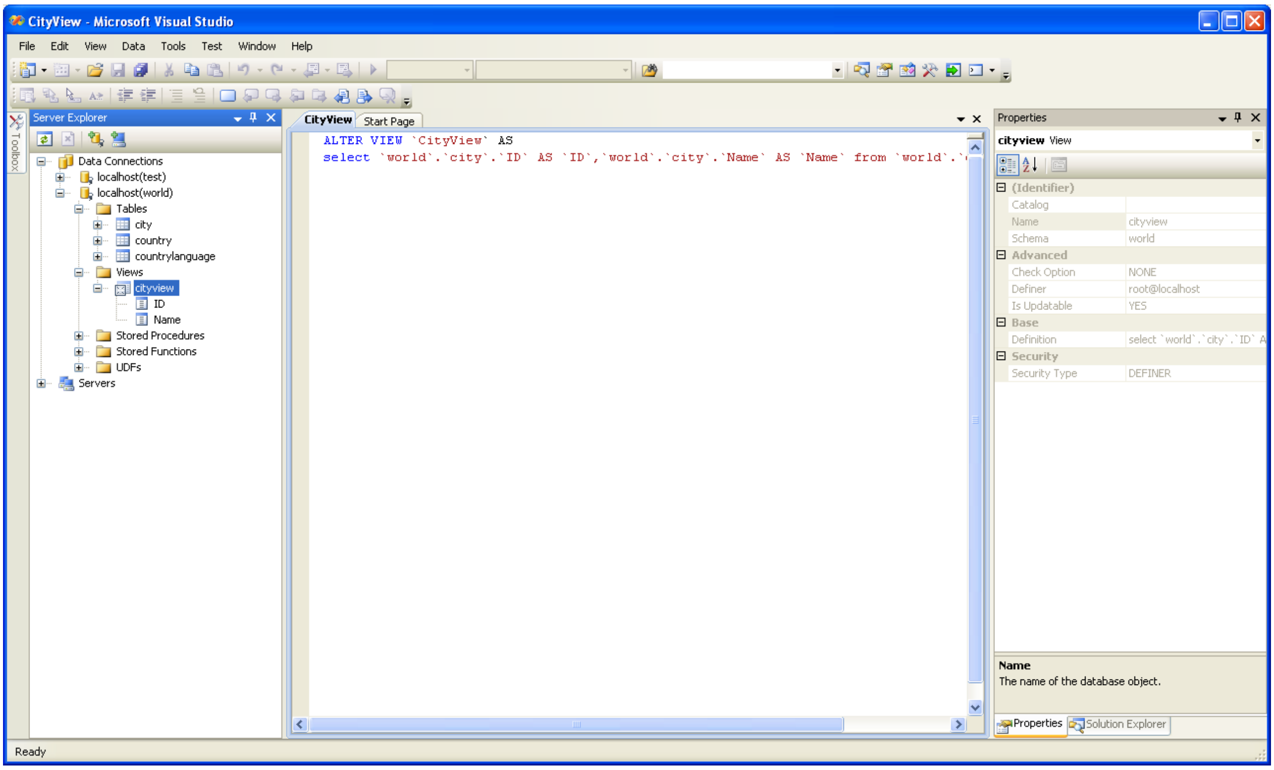
- Definer
- Definition
- Definer
- Is Updateable
- Name
- Schema
- Security Type

Some of these properties can have arbitrary text values, others accept values from a predefined set. In the latter case you set the desired value with an embedded combobox.

The properties `Is Updatable` and `Schema` are readonly.

To save changes you have made, use either SAVE or SAVE ALL buttons of the Visual Studio main toolbar, or just press **Control+S**.

Figure 20.15. View SQL Saved


CityView - Microsoft Visual Studio
File
Edit
View
Data
Tools
Test
Window
Help
Toolbox
Server Explorer
Data Connections
localhost(test)
localhost(world)
Tables
city
country
countrylanguage
Views
cityview
ID
Name
Stored Procedures
Stored Functions
UDFs
Servers
CityView
Start Page
Properties
cityview View
Name
The name of the database object.
Properties
Solution Explorer
Ready

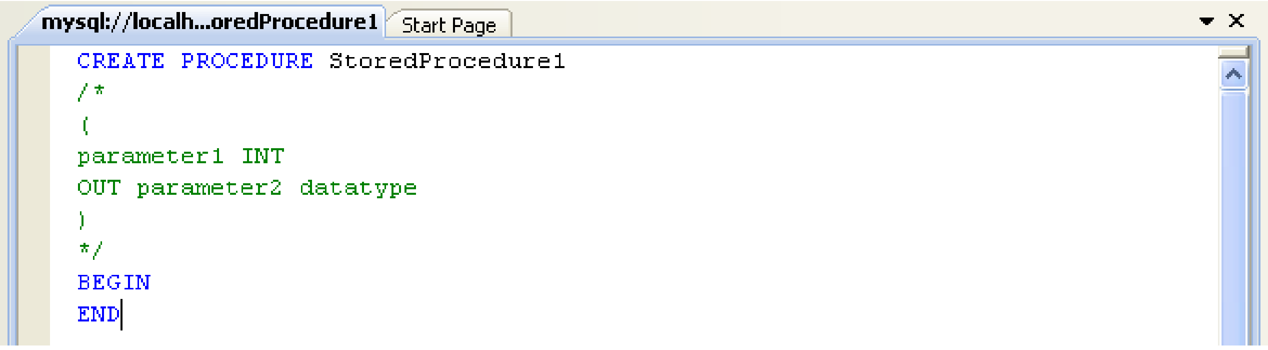
```
ALTER VIEW `CityView` AS
select `world`.`city`.`ID` AS `ID`,`world`.`city`.`Name` AS `Name` from `world`.`
```

(Identifier)	
Catalog	
Name	cityview
Schema	world
Advanced	
Check Option	NONE
Definer	root@localhost
Is Updatable	YES
Base	
Definition	select `world`.`city`.`ID` A
Security	
Security Type	DEFINER

20.2.3.4. Editing Stored Procedures and Functions

To create a new stored procedure, right-click the **STORED PROCEDURES** node under the connection node in Server Explorer. From the node's context menu, choose the **CREATE ROUTINE** command. This command opens the SQL Editor.

Figure 20.16. Edit Stored Procedure SQL



```
CREATE PROCEDURE StoredProcedure1
/*
(
parameter1 INT
OUT parameter2 datatype
)
*/
BEGIN
END
```

To create a new stored function, right-click the **Functions** node under the connection node in Server Explorer. From the node's context menu, choose the **Create Routine** command.

To modify an existing stored routine (procedure or function), double-click the node of the routine you wish to modify, or right-click this node and choose the **Alter Routine** command from the context menu. Either of the commands opens the SQL Editor.

To create or alter the routine definition using SQL Editor, type this definition in the SQL Editor using standard SQL. All other routine properties can be set in the Properties window. These properties are:

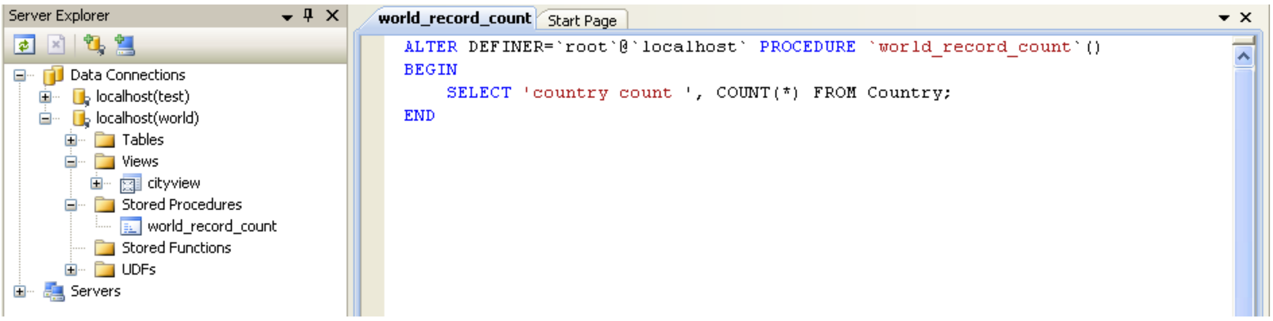
- Body
- Catalog
- Comment
- Creation Time
- Data Access
- Definer
- Definition
- External Name
- External Language
- Is Deterministic
- Last Modified
- Name
- Parameter Style
- Returns
- Schema
- Security Type
- Specific Name
- SQL Mode
- SQL Path
- Type

Some of these properties can have arbitrary text values, others accept values from a predefined set. In the latter case set the desired value using the embedded combo box.

You can also set all the options directly in the SQL Editor, using the standard `CREATE PROCEDURE` or `CREATE FUNCTION` statement. However, it is recommended to use the Properties window instead.

To save changes you have made, use either **Save** or **Save All** buttons of the Visual Studio main toolbar, or just press **Control+S**.

Figure 20.17. Stored Procedure SQL Saved



```
ALTER DEFINER=`root`@`localhost` PROCEDURE `world_record_count`()
BEGIN
    SELECT 'country count ', COUNT(*) FROM Country;
END
```

20.2.3.5. Editing Triggers

To create a new trigger, right-click the node of the table, for which you wish to add a trigger. From the node's context menu, choose the **Create Trigger** command. This command opens the SQL Editor.

To modify an existing trigger, double-click the node of the trigger you wish to modify, or right-click this node and choose the **Alter Trigger** command from the context menu. Either of the commands opens the SQL Editor.

To create or alter the trigger definition using SQL Editor, type the trigger statement in the SQL Editor using standard SQL.

> **Note**
>
> You should enter only the trigger statement, that is, the part of the `CREATE TRIGGER` query that is placed after the `FOR EACH ROW` clause.

All other trigger properties are set in the Properties window. These properties are:

- Definer
- Event Manipulation
- Name
- Timing

Some of these properties can have arbitrary text values, others accept values from a predefined set. In the latter case set the desired value using the embedded combo box.

The properties `Event Table`, `Schema`, and `Server` in the Properties window are read only.

To save changes you have made, use either Save or Save All buttons of the Visual Studio main toolbar, or just press **Control+S**. Before changes are saved, you will be asked to confirm the execution of the corresponding SQL query in a confirmation dialog.

20.2.3.6. Editing User Defined Functions (UDF)

To create a new User Defined Function (UDF), right-click the **UDFs** node under the connection node in Server Explorer. From the node's context menu, choose the Create UDF command. This command opens the UDF Editor.

To modify an existing UDF, double-click the node of the UDF you wish to modify, or right-click this node and choose the Alter UDF command from the context menu. Either of the commands opens the UDF Editor.

The UDF editor enables you to set the following properties:

- Name
- So-name (DLL name)
- Return type

- Is Aggregate

There are text fields for both names, a combo box for the return type, and a check box to indicate if the UDF is aggregate. All these options are also accessible using the Properties window.

The property `Server` in the Properties window is read only.

To save changes you have made, use either SAVE or SAVE ALL buttons of the Visual Studio main toolbar, or just press **Control+S**. Before changes are saved, you will be asked to confirm the execution of the corresponding SQL query in a confirmation dialog.

20.2.3.7. Cloning Database Objects

Tables, views, stored procedures, and functions can be cloned using the appropriate Clone command from the context menu: CLONE TABLE, CLONE VIEW, CLONE ROUTINE. The clone commands open the corresponding editor for a new object: the **TABLE EDITOR** for cloning a table, and the **SQL EDITOR** for cloning a view or a routine.

The editor is filled with values of the original object. You can modify these values in a usual manner.

To save the cloned object, use either Save or Save All buttons of the Visual Studio main toolbar, or just press **Control+S**. Before changes are saved, you will be asked to confirm the execution of the corresponding SQL query in a confirmation dialog.

20.2.3.8. Dropping Database Objects

Tables, views, stored routines, triggers, and UDFs can be dropped with the appropriate Drop command selected from its context menu: DROP TABLE, DROP VIEW, DROP ROUTINE, DROP TRIGGER, DROP UDF.

You will be asked to confirm the execution of the corresponding drop query in a confirmation dialog.

Dropping of multiple objects is not supported.

20.2.3.9. Using the ADO.NET Entity Framework

Connector/Net 6.0 introduced support for the ADO.NET Entity Framework. ADO.NET Entity Framework was included with .NET Framework 3.5 Service Pack 1, and Visual Studio 2008 Service Pack 1. ADO.NET Entity Framework was released on 11th August 2008.

ADO.NET Entity Framework provides an Object Relational Mapping (ORM) service, mapping the relational database schema to objects. The ADO.NET Entity Framework defines several layers, these can be summarized as:

- **Logical** - this layer defines the relational data and is defined by the Store Schema Definition Language (SSDL).
- **Conceptual** - this layer defines the .NET classes and is defined by the Conceptual Schema Definition Language (CSDL)
- **Mapping** - this layer defines the mapping from .NET classes to relational tables and associations, and is defined by Mapping Specification Language (MSL).

Connector/Net integrates with Visual Studio 2008 to provide a range of helpful tools to assist the developer.

A full treatment of ADO.NET Entity Framework is beyond the scope of this manual. You are encouraged to review the Microsoft ADO.NET Entity Framework documentation.

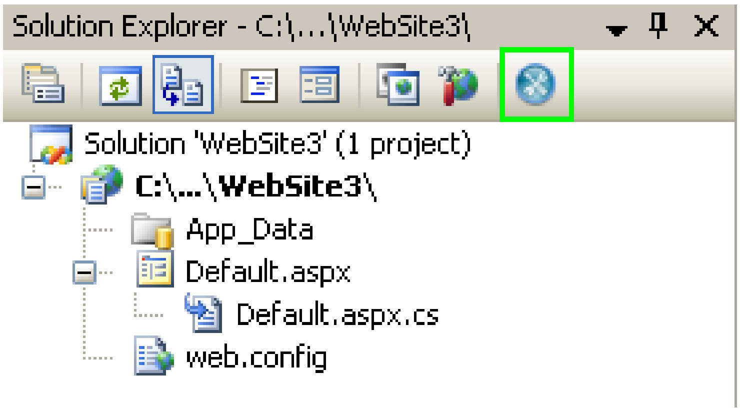
Tutorials on getting started with ADO.NET Entity Framework are available. See Section 20.2.4.5, “Tutorial: Using an Entity Framework Entity as a Windows Forms Data Source” and Section 20.2.4.6, “Tutorial: Databinding in ASP.NET using LINQ on Entities”.

20.2.3.10. MySQL Website Configuration Tool

MySQL Connector/Net 6.1 introduced the MySQL Website Configuration Tool. This is a facility available in Visual Studio that enables you to configure the Membership, Role, Session State and Profile Provider, without having to resort to editing configuration files. You simply run the tool, set your configuration options, and the tool will modify your `web.config` file accordingly.

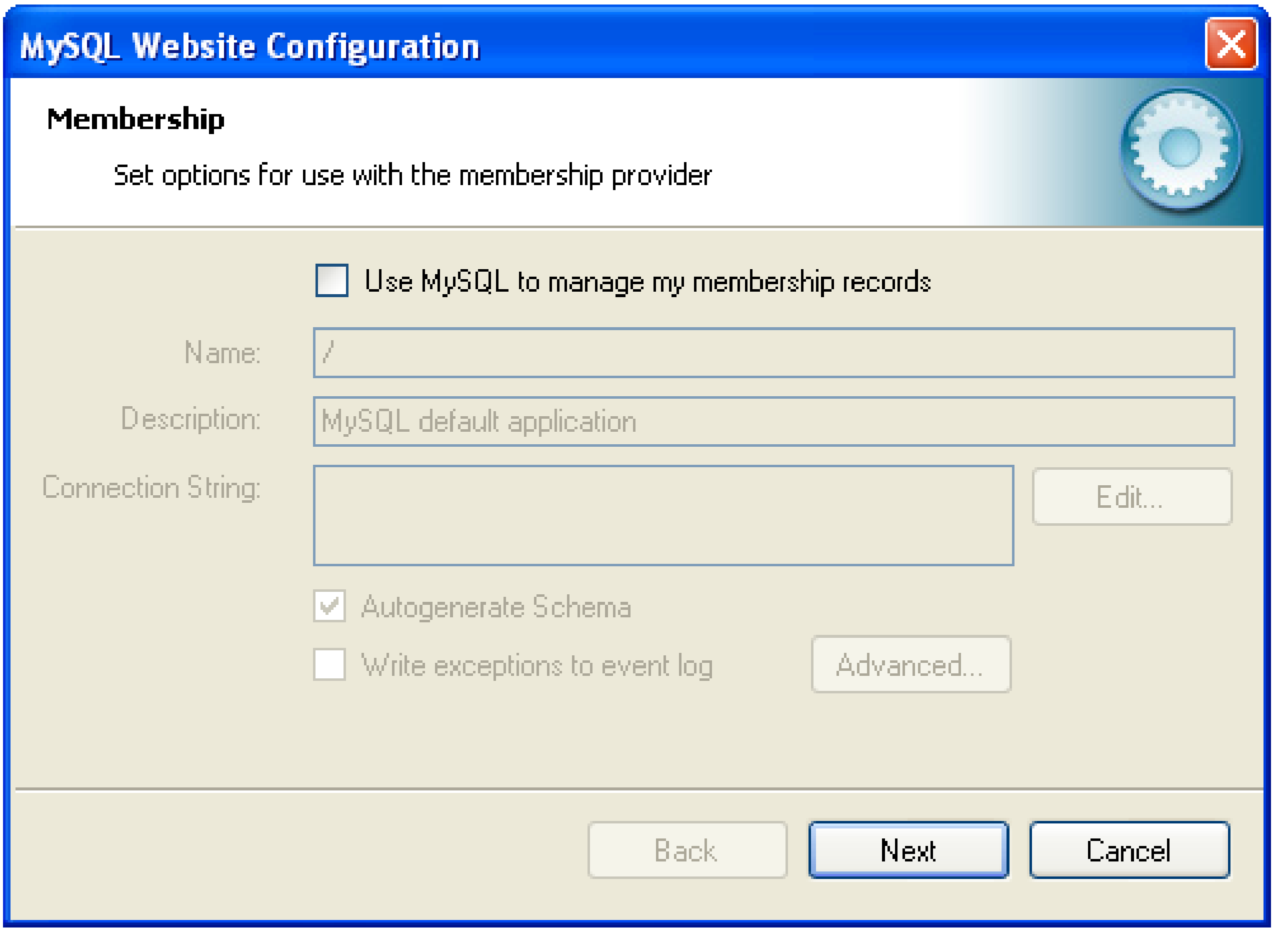
The MySQL Website Configuration Tool appears as a small icon on the Solution Explorer toolbar in Visual Studio, as show by the following screenshot:

Figure 20.18. MySQL Website Configuration Tool


Solution Explorer - C:\...\WebSite3\
Solution 'WebSite3' (1 project)
C:\...\WebSite3\
App_Data
Default.aspx
Default.aspx.cs
web.config

Clicking the Website Configuration Tool icon launches the wizard and displays the first screen:

Figure 20.19. MySQL Website Configuration Tool - Membership


MySQL Website Configuration
Membership
Set options for use with the membership provider
☐ Use MySQL to manage my membership records
Name:
Description:
Connection String:
Edit...
☑ Autogenerate Schema
☐ Write exceptions to event log
Advanced...
Back
Next
Cancel

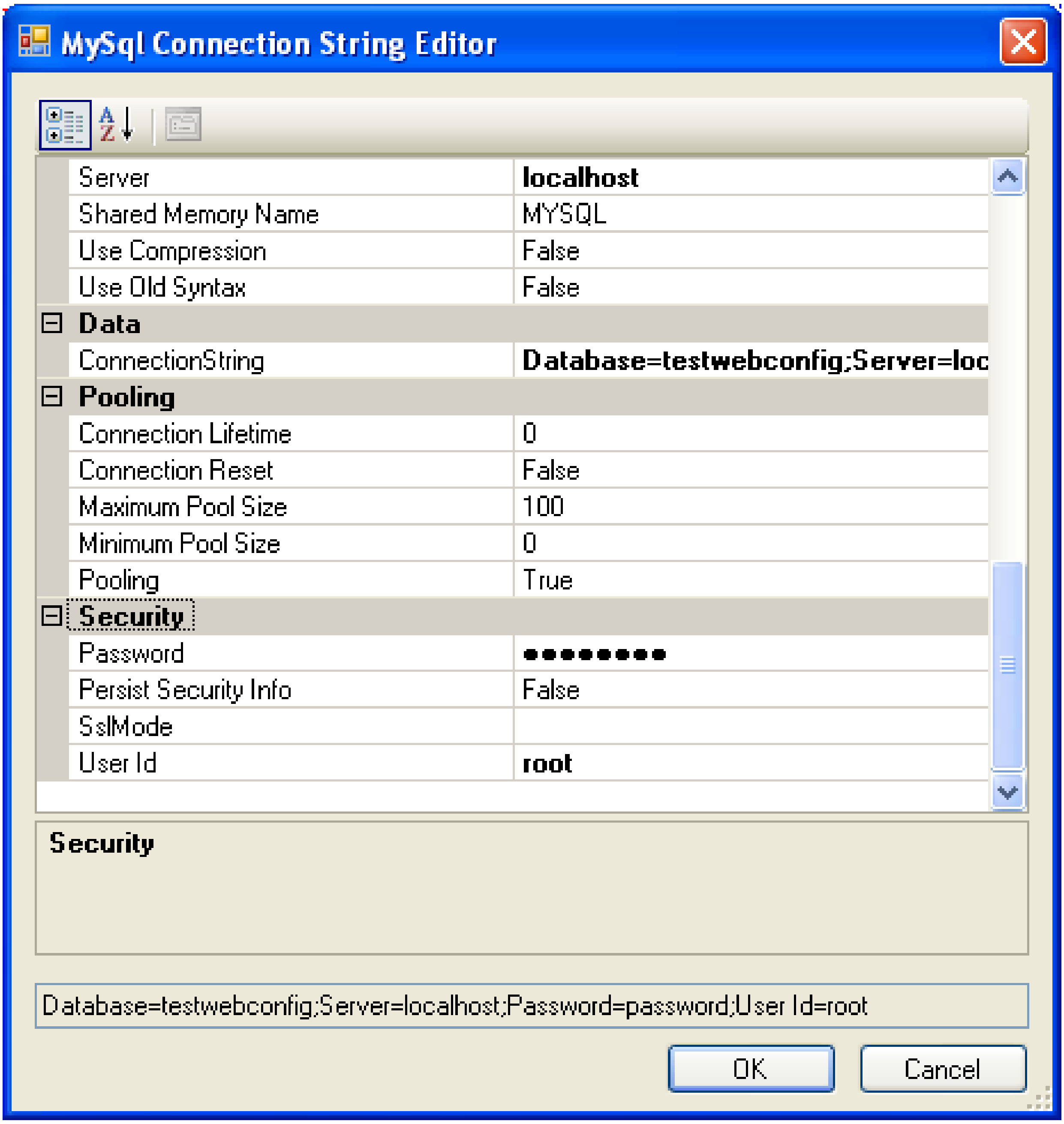
Name: /

Description: MySQL default application

This allows you to enable use of the MySQL Membership Provider. Simply click the check box to enable this. You can now enter the name of the application that you are creating the configuration for. You can also enter a description for the application.

You can then click the EDIT... button to launch the Connection String Editor:

Figure 20.20. MySQL Website Configuration Tool - Connection String Editor



Server	**localhost**
Shared Memory Name	MYSQL
Use Compression	False
Use Old Syntax	False
Data	
ConnectionString	**Database=testwebconfig;Server=loc**
Pooling	
Connection Lifetime	0
Connection Reset	False
Maximum Pool Size	100
Minimum Pool Size	0
Pooling	True
Security	
Password	●●●●●●●●●
Persist Security Info	False
SslMode	
User Id	**root**

Security

Database=testwebconfig;Server=localhost;Password=password;User Id=root

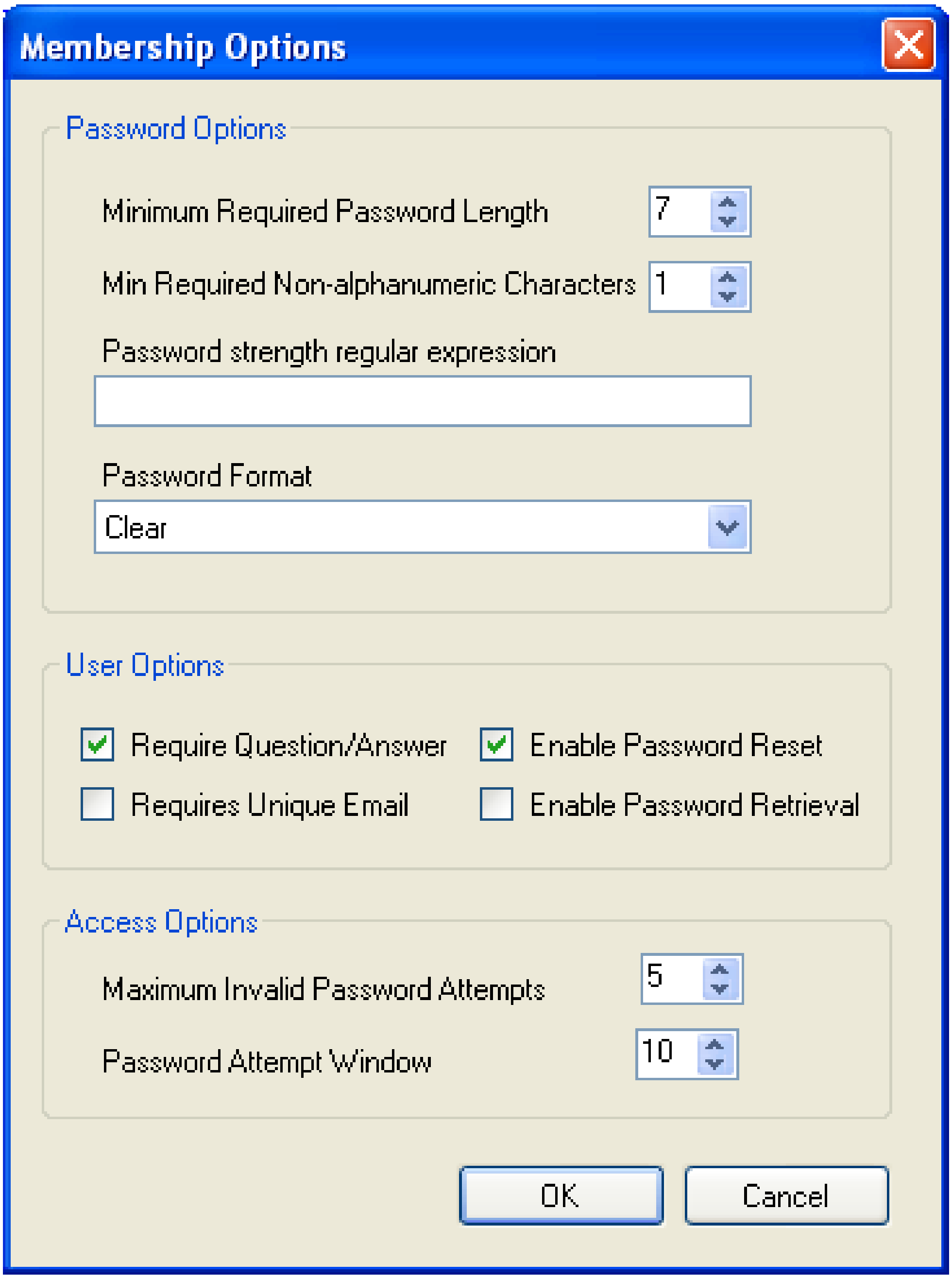
Note that if you have already defined a connection string for the providers manually in `web.config`, or previously using the tool, this will be automatically loaded and displayed, and can then be modified in this dialog.

You can also ensure that the necessary schema are created automatically for you by selecting the Autogenerate Schema check box. These schema are used to store membership information. The database used to storage is the one specified in the connection string.

You can also ensure that exceptions generated by the application will be written to the event log by selecting the **WRITE EXCEPTIONS TO EVENT LOG** check box.

Clicking the ADVANCED... button launches a dialog that enables you to set Membership Options. These options dictate such variables as password length required when a user signs up, whether the password is encrypted and whether the user can reset their password or not.

Figure 20.21. MySQL Website Configuration Tool - Advanced Options



Membership Options

Password Options

Minimum Required Password Length: 7

Min Required Non-alphanumeric Characters: 1

Password strength regular expression:

Password Format: Clear

User Options

☑ Require Question/Answer
☑ Enable Password Reset
☐ Requires Unique Email
☐ Enable Password Retrieval

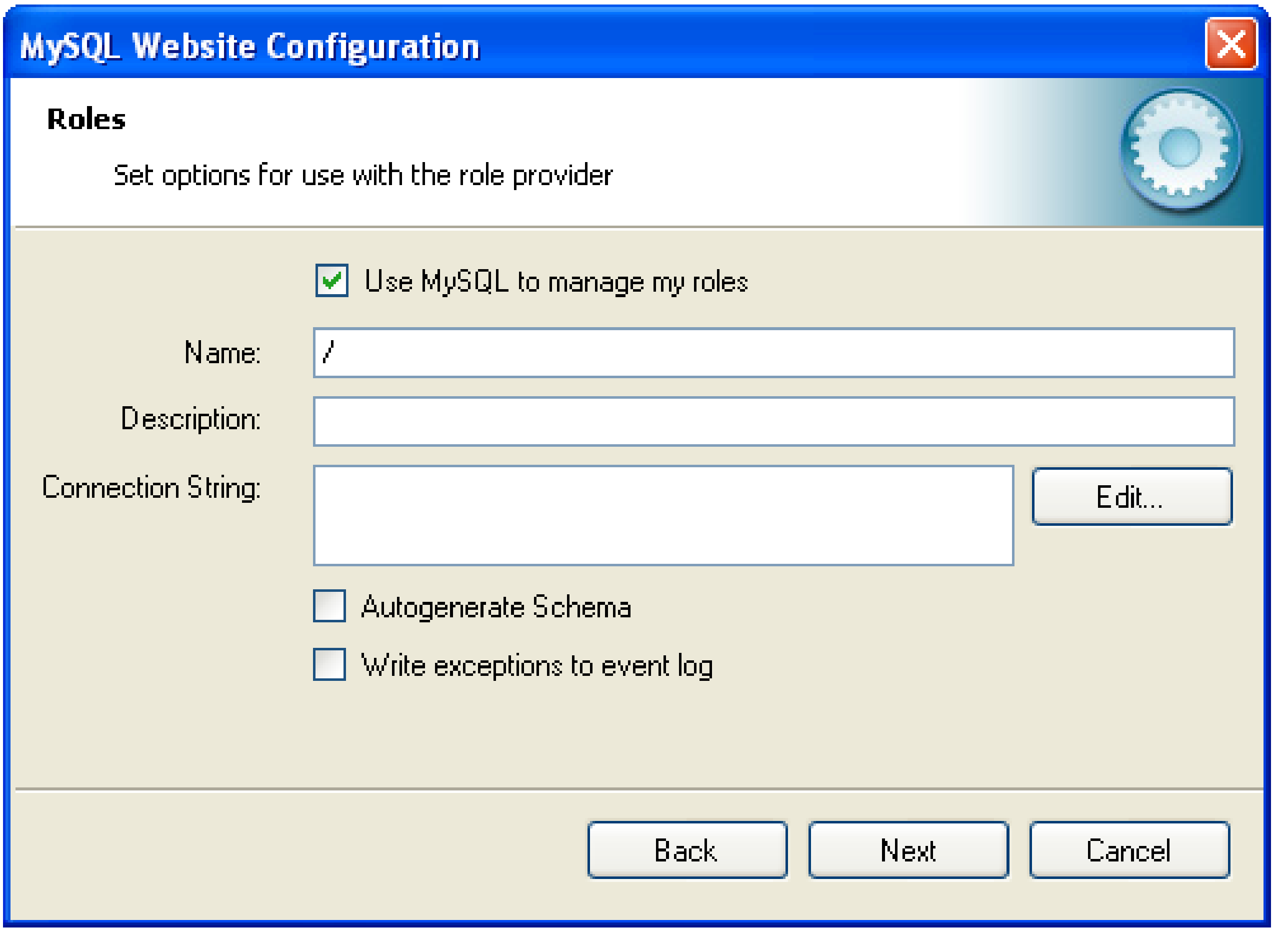
Access Options

Maximum Invalid Password Attempts: 5

Password Attempt Window: 10

Once information has been set up as required for configuration of the Membership Provider the NEXT button can be clicked to display the Roles Provider screen:

Figure 20.22. MySQL Website Configuration Tool - Roles


MySQL Website Configuration
Roles
Set options for use with the role provider
Edit...
Back
Next
Cancel

☑ Use MySQL to manage my roles

Name: /

Description:

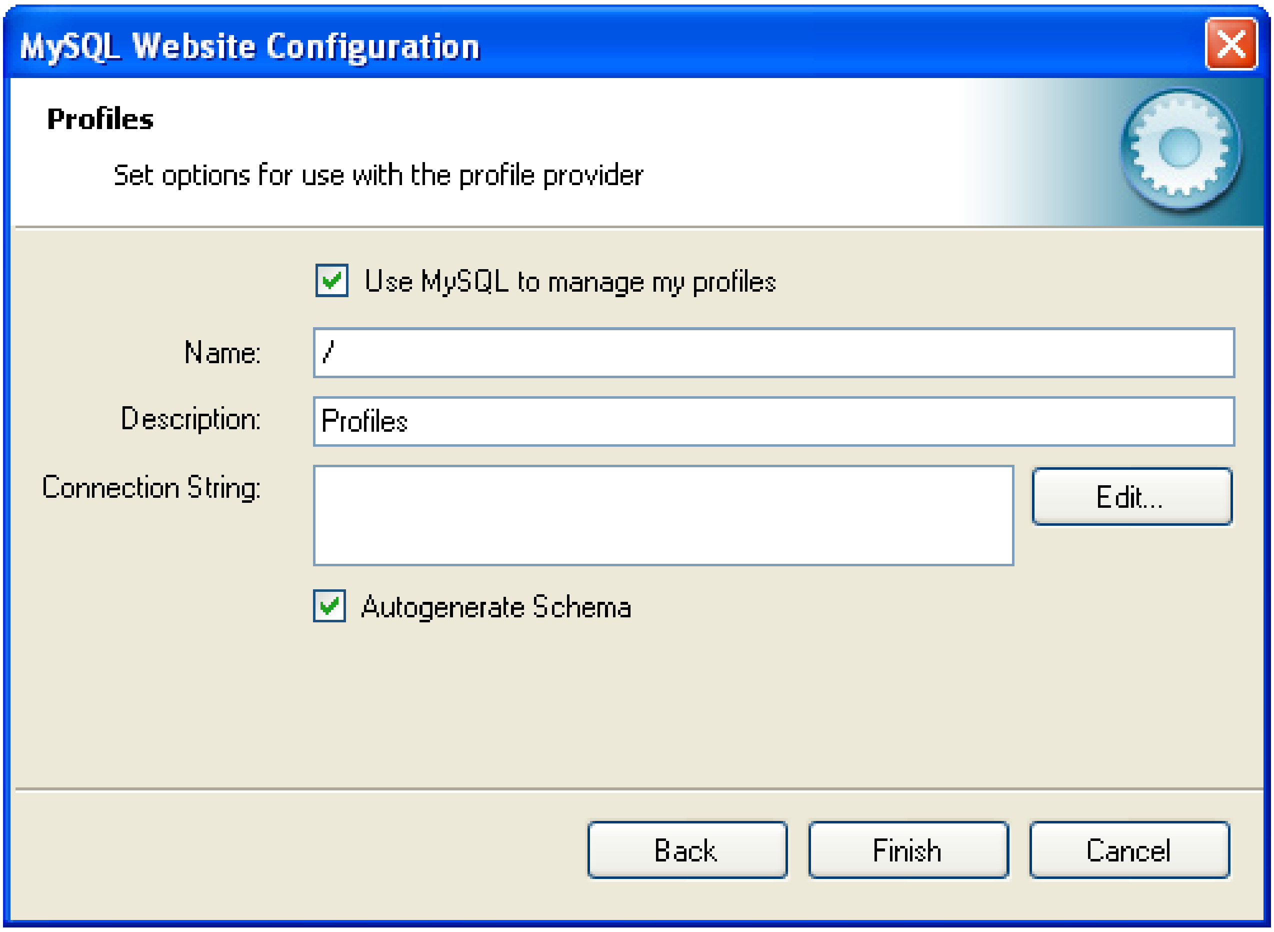
Connection String:

☐ Autogenerate Schema

☐ Write exceptions to event log

Again the connection string can be edited, a description added and Autogenerate Schema can be enabled before clicking NEXT to go to the Profiles Provider screen:

Figure 20.23. MySQL Website Configuration Tool - Profiles


MySQL Website Configuration
Edit...
Back
Finish
Cancel

Profiles

Set options for use with the profile provider

☑ Use MySQL to manage my profiles

Name: /

Description: Profiles

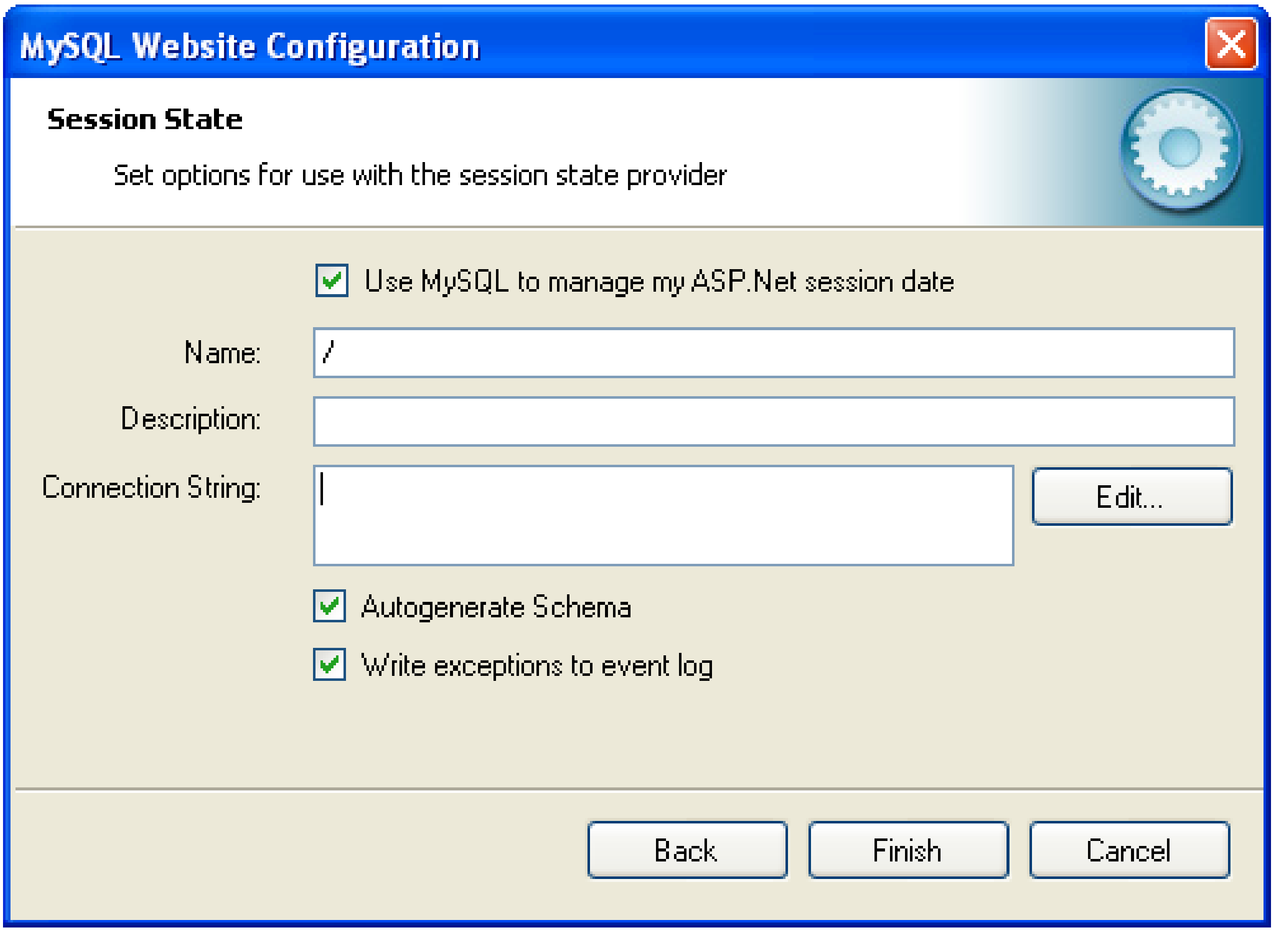
Connection String:

☑ Autogenerate Schema

This screen display similar options to the previous screens.

Click NEXT to proceed to the Session State configuration page:

Figure 20.24. MySQL Website Configuration Tool - Session State


MySQL Website Configuration
Session State
Set options for use with the session state provider
Edit...
Back
Finish
Cancel

☑ Use MySQL to manage my ASP.Net session date

Name: /

Description:

Connection String:

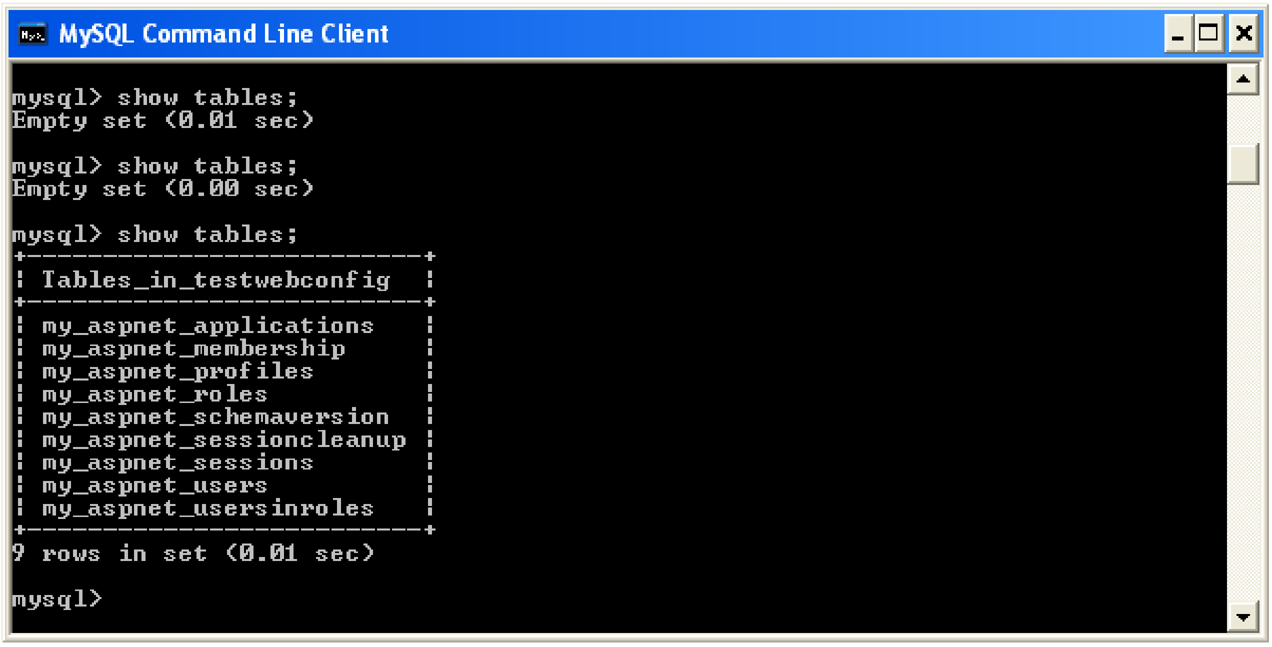
☑ Autogenerate Schema

☑ Write exceptions to event log

Once you have set up the Session State Provider as required, click FINISH to exit the wizard.

At this point it is necessary to select the Authentication Type to From Internet. This can be done by launching the ASP.NET Configuration Tool, and selecting the Security tab. Click the Select authentication type link and ensure that the From the internet radio button is selected. You can now examine the database you created to store membership information. All the necessary tables will have been created for you:

Figure 20.25. MySQL Website Configuration Tool - Tables

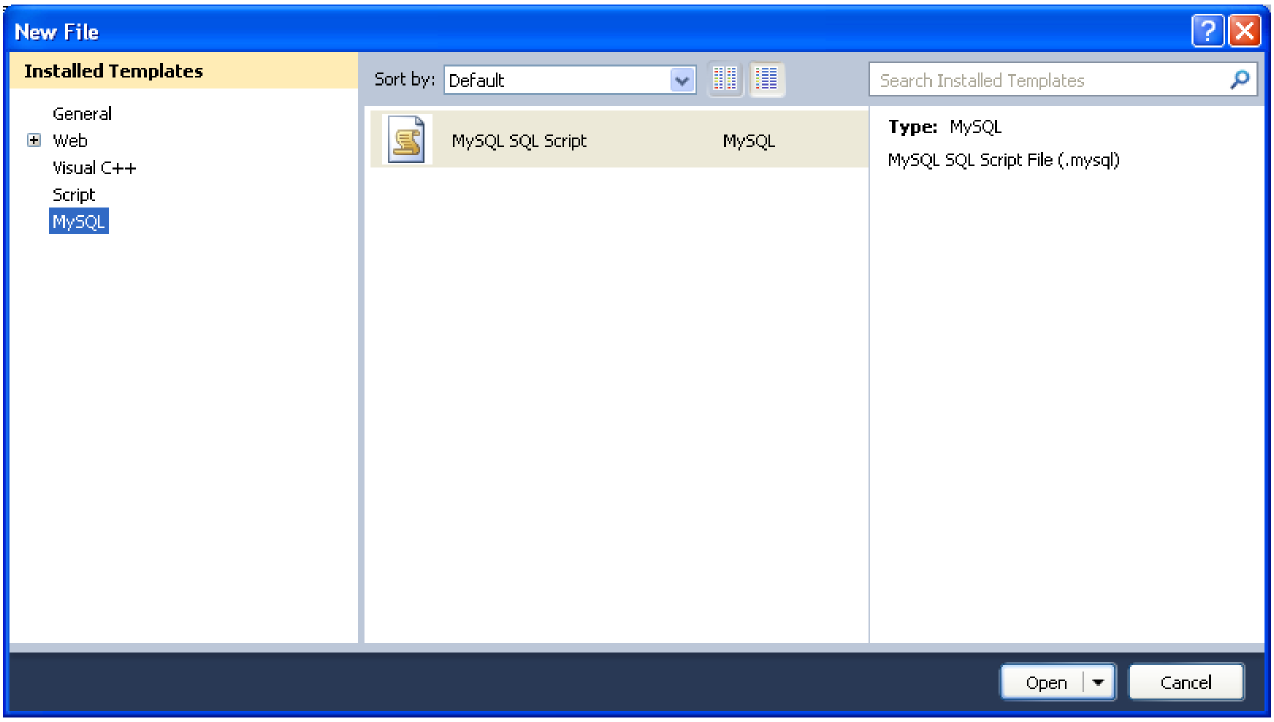

MySQL Command Line Client

```
mysql> show tables;
Empty set (0.01 sec)

mysql> show tables;
Empty set (0.00 sec)

mysql> show tables;
+---------------------------+
| Tables_in_testwebconfig   |
+---------------------------+
| my_aspnet_applications    |
| my_aspnet_membership      |
| my_aspnet_profiles        |
| my_aspnet_roles           |
| my_aspnet_schemaversion   |
| my_aspnet_sessioncleanup  |
| my_aspnet_sessions        |
| my_aspnet_users           |
| my_aspnet_usersinroles    |
+---------------------------+
9 rows in set (0.01 sec)

mysql>
```

20.2.3.11. MySQL SQL Editor

MySQL Connector/Net 6.3.2 introduced a new MySQL SQL Editor. The easiest way to invoke the editor is by selecting the NEW, FILE menu item from the Visual Studio main menu. This displays the **NEW FILE** dialog:

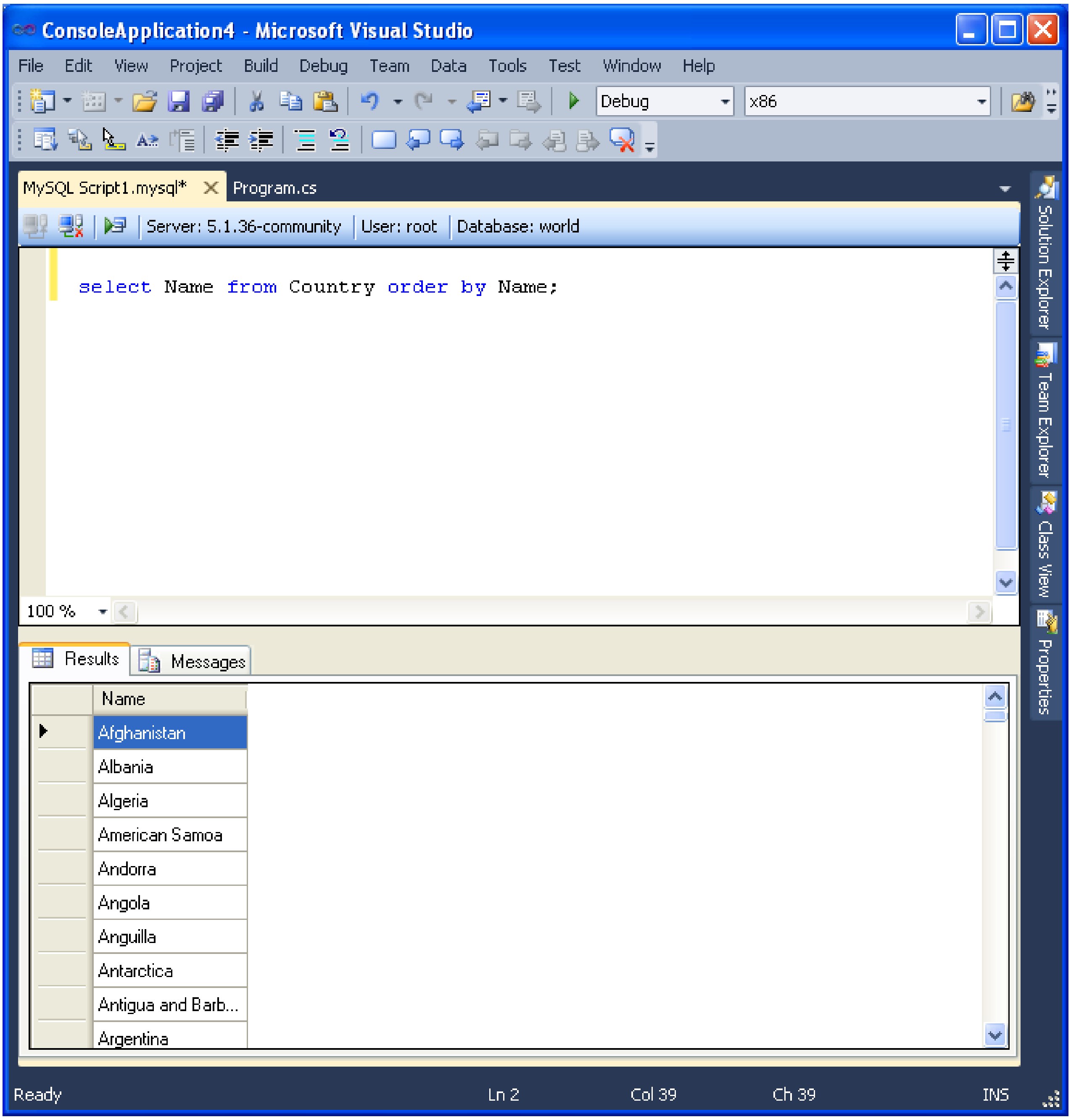
Figure 20.26. MySQL SQL Editor - New File


New File
Installed Templates
General
Web
Visual C++
Script
MySQL
Sort by: Default
Search Installed Templates
MySQL SQL Script
MySQL
Type: MySQL
MySQL SQL Script File (.mysql)
Open
Cancel

From the **NEW FILE** dialog select the MySQL template, and then double-click the **MYSQL SQL SCRIPT** document, or click the OPEN button.

The MySQL SQL Editor will be displayed. You can now enter SQL code as required, or connect to a MySQL server. Click the CONNECT TO MYSQL button in the MySQL SQL Editor toolbar. You can enter the connection details into the **CONNECT TO MYSQL** dialog that is displayed. You can enter the server name, user id, password and database to connect to, or click the ADVANCED button to select other connection string options. Click the CONNECT button to connect to the MySQL server. It is now possible to execute your SQL code against the server by clicking the RUN SQL button on the toolbar.

Figure 20.27. MySQL SQL Editor - Query


ConsoleApplication4 - Microsoft Visual Studio
File
Edit
View
Project
Build
Debug
Team
Data
Tools
Test
Window
Help
Debug
x86
MySQL Script1.mysql*
Program.cs
Solution Explorer
Team Explorer
Class View
Properties
100 %
Results
Messages
Ready
Ln 2
Col 39
Ch 39
INS

Server: 5.1.36-community | User: root | Database: world

```
select Name from Country order by Name;
```

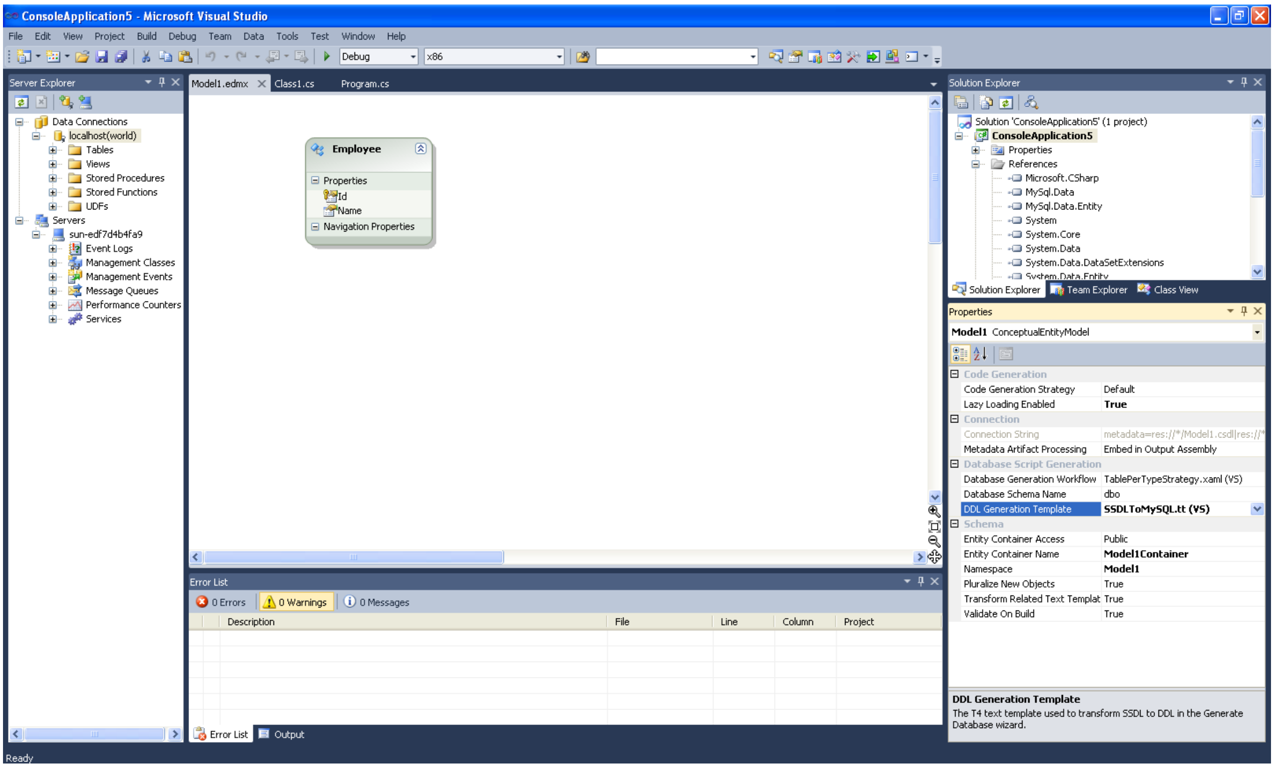
Name
Afghanistan
Albania
Algeria
American Samoa
Andorra
Angola
Anguilla
Antarctica
Antigua and Barb...
Argentina

The results from any queries are displayed on the **RESULTS** tab. Any errors are displayed on the **MESSAGES** tab.

20.2.3.12. DDL T4 Template Macro

MySQL Connector/Net 6.3 introduced the ability to convert an Entity Framework model to MySQL DDL code. Starting with a blank model, an entity model can be developed in Visual Studio's designer. Once the model has been created, the model's properties can be selected, and in the Database Script Generation category of the model's properties, the property **DDL GENERATION** can be found. The value **SSDLTOMYSQL.TT(VS)** can then be selected from the drop-down listbox.

Figure 20.28. DDL T4 Template Macro - Model Properties


ConsoleApplication5 - Microsoft Visual Studio
File Edit View Project Build Debug Team Data Tools Test Window Help
Debug
x86
Server Explorer
Data Connections
localhost(world)
Tables
Views
Stored Procedures
Stored Functions
UDFs
Servers
sun-edf7d4b4fa9
Event Logs
Management Classes
Management Events
Message Queues
Performance Counters
Services
Model1.edmx
Class1.cs
Program.cs
Employee
Properties
Id
Name
Navigation Properties
Solution Explorer
Solution 'ConsoleApplication5' (1 project)
ConsoleApplication5
Properties
References
Microsoft.CSharp
MySql.Data
MySql.Data.Entity
System
System.Core
System.Data
System.Data.DataSetExtensions
System.Data.Entity
Solution Explorer
Team Explorer
Class View
Error List
0 Errors
0 Warnings
0 Messages
Description
File
Line
Column
Project
Error List
Output
Ready

Properties

Model1 ConceptualEntityModel

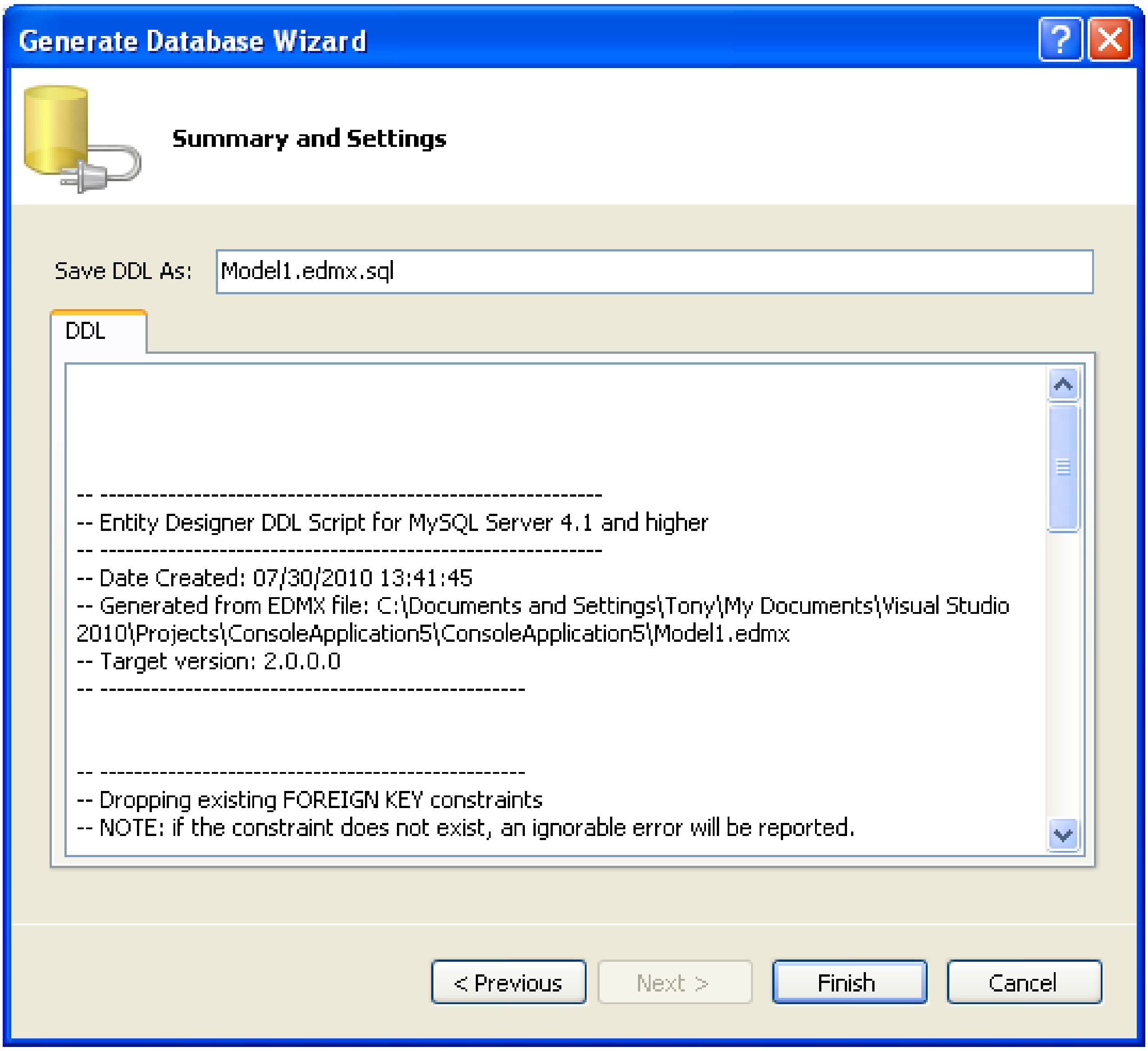
Code Generation	
Code Generation Strategy	Default
Lazy Loading Enabled	**True**
Connection	
Connection String	metadata=res://*/Model1.csdl|res://*
Metadata Artifact Processing	Embed in Output Assembly
Database Script Generation	
Database Generation Workflow	TablePerTypeStrategy.xaml (VS)
Database Schema Name	dbo
DDL Generation Template	**SSDLToMySQL.tt (VS)**
Schema	
Entity Container Access	Public
Entity Container Name	**Model1Container**
Namespace	**Model1**
Pluralize New Objects	True
Transform Related Text Templat	True
Validate On Build	True

DDL Generation Template

The T4 text template used to transform SSDL to DDL in the Generate Database wizard.

Right-clicking the model design area will display a context-sensitive menu. Selecting **GENERATE DATABASE FROM MODEL** from the menu will display the **GENERATE DATABASE WIZARD**. The wizard can then be used to generate MySQL DDL code.

Figure 20.29. DDL T4 Template Macro - Generate Database Wizard



Save DDL As: Model1.edmx.sql

```
-- -----------------------------------------------------------
-- Entity Designer DDL Script for MySQL Server 4.1 and higher
-- -----------------------------------------------------------
-- Date Created: 07/30/2010 13:41:45
-- Generated from EDMX file: C:\Documents and Settings\Tony\My Documents\Visual Studio 
2010\Projects\ConsoleApplication5\ConsoleApplication5\Model1.edmx
-- Target version: 2.0.0.0
-- --------------------------------------------------



-- --------------------------------------------------
-- Dropping existing FOREIGN KEY constraints
-- NOTE: if the constraint does not exist, an ignorable error will be reported.
```

20.2.4. Connector/Net Tutorials

20.2.4.1. Tutorial: An Introduction to Connector/Net Programming

This section provides a gentle introduction to programming with Connector/Net. The example code is written in C#, and is designed to work on both Microsoft .NET Framework and Mono.

This tutorial is designed to get you up and running with Connector/Net as quickly as possible, it does not go into detail on any particular topic. However, the following sections of this manual describe each of the topics introduced in this tutorial in more detail. In this tutorial you are encouraged to type in and run the code, modifying it as required for your setup.

This tutorial assumes you have MySQL and Connector/Net already installed. It also assumes that you have installed the World example database, which can be downloaded from the MySQL Documentation page. You can also find details on how to install the database on the same page.

> **Note**
>
> Before compiling the example code make sure that you have added References to your project as required. The References required are `System`, `System.Data` and `MySql.Data`.

20.2.4.1.1. The MySqlConnection Object

For your Connector/Net application to connect to a MySQL database it needs to establish a connection. This is achieved through the use of a `MySqlConnection` object.

The MySqlConnection constructor takes a connection string as one of its parameters. The connection string provides necessary information to make the connection to the MySQL database. The connection string is discussed more fully in Section 20.2.5.1, “Connecting to MySQL Using Connector/Net”. A reference containing a list of supported connection string options can also be found in Section 20.2.6, “Connector/Net Connection String Options Reference”.

The following code shows how to create a connection object.

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial1
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();
            // Perform database operations
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }
        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

When the `MySqlConnection` constructor is invoked it returns a connection object, which is used for subsequent database operations. The first operation in this example is to open the connection. This needs to be done before further operations take place. Before the application exits the connection to the database needs to be closed by calling `Close` on the connection object.

Sometimes an attempt to perform an `Open` on a connection object can fail, this will generate an exception that can be handled using standard exception handling code.

In this section you have learned how to create a connection to a MySQL database, and open and close the corresponding connection object.

20.2.4.1.2. The MySqlCommand Object

Once a connection has been established with the MySQL database, the next step is do carry out the desired database operations. This can be achieved through the use of the `MySqlCommand` object.

You will see how to create a `MySqlCommand` object. Once it has been created there are three main methods of interest that you can call:

- **ExecuteReader** - used to query the database. Results are usually returned in a `MySqlDataReader` object, created by `ExecuteReader`.
- **ExecuteNonQuery** - used to insert and delete data.
- **ExecuteScalar** - used to return a single value.

Once a `MySqlCommand` object has been created, you will call one of the above methods on it to carry out a database operation, such as perform a query. The results are usually returned into a `MySqlDataReader` object, and then processed, for example the results might be displayed. The following code demonstrates how this could be done.

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial2
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent='Oceania'";
            MySqlCommand cmd = new MySqlCommand(sql, conn);
            MySqlDataReader rdr = cmd.ExecuteReader();

            while (rdr.Read())
            {
                Console.WriteLine(rdr[0]+" -- "+rdr[1]);
            }
            rdr.Close();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

When a connection has been created and opened, the code then creates a `MySqlCommand` object. Note that the SQL query to be executed is passed to the `MySqlCommand` constructor. The `ExecuteReader` method is then used to generate a `MySqlReader` object. The `MySqlReader` object contains the results generated by the SQL executed on the command object. Once the results have been obtained in a `MySqlReader` object, the results can be processed. In this case the information is simply printed out as part of a `while` loop. Finally, the `MySqlReader` object is disposed of by running its `Close` method on it.

In the next example you will see how to use the `ExecuteNonQuery` method.

The procedure for performing an `ExecuteNonQuery` method call is simpler, as there is no need to create an object to store results. This is because `ExecuteNonQuery` is only used for inserting, updating and deleting data. The following example illustrates a simple update to the Country table:

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial3
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "INSERT INTO Country (Name, HeadOfState, Continent) VALUES ('Disneyland','Mickey Mouse', 'Nor
            MySqlCommand cmd = new MySqlCommand(sql, conn);
            cmd.ExecuteNonQuery();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

The query is constructed, the command object created and the `ExecuteNonQuery` method called on the command object. You can access your MySQL database with the MySQL Client program and verify that the update was carried out correctly.

Finally, you will see how the `ExecuteScalar` method can be used to return a single value. Again, this is straightforward, as a `MySqlDataReader` object is not required to store results, a simple variable will do. The following code illustrates how to use `ExecuteScalar`:

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial4
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "SELECT COUNT(*) FROM Country";
            MySqlCommand cmd = new MySqlCommand(sql, conn);
            object result = cmd.ExecuteScalar();
            if (result != null)
            {
                int r = Convert.ToInt32(result);
                Console.WriteLine("Number of countries in the World database is: " + r);
            }

        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

This example uses a simple query to count the rows in the Country table. The result is obtained by calling `ExecuteScalar` on the command object.

20.2.4.1.3. Working with Decoupled Data

Previously, when using MySqlDataReader, the connection to the database was continually maintained, unless explicitly closed. It is also possible to work in a manner where a connection is only established when needed. For example, in this mode, a connection could be established to read a chunk of data, the data could then be modified by the application as required. A connection could then be reestablished only if and when the application needs to write data back to the database. This decouples the working data set from the database.

This decouple mode of working with data is supported by Connector/Net. There are several parts involved in allowing this method to work:

- **Data Set** - The Data Set is the area in which data is loaded to read or modify it. A `DataSet` object is instantiated, which can store multiple tables of data.
- **Data Adapter** - The Data Adapter is the interface between the Data Set and the database itself. The Data Adapter is responsible for efficiently managing connections to the database, opening and closing them as required. The Data Adapter is created by instantiating an object of the `MySqlDataAdapter` class. The `MySqlDataAdapter` object has two main methods: `Fill` which reads data into the Data Set, and `Update`, which writes data from the Data Set to the database.
- **Command Builder** - The Command Builder is a support object. The Command Builder works in conjunction with the Data Adapter. When a `MySqlDataAdapter` object is created it is typically given an initial SELECT statement. From this SELECT statement the Command Builder can work out the corresponding INSERT, UPDATE and DELETE statements that would be required should the database need to be updated. To create the Command Builder an object of the class `MySqlCommandBuilder` is created.

Each of these classes will now be discussed in more detail.

Instantiating a DataSet object

A `DataSet` object can be created simply, as shown in the following example code snippet:

```
DataSet dsCountry;
...
dsCountry = new DataSet();
```

Although this creates the `DataSet` object it has not yet filled it with data. For that a Data Adapter is required.

Instantiating a MySqlDataAdapter object

The `MySqlDataAdapter` can be created as illustrated by the following example:

```
MySqlDataAdapter daCountry;
...
string sql = "SELECT Code, Name, HeadOfState FROM Country WHERE Continent='North America'";
daCountry = new MySqlDataAdapter (sql, conn);
```

Note, the `MySqlDataAdapter` is given the SQL specifying the data you wish to work with.

Instantiating a MySqlCommandBuilder object

Once the `MySqlDataAdapter` has been created, it is necessary to generate the additional statements required for inserting, updating and deleting data. There are several ways to do this, but in this tutorial you will see how this can most easily be done with `MySqlCommandBuilder`. The following code snippet illustrates how this is done:

```
MySqlCommandBuilder cb = new MySqlCommandBuilder(daCountry);
```

Note that the `MySqlDataAdapter` object is passed as a parameter to the command builder.

Filling the Data Set

To do anything useful with the data from your database, you need to load it into a Data Set. This is one of the jobs of the `MySqlDataAdapter` object, and is carried out with its `Fill` method. The following example code illustrates this:

```
DataSet dsCountry;
...
dsCountry = new DataSet();
...
daCountry.Fill(dsCountry, "Country");
```

Note the `Fill` method is a `MySqlDataAdapter` method, the Data Adapter knows how to establish a connec tion with the database and retrieve the required data, and then populates the Data Set when the `Fill` method is called. The second parameter “Country” is the table in the Data Set to update.

Updating the Data Set

The data in the Data Set can now be manipulated by the application as required. At some point, changes to data will need to be written back to the database. This is achieved through a `MySqlDataAdapter` method, the `Update` method.

```
daCountry.Update(dsCountry, "Country");
```

Again, the Data Set and the table within the Data Set to update are specified.

Working Example

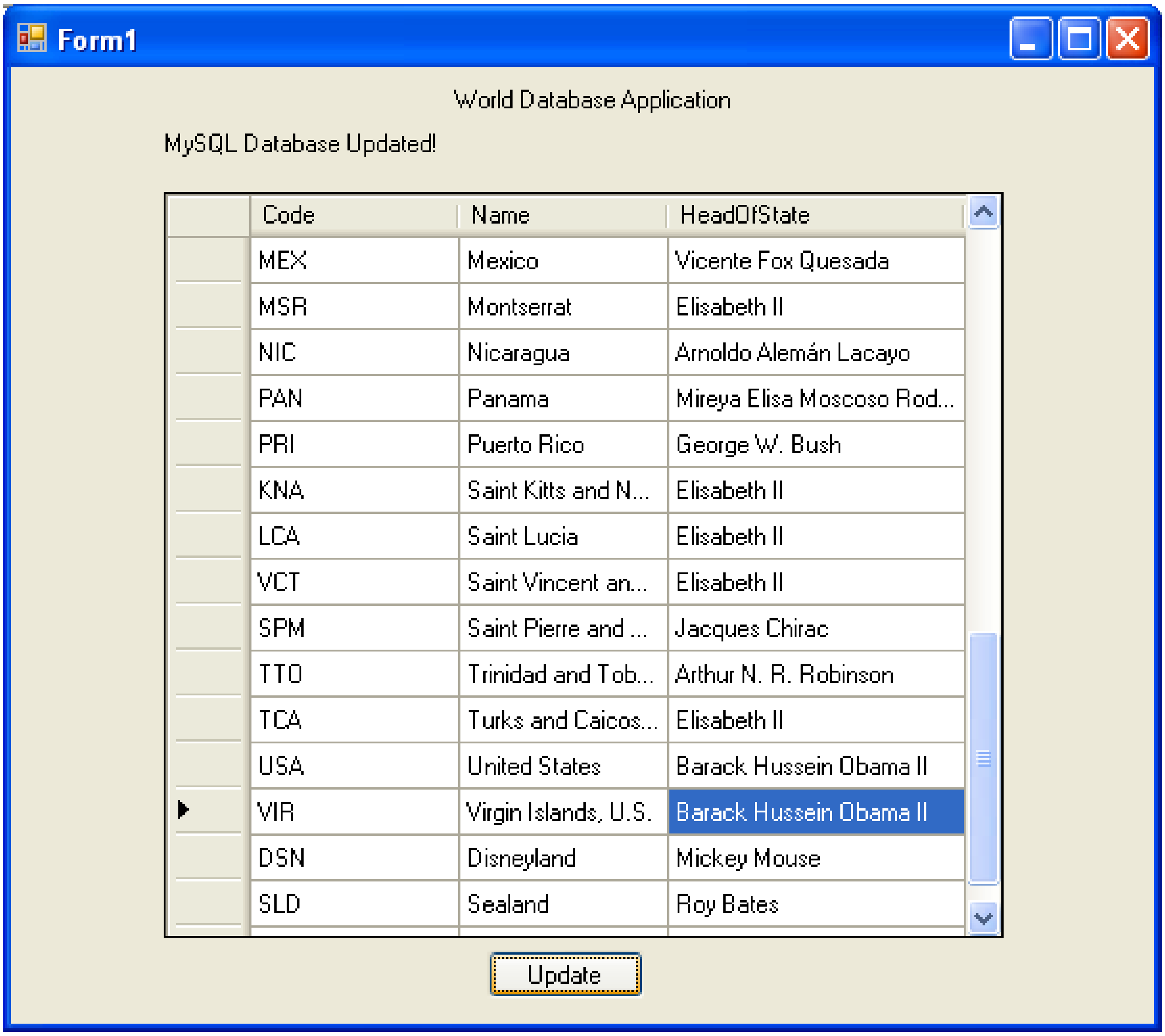
The interactions between the `DataSet`, `MySqlDataAdapter` and `MySqlCommandBuilder` classes can be a little confusing, so their operation can perhaps be best illustrated by working code.

In this example, data from the World database is read into a Data Grid View control. Here, the data can be viewed and changed before clicking an update button. The update button then activates code to write changes back to the database. The code uses the principles explained above. The application was built using the Microsoft Visual Studio to place and create the user interface controls, but the main code that uses the key classes described above is shown below, and is portable.

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;

using MySql.Data;
using MySql.Data.MySqlClient;

namespace WindowsFormsApplication5
{
    public partial class Form1 : Form
    {
        MySqlDataAdapter daCountry;
        DataSet dsCountry;

        public Form1()
        {
            InitializeComponent();
        }

        private void Form1_Load(object sender, EventArgs e)
        {

            string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
            MySqlConnection conn = new MySqlConnection(connStr);
            try
            {
                label2.Text = "Connecting to MySQL...";

                string sql = "SELECT Code, Name, HeadOfState FROM Country WHERE Continent='North America'";
                daCountry = new MySqlDataAdapter (sql, conn);
                MySqlCommandBuilder cb = new MySqlCommandBuilder(daCountry);
                dsCountry = new DataSet();
                daCountry.Fill(dsCountry, "Country");
                dataGridView1.DataSource = dsCountry;
                dataGridView1.DataMember = "Country";
            }
            catch (Exception ex)
            {
                label2.Text = ex.ToString();
            }
        }

        private void button1_Click(object sender, EventArgs e)
        {
            daCountry.Update(dsCountry, "Country");
            label2.Text = "MySQL Database Updated!";
        }

    }
}
```

The application running is shown below:

Figure 20.30. World Database Application



World Database Application

MySQL Database Updated!

	Code	Name	HeadOfState
	MEX	Mexico	Vicente Fox Quesada
	MSR	Montserrat	Elisabeth II
	NIC	Nicaragua	Arnoldo Alemán Lacayo
	PAN	Panama	Mireya Elisa Moscoso Rod...
	PRI	Puerto Rico	George W. Bush
	KNA	Saint Kitts and N...	Elisabeth II
	LCA	Saint Lucia	Elisabeth II
	VCT	Saint Vincent an...	Elisabeth II
	SPM	Saint Pierre and ...	Jacques Chirac
	TTO	Trinidad and Tob...	Arthur N. R. Robinson
	TCA	Turks and Caicos...	Elisabeth II
	USA	United States	Barack Hussein Obama II
▶	VIR	Virgin Islands, U.S.	Barack Hussein Obama II
	DSN	Disneyland	Mickey Mouse
	SLD	Sealand	Roy Bates

20.2.4.1.4. Working with Parameters

This part of the tutorial shows you how to use parameters in your Connector/Net application.

Although it is possible to build SQL query strings directly from user input, this is not advisable as it does not prevent erroneous or malicious information being entered. It is safer to use parameters as they will be processed as field data only. For example, imagine the following query was constructed from user input:

```
string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent = "+user_continent;
```

If the string `user_continent` came from a Text Box control, there would potentially be no control over the string entered by the user. The user could enter a string that generates a run time error, or in the worst case actually harms the system. When using parameters it is not possible to do this because a parameter is only ever treated as a field parameter, rather than an arbitrary piece of SQL code.

The same query written user a parameter for user input would be:

```
string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent = @Continent";
```

Note that the parameter is preceded by an '@' symbol to indicate it is to be treated as a parameter.

As well as marking the position of the parameter in the query string, it is necessary to add a parameter to the Command object. This is illustrated by the following code snippet:

```
cmd.Parameters.AddWithValue("@Continent", "North America");
```

In this example the string "North America" is supplied as the parameter value statically, but in a more practical example it would come from a user input control.

A further example illustrates the complete process:

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial5
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent=@Continent";
            MySqlCommand cmd = new MySqlCommand(sql, conn);

            Console.WriteLine("Enter a continent e.g. 'North America', 'Europe': ");
            string user_input = Console.ReadLine();

            cmd.Parameters.AddWithValue("@Continent", user_input);

            MySqlDataReader rdr = cmd.ExecuteReader();

            while (rdr.Read())
            {
                Console.WriteLine(rdr["Name"]+" --- "+rdr["HeadOfState"]);
            }
            rdr.Close();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

In this part of the tutorial you have see how to use parameters to make your code more secure.

20.2.4.1.5. Working with Stored Procedures

In this section you will see how to work with Stored Procedures. This section assumes you have a basic understanding of what a Stored Procedure is, and how to create one.

For the purposes of this tutorial, you will create a simple Stored Procedure to see how it can be called from Connector/Net. In the MySQL Client program, connect to the World database and enter the following Stored Procedure:

```
DELIMITER //
CREATE PROCEDURE country_hos
```

```
(IN con CHAR(20))
BEGIN
  SELECT Name, HeadOfState FROM Country
  WHERE Continent = con;
END //
DELIMITER ;
```

Test the Stored Procedure works as expected by typing the following into the MySQL Client program:

```
CALL country_hos('Europe');
```

Note that The Stored Routine takes a single parameter, which is the continent you wish to restrict your search to.

Having confirmed that the Stored Procedure is present and correct you can now move on to seeing how it can be accessed from Connector/Net.

Calling a Stored Procedure from your Connector/Net application is similar to techniques you have seen earlier in this tutorial. A `MySqlCommand` object is created, but rather than taking an SQL query as a parameter it takes the name of the Stored Procedure to call. The `MySqlCommand` object also needs to be set to the type of Stored Procedure. This is illustrated by the following code snippet:

```
string rtn = "country_hos";
MySqlCommand cmd = new MySqlCommand(rtn, conn);
cmd.CommandType = CommandType.StoredProcedure;
```

In this case you also need to pass a parameter to the Stored Procedure. This can be achieved using the techniques seen in the previous section on parameters, Section 20.2.4.1.4, “Working with Parameters”. This is shown in the following code snippet:

```
cmd.Parameters.AddWithValue("@con", "Europe");
```

The value of the parameter `@con` could more realistically have come from a user input control, but for simplicity it is set as a static string in this example.

At this point everything is set up and all that now needs to be done is to call the routine. This can be achieved using techniques also learned in earlier sections, but in this case the `ExecuteReader` method of the `MySqlCommand` object is used.

Complete working code for the Stored Procedure example is shown below:

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial6
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string rtn = "country_hos";
            MySqlCommand cmd = new MySqlCommand(rtn, conn);
            cmd.CommandType = CommandType.StoredProcedure;

            cmd.Parameters.AddWithValue("@con", "Europe");

            MySqlDataReader rdr = cmd.ExecuteReader();
            while (rdr.Read())
            {
                Console.WriteLine(rdr[0] + " --- " + rdr[1]);
            }
            rdr.Close();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

In this section you have seen how to call a Stored Procedure from Connector/Net. For the moment, this concludes our introductory tutorial on programming with Connector/Net.

20.2.4.2. Tutorial: MySQL Connector/Net ASP.NET Membership and Role Provider

Many web sites feature the facility for the user to create a user account. They can then log into the web site and enjoy a personalized experience. This requires that the developer creates database tables to store user information, along with code to gather and process this data. This represents a burden on the developer, and there is the possibility for security issues to creep into the developed code. However, ASP.NET 2.0 introduced the Membership system. This system is designed around the concept of Membership, Profile and Role Providers, which together provide all of the functionality to implement a user system, that previously would have to have been created by the developer from scratch.

Currently, MySQL Connector/Net provides Membership, Role, Profile and Session State Providers.

This tutorial shows you how to set up your ASP.NET web application to use the MySQL Connector/Net Membership and Role Providers. It assumes that you have MySQL Server installed, along with MySQL Connector/Net and Microsoft Visual Studio. This tutorial was tested with MySQL Connector/Net 6.0.4 and Microsoft Visual Studio 2008 Professional Edition. It is recommended you use 6.0.4 or above for this tutorial.

1. Create a new database in the MySQL Server using the MySQL Command Line Client program (`mysql`), or other suitable tool. It does not matter what name is used for the database, but it should be noted down so that it can be specified in the connection string constructed later in this tutorial. This database will contain the tables, automatically created for you later, used to store data about users and roles.

2. Create a new ASP.NET Web Site in Visual Studio. If you are not sure how to do this, refer to the following tutorial: Section 20.2.4.6, “Tutorial: Databinding in ASP.NET using LINQ on Entities”, which demonstrates how to create a simple ASP.NET web site.

3. Add References to `MySql.Data` and `MySql.Web` to the web site project.

4. Locate the `machine.config` file on your system, which is the configuration file for the .NET Framework.

5. Search the `machine.config` file to find the membership provider `MySQLMembershipProvider`.

6. Add the attribute `autogenerateschema="true"`. The appropriate section should now resemble the following (note: for the sake of brevity some information has been excluded):

   ```
   <membership>
    <providers>
      <add name="AspNetSqlMembershipProvider"
        type="System.Web.Security.SqlMembershipProvider"
        ...
        connectionStringName="LocalSqlServer"
        ... />
      <add name="MySQLMembershipProvider"
        autogenerateschema="true"
        type="MySql.Web.Security.MySQLMembershipProvider, MySql.Web, Version=6.0.4.0, Culture=neutral, PublicKeyToken
        connectionStringName="LocalMySqlServer"
        ... />
    </providers>
   </membership>
   ```

   Note that the name for the connection string to be used to connect to the server that contains the membership database is `LocalMySqlServer`.

   The `autogenerateschema="true"` attribute will cause MySQL Connector/Net to silently create, or upgrade, the schema on the database server, to contain the required tables for storing membership information.

7. It is now necessary to create the connection string referenced in the previous step. Load the web site's `web.config` file into Visual Studio.

8. Locate the section marked `<connectionStrings>`. Add the following connection string information:

   ```
   <connectionStrings>
     <remove name="LocalMySqlServer"/>
     <add name="LocalMySqlServer"
          connectionString="Datasource=localhost;Database=users;uid=root;pwd=password;"
          providerName="MySql.Data.MySqlClient"/>
   </connectionStrings>
   ```

   The database specified is the one created in the first step. You could alternatively have used an existing database.

9. At this point build the solution to ensure no errors are present. This can be done by selecting BUILD, BUILD SOLUTION from the main menu, or pressing **F6**.

10. ASP.NET supports the concept of locally and remotely authenticated users. With local authentication the user is validated using their Windows credentials when they attempt to access the web site. This can be useful in an Intranet environment. With

remote authentication a user is prompted for their login details when accessing the web site, and these credentials are checked against the membership information stored in a database server such as MySQL Server. You will now see how to choose this form of authentication.

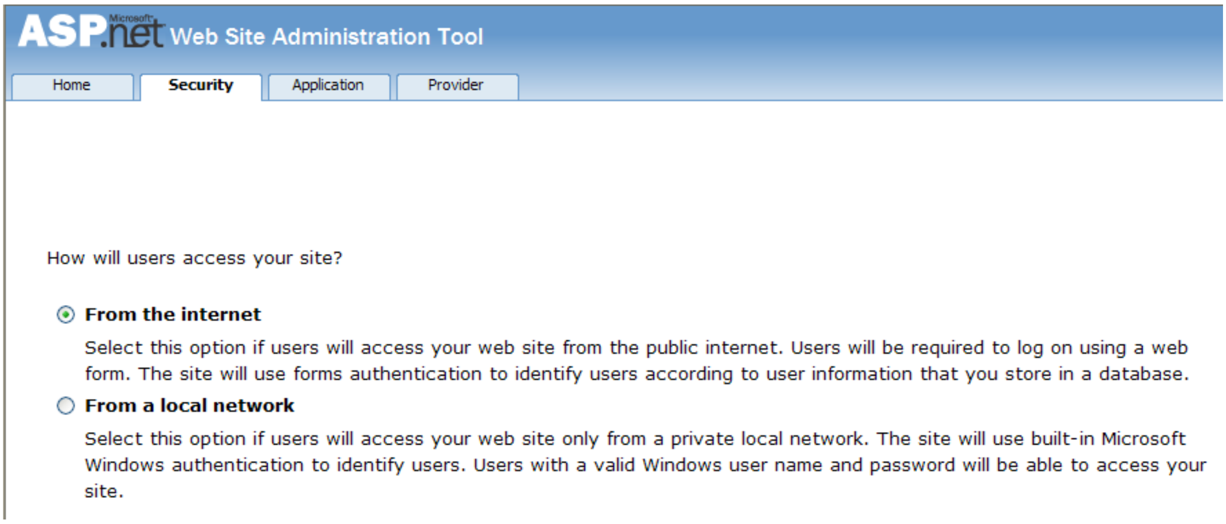
Start the ASP.NET Web Site Administration Tool. This can be done quickly by clicking the small hammer/Earth icon in the Solution Explorer. You can also launch this tool by selecting WEBSITE, ASP.NET CONFIGURATION from the main menu.

11. In the ASP.NET Web Site Administration Tool click the **SECURITY** tab.

12. Now click the **USER AUTHENTICATION TYPE** link.

13. Select the **FROM THE INTERNET** radio button. The web site will now need to provide a form to allow the user to enter their login details. These will be checked against membership information stored in the MySQL database.

Figure 20.31. Authentication Type



How will users access your site?

● **From the internet**

Select this option if users will access your web site from the public internet. Users will be required to log on using a web form. The site will use forms authentication to identify users according to user information that you store in a database.

○ **From a local network**

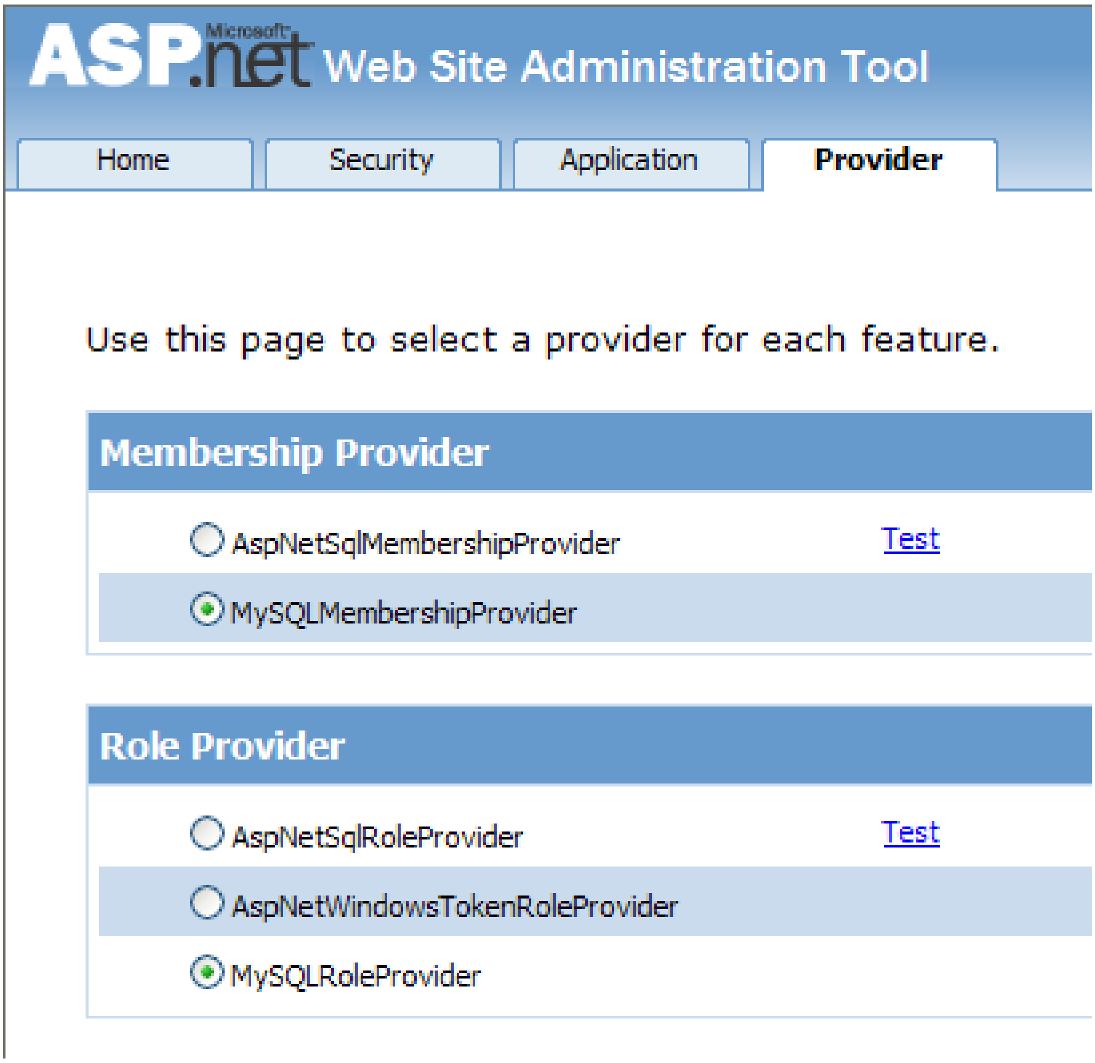
Select this option if users will access your web site only from a private local network. The site will use built-in Microsoft Windows authentication to identify users. Users with a valid Windows user name and password will be able to access your site.

14. You now need to specify the Role and Membership Provider to be used. Click the **PROVIDER** tab.

15. Click the **SELECT A DIFFERENT PROVIDER FOR EACH FEATURE (ADVANCED)** link.

16. Now select the **MYSQLMEMBERSHIPPROVIDER** and the **MYSQLROLEPROVIDER** radio buttons.

Figure 20.32. Select Membership and Role Provider


ASP.net Web Site Administration Tool
Home
Security
Application
Provider
Test
Test

Use this page to select a provider for each feature.

Membership Provider

○ AspNetSqlMembershipProvider

● MySQLMembershipProvider

Role Provider

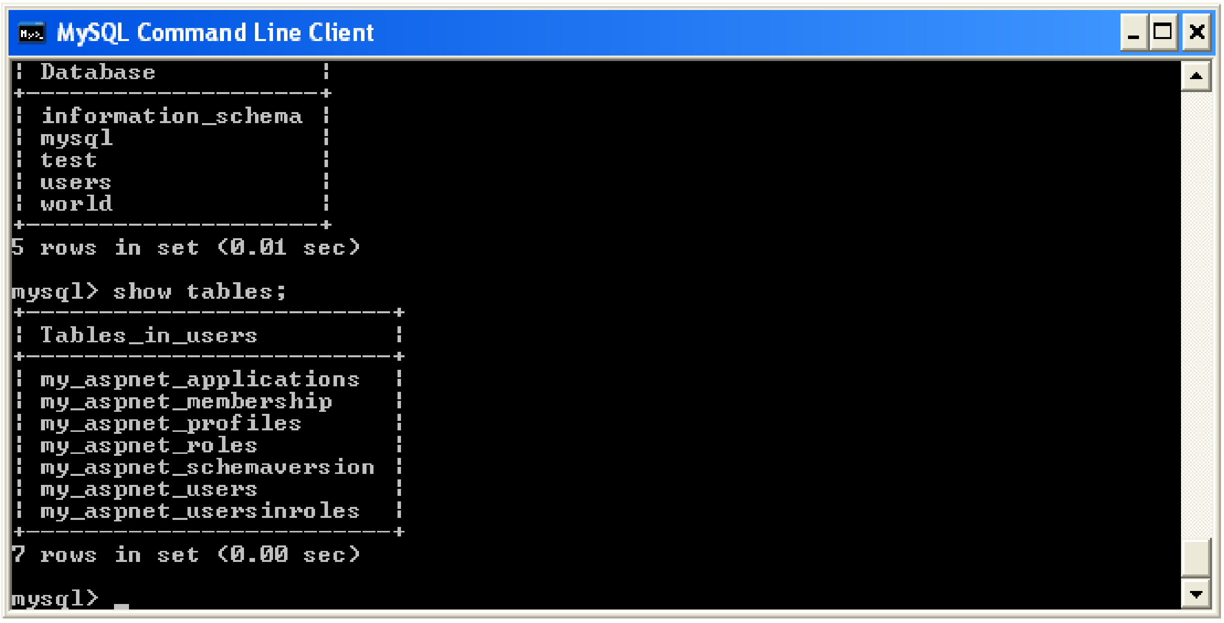
○ AspNetSqlRoleProvider

○ AspNetWindowsTokenRoleProvider

● MySQLRoleProvider

17. In Visual Studio rebuild the solution by selecting BUILD, REBUILD SOLUTION from the main menu.
18. Check that the necessary schema has been created. This can be achieved using the MySQL Command Line Client program.

Figure 20.33. Membership and Role Provider Tables

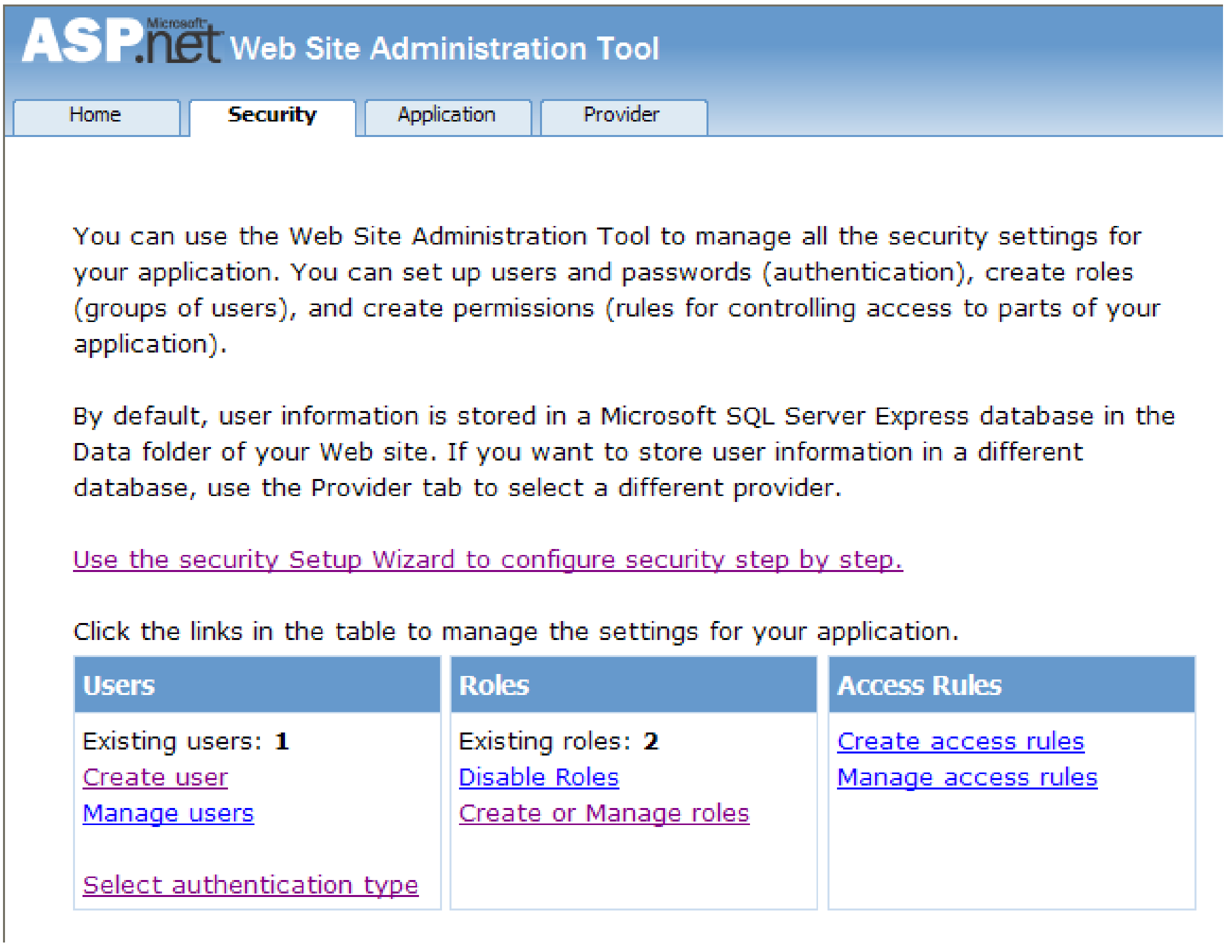


```
| Database           |
+--------------------+
| information_schema |
| mysql              |
| test               |
| users              |
| world              |
+--------------------+
5 rows in set (0.01 sec)

mysql> show tables;
+-------------------------+
| Tables_in_users         |
+-------------------------+
| my_aspnet_applications  |
| my_aspnet_membership    |
| my_aspnet_profiles      |
| my_aspnet_roles         |
| my_aspnet_schemaversion |
| my_aspnet_users         |
| my_aspnet_usersinroles  |
+-------------------------+
7 rows in set (0.00 sec)

mysql> _
```

19. Assuming all is present and correct you can now create users and roles for your web application. The easiest way to do this is with the ASP.NET Web Site Administration Tool. However, many web applications contain their own modules for creating roles and users. For simplicity the ASP.NET Web Site Administration Tool will be used in this tutorial.

20. In the ASP.NET Web Site Administration Tool, click the **SECURITY** tab. Now that both the Membership and Role Provider are enabled you will see links for creating roles and users. Click the **CREATE OR MANAGE ROLES** link.

Figure 20.34. Security Tab



You can use the Web Site Administration Tool to manage all the security settings for your application. You can set up users and passwords (authentication), create roles (groups of users), and create permissions (rules for controlling access to parts of your application).

By default, user information is stored in a Microsoft SQL Server Express database in the Data folder of your Web site. If you want to store user information in a different database, use the Provider tab to select a different provider.

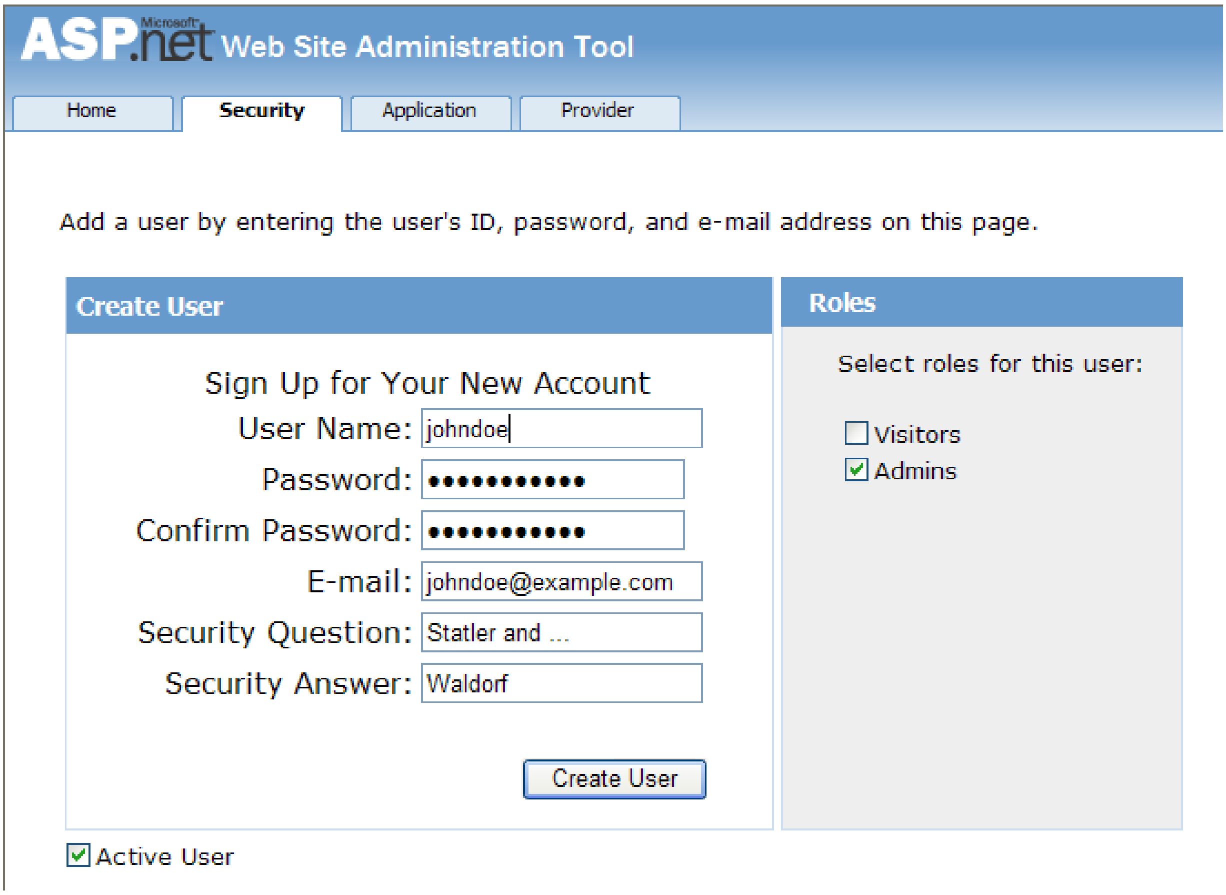
Use the security Setup Wizard to configure security step by step.

Click the links in the table to manage the settings for your application.

Users	Roles	Access Rules
Existing users: **1** Create user Manage users Select authentication type	Existing roles: **2** Disable Roles Create or Manage roles	Create access rules Manage access rules

21. You can now enter the name of a new Role and click ADD ROLE to create the new Role. Create new Roles as required.
22. Click the BACK button.
23. Click the **CREATE USER** link. You can now fill in information about the user to be created, and also allocate that user to one or more Roles.

Figure 20.35. Create User


ASP.net Web Site Administration Tool
Home
Security
Application
Provider
Create User

Add a user by entering the user's ID, password, and e-mail address on this page.

Create User

Sign Up for Your New Account

User Name: johndoe

Password: ●●●●●●●●●●●

Confirm Password: ●●●●●●●●●●●

E-mail: johndoe@example.com

Security Question: Statler and ...

Security Answer: Waldorf

Roles

Select roles for this user:

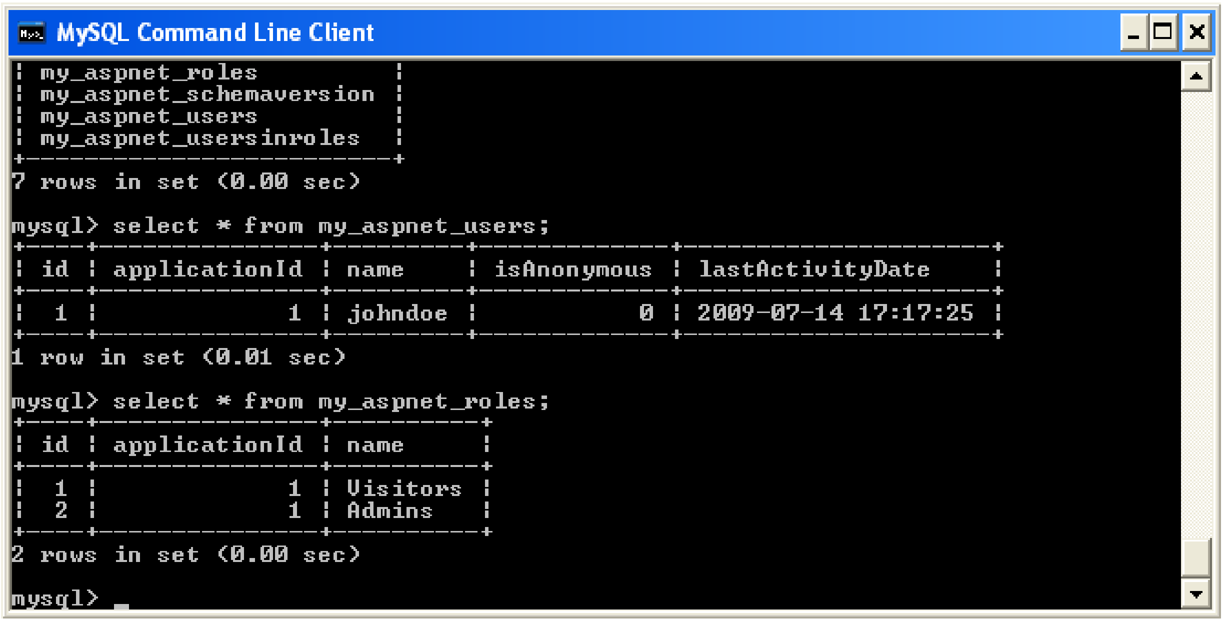
☐ Visitors

☑ Admins

☑ Active User

24. Using the MySQL Command Line Client program you can check that your database has been correctly populated with the Membership and Role data.

Figure 20.36. Membership and Roles Table Contents


MySQL Command Line Client

```
| my_aspnet_roles            |
| my_aspnet_schemaversion    |
| my_aspnet_users            |
| my_aspnet_usersinroles     |
+----------------------------+
7 rows in set (0.00 sec)

mysql> select * from my_aspnet_users;
+----+---------------+---------+-------------+---------------------+
| id | applicationId | name    | isAnonymous | lastActivityDate    |
+----+---------------+---------+-------------+---------------------+
|  1 |             1 | johndoe |           0 | 2009-07-14 17:17:25 |
+----+---------------+---------+-------------+---------------------+
1 row in set (0.01 sec)

mysql> select * from my_aspnet_roles;
+----+---------------+----------+
| id | applicationId | name     |
+----+---------------+----------+
|  1 |             1 | Visitors |
|  2 |             1 | Admins   |
+----+---------------+----------+
2 rows in set (0.00 sec)

mysql> _
```

In this tutorial you have seen how to set up the MySQL Connector/Net Membership and Role Providers for use in your ASP.NET web application.

20.2.4.3. Tutorial: MySQL Connector/Net ASP.NET Session State Provider

MySQL Connector/Net from version 6.1 has included a MySQL Session State Provider. This provider enables you to store session state in a MySQL database. The following tutorial shows you how to prepare to use the MySQL Session State Provider, and then store session data into the MySQL database. This tutorial uses Microsoft Visual Studio 2008 Professional Edition, MySQL Connector/Net 6.1.1 and MySQL Server 5.1. This tutorial also assumes you have created an empty database, for example `test`, where you will store session data. You could do this using the MySQL Command Line Client tool.

1. In Visual Studio create a new ASP.NET web site. If you are not sure how to do this refer to the tutorial Section 20.2.4.6, “Tutorial: Databinding in ASP.NET using LINQ on Entities” which demonstrates how to do this.
2. Launch the MySQL MySQL Website Configuration tool. Due to a bug in 6.1.1 this may not appear unless you are connected to a server in the Server Explorer. If you are unfamiliar with the MySQL Website Configuration tool it is suggested that you first work through the following tutorial Section 20.2.3.10, “MySQL Website Configuration Tool”.
3. Navigate through the wizard to the Session State page. Make sure the check box **USE MYSQL TO MANAGE MY ASP.NET SESSION DATA** is selected.
4. On the same page configure the connection string to the database that will contain your session data. This database can be empty as MySQL Connector/Net will create the schema required to store session data.
5. Ensure that the check box **AUTOGENERATE SCHEMA** is selected so that MySQL Connector/Net will create the schema in your database to store the session data correctly.
6. Enter the name of your application.
7. Click FINISH. The MySQL Website Configuration tool will now update your application's `web.config` file with information about the connection string and default providers to be used. In this case we have selected the MySQL Session State Provider.

At this point you are ready to use the MySQL database to store session data. To test that the set up has worked you can write a simple program that uses session variables.

1. Open `Default.aspx.cs`. In the Page_Load method add the following code:

   ```
   Session["SessionVariable1"] = "Test string";
   ```

2. Build your solution.
3. Run the solution (without debugging). When the application runs, the provider will autogenerate tables required in the database you chose when setting up the application.
4. Check that the schema was in fact created. Using the MySQL Command Line Client use the target database and then type `SHOW TABLES;`. You will see that MySQL Connector/Net has created the required schema automatically, as we selected this to happen in the MySQL Website Configuration tool.
5. Now view the contents of these tables by typing `SELECT * FROM my_aspnet_sessions;` in the MySQL Command Line Client. This will display the session data our application used. Note that this is stored in binary format so some data may not display as expected.

At this point you have installed the Session State Provider and carried out a preliminary test of the installation. You will now work a bit more with the Session State Provider.

In this part of the tutorial you will set and retrieve a session variable. You can work with your existing project.

1. Select the `Default.aspx` and switch to Design View. Add a text box and three buttons. Change the text property for the buttons to “Store Session Variable”, “Clear Textbox”, and “Show Session Variable”. These will be `Button1`, `Button2` and `Button3` respectively. Build your solution to ensure that no errors have been introduced.
2. Still in the Design View, double-click `Button1`. Now to the `Button1_Click` event handler add code some the handler resembles the following:

   ```
   protected void Button1_Click(object sender, EventArgs e)
   {
       Session["SessionString"] = TextBox1.Text;
   }
   ```

You have created a new Session variable accessed using the key “SessionString”. This will be set to the text that was entered into the text box when `Button1` is clicked.

3. In Design View double-click `Button2` to add its click event handler. This button needs to clear text from the text box. The code to do this is as follows:

   ```
   protected void Button2_Click(object sender, EventArgs e)
   {
       TextBox1.Text = "";
   }
   ```

   The code simply assigns an empty string to the `Text` property of the text box.

4. In the Design View double-click `Button3` and modify the click handler as follows:

   ```
   protected void Button3_Click(object sender, EventArgs e)
   {
       TextBox1.Text = (String)Session["SessionString"];
   }
   ```

   This will retrieve the session string and display it in the text box.

5. Now modify the `Page_Load` method as follows:

   ```
   protected void Page_Load(object sender, EventArgs e)
   {
       if (!IsPostBack)
       {
          TextBox1.Text = "Enter some text";
       }
   }
   ```

   This ensures that when the page loads the text box `Text` property is reset.

6. Ensure that the solution is saved and then rebuild the solution.
7. Run the solution without debugging.
8. The form will be displayed. Enter some text into the text box. Now click STORE SESSION VARIABLE. At this point you have stored the string in a session variable.
9. Now click CLEAR TEXT to clear the text box.
10. Now click SHOW SESSION VARIABLE to retrieve and display the session variable.
11. Refresh the page to destroy the form and display a new form.
12. Click SHOW SESSION VARIABLE the text box will display the stored session variable, demonstrating that the refreshing the page does not destroy the session variable.

This illustrates that the session state data is not destroyed when a page is reloaded.

20.2.4.4. Tutorial: MySQL Connector/Net ASP.NET Profile Provider

This tutorial shows you how to use the MySQL Profile Provider to store user profile information in a MySQL database. The tutorial uses MySQL Connector/Net 6.1.1, MySQL Server 5.1 and Microsoft Visual Studio 2008 Professional Edition.

Many modern web sites allow the user to create a personal profile. This requires a significant amount of code, but ASP.NET reduces this considerable by including the functionality in its Profile classes. The Profile Provider provides an abstraction between these classes and a data source. The MySQL Profile Provider enables profile data to be stored in a MySQL database. This enables the profile properties to be written to a persistent store, and be retrieved when required. The Profile Provider also enables profile data to be managed effectively, for example it enables profiles that have not been accessed since a specific date to be deleted.

The following steps show you how you can select the MySQL Profile Provider.

1. Create a new ASP.NET web project.
2. Select the MySQL Website Configuration tool. Due to a bug in 6.1.1 you may have to first connect to a server in Server Explorer before the tool's icon will display in the toolbar of the Solution Explorer.

3. In the MySQL Website Configuration tool navigate through the tool to the Profiles page.
4. Select the **USE MYSQL TO MANAGE MY PROFILES** check box.
5. Select the **AUTOGENERATE SCHEMA** check box.
6. Click the EDIT... button and configure a connection string for the database that will be used to store user profile information.
7. Navigate to the last page of the tool and click FINISH to save your changes and exit the tool.

At this point you are now ready to start using the MySQL Profile Provider. With the following steps you can carry out a preliminary test of your installation.

1. Open your `web.config` file.
2. Add a simple profile such as the following:

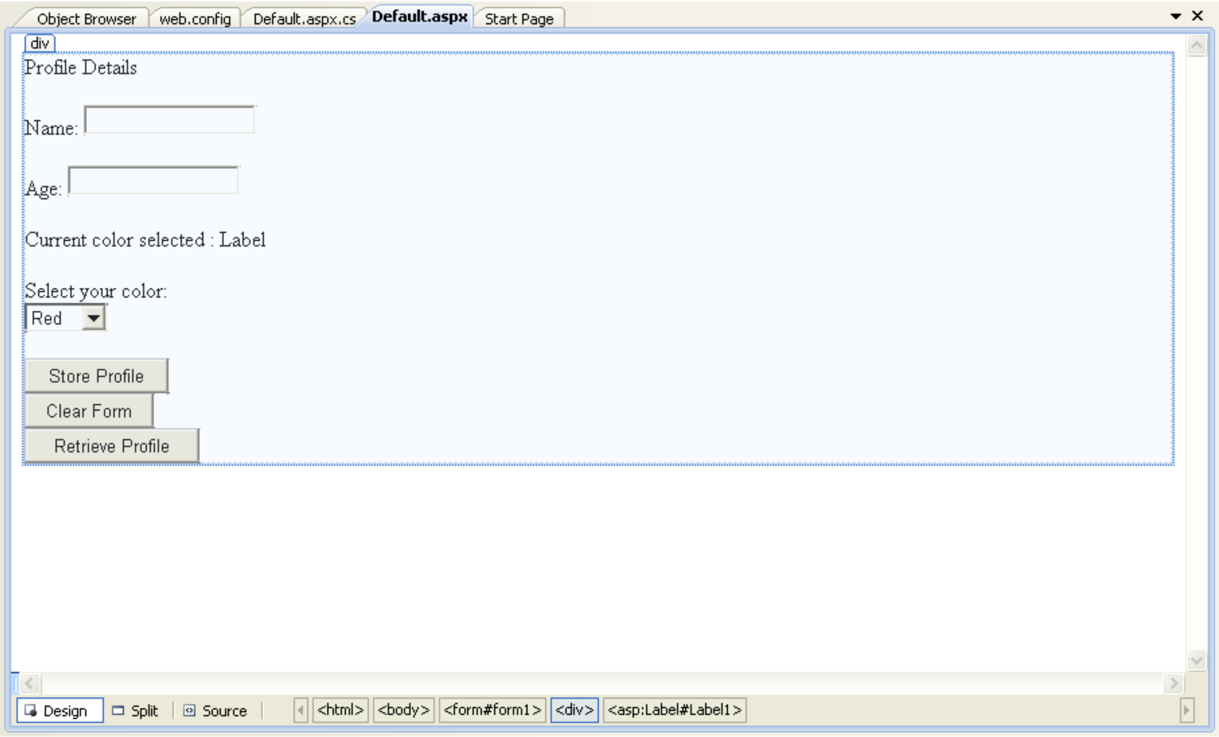
```
<system.web>
  <anonymousIdentification enabled="true"/>
  <profile defaultProvider="MySQLProfileProvider">
    ...
    <properties>
      <add name="Name" allowAnonymous="true"/>
      <add name="Age" allowAnonymous="true" type="System.UInt16"/>
      <group name="UI">
        <add name="Color" allowAnonymous="true" defaultValue="Blue"/>
        <add name="Style" allowAnonymous="true" defaultValue="Plain"/>
      </group>
    </properties>
  </profile>
  ...
```

Note that `anonymousIdentification` has been set to true. This enables users who have not been authenticated to use profiles. They are identified by a GUID in a cookie rather than by user name.

Now that the simple profile has been defined in `web.config`, the next step is to write some code to test the profile.

1. In Design View design a simple page with the following controls:

Figure 20.37. Simple Profile Application



Profile Details

Name:

Age:

Current color selected : Label

Select your color:

Red

Object Browser
web.config
Default.aspx.cs
Default.aspx
Start Page
div
Store Profile
Clear Form
Retrieve Profile
Design
Split
Source
<html>
<body>
<form#form1>
<div>
<asp:Label#Label1>

These will allow the user to enter some profile information. The user can also use the buttons to save their profile, clear the page, and restore their profile data.

2. In the Code View add code as follows:

```
...
protected void Page_Load(object sender, EventArgs e)
{
    if (!IsPostBack)
    {
        TextBox1.Text = Profile.Name;
        TextBox2.Text = Profile.Age.ToString();
        Label1.Text = Profile.UI.Color;
    }
}

// Store Profile
protected void Button1_Click(object sender, EventArgs e)
{
    Profile.Name = TextBox1.Text;
    Profile.Age = UInt16.Parse(TextBox2.Text);
}

// Clear Form
protected void Button2_Click(object sender, EventArgs e)
{
    TextBox1.Text = "";
    TextBox2.Text = "";
    Label1.Text = "";
}

// Retrieve Profile
protected void Button3_Click(object sender, EventArgs e)
{
    TextBox1.Text = Profile.Name;
    TextBox2.Text = Profile.Age.ToString();
    Label1.Text = Profile.UI.Color;
}

protected void DropDownList1_SelectedIndexChanged(object sender, EventArgs e)
{
    Profile.UI.Color = DropDownList1.SelectedValue;
}
...
```

3. Save all files and build the solution to check that no errors have been introduced.

4. Run the application.

5. Enter your name, age and select a color from the listbox. Now store this information in your profile by clicking STORE PROFILE. Note that if you do not select a color from the listbox your profile will use the default color `Blue` that was specified in the `web.config` file.

6. Click CLEAR FORM to clear text from the textboxes and the label that displays your chosen color.

7. Now click RETRIEVE PROFILE to restore your profile data from the MySQL database.

8. Now exit the browser to terminate the application.

9. Run the application again. Note that when the page loads your profile information is restored from the MySQL database.

In this tutorial you have seen how to using the MySQL Profile Provider with MySQL Connector/Net.

20.2.4.5. Tutorial: Using an Entity Framework Entity as a Windows Forms Data Source

In this tutorial you will learn how to create a Windows Forms Data Source from an Entity in an Entity Data Model. This tutorial assumes that you have installed the World example database, which can be downloaded from the MySQL Documentation page. You can also find details on how to install the database on the same page. It will also be convenient for you to create a connection to the World database after it is installed. For instructions on how to do this see Section 20.2.3.1, “Making a connection”.

Creating a new Windows Forms application

The first step is to create a new Windows Forms application.

1. In Visual Studio, select FILE, NEW, PROJECT from the main menu.

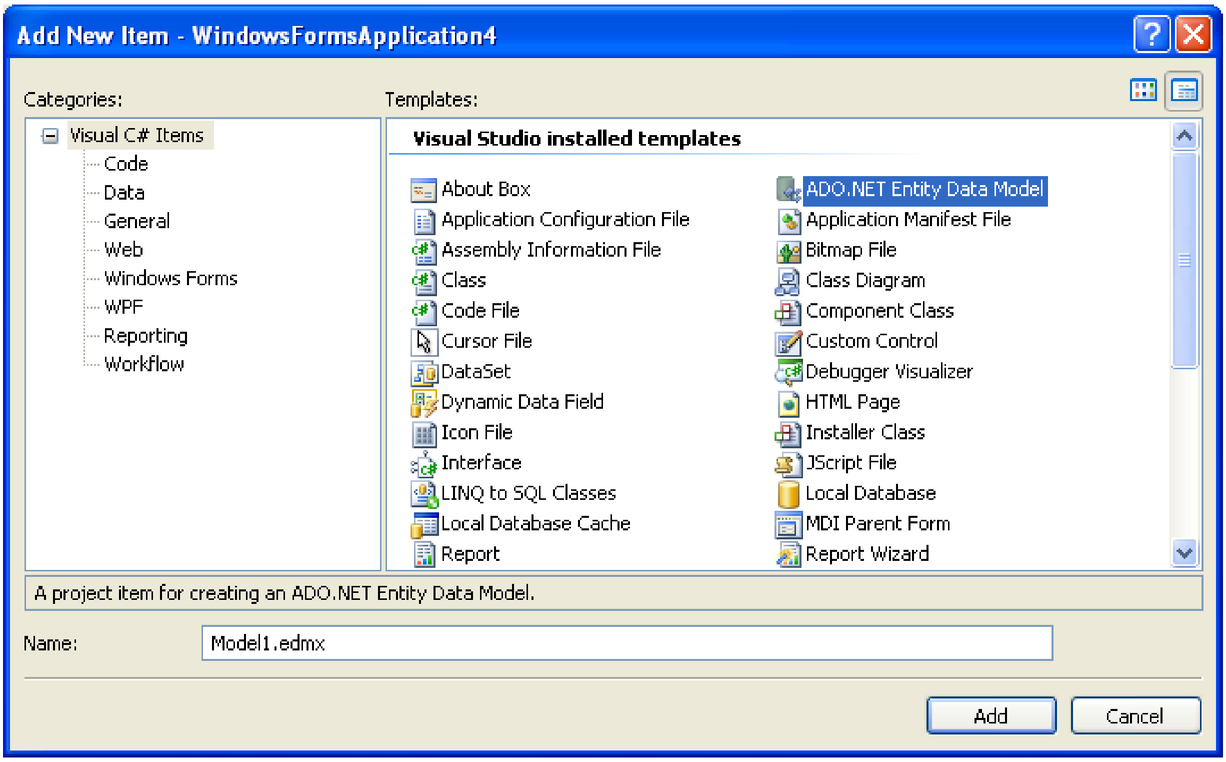
2. Choose the **WINDOWS FORMS APPLICATION** installed template. Click OK. The solution is created.

Adding an Entity Data Model

You will now add an Entity Data Model to your solution.

1. In the Solution Explorer, right-click your application and select Add, New Item.... From **Visual Studio installed templates** select **ADO.NET Entity Data Model**. Click Add.

Figure 20.38. Add Entity Data Model

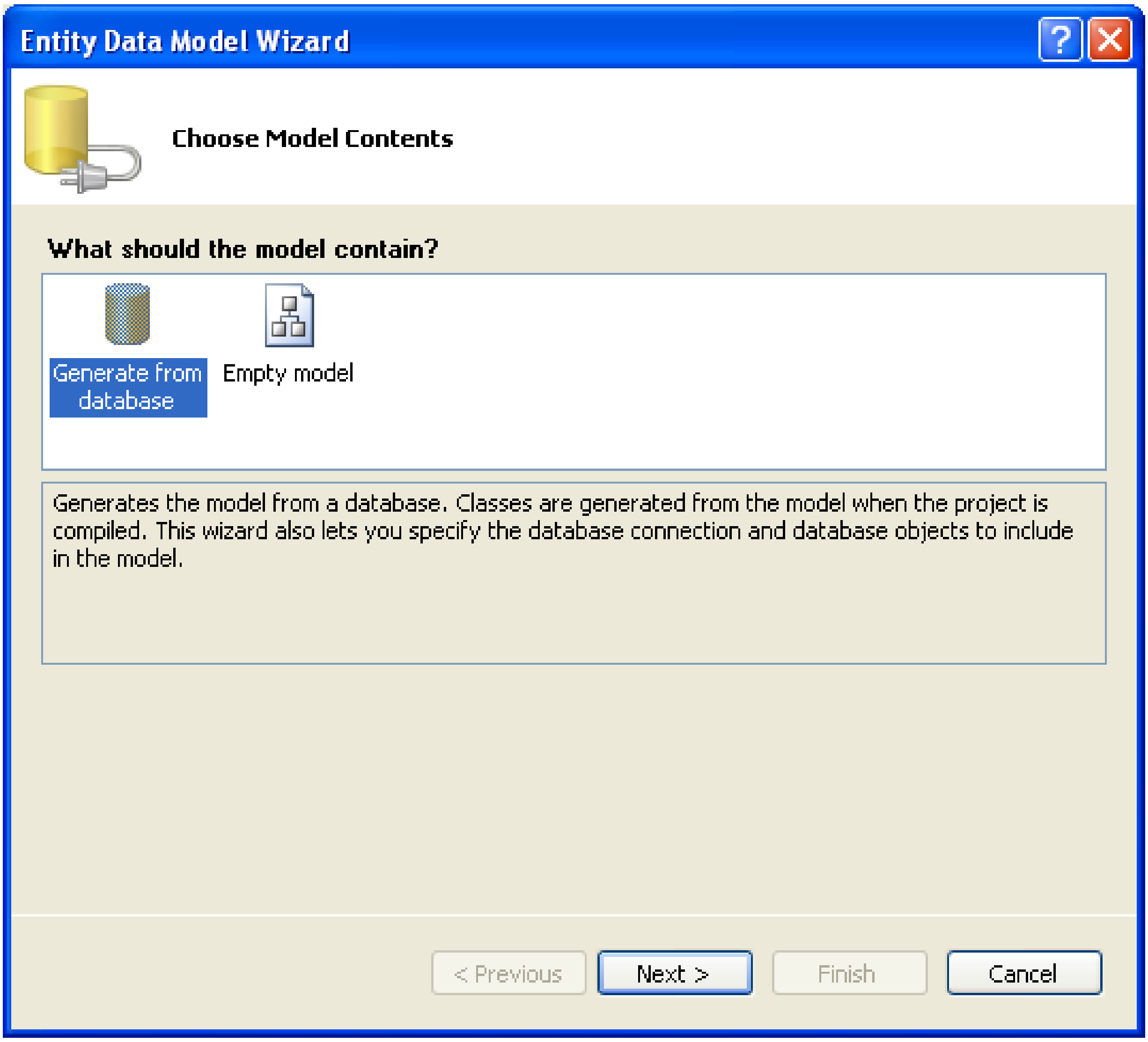

Add New Item - WindowsFormsApplication4
Categories:
Visual C# Items
Code
Data
General
Web
Windows Forms
WPF
Reporting
Workflow
Templates:
Visual Studio installed templates
About Box
Application Configuration File
Assembly Information File
Class
Code File
Cursor File
DataSet
Dynamic Data Field
Icon File
Interface
LINQ to SQL Classes
Local Database Cache
Report
ADO.NET Entity Data Model
Application Manifest File
Bitmap File
Class Diagram
Component Class
Custom Control
Debugger Visualizer
HTML Page
Installer Class
JScript File
Local Database
MDI Parent Form
Report Wizard
Add
Cancel

A project item for creating an ADO.NET Entity Data Model.

Name: Model1.edmx

2. You will now see the Entity Data Model Wizard. You will use the wizard to generate the Entity Data Model from the world example database. Select the icon **Generate from database**. Click Next.

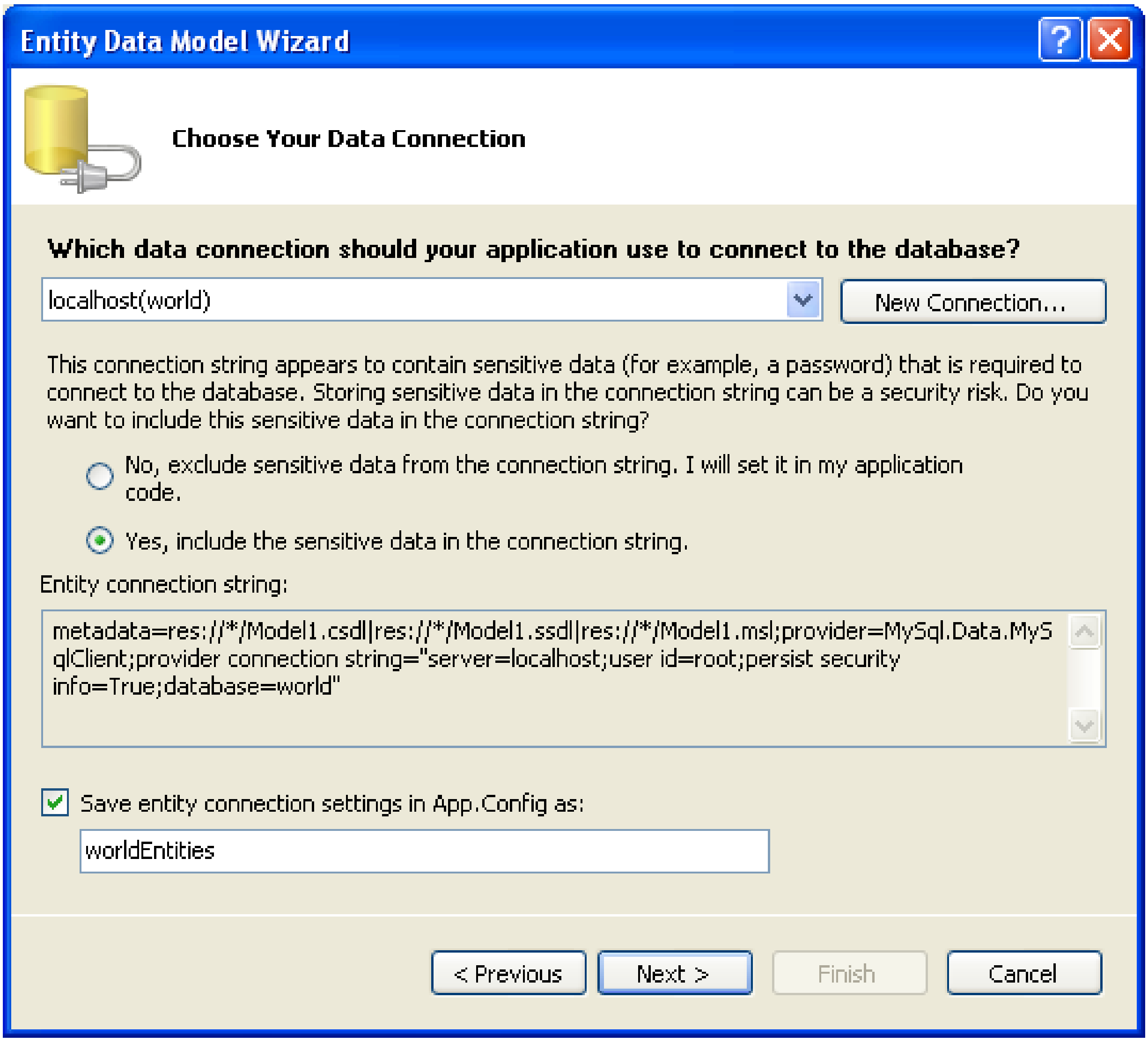
Figure 20.39. Entity Data Model Wizard Screen 1


Entity Data Model Wizard
Choose Model Contents
What should the model contain?
Generate from database
Empty model
< Previous
Next >
Finish
Cancel

Generates the model from a database. Classes are generated from the model when the project is compiled. This wizard also lets you specify the database connection and database objects to include in the model.

3. You can now select the connection you made earlier to the World database. If you have not already done so, you can create the new connection at this time by clicking NEW CONNECTION.... For further instructions on creating a connection to a database see Section 20.2.3.1, “Making a connection”.

Figure 20.40. Entity Data Model Wizard Screen 2



Which data connection should your application use to connect to the database?

localhost(world)

This connection string appears to contain sensitive data (for example, a password) that is required to connect to the database. Storing sensitive data in the connection string can be a security risk. Do you want to include this sensitive data in the connection string?

○ No, exclude sensitive data from the connection string. I will set it in my application code.

● Yes, include the sensitive data in the connection string.

Entity connection string:

```
metadata=res://*/Model1.csdl|res://*/Model1.ssdl|res://*/Model1.msl;provider=MySql.Data.MySqlClient;provider connection string="server=localhost;user id=root;persist security info=True;database=world"
```

☑ Save entity connection settings in App.Config as:

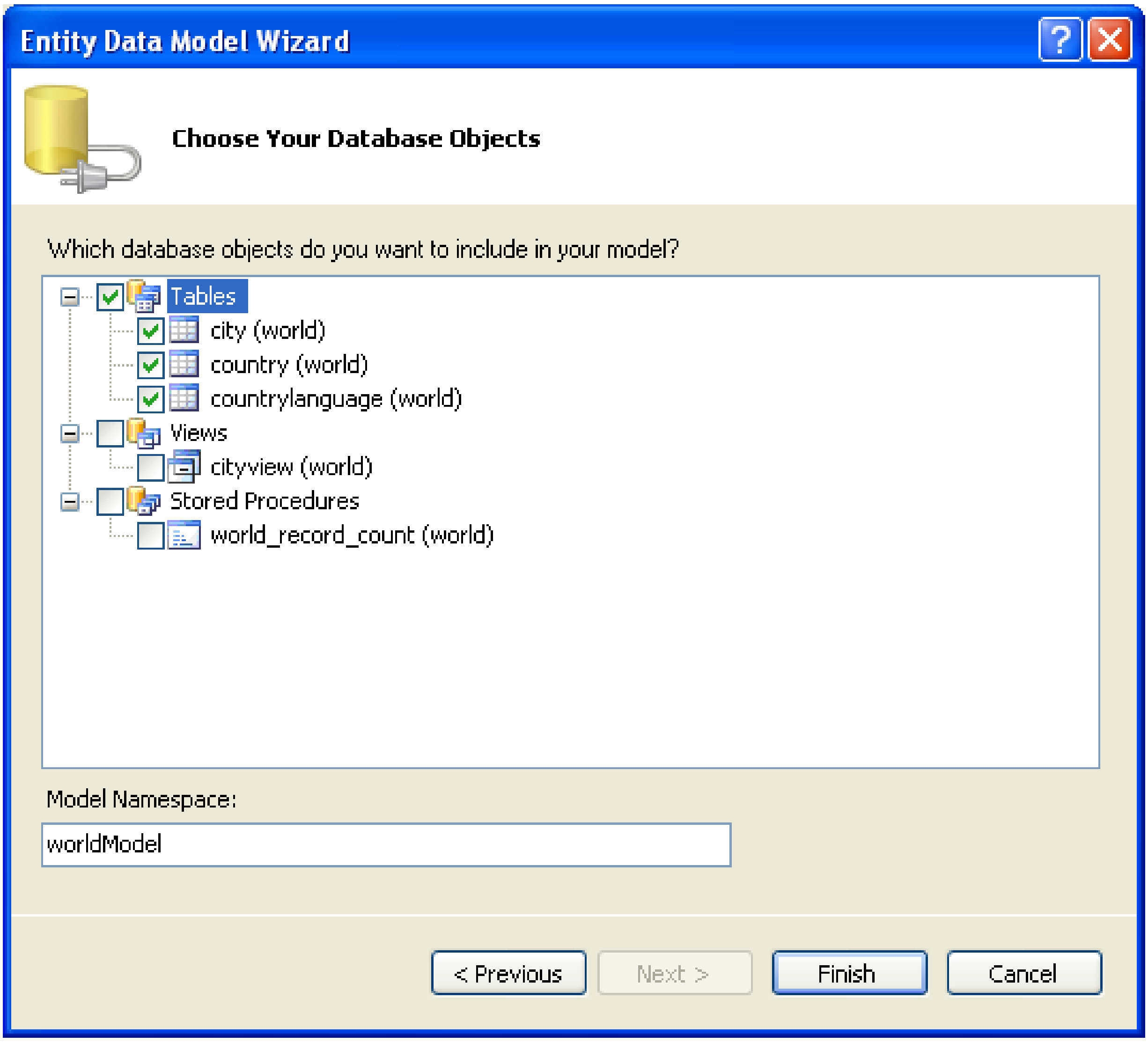
worldEntities

4. Make a note of the entity connection settings to be used in App.Config, as these will be used later to write the necessary control code.

5. Click NEXT.

6. The Entity Data Model Wizard connects to the database. You are then presented with a tree structure of the database. From this you can select the object you would like to include in your model. If you had created Views and Stored Routines these will be displayed along with any tables. In this example you just need to select the tables. Click FINISH to create the model and exit the wizard.

Figure 20.41. Entity Data Model Wizard Screen 3


Entity Data Model Wizard
Choose Your Database Objects

Which database objects do you want to include in your model?

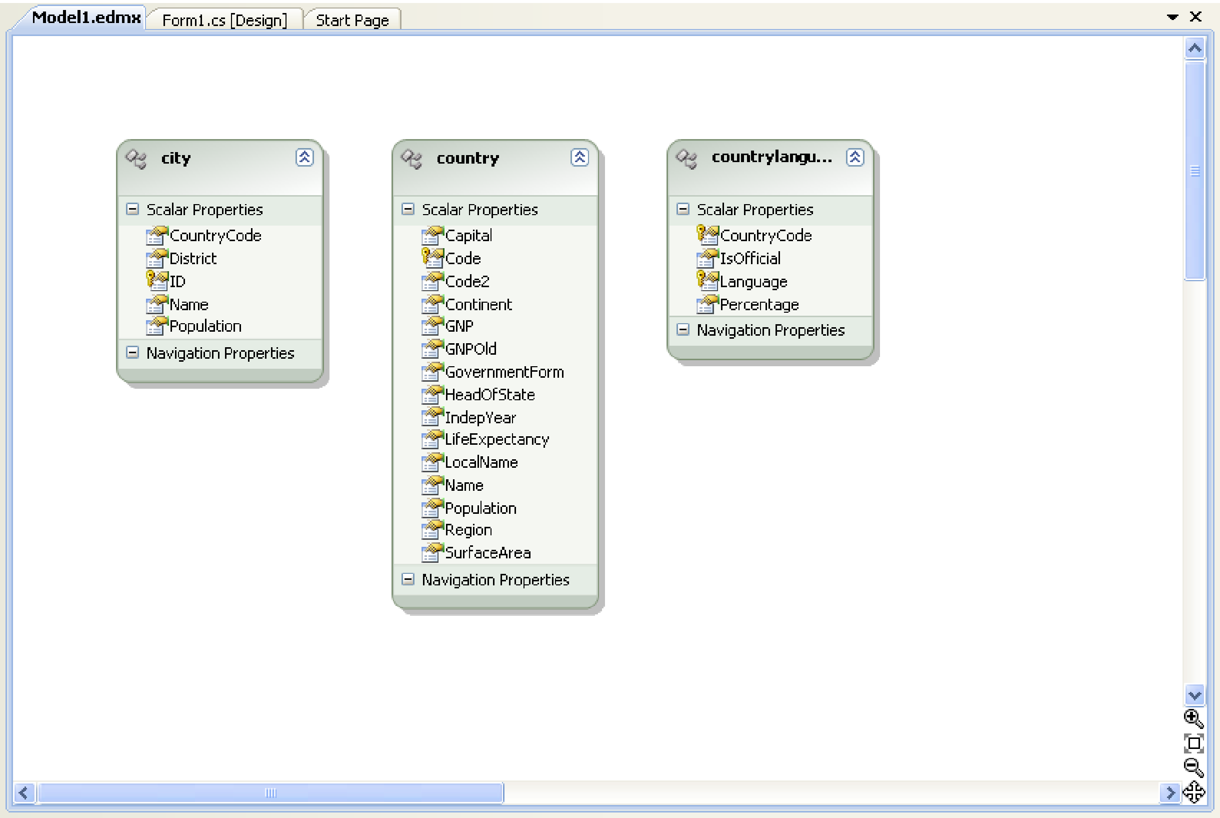
- ☑ Tables
  - ☑ city (world)
  - ☑ country (world)
  - ☑ countrylanguage (world)
- ☐ Views
  - ☐ cityview (world)
- ☐ Stored Procedures
  - ☐ world_record_count (world)

Model Namespace: worldModel

< Previous
Next >
Finish
Cancel

7. Visual Studio will generate the model and then display it.

Figure 20.42. Entity Data Model Diagram


Model1.edmx
Form1.cs [Design]
Start Page
city
Scalar Properties
CountryCode
District
ID
Name
Population
Navigation Properties
country
Scalar Properties
Capital
Code
Code2
Continent
GNP
GNPOld
GovernmentForm
HeadOfState
IndepYear
LifeExpectancy
LocalName
Name
Population
Region
SurfaceArea
Navigation Properties
countrylangu...
Scalar Properties
CountryCode
IsOfficial
Language
Percentage
Navigation Properties

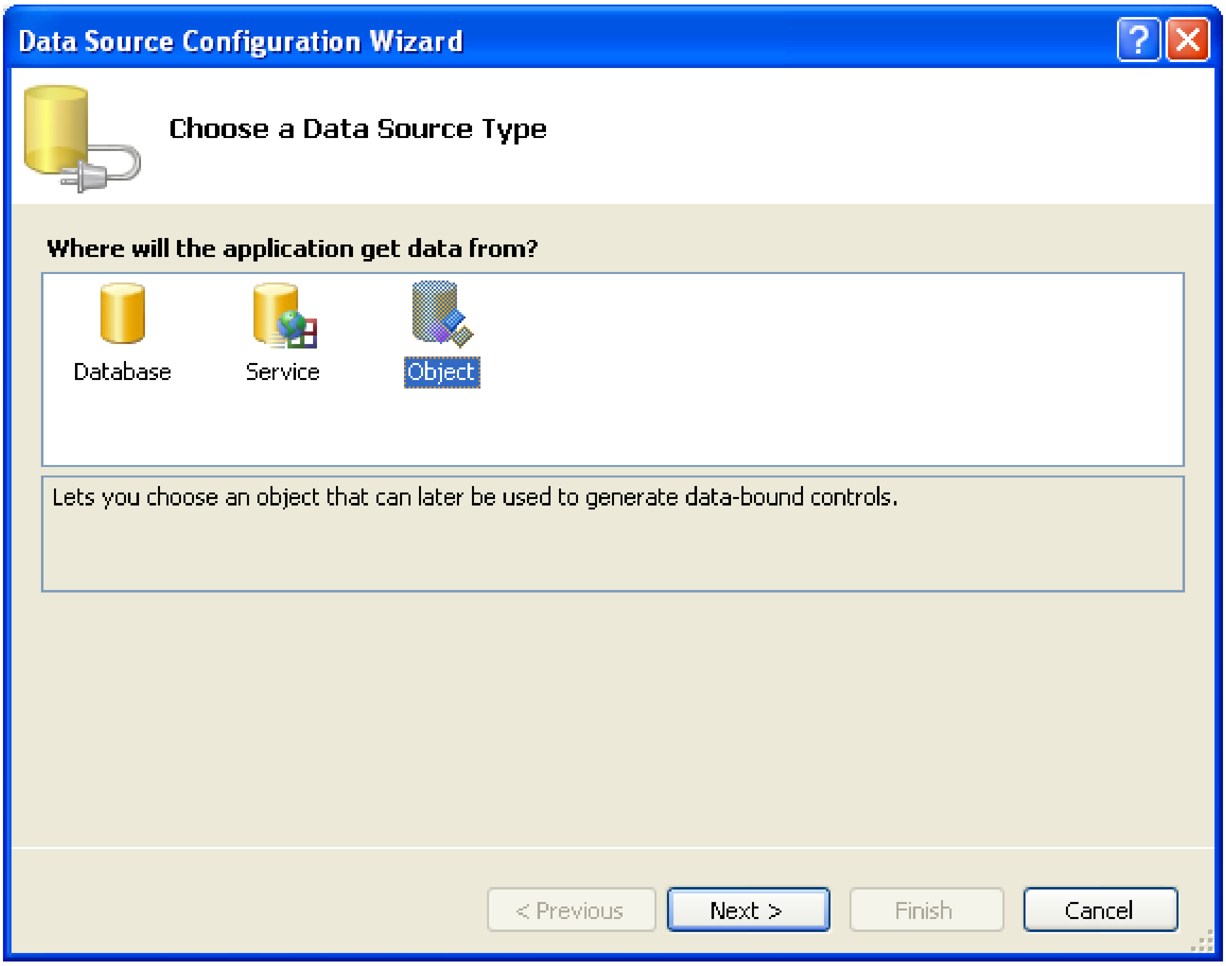
8. From the Visual Studio main menu select BUILD, BUILD SOLUTION, to ensure that everything compiles correctly so far.

Adding a new Data Source

You will now add a new Data Source to your project and see how it can be used to read and write to the database.

1. From the Visual Studio main menu select DATA, ADD NEW DATA SOURCE.... You will be presented with the Data Source Configuration Wizard.

Figure 20.43. Entity Data Source Configuration Wizard Screen 1



Data Source Configuration Wizard

Choose a Data Source Type

Where will the application get data from?

Database
Service
Object

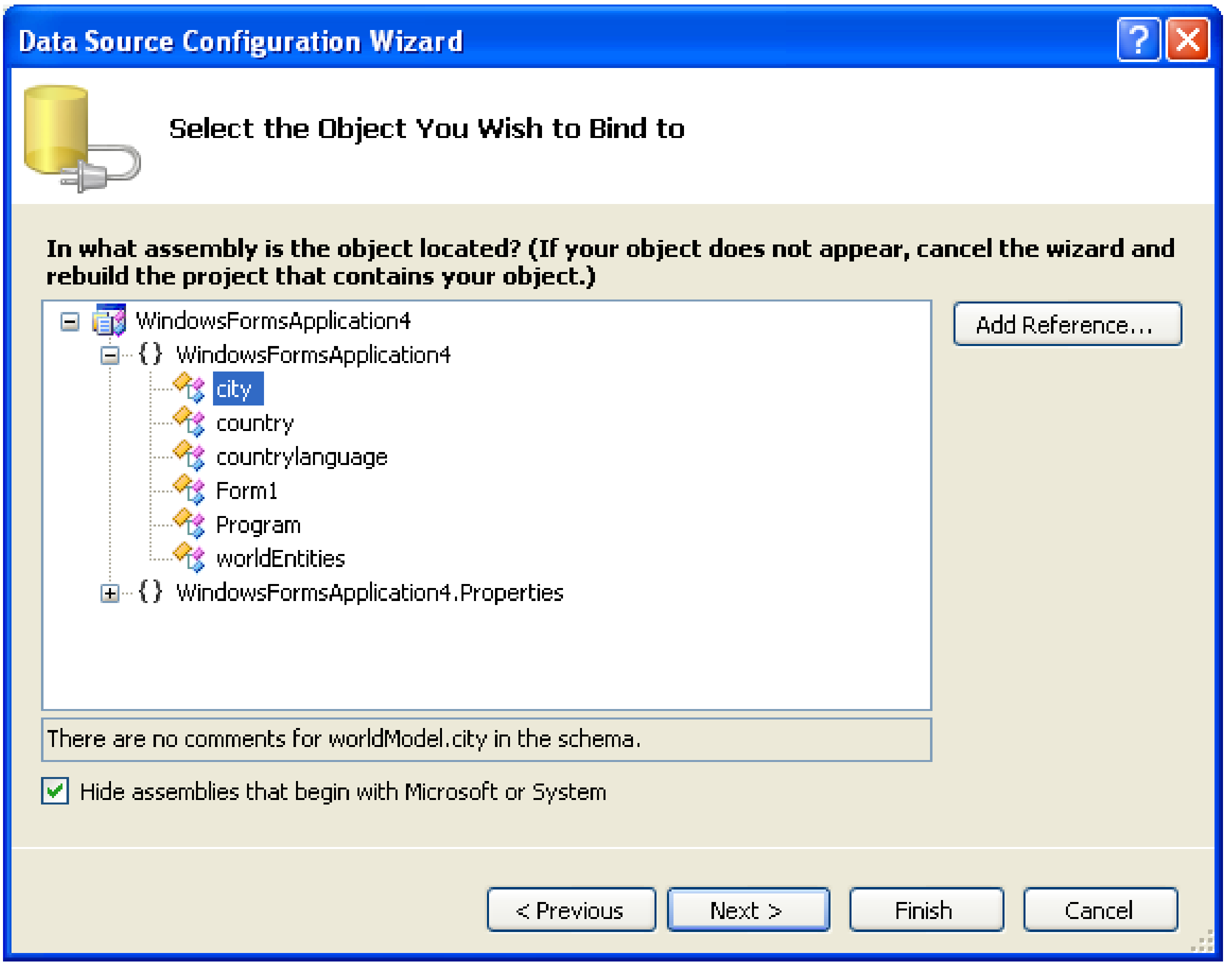
Lets you choose an object that can later be used to generate data-bound controls.

< Previous
Next >
Finish
Cancel

2. Select the **OBJECT** icon. Click NEXT.

3. You will now select the Object you wish to bind to. Expand the tree. In this tutorial you will select the city table. Once the city table has been selected click NEXT.

Figure 20.44. Entity Data Source Configuration Wizard Screen 2


Data Source Configuration Wizard
Select the Object You Wish to Bind to

In what assembly is the object located? (If your object does not appear, cancel the wizard and rebuild the project that contains your object.)

WindowsFormsApplication4
WindowsFormsApplication4
city
country
countrylanguage
Form1
Program
worldEntities
WindowsFormsApplication4.Properties
Add Reference...

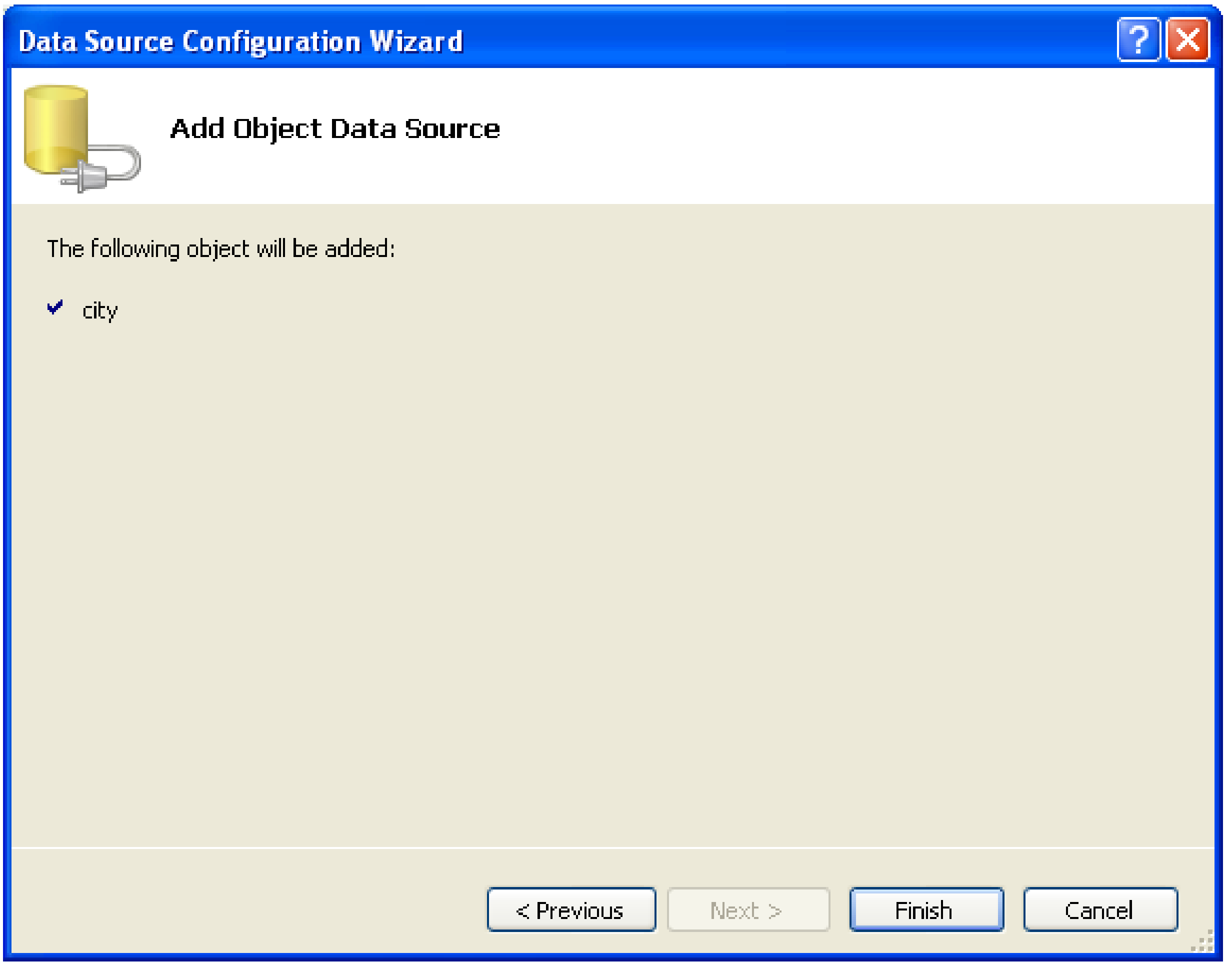
There are no comments for worldModel.city in the schema.

☑ Hide assemblies that begin with Microsoft or System

< Previous
Next >
Finish
Cancel

4. The wizard will confirm that the city object is to be added. Click FINISH.

Figure 20.45. Entity Data Source Configuration Wizard Screen 3

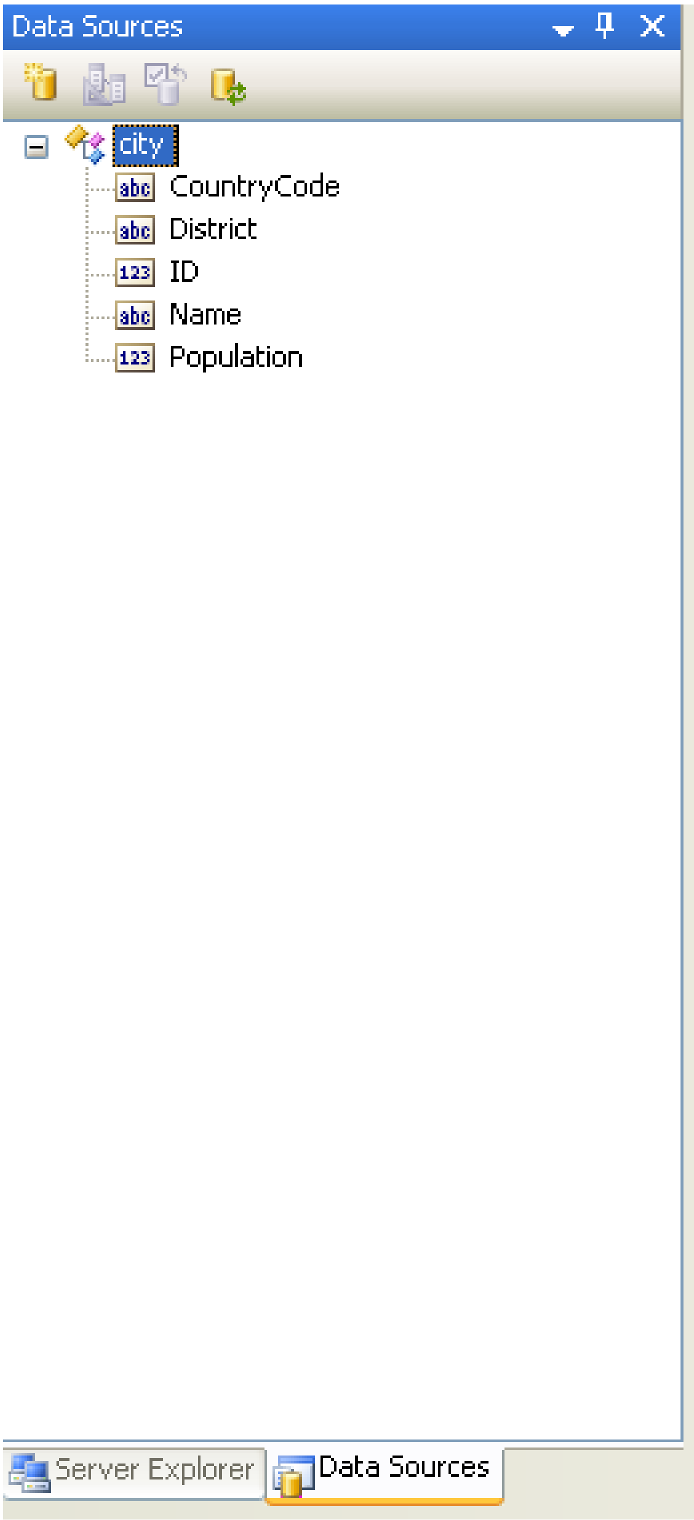

Data Source Configuration Wizard
Add Object Data Source
< Previous
Next >
Finish
Cancel

The following object will be added:

✓ city

5. The city object will be display in the Data Sources panel. If the Data Sources panel is not displayed, select DATA, SHOW DATA SOURCES from the Visual Studio main menu. The docked panel will then be displayed.

Figure 20.46. Data Sources

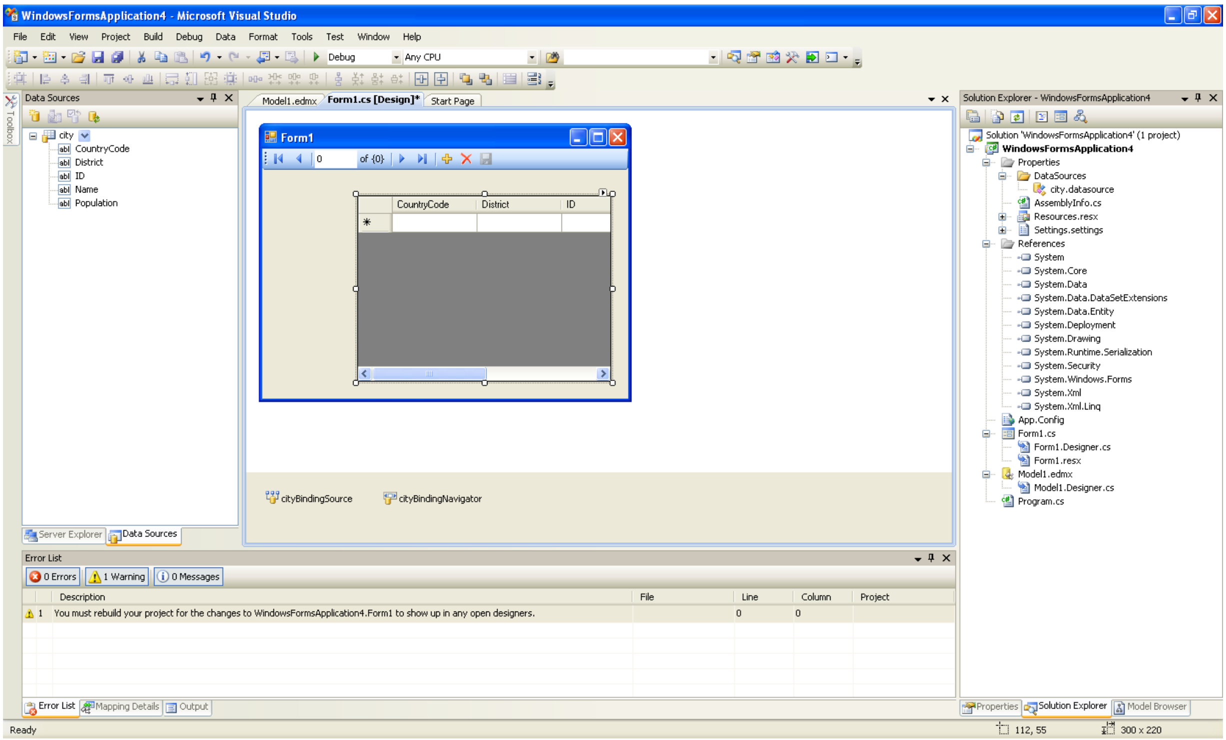

Data Sources
city
CountryCode
District
ID
Name
Population
Server Explorer
Data Sources

Using the Data Source in a Windows Form

You will now learn how to use the Data Source in a Windows Form.

1. In the Data Sources panel select the Data Source you just created and drag and drop it onto the Form Designer. By default the Data Source object will be added as a Data Grid View control. Note that the Data Grid View control is bound to the `cityBindingSource` and the Navigator control is bound to `cityBindingNavigator`.

Figure 20.47. Data Form Designer


WindowsFormsApplication4 - Microsoft Visual Studio
File Edit View Project Build Debug Data Format Tools Test Window Help
Debug
Any CPU
Data Sources
city
CountryCode
District
ID
Name
Population
Model1.edmx
Form1.cs [Design]*
Start Page
Form1
of {0}
CountryCode
District
ID
cityBindingSource
cityBindingNavigator
Server Explorer
Data Sources
Solution Explorer - WindowsFormsApplication4
Solution 'WindowsFormsApplication4' (1 project)
WindowsFormsApplication4
Properties
DataSources
city.datasource
AssemblyInfo.cs
Resources.resx
Settings.settings
References
System
System.Core
System.Data
System.Data.DataSetExtensions
System.Data.Entity
System.Deployment
System.Drawing
System.Runtime.Serialization
System.Security
System.Windows.Forms
System.Xml
System.Xml.Linq
App.Config
Form1.cs
Form1.Designer.cs
Form1.resx
Model1.edmx
Model1.Designer.cs
Program.cs
Error List
0 Errors
1 Warning
0 Messages
Description
File
Line
Column
Project
Error List
Mapping Details
Output
Properties
Solution Explorer
Model Browser
Ready
112, 55
300 x 220

1 You must rebuild your project for the changes to WindowsFormsApplication4.Form1 to show up in any open designers. 0 0

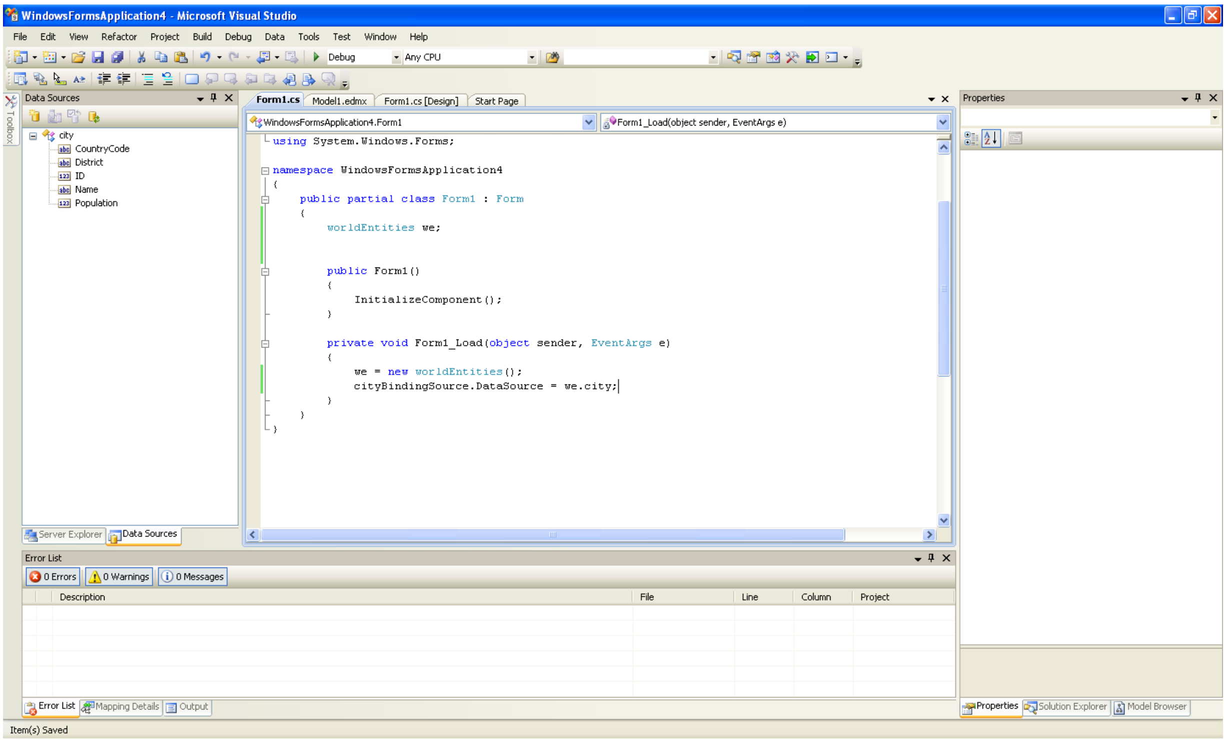
2. Save and rebuild the solution before continuing.

Adding Code to Populate the Data Grid View

You are now ready to add code to ensure that the Data Grid View control will be populated with data from the City database table.

1. Double-click the form to access its code.
2. Add code to instatiate the Entity Data Model's EntityContainer object and retrieve data from the database to populate the control.

Figure 20.48. Adding Code to the Form

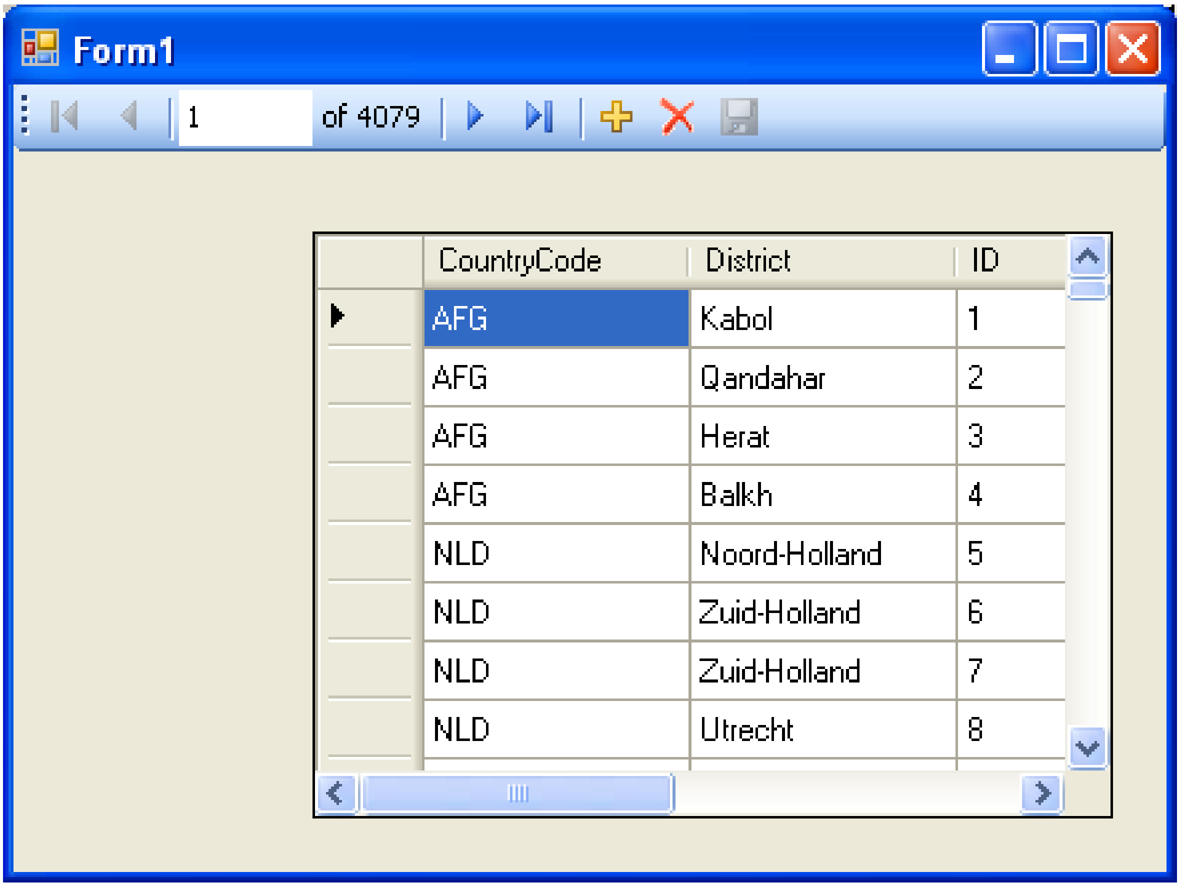

WindowsFormsApplication4 - Microsoft Visual Studio
File Edit View Refactor Project Build Debug Data Tools Test Window Help
Debug
Any CPU
Data Sources
city
CountryCode
District
ID
Name
Population
Server Explorer
Data Sources
Form1.cs
Model1.edmx
Form1.cs [Design]
Start Page
WindowsFormsApplication4.Form1
Form1_Load(object sender, EventArgs e)
Properties
Error List
0 Errors
0 Warnings
0 Messages
Description
File
Line
Column
Project
Error List
Mapping Details
Output
Properties
Solution Explorer
Model Browser
Item(s) Saved

```
using System.Windows.Forms;

namespace WindowsFormsApplication4
{
    public partial class Form1 : Form
    {
        worldEntities we;

        public Form1()
        {
            InitializeComponent();
        }

        private void Form1_Load(object sender, EventArgs e)
        {
            we = new worldEntities();
            cityBindingSource.DataSource = we.city;
        }
    }
}
```

3. Save and rebuild the solution.

4. Run the solution. Ensure the grid is populated and you can navigate the database.

Figure 20.49. The Populated Grid Control


Form1
1
of 4079

CountryCode	District	ID
AFG	Kabol	1
AFG	Qandahar	2
AFG	Herat	3
AFG	Balkh	4
NLD	Noord-Holland	5
NLD	Zuid-Holland	6
NLD	Zuid-Holland	7
NLD	Utrecht	8

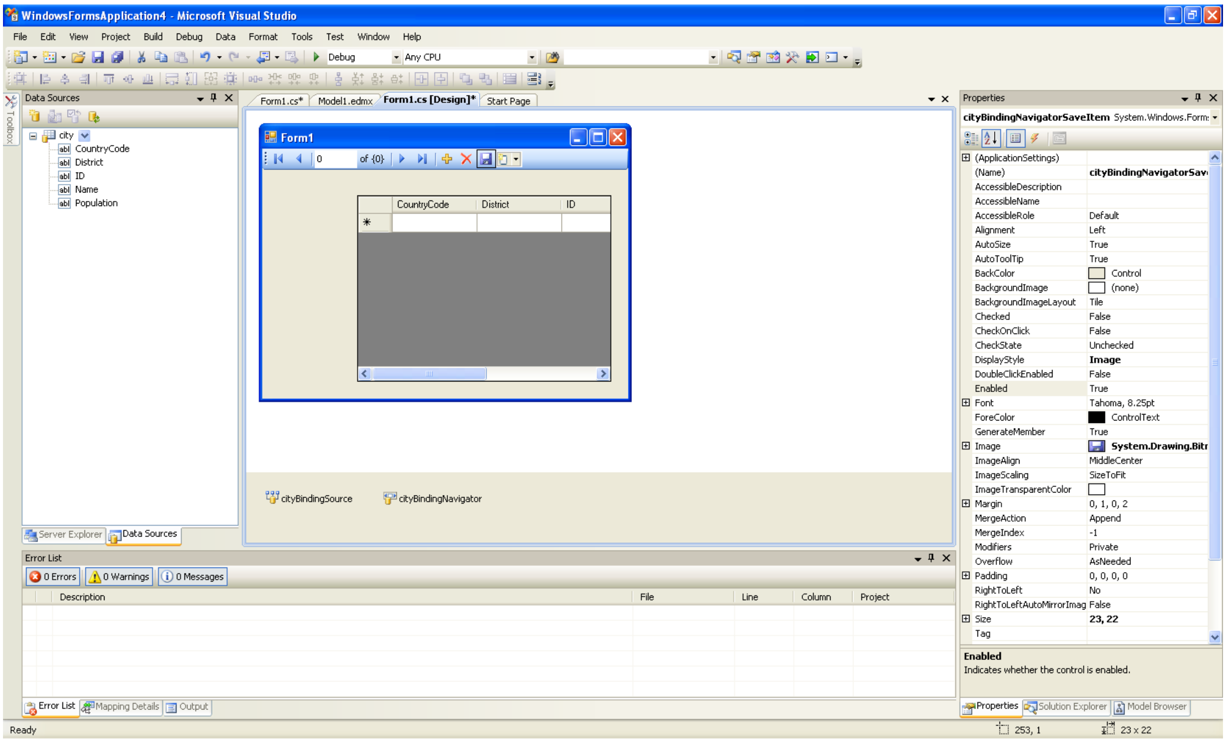
Adding Code to Save Changes to the Database

You will now add code to enable you to save changes to the database.

The Binding source component ensures that changes made in the Data Grid View control are also made to the Entity classes bound to it. However, that data needs to be saved back from the entities to the database itself. This can be achieved by the enabling of the Save button in the Navigator control, and the addition of some code.

1. In the Form Designer, click the Save icon in the Form toolbar and ensure that its Enabled property is set to True.

Figure 20.50. Save Button Enabled


WindowsFormsApplication4 - Microsoft Visual Studio
File Edit View Project Build Debug Data Format Tools Test Window Help
Debug
Any CPU
Data Sources
city
CountryCode
District
ID
Name
Population
Form1.cs*
Model1.edmx
Form1.cs [Design]*
Start Page
Form1
of {0}
CountryCode
District
ID
cityBindingSource
cityBindingNavigator
Server Explorer
Data Sources
Error List
0 Errors
0 Warnings
0 Messages
Description
File
Line
Column
Project
Error List
Mapping Details
Output
Ready
Properties
Solution Explorer
Model Browser
253, 1
23 x 22

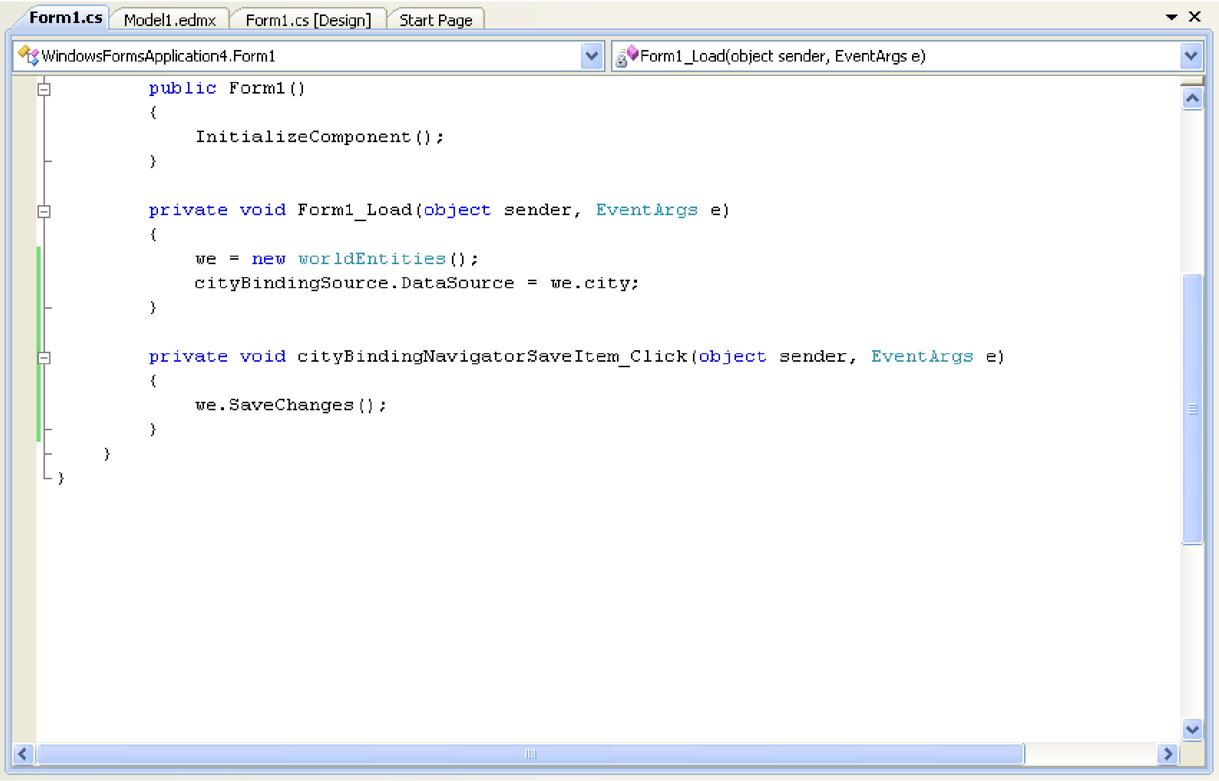
Properties: cityBindingNavigatorSaveItem System.Windows.Form:

(ApplicationSettings)	
(Name)	cityBindingNavigatorSav
AccessibleDescription	
AccessibleName	
AccessibleRole	Default
Alignment	Left
AutoSize	True
AutoToolTip	True
BackColor	Control
BackgroundImage	(none)
BackgroundImageLayout	Tile
Checked	False
CheckOnClick	False
CheckState	Unchecked
DisplayStyle	Image
DoubleClickEnabled	False
Enabled	True
Font	Tahoma, 8.25pt
ForeColor	ControlText
GenerateMember	True
Image	System.Drawing.Bitr
ImageAlign	MiddleCenter
ImageScaling	SizeToFit
ImageTransparentColor	
Margin	0, 1, 0, 2
MergeAction	Append
MergeIndex	-1
Modifiers	Private
Overflow	AsNeeded
Padding	0, 0, 0, 0
RightToLeft	No
RightToLeftAutoMirrorImag	False
Size	23, 22
Tag	

Enabled
Indicates whether the control is enabled.

2. Double-click the Save icon in the Form toolbar to display its code.
3. You now need to add code to ensure that data is saved to the database when the save button is clicked in the application.

Figure 20.51. Adding Save Code to the Form


Form1.cs
Model1.edmx
Form1.cs [Design]
Start Page
WindowsFormsApplication4.Form1
Form1_Load(object sender, EventArgs e)

```
        public Form1()
        {
            InitializeComponent();
        }

        private void Form1_Load(object sender, EventArgs e)
        {
            we = new worldEntities();
            cityBindingSource.DataSource = we.city;
        }

        private void cityBindingNavigatorSaveItem_Click(object sender, EventArgs e)
        {
            we.SaveChanges();
        }
    }
}
```

4. Once the code has been added, save the solution and rebuild it. Run the application and verify that changes made in the grid are saved.

20.2.4.6. Tutorial: Databinding in ASP.NET using LINQ on Entities

In this tutorial you create an ASP.NET web page that binds LINQ queries to entities using the Entity Framework mapping.

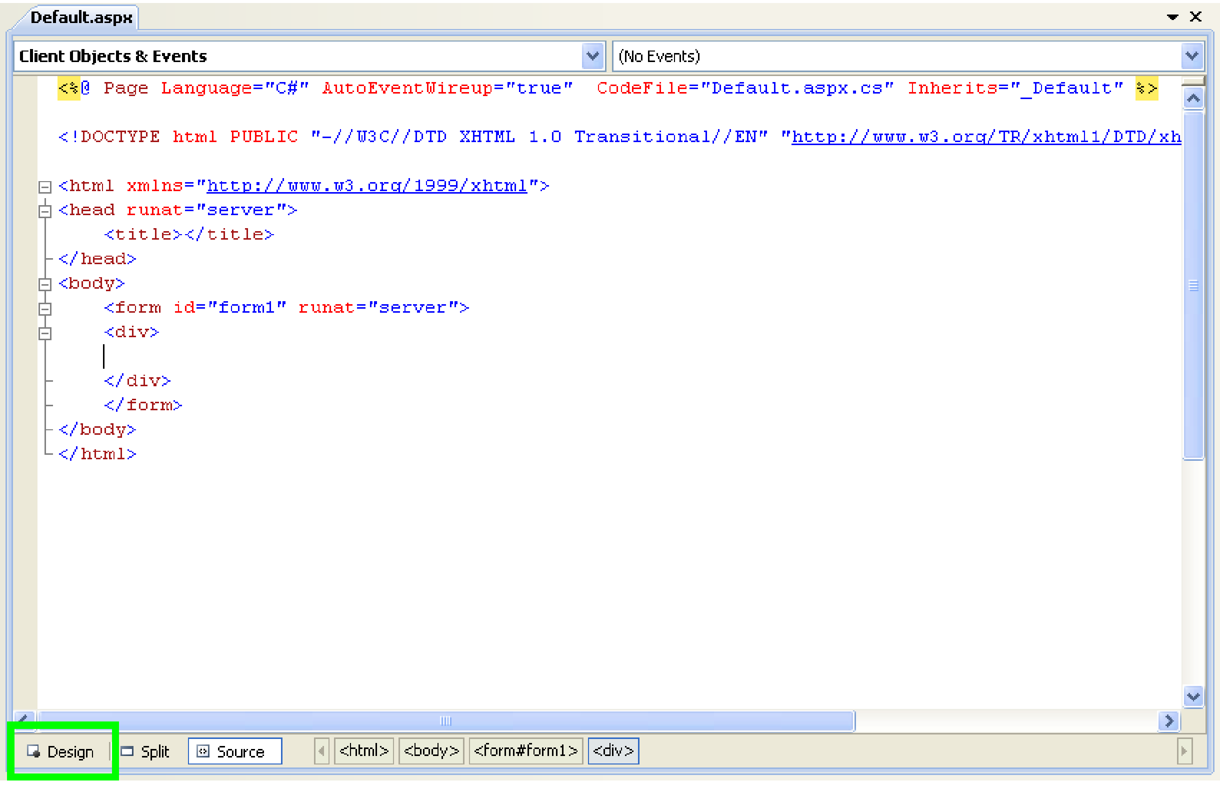
If you have not already done so, you should install the World example database prior to attempting this tutorial. Instructions on where to obtain the database and instructions on how to install it where given in the tutorial Section 20.2.4.5, “Tutorial: Using an Entity Framework Entity as a Windows Forms Data Source”.

Creating an ASP.NET web site

In this part of the tutorial you will create an ASP.NET web site. The web site will use the World database. The main web page will feature a drop down list from which you can select a country, data about that country's cities will then be displayed in a grid view control.

1. From the Visual Studio main menu select FILE, NEW, WEB SITE....
2. From the Visual Studio installed templates select **ASP.NET WEB SITE**. Click OK. You will be presented with the Source view of your web page by default.
3. Click the Design view tab situated underneath the Source view panel.

Figure 20.52. The Design Tab

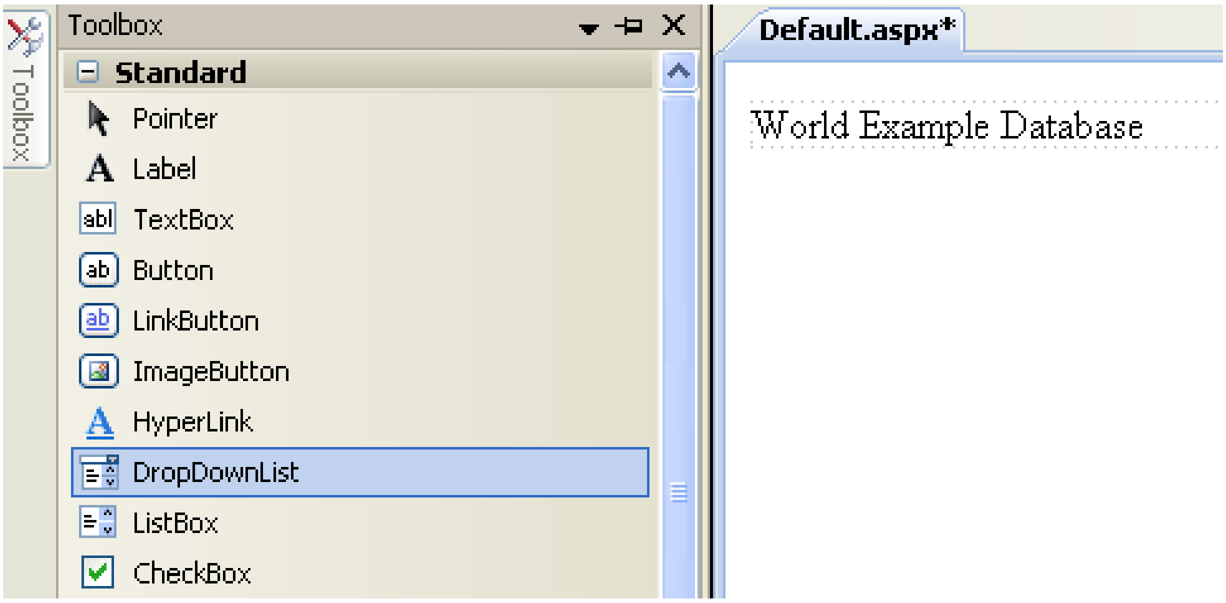

Default.aspx
Client Objects & Events
(No Events)
Design
Split
Source
<html>
<body>
<form#form1>
<div>

```
<%@ Page Language="C#" AutoEventWireup="true"  CodeFile="Default.aspx.cs" Inherits="_Default" %>

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xh

<html xmlns="http://www.w3.org/1999/xhtml">
<head runat="server">
    <title></title>
</head>
<body>
    <form id="form1" runat="server">
    <div>
    
    </div>
    </form>
</body>
</html>
```

4. In the Design view panel, enter some text to decorate the blank web page.

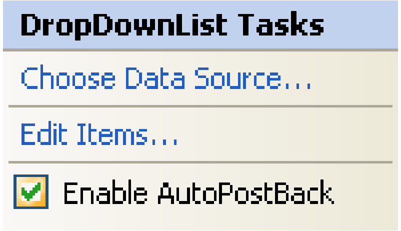
5. Click Toolbox. From the list of controls select **DropDownList**. Drag and drop the control to a location beneath the text on your web page.

Figure 20.53. Drop Down List


Toolbox
Toolbox
Standard
Pointer
Label
TextBox
Button
LinkButton
ImageButton
HyperLink
DropDownList
ListBox
CheckBox
Default.aspx*
World Example Database

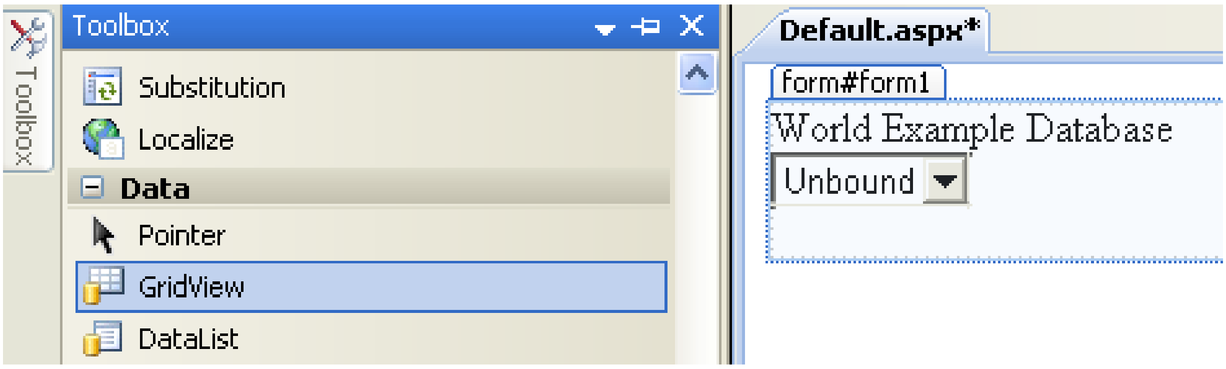
6. From the **DropDownList** control's context menu, ensure that the **Enable AutoPostBack** check box is enabled. This will ensure the control's event handler is called when an item is selected. The user's choice will in turn be used to populate the **GridView** control.

Figure 20.54. Enable AutoPostBack


DropDownList Tasks
Choose Data Source...
Edit Items...
☑ Enable AutoPostBack

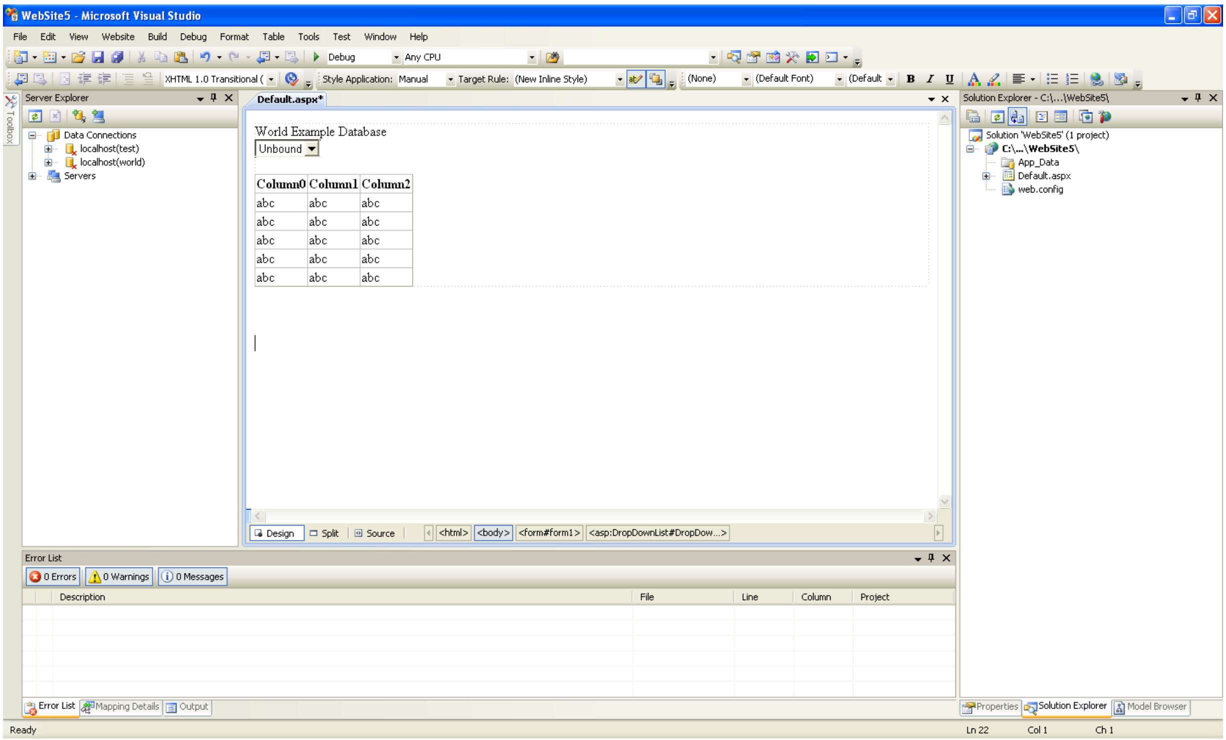
7. From the Toolbox select the **GRIDVIEW** control.

Figure 20.55. Grid View Control


Toolbox
Toolbox
Substitution
Localize
Data
Pointer
GridView
DataList
Default.aspx*
form#form1
World Example Database
Unbound

Drag and drop the Grid Vew control to a location just below the Drop Down List you already placed.

Figure 20.56. Placed Grid Vew Control


WebSite5 - Microsoft Visual Studio
File Edit View Website Build Debug Format Table Tools Test Window Help
Server Explorer
Data Connections
localhost(test)
localhost(world)
Servers
Default.aspx*
Solution Explorer - C:\...\WebSite5\
Solution 'WebSite5' (1 project)
C:\...\WebSite5\
App_Data
Default.aspx
web.config
Design
Split
Source
Error List
0 Errors
0 Warnings
0 Messages
Description
File
Line
Column
Project
Ready
Ln 22
Col 1
Ch 1

World Example Database

Unbound

Column0	Column1	Column2
abc	abc	abc
abc	abc	abc
abc	abc	abc
abc	abc	abc
abc	abc	abc

8. At this point it is recommended that you save your solution, and build the solution to ensure that there are no errors.

9. If you run the solution you will see that the text and drop down list are displayed, but the list is empty. Also, the grid view does not appear at all. Adding this functionality is described in the following sections.

At this stage you have a web site that will build, but further functionality is required. The next step will be to use the Entity Framework to create a mapping from the World database into entities that you can control programmatically.

Creating an ADO.NET Entity Data Model

In this stage of the tutorial you will add an ADO.NET Entity Data Model to your project, using the World database at the storage level. The procedure for doing this is described in the tutorial Section 20.2.4.5, "Tutorial: Using an Entity Framework Entity as a Windows Forms Data Source", and so will not be repeated here.

Populating a Drop Data List Box with using the results of a entity LINQ query

In this part of the tutorial you will write code to populate the DropDownList control. When the web page loads the data to populate the list will be achieved by using the results of a LINQ query on the model created previously.

1. In the Design view panel, double-click any blank area. This brings up the `Page_Load` method.
2. Modify the relevant section of code according to the following listing:

```
...
public partial class _Default : System.Web.UI.Page
{
    worldModel.worldEntities we;

    protected void Page_Load(object sender, EventArgs e)
    {
        we = new worldModel.worldEntities();

        if (!IsPostBack)
        {
            var countryQuery = from c in we.country
                               orderby c.Name
                               select new { c.Code, c.Name };
            DropDownList1.DataValueField = "Code";
            DropDownList1.DataTextField = "Name";
            DropDownList1.DataSource = countryQuery;
            DataBind();
        }
    }
...
```

   Note that the list control only needs to be populated when the page first loads. The conditional code ensures that if the page is subsequently reloaded, the list control is not repopulated, which would cause the user selection to be lost.

3. Save the solution, build it and run it. You should see the list control has been populated. You can select an item, but as yet the grid view control does not appear.

At this point you have a working Drop Down List control, populated by a LINQ query on your entity data model.

Populating a Grid View control using an entity LINQ query

In the last part of this tutorial you will populate the Grid View Control using a LINQ query on your entity data model.

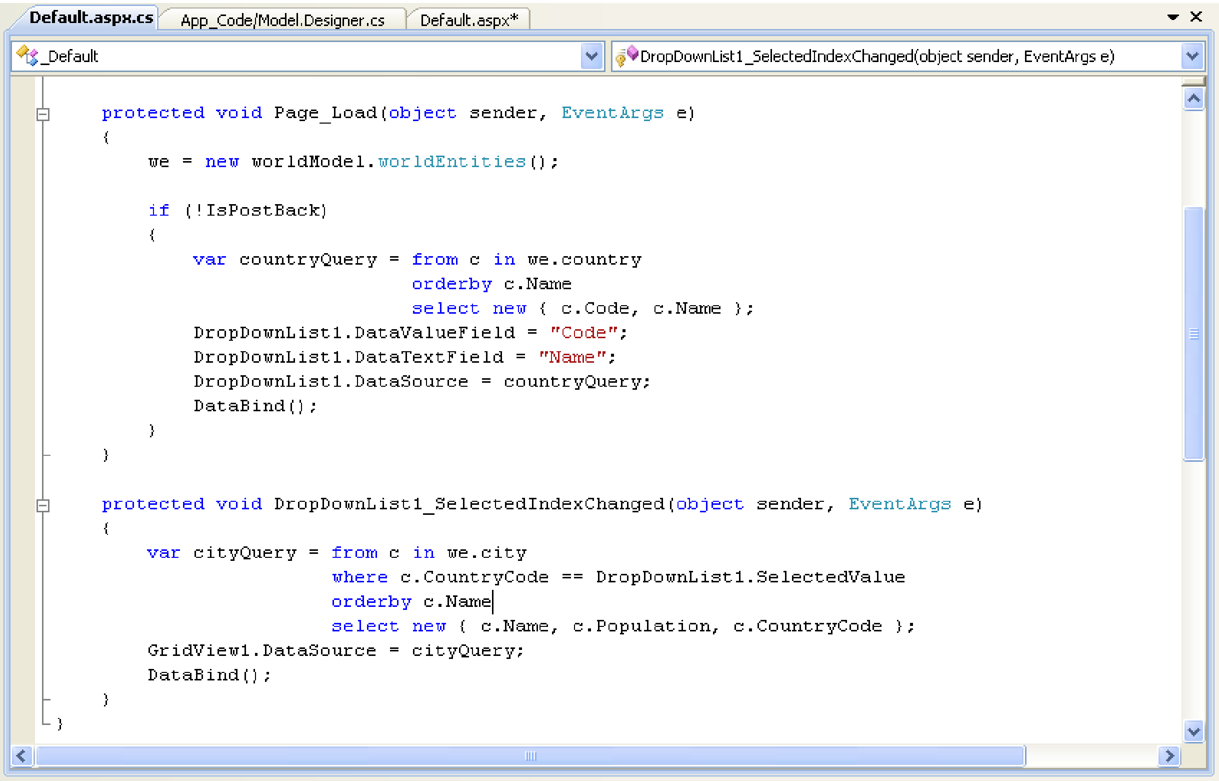
1. In the Design view, double-click the **DropDownList** control. This causes its `SelectedIndexChanged` code to be displayed. This method is called when a user selects an item in the list control and thus fires an AutoPostBack event.
2. Modify the relevant section of code accordingly to the following listing:

```
...
    protected void DropDownList1_SelectedIndexChanged(object sender, EventArgs e)
    {
        var cityQuery = from c in we.city
                        where c.CountryCode == DropDownList1.SelectedValue
                        orderby c.Name
                        select new { c.Name, c.Population, c.CountryCode };
        GridView1.DataSource = cityQuery;
        DataBind();
    }
...
```

   The grid view control is populated from the result of the LINQ query on the entity data model.

3. As a check compare your code to that shown in the following screenshot:

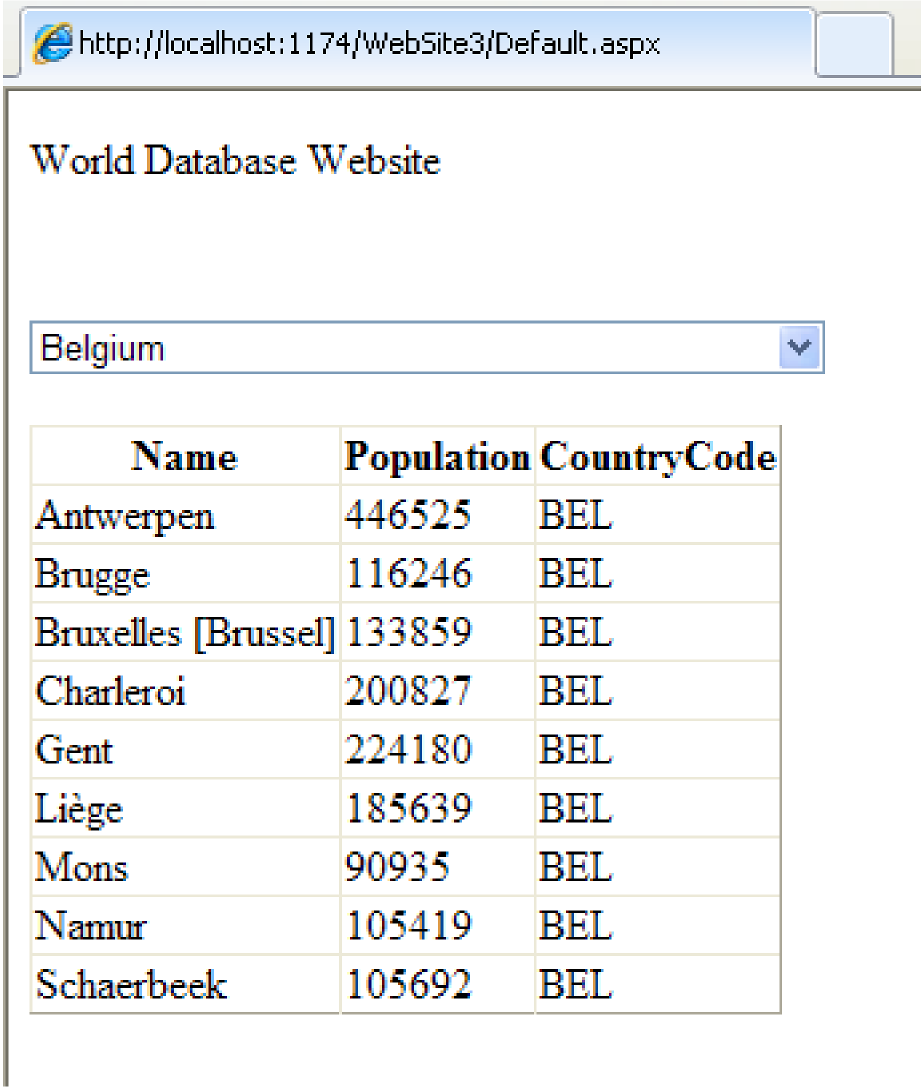
Figure 20.57. Source Code


Default.aspx.cs
App_Code/Model.Designer.cs
Default.aspx*
_Default
DropDownList1_SelectedIndexChanged(object sender, EventArgs e)

```
    protected void Page_Load(object sender, EventArgs e)
    {
        we = new worldModel.worldEntities();

        if (!IsPostBack)
        {
            var countryQuery = from c in we.country
                               orderby c.Name
                               select new { c.Code, c.Name };
            DropDownList1.DataValueField = "Code";
            DropDownList1.DataTextField = "Name";
            DropDownList1.DataSource = countryQuery;
            DataBind();
        }
    }

    protected void DropDownList1_SelectedIndexChanged(object sender, EventArgs e)
    {
        var cityQuery = from c in we.city
                        where c.CountryCode == DropDownList1.SelectedValue
                        orderby c.Name
                        select new { c.Name, c.Population, c.CountryCode };
        GridView1.DataSource = cityQuery;
        DataBind();
    }
}
```

4. Save, build and run the solution. As you select a country you will see its cities are displayed in the grid view control.

Figure 20.58. The Working Web Site



World Database Website

Belgium

Name	Population	CountryCode
Antwerpen	446525	BEL
Brugge	116246	BEL
Bruxelles [Brussel]	133859	BEL
Charleroi	200827	BEL
Gent	224180	BEL
Liège	185639	BEL
Mons	90935	BEL
Namur	105419	BEL
Schaerbeek	105692	BEL

In this tutorial you have seen how to create an ASP.NET web site, you have also seen how you can access a MySQL database using LINQ queries on an entity data model.

20.2.4.7. Tutorial: Using SSL with MySQL Connector/Net

In this tutorial you will learn how you can use MySQL Connector/Net to connect to a MySQL server configured to use SSL. Support for SSL client certificates was added with MySQL Connector/Net 6.2.

MySQL Server uses the PEM format for certificates and private keys. This tutorial will use the test certificates from the server test suite by way of example. You can obtain the MySQL Server source code from MySQL Downloads. The certificates can be found in the directory `./mysql-test/std_data`.

To carry out the steps in this tutorial you will also need to have Open SSL installed. This can be downloaded for Microsoft Windows at no charge from Shining Light Productions.

Further details on the connection string options used in this tutorial can be found at Section 20.2.6, “Connector/Net Connection String Options Reference”.

Configuring the MySQL Server to use SSL

1. In the MySQL Server configuration file, set the SSL parameters as follows:

```
ssl-ca=path/to/repo/mysql-test/std_data/cacert.pem
ssl-cert=path/to/repo/mysql-test/std_data/server-cert.pem
ssl-key=path/to/repo/mysql-test/std_data/server-key.pem
```

Adjust the directories according to the location in which you installed the MySQL source code.

2. In this step you create a test user and set the user to require SSL.

   Using the MySQL Command Line Client, connect as root and create the user `sslclient`.

3. To set privileges and requirements, issue the following command:

   ```
   GRANT ALL PRIVILEGES ON *.* TO sslclient@'%' REQUIRE SSL;
   ```

Creating a certificate file to use with the .NET client

1. The .NET client does not use the PEM file format, as .NET does not support this format natively. You will be using test client certificates from the same server repository, for the purposes of this example. You will need to convert these to PFX format first. This format is also known as PKCS#12. An article describing this procedure can be found at the Citrix website. From the directory *`server-repository-root/`*`mysql-test/std_data`, issue the following command:

   ```
   openssl pkcs12 -export -in client-cert.pem -inkey client-key.pem -certfile cacert.pem -out client.pfx
   ```

2. When asked for an export password, enter the password “pass”. The file `client.pfx` will be generated. This file is used in the remainder of the tutorial.

Connecting to the server using a file-based certificate

1. You will use PFX file, `client.pfx` you created in the previous step to authenticate the client. The following example demonstrates how to connect using the `SSL Mode`, `CertificateFile` and `CertificatePassword` connection string options:

   ```
   using (MySqlConnection connection = new MySqlConnection(
     "database=test;user=sslclient;" +
     "CertificateFile=H:\\bzr\\mysql-trunk\\mysqlest\\std_data\\client.pfx" +
     "CertificatePassword=pass;" +
     "SSL Mode=Required "))
   {
       connection.Open();
   }
   ```

   The path to the certificate file will need to be changed to reflect your individual installation.

Connecting to the server using a store-based certificate

1. The first step is to import the PFX file, `client.pfx`, into the Personal Store. Double-click the file in Windows explorer. This launches the Certificate Import Wizard.

2. Follow the steps dictated by the wizard, and when prompted for the password for the PFX file, enter “pass”.

3. Click FINISH to close the wizard and import the certificate into the personal store.

Examine certificates in the Personal Store

1. Start the Microsoft Management Console by entering `mmc.exe` at a command prompt.

2. Select FILE, ADD/REMOVE SNAP-IN. Click ADD. Select **CERTIFICATES** from the list of available snap-ins in the dialog.

3. Click ADD button in the dialog, and select the **MY USER ACCOUNT** radio button. This is used for personal certificates.

4. Click the FINISH button.

5. Click OK to close the Add/Remove Snap-in dialog.

6. You will now have **CERTIFICATES – CURRENT USER** displayed in the left panel of the Microsoft Management Console. Expand the Certificates - Current User tree item and select **PERSONAL**, **CERTIFICATES**. The right-hand panel will display a certificate issued to MySQL. This is the certificate that was previously imported. Double-click the certificate to display its details.

7. After you have imported the certificate to the Personal Store, you can use a more succint connection string to connect to the database, as illustrated by the following code:

   ```
   using (MySqlConnection connection = new MySqlConnection(
      "database=test;user=sslclient;" +
      "Certificate Store Location=CurrentUser;" +
      "SSL Mode=Required"))
   {
      connection.Open();
   }
   ```

Certificate Thumbprint Parameter

If you have a large number of certificates in your store, and many have the same Issuer, this can be a source of confusion and result in the wrong certificate being used. To alleviate this situation, there is an optional Certificate Thumbprint parameter that can additionally be specified as part of the connection string. As mentioned before, you can double-click a certificate in the Microsoft Management Console to display the certificate's details. When the Certificate dialog is displayed click the **DETAILS** tab and scroll down to see the thumbprint. The thumbprint will typically be a number such as `□47 94 36 00 9a 40 f3 01 7a 14 5c f8 47 9e 76 94 d7 aa de f0`. This thumbprint can be used in the connection string, as the following code illustrates:

```
using (MySqlConnection connection = new MySqlConnection(
      "database=test;user=sslclient;" +
      "Certificate Store Location=CurrentUser;" +
      "Certificate Thumbprint=479436009a40f3017a145cf8479e7694d7aadef0;"+
      "SSL Mode=Required"))
{
    connection.Open();
}
```

Spaces in the thumbprint parameter are optional and the value is case-insensitive.

20.2.4.8. Tutorial: Using MySqlScript

In this tutorial you will learn how to use the `MySqlScript` class. This class enables you to execute a series of statements. Depending on the circumstances, this can be more convenient than using the `MySqlCommand` approach.

Further details of the `MySqlScript` class can be found in the reference documentation supplied with MySQL Connector/Net.

If you wish to run the example programs in this tutorial, you will need to set up a simple test database and table. This can be achieved using the MySQL Command Line Client or MySql Workbench. Commands for the MySQL Command Line Client are given here:

1. `CREATE DATABASE TestDB;`
2. `USE TestDB;`
3. `CREATE TABLE TestTable (id INT NOT NULL PRIMARY KEY AUTO_INCREMENT, name VARCHAR(100));`

The main method of the `MySqlScript` class is the `Execute` method. This method causes the script (sequence of statements) assigned to the Query property of the MySqlScript object to be executed. Note the Query property can be set through the `MySqlScript` constructor or using the Query property. `Execute` returns the number of statements executed.

The `MySqlScript` object will execute the specified script on the connection set using the Connection property. Again, this property can be set directly or through the `MySqlScript` constructor. The following code snippets illustrate this:

```
string sql = "SELECT * FROM TestTable";
...
MySqlScript script = new MySqlScript(conn, sql);
...
MySqlScript script = new MySqlScript();
script.Query = sql;
script.Connection = conn;
...
script.Execute();
```

The MySqlScript class has several events associated with it. There are:

1. Error - generated in an error occurs.
2. ScriptCompleted - generated when the script successfully completes execution.

3. StatementExecuted - generated after each statement is executed.

It is possible to assign event handlers to each of these events. These user-provided routines will be called back should the connected event occur. The following code shows how the event handlers are set up.

```
script.Error += new MySqlScriptErrorEventHandler(script_Error);
script.ScriptCompleted += new EventHandler(script_ScriptCompleted);
script.StatementExecuted += new MySqlStatementExecutedEventHandler(script_StatementExecuted);
```

In VisualStudio you can use tab completion to fill out stub routines for you, to save typing. To do this start by typing, for example, “script.Error +=”. Then press **TAB**, and then press **TAB** again. The assignment will be completed, and a stub event handler created. A complete working example is shown below:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using System.Data;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace MySqlScriptTest
{
    class Program
    {
        static void Main(string[] args)
        {
            string connStr = "server=localhost;user=root;database=TestDB;port=3306;password=******;";
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql = "INSERT INTO TestTable(name) VALUES ('Superman');" +
                             "INSERT INTO TestTable(name) VALUES ('Batman');" +
                             "INSERT INTO TestTable(name) VALUES ('Wolverine');" +
                             "INSERT INTO TestTable(name) VALUES ('Storm');";

                MySqlScript script = new MySqlScript(conn, sql);

                script.Error += new MySqlScriptErrorEventHandler(script_Error);
                script.ScriptCompleted += new EventHandler(script_ScriptCompleted);
                script.StatementExecuted += new MySqlStatementExecutedEventHandler(script_StatementExecuted);

                int count = script.Execute();

                Console.WriteLine("Executed " + count + " statement(s).");
                Console.WriteLine("Delimiter: " + script.Delimiter);
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }

            conn.Close();
            Console.WriteLine("Done.");
        }

        static void script_StatementExecuted(object sender, MySqlScriptEventArgs args)
        {
            Console.WriteLine("script_StatementExecuted");
        }

        static void script_ScriptCompleted(object sender, EventArgs e)
        {
            /// EventArgs e will be EventArgs.Empty for this method
            Console.WriteLine("script_ScriptCompleted!");
        }

        static void script_Error(Object sender, MySqlScriptErrorEventArgs args)
        {
            Console.WriteLine("script_Error: " + args.Exception.ToString());
        }
    }
}
```

Note that in the `script_ScriptCompleted` event handler, the `EventArgs` parameter `e` will be `EventArgs.Empty`. In the case of the `ScriptCompleted` event there is no additional data to be obtained, which is why the event object is `EventArgs.Empty`.

20.2.4.8.1. Using Delimiters with MySqlScript

Depending on the nature of the script, you made need control of the delimiter used to separate the statements that will make up a script. The most common example of this is where you have a multi-statement stored routine as part of your script. In this case if the default delimiter of “;” is used you will get an error when you attempt to execute the script. For example, consider the following stored routine:

```
CREATE PROCEDURE test_routine()
BEGIN
    SELECT name FROM TestTable ORDER BY name;
    SELECT COUNT(name) FROM TestTable;
END
```

This routine actually needs to be executed on the MySQL Server as a single statement. However, with the default delimiter of “;”, the `MySqlScript` class would interpret the above as two statements, the first being:

```
CREATE PROCEDURE test_routine()
BEGIN
    SELECT name FROM TestTable ORDER BY name;
```

Executing this as a statement would generate an error. To solve this problem `MySqlScript` supports the ability to set a different delimiter. This is achieved through the Delimiter property. For example, you could set the delimiter to “??”, in which case the above stored routine would no longer generate an error when executed. Multiple statements can be delimited in the script, so for example, you could have a three statement script such as:

```
string sql = "DROP PROCEDURE IF EXISTS test_routine??" +
             "CREATE PROCEDURE test_routine() " +
             "BEGIN " +
             "SELECT name FROM TestTable ORDER BY name;" +
             "SELECT COUNT(name) FROM TestTable;" +
             "END??" +
             "CALL test_routine()";
```

You can change the delimiter back at any point by setting the Delimiter property. The following code shows a complete working example:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using MySql.Data;
using MySql.Data.MySqlClient;

namespace ConsoleApplication8
{
    class Program
    {
        static void Main(string[] args)
        {
            string connStr = "server=localhost;user=root;database=TestDB;port=3306;password=******;";
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql =    "DROP PROCEDURE IF EXISTS test_routine??" +
                                "CREATE PROCEDURE test_routine() " +
                                "BEGIN " +
                                "SELECT name FROM TestTable ORDER BY name;" +
                                "SELECT COUNT(name) FROM TestTable;" +
                                "END??" +
                                "CALL test_routine()";

                MySqlScript script = new MySqlScript(conn);

                script.Query = sql;
                script.Delimiter = "??";
                int count = script.Execute();
                Console.WriteLine("Executed " + count + " statement(s)");
                script.Delimiter = ";";
                Console.WriteLine("Delimiter: " + script.Delimiter);
                Console.WriteLine("Query: " + script.Query);
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }

            conn.Close();
            Console.WriteLine("Done.");
        }
    }
}
```

20.2.4.9. Tutorial: Generating MySQL DDL from an Entity Framework Model

In this tutorial you will learn how to create MySQL DDL from an Entity Framework model. You will need to use Visual Studio 2010 and MySQL Connector/Net 6.3 to carry out this tutorial.

1. Create a new console application in Visual Studio 2010.
2. Using the **SOLUTION EXPLORER** add a reference to `MySql.Data.Entity`.
3. From the **SOLUTION EXPLORER** select ADD, NEW ITEM. In the **ADD NEW ITEM** dialog select **ONLINE TEMPLATES**. Select **ADO.NET ENTITY DATA MODEL** and click ADD. The **ENTITY DATA MODEL** dialog will be displayed.
4. In the **ENTITY DATA MODEL** dialog select **EMPTY MODEL**. Click FINISH. A blank model will be created.
5. Create a simple model. A single Entity will do for the purposes of this tutorial.
6. In the **PROPERTIES** panel select CONCEPTUALENTITYMODEL from the drop-down listbox.
7. In the **PROPERTIES** panel, locate the **DDL GENERATION TEMPLATE** in the category **DATABASE SCRIPT GENERATION**.
8. For the **DDL GENERATION** property select SSDLTOMYSQL.TT(VS) from the drop-down listbox.
9. Save the solution.
10. Right-click an empty space in the model design area. The context-sensitive menu will be displayed.
11. From the context-sensitive menu select GENERATE DATABASE FROM MODEL. The **GENERATE DATABASE WIZARD** dialog will be displayed.
12. In the **GENERATE DATABASE WIZARD** dialog select an existing connection, or create a new connection to a server. Select an appropriate radio button to show or hide sensitive data. For the purposes of this tutorial you can select **YES** (although you may not want to do this for commercial applications).
13. Click NEXT. MySQL compatible DDL code will be generated. Click FINISH to exit the wizard.

You have seen how to create MySQL DDL code from an Entity Framework model.

20.2.5. Connector/Net Programming

Connector/Net comprises several classes that are used to connect to the database, execute queries and statements, and manage query results.

The following are the major classes of Connector/Net:

- `MySqlCommand`: Represents an SQL statement to execute against a MySQL database.
- `MySqlCommandBuilder`: Automatically generates single-table commands used to reconcile changes made to a DataSet with the associated MySQL database.
- `MySqlConnection`: Represents an open connection to a MySQL Server database.
- `MySqlDataAdapter`: Represents a set of data commands and a database connection that are used to fill a data set and update a MySQL database.
- `MySqlDataReader`: Provides a means of reading a forward-only stream of rows from a MySQL database.
- `MySqlException`: The exception that is thrown when MySQL returns an error.
- `MySqlHelper`: Helper class that makes it easier to work with the provider.
- `MySqlTransaction`: Represents an SQL transaction to be made in a MySQL database.

In the following sections you will learn about some common use cases for Connector/Net, including BLOB handling, date handling, and using Connector/Net with common tools such as Crystal Reports.

20.2.5.1. Connecting to MySQL Using Connector/Net

Introduction

All interaction between a .NET application and the MySQL server is routed through a `MySqlConnection` object. Before your application can interact with the server, a `MySqlConnection` object must be instanced, configured, and opened.

Even when using the `MySqlHelper` class, a `MySqlConnection` object is created by the helper class.

In this section, we will describe how to connect to MySQL using the `MySqlConnection` object.

20.2.5.2. Creating a Connection String

The `MySqlConnection` object is configured using a connection string. A connection string contains sever key/value pairs, separated by semicolons. Each key/value pair is joined with an equal sign.

The following is a sample connection string:

```
Server=127.0.0.1;Uid=root;Pwd=12345;Database=test;
```

In this example, the `MySqlConnection` object is configured to connect to a MySQL server at `127.0.0.1`, with a user name of `root` and a password of `12345`. The default database for all statements will be the `test` database.

The following options are available:

> **Note**
>
> Using the '@' symbol for parameters is now the preferred approach although the old pattern of using '?' is still supported.
>
> Please be aware however that using '@' can cause conflicts when user variables are also used. To help with this situation please see the documentation on the `Allow User Variables` connection string option, which can be found here: Section 20.2.5.2, “Creating a Connection String”. The `Old Syntax` connection string option has now been deprecated.

20.2.5.2.1. Opening a Connection

Once you have created a connection string it can be used to open a connection to the MySQL server.

The following code is used to create a `MySqlConnection` object, assign the connection string, and open the connection.

Visual Basic Example

```
Dim conn As New MySql.Data.MySqlClient.MySqlConnection
Dim myConnectionString as String

myConnectionString = "server=127.0.0.1;" _
            & "uid=root;" _
            & "pwd=12345;" _
            & "database=test;"

Try
  conn.ConnectionString = myConnectionString
  conn.Open()

Catch ex As MySql.Data.MySqlClient.MySqlException
  MessageBox.Show(ex.Message)
End Try
```

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
string myConnectionString;

myConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;";

try
{
    conn = new MySql.Data.MySqlClient.MySqlConnection();
    conn.ConnectionString = myConnectionString;
    conn.Open();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message);
}
```

You can also pass the connection string to the constructor of the `MySqlConnection` class:

Visual Basic Example

```
Dim myConnectionString as String

myConnectionString = "server=127.0.0.1;" _
              & "uid=root;" _
              & "pwd=12345;" _
              & "database=test;"

Try
    Dim conn As New MySql.Data.MySqlClient.MySqlConnection(myConnectionString)
    conn.Open()
Catch ex As MySql.Data.MySqlClient.MySqlException
   MessageBox.Show(ex.Message)
End Try
```

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
string myConnectionString;

myConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;";

try
{
    conn = new MySql.Data.MySqlClient.MySqlConnection(myConnectionString);
    conn.Open();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message);
}
```

Once the connection is open it can be used by the other Connector/Net classes to communicate with the MySQL server.

20.2.5.2.2. Handling Connection Errors

Because connecting to an external server is unpredictable, it is important to add error handling to your .NET application. When there is an error connecting, the `MySqlConnection` class will return a `MySqlException` object. This object has two properties that are of interest when handling errors:

- `Message`: A message that describes the current exception.
- `Number`: The MySQL error number.

When handling errors, you can your application's response based on the error number. The two most common error numbers when connecting are as follows:

- `0`: Cannot connect to server.
- `1045`: Invalid user name and/or password.

The following code shows how to adapt the application's response based on the actual error:

Visual Basic Example

```
Dim myConnectionString as String

myConnectionString = "server=127.0.0.1;" _
          & "uid=root;" _
          & "pwd=12345;" _
          & "database=test;"

Try
    Dim conn As New MySql.Data.MySqlClient.MySqlConnection(myConnectionString)
    conn.Open()
Catch ex As MySql.Data.MySqlClient.MySqlException
    Select Case ex.Number
        Case 0
            MessageBox.Show("Cannot connect to server. Contact administrator")
        Case 1045
            MessageBox.Show("Invalid username/password, please try again")
    End Select
End Try
```

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
string myConnectionString;

myConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;";

try
{
    conn = new MySql.Data.MySqlClient.MySqlConnection(myConnectionString);
    conn.Open();
}
    catch (MySql.Data.MySqlClient.MySqlException ex)
{
    switch (ex.Number)
    {
        case 0:
            MessageBox.Show("Cannot connect to server.  Contact administrator");
        case 1045:
            MessageBox.Show("Invalid username/password, please try again");
    }
}
```

> **Important**
>
> Note that if you are using multilanguage databases you must specify the character set in the connection string. If you do not specify the character set, the connection defaults to the `latin1` charset. You can specify the character set as part of the connection string, for example:

```
MySqlConnection myConnection = new MySqlConnection("server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;Charset=latin1;");
```

20.2.5.2.3. Using GetSchema on a Connection

The `GetSchema()` method of the connection object can be used to retrieve schema information about the database currently connected to. The schema information is returned in the form of a `DataTable`. The schema information is organized into a number of collections. Different forms of the `GetSchema()` method can be used depending on the information required. There are three forms of the `GetSchema()` method:

- `GetSchema()` - This call will return a list of available collections.
- `GetSchema(String)` - This call returns information about the collection named in the string parameter. If the string “MetaDataCollections” is used then a list of all available collections is returned. This is the same as calling `GetSchema()` without any parameters.
- `GetSchema(String, String[])` - In this call the first string parameter represents the collection name, and the second parameter represents a string array of restriction values. Restriction values limit the amount of data that will be returned. Restriction values are explained in more detail in the Microsoft .NET documentation.

20.2.5.2.3.1. Collections

The collections can be broadly grouped into two types: collections that are common to all data providers, and collections specific to a particular provider.

Common

The following collections are common to all data providers:

- MetaDataCollections
- DataSourceInformation
- DataTypes
- Restrictions
- ReservedWords

Provider-specific

The following are the collections currently provided by MySQL Connector/Net, in addition to the common collections above:

- Databases
- Tables
- Columns
- Users
- Foreign Keys
- IndexColumns
- Indexes
- Foreign Key Columns
- UDF
- Views
- ViewColumns
- Procedure Parameters
- Procedures
- Triggers

Example Code

A list of available collections can be obtained using the following code:

```
using System;
using System.Data;
using System.Text;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace ConsoleApplication2
{
    class Program
    {

        private static void DisplayData(System.Data.DataTable table)
        {
            foreach (System.Data.DataRow row in table.Rows)
            {
                foreach (System.Data.DataColumn col in table.Columns)
                {
                    Console.WriteLine("{0} = {1}", col.ColumnName, row[col]);
                }
                Console.WriteLine("============================");
            }
        }

        static void Main(string[] args)
        {

            string connStr = "server=localhost;user=root;database=world;port=3306;password=******;";
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                DataTable table = conn.GetSchema("MetaDataCollections");
                //DataTable table = conn.GetSchema("UDF");
                DisplayData(table);

                conn.Close();
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }
            Console.WriteLine("Done.");
        }
    }
}
```

Further information on the `GetSchema()` method and schema collections can be found in the Microsoft .NET documentation.

20.2.5.3. Using MySqlCommand

A MySqlCommand has the `CommandText` and `CommandType` properties associated with it. The `CommandText` will be handled differently depending on the setting of `CommandType`. `CommandType` can be one of:

1. Text - A SQL text command (default)
2. StoredProcedure - The name of a Stored Procedure
3. TableDirect - The name of a table (new in Connector/Net 6.2)

The default `CommandType`, `Text`, is used for executing queries and other SQL commands. Some example of this can be found in the following section Section 20.2.4.1.2, "The MySqlCommand Object".

If `CommandType` is set to `StoredProcedure`, `CommandText` should be set to the name of the Stored Procedure to access.

If `CommandType` is set to `TableDirect`, all rows and columns of the named table will be returned when you call one of the Execute methods. In effect, this command performs a `SELECT *` on the table specified. The `CommandText` property is set to the name of the table you wish to query. This is illustrated by the following code snippet:

```
...
MySqlCommand cmd = new MySqlCommand();
cmd.CommandText = "mytable";
cmd.Connection = someConnection;
cmd.CommandType = CommandType.TableDirect;
MySqlDataReader reader = cmd.ExecuteReader();
while (reader.Read())
{
   Console.WriteLn(reader[0], reader[1]...);
}
...
```

Examples of using the CommandType of StoredProcedure can be found in the section Section 20.2.5.6, "Accessing Stored Procedures with Connector/Net".

Commands can have a timeout associated with them. This is useful as you may not want a situation were a command takes up an excessive amount of time. A timeout can be set using the `CommandTimeout` property. The following code snippet sets a timeout of one minute:

```
MySqlCommand cmd = new MySqlCommand();
cmd.CommandTimeout = 60;
```

The default value is 30 secs. A value of 0 indicates an indefinite wait and should be avoided. Note the default command timeout can be changed using the connection string option `Default Command Timeout`.

Prior to MySQL Connector/Net 6.2, `MySqlCommand.CommandTimeout` included user processing time, that is processing time not related to direct use of the connector. Timeout was implemented through a .NET Timer, that triggered after `CommandTimeout` seconds. This timer consumed a thread.

MySQL Connector/Net 6.2 introduced timeouts that are aligned with how Microsoft handles `SqlCommand.CommandTimeout`. This property is the cumulative timeout for all network reads and writes during command execution or processing of the results. A timeout can still occur in the `MySqlReader.Read` method after the first row is returned, and does not include user processing time, only IO operations. The 6.2 implementation uses the underlying stream timeout facility, so is more efficient in that it does not require the additional timer thread as was the case with the previous implementation.

Further details on this can be found in the relevant Microsoft documentation.

20.2.5.4. Using Connector/Net with Connection Pooling

The Connector/Net supports connection pooling. This is enabled by default, but can be turned off using connection string options. See Section 20.2.5.2, "Creating a Connection String" for further information.

Connection pooling works by keeping the native connection to the server live when the client disposes of a `MySqlConnection`. Subsequently, if a new `MySqlConnection` object is opened, it will be created from the connection pool, rather than creating a new native connection. This improves performance.

To work as designed, it is best to let the connection pooling system manage all connections. You should not create a globally accessible instance of `MySqlConnection` and then manually open and close it. This interferes with the way the pooling works and can lead to unpredictable results or even exceptions.

One approach that simplifies things is to avoid manually creating a `MySqlConnection` object. Instead use the overloaded methods that take a connection string as an argument. Using this approach, Connector/Net will automatically create, open, close and destroy connections, using the connection pooling system for best performance.

Typed Datasets and the `MembershipProvider` and `RoleProvider` classes use this approach. Most classes that have methods that take a `MySqlConnection` as an argument, also have methods that take a connection string as an argument. This includes `MySqlDataAdapter`.

Instead of manually creating `MySqlCommand` objects, you can use the static methods of the `MySqlHelper` class. These take a connection string as an argument, and they fully support connection pooling.

Starting with MySQL Connector/Net 6.2, there is a background job that runs every three minutes and removes connections from pool that have been idle (unused) for more than three minutes. The pool cleanup frees resources on both client and server side. This is because on the client side every connection uses a socket, and on the server side every connection uses a socket and a thread.

Prior to this change, connections were never removed from the pool, and the pool always contained the peak number of open connections. For example, a web application that peaked at 1000 concurrent database connections would consume 1000 threads and 1000 open sockets at the server, without ever freeing up those resources from the connection pool. Note, connections, no matter how old, will not be closed if the number of connections in the pool is less than or equal to the value set by the `Min Pool Size` connection string parameter.

20.2.5.5. Using the Connector/Net with Prepared Statements

Introduction

As of MySQL 4.1, it is possible to use prepared statements with Connector/Net. Use of prepared statements can provide significant performance improvements on queries that are executed more than once.

Prepared execution is faster than direct execution for statements executed more than once, primarily because the query is parsed only once. In the case of direct execution, the query is parsed every time it is executed. Prepared execution also can provide a reduction of network traffic because for each execution of the prepared statement, it is necessary only to send the data for the parameters.

Another advantage of prepared statements is that it uses a binary protocol that makes data transfer between client and server more efficient.

20.2.5.5.1. Preparing Statements in Connector/Net

To prepare a statement, create a command object and set the `.CommandText` property to your query.

After entering your statement, call the `.Prepare` method of the `MySqlCommand` object. After the statement is prepared, add parameters for each of the dynamic elements in the query.

After you enter your query and enter parameters, execute the statement using the `.ExecuteNonQuery()`, `.ExecuteScalar()`, or `.ExecuteReader` methods.

For subsequent executions, you need only modify the values of the parameters and call the execute method again, there is no need to set the `.CommandText` property or redefine the parameters.

Visual Basic Example

```
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand

conn.ConnectionString = strConnection

Try
   conn.Open()
   cmd.Connection = conn

   cmd.CommandText = "INSERT INTO myTable VALUES(NULL, @number, @text)"
   cmd.Prepare()

   cmd.Parameters.AddWithValue("@number", 1)
   cmd.Parameters.AddWithValue("@text", "One")

   For i = 1 To 1000
       cmd.Parameters("@number").Value = i
       cmd.Parameters("@text").Value = "A string value"

       cmd.ExecuteNonQuery()
     Next
Catch ex As MySqlException
    MessageBox.Show("Error " & ex.Number & " has occurred: " & ex.Message, "Error", MessageBoxButtons.OK, MessageBoxIc
End Try
```

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();

conn.ConnectionString = strConnection;

try
{
    conn.Open();
    cmd.Connection = conn;

    cmd.CommandText = "INSERT INTO myTable VALUES(NULL, @number, @text)";
    cmd.Prepare();

    cmd.Parameters.AddWithValue("@number", 1);
    cmd.Parameters.AddWithValue("@text", "One");

    for (int i=1; i <= 1000; i++)
    {
        cmd.Parameters["@number"].Value = i;
        cmd.Parameters["@text"].Value = "A string value";

        cmd.ExecuteNonQuery();
    }
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show("Error " + ex.Number + " has occurred: " + ex.Message,
        "Error", MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

20.2.5.6. Accessing Stored Procedures with Connector/Net

Introduction

With the release of MySQL version 5 the MySQL server now supports stored procedures with the SQL 2003 stored procedure syntax.

A stored procedure is a set of SQL statements that can be stored in the server. Once this has been done, clients do not need to keep reissuing the individual statements but can refer to the stored procedure instead.

Stored procedures can be particularly useful in situations such as the following:

- When multiple client applications are written in different languages or work on different platforms, but need to perform the same database operations.
- When security is paramount. Banks, for example, use stored procedures for all common operations. This provides a consistent and secure environment, and procedures can ensure that each operation is properly logged. In such a setup, applications and users would not get any access to the database tables directly, but can only execute specific stored procedures.

Connector/Net supports the calling of stored procedures through the `MySqlCommand` object. Data can be passed in and out of a MySQL stored procedure through use of the `MySqlCommand.Parameters` collection.

> **Note**
>
> When you call a stored procedure, the command object makes an additional `SELECT` call to determine the parameters of the stored procedure. You must ensure that the user calling the procedure has the `SELECT` privilege on the `mysql.proc` table to enable them to verify the parameters. Failure to do this will result in an error when calling the procedure.

This section will not provide in-depth information on creating Stored Procedures. For such information, please refer to http://dev.mysql.com/doc/mysql/en/stored-routines.html.

A sample application demonstrating how to use stored procedures with Connector/Net can be found in the `Samples` directory of your Connector/Net installation.

20.2.5.6.1. Using Stored Routines from Connector/Net

Stored procedures in MySQL can be created using a variety of tools. First, stored procedures can be created using the `mysql` command-line client. Second, stored procedures can be created using MySQL Workbench. Finally, stored procedures can be created using the `.ExecuteNonQuery` method of the `MySqlCommand` object.

It should be noted that, unlike the command-line and GUI clients, you are not required to specify a special delimiter when creating stored procedures in Connector/Net.

To call a stored procedure using Connector/Net, you create a `MySqlCommand` object and pass the stored procedure name as the `.CommandText` property. You then set the `.CommandType` property to `CommandType.StoredProcedure`.

After the stored procedure is named, you create one `MySqlCommand` parameter for every parameter in the stored procedure. `IN` parameters are defined with the parameter name and the object containing the value, `OUT` parameters are defined with the parameter name and the data type that is expected to be returned. All parameters need the parameter direction defined.

After defining the parameters, you call the stored procedure by using the `MySqlCommand.ExecuteNonQuery()` method.

Once the stored procedure is called, the values of the output parameters can be retrieved by using the `.Value` property of the `MySqlConnector.Parameters` collection.

> ### Note
>
> When a stored procedure is called using `MySqlCommand.ExecuteReader`, and the stored procedure has output parameters, the output parameters are only set after the `MySqlDataReader` returned by `ExecuteReader` is closed.

The following C# example code demonstrates the use of stored procedures. It assumes the database 'employees' has already been created:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using System.Data;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace UsingStoredRoutines
{
    class Program
    {
        static void Main(string[] args)
        {
            MySqlConnection conn = new MySqlConnection();
            conn.ConnectionString = "server=localhost;user=root;database=employees;port=3306;password=******;";
            MySqlCommand cmd = new MySqlCommand();

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();
                cmd.Connection = conn;
                cmd.CommandText = "DROP PROCEDURE IF EXISTS add_emp";
                cmd.ExecuteNonQuery();
                cmd.CommandText = "DROP TABLE IF EXISTS emp";
                cmd.ExecuteNonQuery();
                cmd.CommandText = "CREATE TABLE emp (empno INT UNSIGNED NOT NULL AUTO_INCREMENT PRIMARY KEY, first_name
                cmd.ExecuteNonQuery();

                cmd.CommandText = "CREATE PROCEDURE add_emp(" +
                                  "IN fname VARCHAR(20), IN lname VARCHAR(20), IN bday DATETIME, OUT empno INT)" +
                                  "BEGIN INSERT INTO emp(first_name, last_name, birthdate) " +
                                  "VALUES(fname, lname, DATE(bday)); SET empno = LAST_INSERT_ID(); END";

                cmd.ExecuteNonQuery();
            }
            catch (MySqlException ex)
            {
                Console.WriteLine ("Error " + ex.Number + " has occurred: " + ex.Message);
            }
            conn.Close();
            Console.WriteLine("Connection closed.");
            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();
                cmd.Connection = conn;

                cmd.CommandText = "add_emp";
                cmd.CommandType = CommandType.StoredProcedure;

                cmd.Parameters.AddWithValue("@lname", "Jones");
                cmd.Parameters["@lname"].Direction = ParameterDirection.Input;

                cmd.Parameters.AddWithValue("@fname", "Tom");
                cmd.Parameters["@fname"].Direction = ParameterDirection.Input;

                cmd.Parameters.AddWithValue("@bday", "1940-06-07");
                cmd.Parameters["@bday"].Direction = ParameterDirection.Input;

                cmd.Parameters.AddWithValue("@empno", MySqlDbType.Int32);
                cmd.Parameters["@empno"].Direction = ParameterDirection.Output;
                cmd.ExecuteNonQuery();

                Console.WriteLine("Employee number: "+cmd.Parameters["@empno"].Value);
                Console.WriteLine("Birthday: " + cmd.Parameters["@bday"].Value);
            }
            catch (MySql.Data.MySqlClient.MySqlException ex)
            {
                Console.WriteLine("Error " + ex.Number + " has occurred: " + ex.Message);
            }
            conn.Close();
            Console.WriteLine("Done.");
        }
    }
}
```

The following code shows the same application in Visual Basic:

```
Imports System
Imports System.Collections.Generic
Imports System.Linq
Imports System.Text

Imports System.Data
Imports MySql.Data
Imports MySql.Data.MySqlClient

Module Module1

    Sub Main()
        Dim conn As New MySqlConnection()
        conn.ConnectionString = "server=localhost;user=root;database=world;port=3306;password=******;"
        Dim cmd As New MySqlCommand()

        Try
            Console.WriteLine("Connecting to MySQL...")
            conn.Open()
            cmd.Connection = conn
            cmd.CommandText = "DROP PROCEDURE IF EXISTS add_emp"
            cmd.ExecuteNonQuery()
            cmd.CommandText = "DROP TABLE IF EXISTS emp"
            cmd.ExecuteNonQuery()
            cmd.CommandText = "CREATE TABLE emp (empno INT UNSIGNED NOT NULL AUTO_INCREMENT PRIMARY KEY, first_name VAR
            cmd.ExecuteNonQuery()

            cmd.CommandText = "CREATE PROCEDURE add_emp(" & "IN fname VARCHAR(20), IN lname VARCHAR(20), IN bday DATETI

            cmd.ExecuteNonQuery()
        Catch ex As MySqlException
            Console.WriteLine(("Error " & ex.Number & " has occurred: ") + ex.Message)
        End Try
        conn.Close()
        Console.WriteLine("Connection closed.")
        Try
            Console.WriteLine("Connecting to MySQL...")
            conn.Open()
            cmd.Connection = conn

            cmd.CommandText = "add_emp"
            cmd.CommandType = CommandType.StoredProcedure

            cmd.Parameters.AddWithValue("@lname", "Jones")
            cmd.Parameters("@lname").Direction = ParameterDirection.Input

            cmd.Parameters.AddWithValue("@fname", "Tom")
            cmd.Parameters("@fname").Direction = ParameterDirection.Input

            cmd.Parameters.AddWithValue("@bday", "1940-06-07")
            cmd.Parameters("@bday").Direction = ParameterDirection.Input

            cmd.Parameters.AddWithValue("@empno", MySqlDbType.Int32)
            cmd.Parameters("@empno").Direction = ParameterDirection.Output

            cmd.ExecuteNonQuery()

            Console.WriteLine("Employee number: " & cmd.Parameters("@empno").Value)
            Console.WriteLine("Birthday: " & cmd.Parameters("@bday").Value)
        Catch ex As MySql.Data.MySqlClient.MySqlException
            Console.WriteLine(("Error " & ex.Number & " has occurred: ") + ex.Message)
        End Try
        conn.Close()
        Console.WriteLine("Done.")

    End Sub

End Module
```

20.2.5.7. Handling BLOB Data With Connector/Net

Introduction

One common use for MySQL is the storage of binary data in `BLOB` columns. MySQL supports four different BLOB data types: `TINYBLOB`, `BLOB`, `MEDIUMBLOB`, and `LONGBLOB`.

Data stored in a BLOB column can be accessed using Connector/Net and manipulated using client-side code. There are no special requirements for using Connector/Net with BLOB data.

Simple code examples will be presented within this section, and a full sample application can be found in the `Samples` directory of the Connector/Net installation.

20.2.5.7.1. Preparing the MySQL Server

The first step is using MySQL with BLOB data is to configure the server. Let's start by creating a table to be accessed. In my file tables, I usually have four columns: an AUTO_INCREMENT column of appropriate size (UNSIGNED SMALLINT) to serve as a primary key to identify the file, a VARCHAR column that stores the file name, an UNSIGNED MEDIUMINT column that stores the size of the file, and a MEDIUMBLOB column that stores the file itself. For this example, I will use the following table definition:

```
CREATE TABLE file(
file_id SMALLINT UNSIGNED AUTO_INCREMENT NOT NULL PRIMARY KEY,
file_name VARCHAR(64) NOT NULL,
file_size MEDIUMINT UNSIGNED NOT NULL,
file MEDIUMBLOB NOT NULL);
```

After creating a table, you may need to modify the max_allowed_packet system variable. This variable determines how large of a packet (that is, a single row) can be sent to the MySQL server. By default, the server will only accept a maximum size of 1MB from our client application. If you do not intend to exceed 1MB, this should be fine. If you do intend to exceed 1MB in your file transfers, this number has to be increased.

The max_allowed_packet option can be modified using MySQL Administrator's Startup Variables screen. Adjust the Maximum permitted option in the Memory section of the Networking tab to an appropriate setting. After adjusting the value, click the APPLY CHANGES button and restart the server using the `Service Control` screen of MySQL Administrator. You can also adjust this value directly in the my.cnf file (add a line that reads max_allowed_packet=xxM), or use the SET max_allowed_packet=xxM; syntax from within MySQL.

Try to be conservative when setting max_allowed_packet, as transfers of BLOB data can take some time to complete. Try to set a value that will be adequate for your intended use and increase the value if necessary.

20.2.5.7.2. Writing a File to the Database

To write a file to a database we need to convert the file to a byte array, then use the byte array as a parameter to an `INSERT` query.

The following code opens a file using a FileStream object, reads it into a byte array, and inserts it into the `file` table:

Visual Basic Example

```
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand

Dim SQL As String

Dim FileSize As UInt32
Dim rawData() As Byte
Dim fs As FileStream

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=test"

Try
    fs = New FileStream("c:\image.png", FileMode.Open, FileAccess.Read)
    FileSize = fs.Length

    rawData = New Byte(FileSize) {}
    fs.Read(rawData, 0, FileSize)
    fs.Close()

    conn.Open()

    SQL = "INSERT INTO file VALUES(NULL, @FileName, @FileSize, @File)"

    cmd.Connection = conn
    cmd.CommandText = SQL
    cmd.Parameters.AddWithValue("@FileName", strFileName)
    cmd.Parameters.AddWithValue("@FileSize", FileSize)
    cmd.Parameters.AddWithValue("@File", rawData)

    cmd.ExecuteNonQuery()

    MessageBox.Show("File Inserted into database successfully!", _
    "Success!", MessageBoxButtons.OK, MessageBoxIcon.Asterisk)
    conn.Close()
Catch ex As Exception
    MessageBox.Show("There was an error: " & ex.Message, "Error", _
        MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();

string SQL;
UInt32 FileSize;
byte[] rawData;
FileStream fs;

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;";

try
{
    fs = new FileStream(@"c:\image.png", FileMode.Open, FileAccess.Read);
    FileSize = fs.Length;

    rawData = new byte[FileSize];
    fs.Read(rawData, 0, FileSize);
    fs.Close();

    conn.Open();

    SQL = "INSERT INTO file VALUES(NULL, @FileName, @FileSize, @File)";

    cmd.Connection = conn;
    cmd.CommandText = SQL;
    cmd.Parameters.AddWithValue("@FileName", strFileName);
    cmd.Parameters.AddWithValue("@FileSize", FileSize);
    cmd.Parameters.AddWithValue("@File", rawData);

    cmd.ExecuteNonQuery();

    MessageBox.Show("File Inserted into database successfully!",
        "Success!", MessageBoxButtons.OK, MessageBoxIcon.Asterisk);

    conn.Close();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show("Error " + ex.Number + " has occurred: " + ex.Message,
        "Error", MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

The `Read` method of the `FileStream` object is used to load the file into a byte array which is sized according to the `Length` property of the FileStream object.

After assigning the byte array as a parameter of the `MySqlCommand` object, the `ExecuteNonQuery` method is called and the BLOB is inserted into the `file` table.

20.2.5.7.3. Reading a BLOB from the Database to a File on Disk

Once a file is loaded into the `file` table, we can use the `MySqlDataReader` class to retrieve it.

The following code retrieves a row from the `file` table, then loads the data into a `FileStream` object to be written to disk:

Visual Basic Example

```
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myData As MySqlDataReader
Dim SQL As String
Dim rawData() As Byte
Dim FileSize As UInt32
Dim fs As FileStream

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=test"

SQL = "SELECT file_name, file_size, file FROM file"

Try
    conn.Open()
    cmd.Connection = conn
    cmd.CommandText = SQL

    myData = cmd.ExecuteReader

    If Not myData.HasRows Then Throw New Exception("There are no BLOBs to save")

    myData.Read()

    FileSize = myData.GetUInt32(myData.GetOrdinal("file_size"))
    rawData = New Byte(FileSize) {}

    myData.GetBytes(myData.GetOrdinal("file"), 0, rawData, 0, FileSize)

    fs = New FileStream("C:\newfile.png", FileMode.OpenOrCreate, FileAccess.Write)
    fs.Write(rawData, 0, FileSize)
    fs.Close()

    MessageBox.Show("File successfully written to disk!", "Success!", MessageBoxButtons.OK, MessageBoxIcon.Asterisk)

    myData.Close()
    conn.Close()
Catch ex As Exception
    MessageBox.Show("There was an error: " & ex.Message, "Error", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataReader myData;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();

string SQL;
UInt32 FileSize;
byte[] rawData;
FileStream fs;

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;";

SQL = "SELECT file_name, file_size, file FROM file";

try
{
    conn.Open();

    cmd.Connection = conn;
    cmd.CommandText = SQL;

    myData = cmd.ExecuteReader();

    if (! myData.HasRows)
        throw new Exception("There are no BLOBs to save");

    myData.Read();

    FileSize = myData.GetUInt32(myData.GetOrdinal("file_size"));
    rawData = new byte[FileSize];

    myData.GetBytes(myData.GetOrdinal("file"), 0, rawData, 0, FileSize);

    fs = new FileStream(@"C:\newfile.png", FileMode.OpenOrCreate, FileAccess.Write);
    fs.Write(rawData, 0, FileSize);
    fs.Close();

    MessageBox.Show("File successfully written to disk!",
        "Success!", MessageBoxButtons.OK, MessageBoxIcon.Asterisk);

    myData.Close();
    conn.Close();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show("Error " + ex.Number + " has occurred: " + ex.Message,
        "Error", MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

After connecting, the contents of the `file` table are loaded into a `MySqlDataReader` object. The `GetBytes` method of the MySqlDataReader is used to load the BLOB into a byte array, which is then written to disk using a FileStream object.

The `GetOrdinal` method of the MySqlDataReader can be used to determine the integer index of a named column. Use of the GetOrdinal method prevents errors if the column order of the `SELECT` query is changed.

20.2.5.8. Using Connector/Net with Crystal Reports

Introduction

Crystal Reports is a common tool used by Windows application developers to perform reporting and document generation. In this section we will show how to use Crystal Reports XI with MySQL and Connector/Net.

20.2.5.8.1. Creating a Data Source

When creating a report in Crystal Reports there are two options for accessing the MySQL data while designing your report.

The first option is to use Connector/ODBC as an ADO data source when designing your report. You will be able to browse your database and choose tables and fields using drag and drop to build your report. The disadvantage of this approach is that additional work must be performed within your application to produce a data set that matches the one expected by your report.

The second option is to create a data set in VB.NET and save it as XML. This XML file can then be used to design a report. This works quite well when displaying the report in your application, but is less versatile at design time because you must choose all relevant columns when creating the data set. If you forget a column you must re-create the data set before the column can be added to the report.

The following code can be used to create a data set from a query and write it to disk:

Visual Basic Example

```
Dim myData As New DataSet
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myAdapter As New MySqlDataAdapter

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=world"

Try
    conn.Open()
    cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " _
        & "country.name, country.population, country.continent " _
        & "FROM country, city ORDER BY country.continent, country.name"
    cmd.Connection = conn

    myAdapter.SelectCommand = cmd
    myAdapter.Fill(myData)

    myData.WriteXml("C:\dataset.xml", XmlWriteMode.WriteSchema)
Catch ex As Exception
    MessageBox.Show(ex.Message, "Report could not be created", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

C# Example

```
DataSet myData = new DataSet();
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataAdapter myAdapter;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();
myAdapter = new MySql.Data.MySqlClient.MySqlDataAdapter();

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
  "pwd=12345;database=test;";

try
{
  cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " +
  "country.name, country.population, country.continent " +
  "FROM country, city ORDER BY country.continent, country.name";
  cmd.Connection = conn;

  myAdapter.SelectCommand = cmd;
  myAdapter.Fill(myData);

  myData.WriteXml(@"C:\dataset.xml", XmlWriteMode.WriteSchema);
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
  MessageBox.Show(ex.Message, "Report could not be created",
  MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

The resulting XML file can be used as an ADO.NET XML datasource when designing your report.

If you choose to design your reports using Connector/ODBC, it can be downloaded from dev.mysql.com.

20.2.5.8.2. Creating the Report

For most purposes the Standard Report wizard should help with the initial creation of a report. To start the wizard, open Crystal Reports and choose the New > Standard Report option from the File menu.

The wizard will first prompt you for a data source. If you are using Connector/ODBC as your data source, use the OLEDB provider for ODBC option from the OLE DB (ADO) tree instead of the ODBC (RDO) tree when choosing a data source. If using a saved data set, choose the ADO.NET (XML) option and browse to your saved data set.

The remainder of the report creation process is done automatically by the wizard.

After the report is created, choose the Report Options... entry of the File menu. Un-check the Save Data With Report option. This prevents saved data from interfering with the loading of data within our application.

20.2.5.8.3. Displaying the Report

To display a report we first populate a data set with the data needed for the report, then load the report and bind it to the data set. Finally we pass the report to the crViewer control for display to the user.

The following references are needed in a project that displays a report:

- CrystalDecisions.CrystalReports.Engine
- CrystalDecisions.ReportSource
- CrystalDecisions.Shared
- CrystalDecisions.Windows.Forms

The following code assumes that you created your report using a data set saved using the code shown in Section 20.2.5.8.1, “Creating a Data Source”, and have a crViewer control on your form named `myViewer`.

Visual Basic Example

```
Imports CrystalDecisions.CrystalReports.Engine
Imports System.Data
Imports MySql.Data.MySqlClient

Dim myReport As New ReportDocument
Dim myData As New DataSet
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myAdapter As New MySqlDataAdapter

conn.ConnectionString = _
    "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=test"

Try
    conn.Open()

    cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " _
        & "country.name, country.population, country.continent " _
        & "FROM country, city ORDER BY country.continent, country.name"
    cmd.Connection = conn

    myAdapter.SelectCommand = cmd
    myAdapter.Fill(myData)

    myReport.Load(".\world_report.rpt")
    myReport.SetDataSource(myData)
    myViewer.ReportSource = myReport
Catch ex As Exception
    MessageBox.Show(ex.Message, "Report could not be created", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

C# Example

```
using CrystalDecisions.CrystalReports.Engine;
using System.Data;
using MySql.Data.MySqlClient;

ReportDocument myReport = new ReportDocument();
DataSet myData = new DataSet();
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataAdapter myAdapter;
```

```
conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();
myAdapter = new MySql.Data.MySqlClient.MySqlDataAdapter();

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;";

try
{
    cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " +
        "country.name, country.population, country.continent " +
        "FROM country, city ORDER BY country.continent, country.name";
    cmd.Connection = conn;

    myAdapter.SelectCommand = cmd;
    myAdapter.Fill(myData);

    myReport.Load(@".\world_report.rpt");
    myReport.SetDataSource(myData);
    myViewer.ReportSource = myReport;
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message, "Report could not be created",
        MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

A new data set it generated using the same query used to generate the previously saved data set. Once the data set is filled, a ReportDocument is used to load the report file and bind it to the data set. The ReportDocument is the passed as the ReportSource of the crViewer.

This same approach is taken when a report is created from a single table using Connector/ODBC. The data set replaces the table used in the report and the report is displayed properly.

When a report is created from multiple tables using Connector/ODBC, a data set with multiple tables must be created in our application. This enables each table in the report data source to be replaced with a report in the data set.

We populate a data set with multiple tables by providing multiple `SELECT` statements in our MySqlCommand object. These `SELECT` statements are based on the SQL query shown in Crystal Reports in the Database menu's Show SQL Query option. Assume the following query:

```
SELECT `country`.`Name`, `country`.`Continent`, `country`.`Population`, `city`.`Name`, `city`.`Population`
FROM `world`.`country` `country` LEFT OUTER JOIN `world`.`city` `city` ON `country`.`Code`=`city`.`CountryCode`
ORDER BY `country`.`Continent`, `country`.`Name`, `city`.`Name`
```

This query is converted to two `SELECT` queries and displayed with the following code:

Visual Basic Example

```
Imports CrystalDecisions.CrystalReports.Engine
Imports System.Data
Imports MySql.Data.MySqlClient

Dim myReport As New ReportDocument
Dim myData As New DataSet
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myAdapter As New MySqlDataAdapter

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=world"

Try
    conn.Open()
    cmd.CommandText = "SELECT name, population, countrycode FROM city ORDER BY countrycode, name; " _
        & "SELECT name, population, code, continent FROM country ORDER BY continent, name"
    cmd.Connection = conn

    myAdapter.SelectCommand = cmd
    myAdapter.Fill(myData)

    myReport.Load(".\world_report.rpt")
    myReport.Database.Tables(0).SetDataSource(myData.Tables(0))
    myReport.Database.Tables(1).SetDataSource(myData.Tables(1))
    myViewer.ReportSource = myReport
Catch ex As Exception
    MessageBox.Show(ex.Message, "Report could not be created", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

C# Example

```
using CrystalDecisions.CrystalReports.Engine;
using System.Data;
using MySql.Data.MySqlClient;
```

```
ReportDocument myReport = new ReportDocument();
DataSet myData = new DataSet();
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataAdapter myAdapter;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();
myAdapter = new MySql.Data.MySqlClient.MySqlDataAdapter();

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;";

try
{
    cmd.CommandText = "SELECT name, population, countrycode FROM city ORDER " +
        "BY countrycode, name; SELECT name, population, code, continent FROM " +
        "country ORDER BY continent, name";
    cmd.Connection = conn;

    myAdapter.SelectCommand = cmd;
    myAdapter.Fill(myData);

    myReport.Load(@".\world_report.rpt");
    myReport.Database.Tables(0).SetDataSource(myData.Tables(0));
    myReport.Database.Tables(1).SetDataSource(myData.Tables(1));
    myViewer.ReportSource = myReport;
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message, "Report could not be created",
        MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

It is important to order the `SELECT` queries in alphabetic order, as this is the order the report will expect its source tables to be in. One SetDataSource statement is needed for each table in the report.

This approach can cause performance problems because Crystal Reports must bind the tables together on the client-side, which will be slower than using a pre-saved data set.

20.2.5.9. Handling Date and Time Information in Connector/Net

Introduction

MySQL and the .NET languages handle date and time information differently, with MySQL allowing dates that cannot be represented by a .NET data type, such as '`0000-00-00 00:00:00`'. These differences can cause problems if not properly handled.

In this section we will demonstrate how to properly handle date and time information when using Connector/Net.

20.2.5.9.1. Problems when Using Invalid Dates

The differences in date handling can cause problems for developers who use invalid dates. Invalid MySQL dates cannot be loaded into native .NET `DateTime` objects, including `NULL` dates.

Because of this issue, .NET `DataSet` objects cannot be populated by the `Fill` method of the `MySqlDataAdapter` class as invalid dates will cause a `System.ArgumentOutOfRangeException` exception to occur.

20.2.5.9.2. Restricting Invalid Dates

The best solution to the date problem is to restrict users from entering invalid dates. This can be done on either the client or the server side.

Restricting invalid dates on the client side is as simple as always using the .NET `DateTime` class to handle dates. The `DateTime` class will only allow valid dates, ensuring that the values in your database are also valid. The disadvantage of this is that it is not useful in a mixed environment where .NET and non .NET code are used to manipulate the database, as each application must perform its own date validation.

Users of MySQL 5.0.2 and higher can use the new `traditional` SQL mode to restrict invalid date values. For information on using the `traditional` SQL mode, see Section 5.1.6, “Server SQL Modes”.

20.2.5.9.3. Handling Invalid Dates

Although it is strongly recommended that you avoid the use of invalid dates within your .NET application, it is possible to use invalid dates by means of the `MySqlDateTime` data type.

The `MySqlDateTime` data type supports the same date values that are supported by the MySQL server. The default behavior of

Connector/Net is to return a .NET DateTime object for valid date values, and return an error for invalid dates. This default can be modified to cause Connector/Net to return `MySqlDateTime` objects for invalid dates.

To instruct Connector/Net to return a `MySqlDateTime` object for invalid dates, add the following line to your connection string:

```
Allow Zero Datetime=True
```

Please note that the use of the `MySqlDateTime` class can still be problematic. The following are some known issues:

1. Data binding for invalid dates can still cause errors (zero dates like 0000-00-00 do not seem to have this problem).
2. The `ToString` method return a date formatted in the standard MySQL format (for example, `2005-02-23 08:50:25`). This differs from the `ToString` behavior of the .NET DateTime class.
3. The `MySqlDateTime` class supports NULL dates, while the .NET DateTime class does not. This can cause errors when trying to convert a MySQLDateTime to a DateTime if you do not check for NULL first.

Because of the known issues, the best recommendation is still to use only valid dates in your application.

20.2.5.9.4. Handling NULL Dates

The .NET `DateTime` data type cannot handle `NULL` values. As such, when assigning values from a query to a `DateTime` variable, you must first check whether the value is in fact `NULL`.

When using a `MySqlDataReader`, use the `.IsDBNull` method to check whether a value is `NULL` before making the assignment:

Visual Basic Example

```
If Not myReader.IsDBNull(myReader.GetOrdinal("mytime")) Then
    myTime = myReader.GetDateTime(myReader.GetOrdinal("mytime"))
Else
    myTime = DateTime.MinValue
End If
```

C# Example

```
if (! myReader.IsDBNull(myReader.GetOrdinal("mytime")))
    myTime = myReader.GetDateTime(myReader.GetOrdinal("mytime"));
else
    myTime = DateTime.MinValue;
```

`NULL` values will work in a data set and can be bound to form controls without special handling.

20.2.5.10. ASP.NET Provider Model

MySQL Connector/Net provides support for the ASP.NET 2.0 provider model. This model enables application developers to focus on the business logic of their application instead of having to recreate such boilerplate items as membership and roles support.

MySQL Connector/Net supplies the following providers:

- Membership Provider
- Role Provider
- Profile Provider
- Session State Provider (MySQL Connector/Net 6.1 and later)

The following tables show the supported providers, their default provider and the corresponding MySQL provider.

Membership Provider

Default Provider	MySQL Provider
System.Web.Security.SqlMembershipProvider	MySql.Web.Security.MySQLMembershipProvider

Role Provider

Default Provider	MySQL Provider
System.Web.Security.SqlRoleProvider	MySql.Web.Security.MySQLRoleProvider

Profile Provider

Default Provider	MySQL Provider
System.Web.Profile.SqlProfileProvider	MySql.Web.Profile.MySQLProfileProvider

SessionState Provider

Default Provider	MySQL Provider
System.Web.SessionState.InProcSessionStateStore	MySql.Web.SessionState.MySqlSessionStateStore

> **Note**
>
> The MySQL Session State provider uses slightly different capitalization on the class name compared to the other MySQL providers.

Installing The Providers

The installation of Connector/Net 5.1 or later will install the providers and register them in your machine's .NET configuration file, `machine.config`. The additional entries created will result in the `system.web` section appearing similar to the following code:

```
<system.web>
  <processModel autoConfig="true" />
  <httpHandlers />
  <membership>
    <providers>
      <add name="AspNetSqlMembershipProvider" type="System.Web.Security.SqlMembershipProvider, System.Web, Version=2.0
      <add name="MySQLMembershipProvider" type="MySql.Web.Security.MySQLMembershipProvider, MySql.Web, Version=6.1.1.0,
    </providers>
  </membership>
  <profile>
    <providers>
      <add name="AspNetSqlProfileProvider" connectionStringName="LocalSqlServer" applicationName="/" type="System.Web.
      <add name="MySQLProfileProvider" type="MySql.Web.Profile.MySQLProfileProvider, MySql.Web, Version=6.1.1.0, Cultu
    </providers>
  </profile>
  <roleManager>
    <providers>
      <add name="AspNetSqlRoleProvider" connectionStringName="LocalSqlServer" applicationName="/" type="System.Web.Sec
      <add name="AspNetWindowsTokenRoleProvider" applicationName="/" type="System.Web.Security.WindowsTokenRoleProvide
      <add name="MySQLRoleProvider" type="MySql.Web.Security.MySQLRoleProvider, MySql.Web, Version=6.1.1.0, Culture=ne
    </providers>
  </roleManager>
</system.web>
```

Each provider type can have multiple provider implementations. The default provider can also be set here using the `defaultProvider` attribute, but usually this is set in the `web.config` file either manually or by using the ASP.NET configuration tool.

At time of writing the `MySqlSessionStateStore` is not added to `machine.config` at install time, and so you would need to add the following:

```
<sessionState>
  <providers>
    <add name="MySqlSessionStateStore" type="MySql.Web.SessionState.MySqlSessionStateStore, MySql.Web, Version=6.1.1.0,
  </providers>
</sessionState>
```

It should be pointed out that the SessionState Provider uses the `customProvider` attribute, rather than `defaultProvider`, to set the provider as the default. A typical `web.config` file might contain:

```
   <system.web>
        <membership defaultProvider="MySQLMembershipProvider" />
        <roleManager defaultProvider="MySQLRoleProvider" />
        <profile defaultProvider="MySQLProfileProvider" />
        <sessionState customProvider="MySqlSessionStateStore" />
        <compilation debug="false">
          ...
```

This sets the MySQL Providers as the defaults to be used in this web application.

The providers are implemented in the file `mysql.web.dll` and this file can be found in your MySQL Connector/Net installation folder. There is no need to run any type of SQL script to set up the database schema as the providers create and maintain the proper schema automatically.

Using The Providers

The easiest way to start using the providers is to use the ASP.NET configuration tool that is available on the Solution Explorer toolbar when you have a website project loaded.

In the web pages that open you will be able to select the MySQL membership and roles providers by indicating that you want to pick a custom provider for each area.

When the provider is installed, it creates a dummy connection string named `LocalMySqlServer`. This has to be done so that the provider will work in the ASP.NET configuration tool. However, you will want to override this connection string in your `web.config` file. You do this by first removing the dummy connection string and then adding in the proper one, as shown in the following example:

```
<connectionStrings>
  <remove name="LocalMySqlServer"/>
  <add name="LocalMySqlServer" connectionString="server=xxx;uid=xxx;pwd=xxx;database=xxx;"/>
</connectionStrings>
```

Note the database you want to connect to must be specified.

Rather than manually editing configuration files it is recommended that you use the MySQL Website Configuration tool to config your desired provider setup. From MySQL Connector/Net 6.1.1 onwards all providers can be selected and configured from this wizard. The tool will modify your `website.config` file to the desired configuration. A tutorial on doing this is available in the following section Section 20.2.3.10, “MySQL Website Configuration Tool”.

A tutorial demonstrating how to use the Membership and Role Providers can be found in the following section Section 20.2.4.2, “Tutorial: MySQL Connector/Net ASP.NET Membership and Role Provider”.

Deployment

To use the providers on a production server you will need to distribute the `MySql.Data` and the `MySql.Web` assemblies and either register them in the remote systems Global Assembly Cache or keep them in your application's `bin/` directory.

20.2.5.11. Binary/Nonbinary Issues

There are certain situations where MySQL will return incorrect metadata about one or more columns. More specifically, the server will sometimes report that a column is binary when it is not and vice versa. In these situations, it becomes practically impossible for the connector to be able to correctly identify the correct metadat.

Some examples of situations that may return incorrect metadata are:

- Execution of `SHOW PROCESSLIST`. Some of the columns will be returned as binary even though they only hold string data.
- When a temp table is used to process a resultset, some columns may be returned with incorrect binary flags.
- Some server functions such `DATE_FORMAT` will incorrectly return the column as binary.

With the availability of `BINARY` and `VARBINARY` data types it is important that we respect the metadata returned by the sever. However, we are aware that some existing applications may break with this change so we are creating a connection string option to enable or disable it. By default, Connector/Net 5.1 will respect the binary flags returned by the server. This will mean that you may need to make small changes to your application to accommodate this change.

In the event that the changes required to your application would be too large, you can add 'respect binary flags=false' to your connection string. This will cause the connector to use the prior behavior. In a nutshell, that behavior was that any column that is marked as string, regardless of binary flags, will be returned as string. Only columns that are specifically marked as a `BLOB` will be returned as `BLOB`.

20.2.5.12. Character Sets

Treating Binary Blobs As UTF8

MySQL doesn't currently support 4 byte UTF8 sequences. This makes it difficult to represent some multi-byte languages such as Japanese. To try and alleviate this, Connector/Net now supports a mode where binary blobs can be treated as strings.

To do this, you set the 'Treat Blobs As UTF8' connection string keyword to yes. This is all that needs to be done to enable conversion of all binary blobs to UTF8 strings. If you wish to convert only some of your blob columns, then you can make use of the 'BlobAsUTF8IncludePattern' and 'BlobAsUTF8ExcludePattern' keywords. These should be set to the regular expression pattern that matches the column names you wish to include or exclude respectively.

One thing to note is that the regular expression patterns can both match a single column. When this happens, the include pattern is applied before the exclude pattern. The result, in this case, would be that the column would be excluded. You should also be aware that this mode does not apply to columns of type `BINARY` or `VARBINARY` and also do not apply to nonbinary `BLOB` columns.

Currently this mode only applies to reading strings out of MySQL. To insert 4-byte UTF8 strings into blob columns you will need to use the .NET `Encoding.GetBytes` function to convert your string to a series of bytes. You can then set this byte array as a parameter for a `BLOB` column.

20.2.5.13. Working with medium trust

.NET applications operate under a given trust level. Normal desktop applications operate under full trust while web applications that are hosted in shared environments are normally run under the medium trust level. Some hosting providers host shared applications in their own app pools and allow the application to run under full trust, but this seems to be the exception rather than the rule.

Connector/Net versions prior to 5.0.8 and 5.1.3 were not compatible with medium trust hosting. Starting with these versions, Connector/Net can be used under medium trust hosting that has been modified to allow the use of sockets for communication. By default, medium trust does not include `SocketPermission`. Connector/Net uses sockets to talk with the MySQL server so it is required that a new trust level be created that is an exact clone of medium trust but that has `SocketPermission` added.

20.2.5.14. Using the MySQL Connector/Net Trace Source Object

MySQL Connector/Net 6.2 introduced support for .NET 2.0 compatible tracing, using `TraceSource` objects.

The .NET 2.0 tracing architecture consists of four main parts:

- *Source* - This is the originator of the trace information. The source is used to send trace messages. The name of the source provided by MySQL Connector/Net is `mysql`.
- *Switch* - This defines the level of trace information to emit. Typically, this is specified in the `app.config` file, so that it is not necessary to recompile an application to change the trace level.
- *Listener* - Trace listeners define where the trace information will be written to. Supported listeners include, for example, the Visual Studio Output window, the Windows Event Log, and the console.
- *Filter* - Filters can be attached to listeners. Filters determine the level of trace information that will be written. While a switch defines the level of information that will be written to all listeners, a filter can be applied on a per-listener basis, giving finer grained control of trace information.

To use tracing a `TraceSource` object first needs to be created. To create a `TraceSource` object in MySQL Connector/Net you would use code similar to the following:

```
TraceSource ts = new TraceSource("mysql");
```

To enable trace messages you also need to configure a trace switch. There are three main switch classes, `BooleanSwitch`, `SourceSwitch`, and `TraceSwitch`. Trace switches also have associated with them a trace level enumeration, these are `Off`, `Error`, `Warning`, `Info`, and `Verbose`. The following code snippet illustrates creating a switch:

```
ts.Switch = new SourceSwitch("MySwitch", "Verbose");
```

This creates a `SourceSwitch`, called `MySwitch`, and sets the trace level to `Verbose`, meaning that all trace messages will be written.

It is convenient to be able to change the trace level without having to recompile the code. This is achieved by specifying the trace level in application configuration file, `app.config`. You then simply need to specify the desired trace level in the configuration file and restart the application. The trace source is configured within the `system.diagnostics` section of the file. The following XML snippet illustrates this:

```
<configuration>
  ...
  <system.diagnostics>
    <sources>
      <source name="mysql" switchName="MySwitch"
              switchType="System.Diagnostics.SourceSwitch" />
      ...
    </sources>
    <switches>
      <add name="MySwitch" value="Verbose"/>
      ...
    </switches>
  </system.diagnostics>
  ...
</configuration>
```

By default trace information is written to the Output window of Microsoft Visual Studio. However, there are a wide range of listeners than can be attached to the trace source, so that trace messages can be written out to various destinations. It is also possible to create custom listeners to allow trace messages to be written to other destinations as mobile devices and web services. A commonly used example of a listener is `ConsoleTraceListener`, which writes trace messages to the console.

To add a listener at run time you can use code such as the following:

```
ts.Listeners.Add(new ConsoleTraceListener());
```

You can then call methods on trace source object to generate trace information. For example, the `TraceInformation()`, `TraceEvent()`, or `TraceData()` methods can be used.

The `TraceInformation()` method simply prints a string passed as a parameter. The `TraceEvent()` method, as well as the optional informational string, requires a `TraceEventType` value to be passed to indicate the trace message type, and also an application specific ID. The `TraceEventType` can have a value of `Verbose`, `Information`, `Warning`, `Error`, and `Critical`. Using the `TraceData()` method you can pass any object, for example an exception object, instead of a message.

To ensure than these generated trace messages gets flushed from the trace source buffers to listeners, you need to invoke the `Flush()` method. When you are finished using a trace source, you should call the `Close()` method. The `Close()` method first calls `Flush()`, to ensure any remaining data is written out. It then frees up resources, and closes the listeners associated with the trace source.

```
ts.TraceInformation("Informational message");
ts.TraceEvent(TraceEventType.Error, 3, "Optional error message");
ts.TraceData(TraceEventType.Error, 3, ex); // pass exception object
ts.Flush();
...
ts.Close();
```

20.2.5.14.1. Viewing MySQL Trace Information

This section describes how to set up your application to view MySQL trace information.

The first thing you need to do is create a suitable `app.config` file for your application. An example is shown in the following code:

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
  <system.diagnostics>
    <sources>
      <source name="mysql" switchName="SourceSwitch"
        switchType="System.Diagnostics.SourceSwitch" >
        <listeners>
          <add name="console" />
          <remove name ="Default" />
        </listeners>
      </source>
    </sources>
    <switches>
      <!-- You can set the level at which tracing is to occur -->
      <add name="SourceSwitch" value="Verbose" />
      <!-- You can turn tracing off -->
      <!--add name="SourceSwitch" value="Off" -->
    </switches>
    <sharedListeners>
      <add name="console"
        type="System.Diagnostics.ConsoleTraceListener"
        initializeData="false"/>
    </sharedListeners>
  </system.diagnostics>
</configuration>
```

This ensures a suitable trace source is created, along with a switch. The switch level in this case is set to `Verbose` to display the maximum amount of information.

In the application the only other step required is to add `logging=true` to the connection string. An example application could be:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Diagnostics;
using MySql.Data;
using MySql.Data.MySqlClient;
using MySql.Web;


namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {

            string connStr = "server=localhost;user=root;database=world;port=3306;password=******;logging=true;";
            MySqlConnection conn = new MySqlConnection(connStr);
            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent='Oceania'";
                MySqlCommand cmd = new MySqlCommand(sql, conn);
                MySqlDataReader rdr = cmd.ExecuteReader();

                while (rdr.Read())
                {
                    Console.WriteLine(rdr[0] + " -- " + rdr[1]);
                }

                rdr.Close();

                conn.Close();
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }
            Console.WriteLine("Done.");
        }
    }
}
```

This simple application will then generate the following output:

```
Connecting to MySQL...
mysql Information: 1 : 1: Connection Opened: connection string = 'server=localhost;User Id=root;database=world;port=330
;password=******;logging=True'
mysql Information: 3 : 1: Query Opened: SHOW VARIABLES
mysql Information: 4 : 1: Resultset Opened: field(s) = 2, affected rows = -1, inserted id = -1
mysql Information: 5 : 1: Resultset Closed. Total rows=272, skipped rows=0, size (bytes)=7058
mysql Information: 6 : 1: Query Closed
mysql Information: 3 : 1: Query Opened: SHOW COLLATION
mysql Information: 4 : 1: Resultset Opened: field(s) = 6, affected rows = -1, inserted id = -1
mysql Information: 5 : 1: Resultset Closed. Total rows=127, skipped rows=0, size (bytes)=4102
mysql Information: 6 : 1: Query Closed
mysql Information: 3 : 1: Query Opened: SET character_set_results=NULL
mysql Information: 4 : 1: Resultset Opened: field(s) = 0, affected rows = 0, inserted id = 0
mysql Information: 5 : 1: Resultset Closed. Total rows=0, skipped rows=0, size (bytes)=0
mysql Information: 6 : 1: Query Closed
mysql Information: 10 : 1: Set Database: world
mysql Information: 3 : 1: Query Opened: SELECT Name, HeadOfState FROM Country WHERE Continent='Oceania'
mysql Information: 4 : 1: Resultset Opened: field(s) = 2, affected rows = -1, inserted id = -1
American Samoa -- George W. Bush
Australia -- Elisabeth II
...
Wallis and Futuna -- Jacques Chirac
Vanuatu -- John Bani
United States Minor Outlying Islands -- George W. Bush
mysql Information: 5 : 1: Resultset Closed. Total rows=28, skipped rows=0, size (bytes)=788
mysql Information: 6 : 1: Query Closed
Done.
mysql Information: 2 : 1: Connection Closed
```

The first number displayed in the trace message corresponds to the MySQL event type:

Event	**Description**
1	ConnectionOpened: connection string
2	ConnectionClosed:
3	QueryOpened: mysql server thread id, query text
4	ResultOpened: field count, affected rows (-1 if select), inserted id (-1 if select)
5	ResultClosed: total rows read, rows skipped, size of resultset in bytes
6	QueryClosed:

Event	Description
7	StatementPrepared: prepared sql, statement id
8	StatementExecuted: statement id, mysql server thread id
9	StatementClosed: statement id
10	NonQuery: [varies]
11	UsageAdvisorWarning: usage advisor flag. NoIndex = 1, BadIndex = 2, SkippedRows = 3, SkippedColumns = 4, FieldConversion = 5.
12	Warning: level, code, message
13	Error: error number, error message

The second number displayed in the trace message is the connection count.

Although this example uses the `ConsoleTraceListener`, any of the other standard listeners could have been used. Another possibility is to create a custom listener that uses the information passed using the `TraceEvent` method. For example, a custom trace listener could be created to perform active monitoring of the MySQL event messages, rather than simply writing these to an output device.

It is also possible to add listeners to the MySQL Trace Source at run time. This can be done with the following code:

```
MySqlTrace.Listeners.Add(new ConsoleTraceListener());
```

MySQL Connector/Net 6.3.2 introduced the ability to switch tracing on and off at run time. This can be achieved using the calls `MySqlTrace.EnableQueryAnalyzer(string host, int postInterval)` and `MySqlTrace.DisableQueryAnalyzer()`. The parameter `host` is the URL of the MySQL Enterprise Monitor server to monitor. The parameter `postInterval` is how often the data should be periodically posted to MySQL Enterprise Monitor, in seconds.

20.2.5.14.2. Building Custom Listeners

To build custom listeners that work with the MySQL Connector/Net Trace Source, it is necessary to understand the key methods used, and the event data formats used.

The main method involved in passing trace messages is the `TraceSource.TraceEvent` method. This has the prototype:

```
public void TraceEvent(
    TraceEventType eventType,
    int id,
    string format,
    params Object[] args
)
```

This trace source method will process the list of attached listeners and call the listener's TraceListener.TraceEvent method. The prototype for the `TraceListener.TraceEvent` method is as follows:

```
public virtual void TraceEvent(
    TraceEventCache eventCache,
    string source,
    TraceEventType eventType,
    int id,
    string format,
    params Object[] args
)
```

The first three parameters are used in the standard as defined by Microsoft. The last three parameters contain MySQL-specific trace information. Each of these parameters is now discussed in more detail.

`int id`

This is a MySQL-specific identifier. It identifies the MySQL event type that has occurred, resulting in a trace message being generated. This value is defined by the `MySqlTraceEventType` public enum contained in the MySQL Connector/Net code:

```
public enum MySqlTraceEventType : int
{
    ConnectionOpened = 1,
    ConnectionClosed,
    QueryOpened,
    ResultOpened,
    ResultClosed,
    QueryClosed,
    StatementPrepared,
    StatementExecuted,
    StatementClosed,
    NonQuery,
    UsageAdvisorWarning,
    Warning,
    Error
}
```

The MySQL event type also determines the contents passed using the parameter `params Object[] args`. The nature of the `args` parameters are described in further detail in the following material.

`string format`

This is the format string that contains zero or more format items, which correspond to objects in the args array. This would be used by a listener such as `ConsoleTraceListener` to write a message to the output device.

`params Object[] args`

This is a list of objects that depends on the MySQL event type, `id`. However, the first parameter passed using this list is always the driver id. The driver id is a unique number that is incremented each time the connector is opened. This enables groups of queries on the same connection to be identified. The parameters that follow driver id depend of the MySQL event id, and are as follows:

MySQL-specific event type	Arguments (params Object[] args)
ConnectionOpened	Connection string
ConnectionClosed	No additional parameters
QueryOpened	mysql server thread id, query text
ResultOpened	field count, affected rows (-1 if select), inserted id (-1 if select)
ResultClosed	total rows read, rows skipped, size of resultset in bytes
QueryClosed	No additional parameters
StatementPrepared	prepared sql, statement id
StatementExecuted	statement id, mysql server thread id
StatementClosed	statement id
NonQuery	Varies
UsageAdvisorWarning	usage advisor flag. NoIndex = 1, BadIndex = 2, SkippedRows = 3, SkippedColumns = 4, FieldConversion = 5.
Warning	level, code, message
Error	error number, error message

This information will allow you to create custom trace listeners that can actively monitor the MySQL-specific events.

20.2.5.15. Using the Bulk Loader

MySQL Connector/Net features a bulk loader class that wraps the MySQL statement `LOAD DATA INFILE`. This gives MySQL Connector/Net the ability to load a data file from a local or remote host to the server. The class concerned is `MySqlBulkLoader`. This class has various methods, the main one being `load` to cause the specified file to be loaded to the server. Various parameters can be set to control how the data file is processed. This is achieved through setting various properties of the class. For example, the field separator used, such as comma or tab, can be specified, along with the record terminator, such as newline.

The following code shows a simple example of using the `MySqlBulkLoader` class. First an empty table needs to be created, in this case in the `test` database:

```
CREATE TABLE Career (
       Name VARCHAR(100) NOT NULL,
       Age INTEGER,
       Profession VARCHAR(200)
);
```

A simple tab-delimited data file is also created (it could use any other field delimiter such as comma):

```
Table Career in Test Database
Name Age Profession

Tony 47 Technical Writer
Ana 43 Nurse
Fred 21 IT Specialist
Simon 45 Hairy Biker
```

Note that with this test file the first three lines will need to be ignored, as they do not contain table data. This can be achieved using the `NumberOfLinesToSkip` property. This file can then be loaded and used to populate the `Career` table in the `test` database:

```
using System;
using System.Text;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {

            string connStr = "server=localhost;user=root;database=test;port=3306;password=******;";
            MySqlConnection conn = new MySqlConnection(connStr);

            MySqlBulkLoader bl = new MySqlBulkLoader(conn);
            bl.TableName = "Career";
            bl.FieldTerminator = "\t";
            bl.LineTerminator = "\n";
            bl.FileName = "c:/career_data.txt";
            bl.NumberOfLinesToSkip = 3;

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                // Upload data from file
                int count = bl.Load();
                Console.WriteLine(count + " lines uploaded.");

                string sql = "SELECT Name, Age, Profession FROM Career";
                MySqlCommand cmd = new MySqlCommand(sql, conn);
                MySqlDataReader rdr = cmd.ExecuteReader();

                while (rdr.Read())
                {
                    Console.WriteLine(rdr[0] + " -- " + rdr[1] + " -- " + rdr[2]);
                }

                rdr.Close();

                conn.Close();
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }
            Console.WriteLine("Done.");
        }
    }
}
```

Further information on `LOAD DATA INFILE` can be found in Section 12.2.6, “`LOAD DATA INFILE` Syntax”. Further information on `MySqlBulkLoader` can be found in the reference documentation that was included with your connector.

20.2.6. Connector/Net Connection String Options Reference

Name	Default	Description
`Allow Batch`	true	When true, multiple SQL statements can be sent with one command execution. -Note- Starting with MySQL 4.1.1, batch statements should be separated by the server-defined separator character. Commands sent to earlier versions of MySQL should be separated with ';'.
`Allow User Variables`	false	Setting this to `true` indicates that the provider expects user variables in the SQL. This option was added in Connector/Net version 5.2.2.
`Allow Zero Datetime`	false	If set to `True`, `MySqlDataReader.GetValue()` will return a `MySqlDateTime` object for date or datetime columns that have illegal values, such as zero datetime values, and a `System.DateTime` object for legal values. If set to `False` (the default setting) it will cause a `System.DateTime` object to be returned for all legal values and an exception to be thrown for illegal values, such as zero datetime values.
`AutoEnlist`	true	If `AutoEnlist` is set to `true`, which is the default, a connection opened using `TransactionScope` participates in this scope, it commits when the scope commits and rolls back if `TransactionScope` does not commit. However, this feature is considered security sensitive and therefore cannot be used in a medium trust environment.

Name	Default	Description
`BlobAsUTF8ExcludePattern`	null	
`BlobAsUTF8IncludePattern`	null	
`CertificateFile`	null	This option specifies the path to a certificate file in PFX format. For an example of usage see Section 20.2.4.7, "Tutorial: Using SSL with MySQL Connector/Net". Was introduced with 6.2.1.
`CertificatePassword`	null	This option enables you to specify a password which is used in conjunction with a certificate specified using the option `CertificateFile`. For an example of usage see Section 20.2.4.7, "Tutorial: Using SSL with MySQL Connector/Net". Was introduced with 6.2.1.
`Certificate Store Location`	null	This option enables you to access a certificate held in a personal store, rather than use a certificate file and password combination. For an example of usage see Section 20.2.4.7, "Tutorial: Using SSL with MySQL Connector/Net". Was introduced with 6.2.1.
`Certificate Thumbprint`	null	This option enables you to specify a certificate thumbprint to ensure correct identifcation of a certificate contained within a personal store. For an example of usage see Section 20.2.4.7, "Tutorial: Using SSL with MySQL Connector/Net". Was introduced with 6.2.1.
`CharSet`, `Character Set`		Specifies the character set that should be used to encode all queries sent to the server. Resultsets are still returned in the character set of the data returned.
`Connect Timeout`, `Connection Timeout`	15	The length of time (in seconds) to wait for a connection to the server before terminating the attempt and generating an error.
`Connection Reset`	false	If true, the connection state will be reset when it is retrieved from the pool. If set to false this avoids making an additional server round trip when obtaining a connection, but the connection state is not reset.
`Convert Zero Datetime`	false	True to have `MySqlDataReader.GetValue()` and `MySqlDataReader.GetDateTime()` return DateTime.MinValue for date or datetime columns that have illegal values.
`Default Command Timeout`	30	Sets the default value of the command timeout to be used. This does not supercede the individual command timeout property on an individual command object. If you set the command timeout property, that will be used. This option was added in Connector/Net 5.1.4
`Encrypt`, `UseSSL`	false	For Connector/Net 5.0.3 and later, when `true`, SSL encryption is used for all data sent between the client and server if the server has a certificate installed. Recognized values are `true`, `false`, `yes`, and `no`. In versions before 5.0.3, this option had no effect. From version 6.2.1 this option is deprecated and is replaced by `SSL Mode`. However, the option is still supported if used. If this option is set to true it is equivalent to `SSL Mode = Preferred`.
`FunctionsReturnString`	false	This will cause the connector to return binary/varbinary values as strings, if they do not have a tablename in the metadata.
`Host`, `Server`, `Data Source`, `DataSource`, `Address`, `Addr`, `Network Address`	localhost	The name or network address of the instance of MySQL to which to connect. Multiple hosts can be specified separated by &. This can be useful where multiple MySQL servers are configured for replication and you are not concerned about the precise server you are connecting to. No attempt is made by the provider to synchronize writes to the database so care should be taken when using this option. In Unix environment with Mono, this can be a fully qualified path to MySQL socket file name. With this configuration, the Unix socket will be used instead of TCP/IP socket. Currently only a single socket name can be given so accessing MySQL in a replicated environment using Unix sockets is not currently supported.
`Ignore Prepare`	true	When true, instructs the provider to ignore any calls to `MySqlCommand.Prepare()`. This option is provided to prevent issues with corruption of the statements when use with server side prepared statements. If you want to use server-side prepare statements, set this option to false. This option was added in Connector/Net 5.0.3 and Connector/Net 1.0.9.
`Initial Catalog`, `Database`	mysql	The name of the database to use initially
`Interactive, InteractiveSession`	false	If set to true the client is interactive. An interactive client is one where the server variable `CLIENT_INTERACTIVE` is set. If an interactive

Name	Default	Description
		client is set, the `wait_timeout` variable is set to the value of `interactive_timeout`. The client will then timeout after this period of inactivity. More details can be found in the server manual Section 5.1.3, “Server System Variables”.
`Logging`	false	When true, various pieces of information is output to any configured TraceListeners. See Section 20.2.5.14, “Using the MySQL Connector/Net Trace Source Object” for further details.
`Old Guids`	false	This option was introduced in Connector/Net 6.1.1. The backend representation of a GUID type was changed from `BINARY(16)` to `CHAR(36)`. This was done to allow developers to use the server function `UUID()` to populate a GUID table - `UUID()` generates a 36-character string. Developers of older applications can add 'Old Guids=true' to the connection string to use a GUID of data type `BINARY(16)`.
`Old Syntax`, `OldSyntax`	false	This option was deprecated in Connector/Net 5.2.2. All code should now be written using the '@' symbol as the parameter marker.
`Password`, `pwd`		The password for the MySQL account being used.
`Persist Security Info`	false	When set to `false` or `no` (strongly recommended), security-sensitive information, such as the password, is not returned as part of the connection if the connection is open or has ever been in an open state. Resetting the connection string resets all connection string values including the password. Recognized values are `true`, `false`, `yes`, and `no`.
`Pipe Name`, `Pipe`	mysql	When set to the name of a named pipe, the `MySqlConnection` will attempt to connect to MySQL on that named pipe.This settings only applies to the Windows platform.
`Port`	3306	The port MySQL is using to listen for connections. This value is ignored if Unix socket is used.
`Procedure Cache Size`	25	Sets the size of the stored procedure cache. By default, Connector/Net will store the metadata (input/output data types) about the last 25 stored procedures used. To disable the stored procedure cache, set the value to zero (0). This option was added in Connector/Net 5.0.2 and Connector/Net 1.0.9.
`Protocol`	socket	Specifies the type of connection to make to the server. Values can be: `socket` or `tcp` for a socket connection, `pipe` for a named pipe connection, `unix` for a Unix socket connection, `memory` to use MySQL shared memory.
`Respect Binary Flags`	true	Setting this option to `false` means that Connector/Net will ignore a column's binary flags as set by the server. This option was added in Connector/Net version 5.1.3.
`Shared Memory Name`	MYSQL	The name of the shared memory object to use for communication if the connection protocol is set to memory.
`Sql Server Mode`	false	Allow SQL Server syntax. When set to `true` enables Connector/Net to support square brackets around symbols instead of backticks. This enables Visual Studio wizards that bracket symbols with [] to work with Connector/Net. This option incurs a performance hit, so should only be used if necessary. This option was added in version 6.3.1.
`SSL Mode`	None	This option has the following values: • **None** - do not use SSL. • **Preferred** - use SSL if the server supports it, but allow connection in all cases. • **Required** - Always use SSL. Deny connection if server does not support SSL. • **VerifyCA** - Always use SSL. Validate the CA but tolerate name mismatch. • **VerifyFull** - Always use SSL. Fail if the host name is not correct.

Name	**Default**	**Description**
		This option was introduced in MySQL Connector/Net 6.2.1.
`TreatBlobsAsUTF8`	false	
`Treat Tiny As Boolean`	true	Setting this value to `false` indicates that `TINYINT(1)` will be treated as an `INT`. See also Section 10.1.1, "Overview of Numeric Types" for a further explanation of the `TINYINT` and `BOOL` data types.
`Use Affected Rows`	false	When `true` the connection will report changed rows instead of found rows. This option was added in Connector/Net version 5.2.6.
`Use Procedure Bodies`	true	When set to `true`, the default value, MySQL Connector/Net expects the body of the procedure to be viewable. This enables it to determine the parameter types and order. The option should be set to `false` when the user connecting to the database does not have the `SELECT` privileges for the `mysql.proc` (stored procedures) table, or cannot view `I_S.ROUTINES`. In this case, MySQL Connector/Net will not be able to determine the types and order of the parameters, and must be alerted to this fact by setting this option to `false`. When set to `false`, MySQL Connector/Net will not rely on this information being available when the procedure is called. Because MySQL Connector/Net will not be able to determine this information, you should explicitly set the types of all the parameters before the call and the parameters should be added to the command in the same order as they appear in the procedure definition. This option was added in MySQL Connector/Net 5.0.4 and MySQL Connector/Net 1.0.10.
`User Id`, `Username`, `Uid`, `User name`		The MySQL login account being used.
`Use Compression`	false	Setting this option to `true` enables compression of packets exchanged between the client and the server. This exchange is defined by the MySQL client/server protocol. Compression is used if both client and server support ZLIB compression, and the client has requested compression using this option. A compressed packet header is: packet length (3 bytes), packet number (1 byte), and Uncompressed Packet Length (3 bytes). The Uncompressed Packet Length is the number of bytes in the original, uncompressed packet. If this is zero then the data in this packet has not been compressed. When the compression protocol is in use, either the client or the server may compress packets. However, compression will not occur if the compressed length is greater than the original length. Thus, some packets will contain compressed data while other packets will not.
`Use Usage Advisor`	false	
`Use Performance Monitor`	false	

The following table lists the valid names for connection pooling values within the `ConnectionString`. For more information about connection pooling, see Connection Pooling for the MySQL Data Provider.

Name	**Default**	**Description**
`Cache Server Configuration`, `CacheServerConfiguration`, `CacheServerConfig`	false	Specifies whether server variables should be updated when a pooled connection is returned. Turning this on will yield faster opens but will also not catch any server changes made by other connections.
`Connection Lifetime`	0	When a connection is returned to the pool, its creation time is compared with the current time, and the connection is destroyed if that time span (in seconds) exceeds the value specified by `Connection Lifetime`. This is useful in clustered configurations to force load balancing between a running server and a server just brought online. A value of zero (0) causes pooled connections to have the maximum connection timeout.
`Max Pool Size`	100	The maximum number of connections allowed in the pool.
`Min Pool Size`	0	The minimum number of connections allowed in the pool.

Name	Default	Description
`Pooling`	true	When `true`, the `MySqlConnection` object is drawn from the appropriate pool, or if necessary, is created and added to the appropriate pool. Recognized values are `true`, `false`, `yes`, and `no`.

20.2.7. Connector/Net API Reference

This section of the manual contains a complete reference to the Connector/Net ADO.NET component, automatically generated from the embedded documentation.

20.2.7.1. `MySql.Data.MySqlClient`

Namespace hierarchy

Classes

Class	Description
MySqlCommand	
MySqlCommandBuilder	
MySqlConnection	
MySqlDataAdapter	
MySqlDataReader	Provides a means of reading a forward-only stream of rows from a MySQL database. This class cannot be inherited.
MySqlError	Collection of error codes that can be returned by the server
MySqlException	The exception that is thrown when MySQL returns an error. This class cannot be inherited.
MySqlHelper	Helper class that makes it easier to work with the provider.
MySqlInfoMessageEventArgs	Provides data for the InfoMessage event. This class cannot be inherited.
MySqlParameter	Represents a parameter to a MySqlCommand , and optionally, its mapping to DataSetcolumns. This class cannot be inherited.
MySqlParameterCollection	Represents a collection of parameters relevant to a MySqlCommand as well as their respective mappings to columns in a DataSet. This class cannot be inherited.
MySqlRowUpdatedEventArgs	Provides data for the RowUpdated event. This class cannot be inherited.
MySqlRowUpdatingEventArgs	Provides data for the RowUpdating event. This class cannot be inherited.
MySqlTransaction	

Delegates

Delegate	Description
MySqlInfoMessageEventHandler	Represents the method that will handle the InfoMessage event of a MySqlConnection.
MySqlRowUpdatedEventHandler	Represents the method that will handle the RowUpdatedevent of a MySqlDataAdapter .
MySqlRowUpdatingEventHandler	Represents the method that will handle the RowUpdatingevent of a MySqlDataAdapter .

Enumerations

Enumeration	Description
MySqlDbType	Specifies MySQL specific data type of a field, property, for use in a MySqlParameter .
MySqlErrorCode	

20.2.7.1.1. `MySql.Data.MySqlClientHierarchy`

See Also

MySql.Data.MySqlClient Namespace

20.2.7.1.2. `MySqlCommand` Class

For a list of all members of this type, see MySqlCommand Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlCommand_
  Inherits Component_
  Implements IDbCommand, ICloneable
```

Syntax: C#

```
public sealed class MySqlCommand : Component, IDbCommand, ICloneable
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlCommand Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1. `MySqlCommand` Members

MySqlCommand overview

Public Instance Constructors

MySqlCommand	Overloaded. Initializes a new instance of the MySqlCommand class.

Public Instance Properties

CommandText	
CommandTimeout	
CommandType	
Connection	
Container(inherited from Component)	Gets the IContainerthat contains the Component.
IsPrepared	
Parameters	
Site(inherited from Component)	Gets or sets the ISiteof the Component.
Transaction	
UpdatedRowSource	

Public Instance Methods

Cancel	Attempts to cancel the execution of a MySqlCommand. This operation is not supported.
CreateObjRef(inherited from MarshalByRefObject)	Creates an object that contains all the relevant information required to generate a proxy used to communicate with a remote

	object.
CreateParameter	Creates a new instance of a MySqlParameter object.
Dispose(inherited from Component)	Releases all resources used by the Component.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
ExecuteNonQuery	
ExecuteReader	Overloaded.
ExecuteScalar	
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetLifetimeService(inherited from MarshalByRefObject)	Retrieves the current lifetime service object that controls the lifetime policy for this instance.
GetType(inherited from Object)	Gets the Typeof the current instance.
InitializeLifetimeService(inherited from MarshalByRefObject)	Obtains a lifetime service object to control the lifetime policy for this instance.
Prepare	
ToString(inherited from Component)	Returns a Stringcontaining the name of the Component, if any. This method should not be overridden.

Public Instance Events

Disposed(inherited from Component)	Adds an event handler to listen to the Disposedevent on the component.

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1. `MySqlCommand` Constructor

Initializes a new instance of the MySqlCommand class.

Overload List

Initializes a new instance of the MySqlCommand class.

- public MySqlCommand();
- public MySqlCommand(string);
- public MySqlCommand(string,MySqlConnection);
- public MySqlCommand(string,MySqlConnection,MySqlTransaction);

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.1. `MySqlCommand` Constructor ()

Initializes a new instance of the MySqlCommand class.

Syntax: Visual Basic

```
Overloads Public Sub New()
```

Syntax: C#

```
public MySqlCommand();
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace, MySqlCommand Constructor Overload List

20.2.7.1.2.1.1.2. `MySqlCommand` Constructor (String)

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal cmdText As String _
)
```

Syntax: C#

```
public MySqlCommand(
stringcmdText
);
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace, MySqlCommand Constructor Overload List

20.2.7.1.2.1.1.3. `MySqlCommand` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal cmdText As String, _
   ByVal connection As MySqlConnection _
)
```

Syntax: C#

```
public MySqlCommand(
stringcmdText,
MySqlConnectionconnection
);
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace, MySqlCommand Constructor Overload List

20.2.7.1.2.1.1.3.1. `MySqlConnection` Class

For a list of all members of this type, see MySqlConnection Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlConnection_
  Inherits Component_
  Implements IDbConnection, ICloneable
```

Syntax: C#

```
public sealed class MySqlConnection : Component, IDbConnection, ICloneable
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlConnection Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1. `MySqlConnection` Members

MySqlConnection overview

Public Instance Constructors

MySqlConnection	Overloaded. Initializes a new instance of the MySqlConnection class.

Public Instance Properties

ConnectionString	
ConnectionTimeout	
Container(inherited from Component)	Gets the IContainerthat contains the Component.
Database	
DataSource	Gets the name of the MySQL server to which to connect.
ServerThread	Returns the id of the server thread this connection is executing on
ServerVersion	
Site(inherited from Component)	Gets or sets the ISiteof the Component.
State	
UseCompression	Indicates if this connection should use compression when communicating with the server.

Public Instance Methods

BeginTransaction	Overloaded.
ChangeDatabase	
Close	
CreateCommand	
CreateObjRef(inherited from MarshalByRefObject)	Creates an object that contains all the relevant information required to generate a proxy used to communicate with a remote object.
Dispose(inherited from Component)	Releases all resources used by the Component.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetLifetimeService(inherited from MarshalByRefObject)	Retrieves the current lifetime service object that controls the lifetime policy for this instance.
GetType(inherited from Object)	Gets the Typeof the current instance.
InitializeLifetimeService(inherited from MarshalByRefObject)	Obtains a lifetime service object to control the lifetime policy for this instance.
Open	
Ping	Ping
ToString(inherited from Component)	Returns a Stringcontaining the name of the Component, if any. This method should not be overridden.

Public Instance Events

Disposed(inherited from Component)	Adds an event handler to listen to the Disposedevent on the component.
InfoMessage	
StateChange	

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.1. `MySqlConnection` Constructor

Initializes a new instance of the MySqlConnection class.

Overload List

Initializes a new instance of the MySqlConnection class.

- public MySqlConnection();
- public MySqlConnection(string);

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.1.1. `MySqlConnection` Constructor

Initializes a new instance of the MySqlConnection class.

Syntax: Visual Basic

```
Overloads Public Sub New()
```

Syntax: C#

```
public MySqlConnection();
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace, MySqlConnection Constructor Overload List

20.2.7.1.2.1.1.3.1.1.1.2. `MySqlConnection` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal connectionString As String _
)
```

Syntax: C#

```
public MySqlConnection(
stringconnectionString
);
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace, MySqlConnection Constructor Overload List

20.2.7.1.2.1.1.3.1.1.2. ConnectionString Property

Syntax: Visual Basic

```
NotOverridable Public Property ConnectionString As String _
_
  Implements IDbConnection.ConnectionString
```

Syntax: C#

```
public string ConnectionString {get; set;}
```

Implements

IDbConnection.ConnectionString

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.3. ConnectionTimeout Property

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property ConnectionTimeout As Integer _
_ Implements IDbConnection.ConnectionTimeout
```

Syntax: C#

```
public int ConnectionTimeout {get;}
```

Implements

IDbConnection.ConnectionTimeout

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.4. Database Property

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property Database As String _
_ Implements IDbConnection.Database
```

Syntax: C#

```
public string Database {get;}
```

Implements

IDbConnection.Database

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.5. DataSource Property

Gets the name of the MySQL server to which to connect.

Syntax: Visual Basic

```
Public ReadOnly Property DataSource As String
```

Syntax: C#

```
public string DataSource {get;}
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.6. ServerThread Property

Returns the id of the server thread this connection is executing on

Syntax: Visual Basic

```
Public ReadOnly Property ServerThread As Integer
```

Syntax: C#

```
public int ServerThread {get;}
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.7. ServerVersion Property

Syntax: Visual Basic

```
Public ReadOnly Property ServerVersion As String
```

Syntax: C#

```
public string ServerVersion {get;}
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.8. State Property

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property State As ConnectionState _
_ Implements IDbConnection.State
```

Syntax: C#

```
public System.Data.ConnectionState State {get;}
```

Implements

IDbConnection.State

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.9. UseCompression Property

Indicates if this connection should use compression when communicating with the server.

Syntax: Visual Basic

```
Public ReadOnly Property UseCompression As Boolean
```

Syntax: C#

```
public bool UseCompression {get;}
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.10. BeginTransaction Method

Overload List

- public MySqlTransaction BeginTransaction();
- public MySqlTransaction BeginTransaction(IsolationLevel);

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.10.1. `MySqlConnection.BeginTransaction` Method

Syntax: Visual Basic

```
Overloads Public Function BeginTransaction() As MySqlTransaction
```

Syntax: C#

```
public MySqlTransaction BeginTransaction();
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace, MySqlConnection.BeginTransaction Overload List

20.2.7.1.2.1.1.3.1.1.10.1.1. `MySqlTransaction` Class

For a list of all members of this type, see MySqlTransaction Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlTransaction_
  Implements IDbTransaction, IDisposable
```

Syntax: C#

```
public sealed class MySqlTransaction : IDbTransaction, IDisposable
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlTransaction Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.10.1.1.1. `MySqlTransaction` Members

MySqlTransaction overview

Public Instance Properties

Connection	Gets the MySqlConnection object associated with the transaction, or a null reference (Nothing in Visual Basic) if the transaction is no longer valid.
IsolationLevel	Specifies the IsolationLevelfor this transaction.

Public Instance Methods

Commit	
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
Rollback	

ToString(inherited from Object)	Returns a Stringthat represents the current Object.

See Also

MySqlTransaction Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.10.1.1.1.1. Connection Property

Gets the MySqlConnection object associated with the transaction, or a null reference (Nothing in Visual Basic) if the transaction is no longer valid.

Syntax: Visual Basic

```
Public ReadOnly Property Connection As MySqlConnection
```

Syntax: C#

```
public MySqlConnection Connection {get;}
```

Property Value

The MySqlConnection object associated with this transaction.

Remarks

A single application may have multiple database connections, each with zero or more transactions. This property enables you to determine the connection object associated with a particular transaction created by BeginTransaction .

See Also

MySqlTransaction Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.10.1.1.1.2. IsolationLevel Property

Specifies the IsolationLevelfor this transaction.

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property IsolationLevel As IsolationLevel _
_ Implements IDbTransaction.IsolationLevel
```

Syntax: C#

```
public System.Data.IsolationLevel IsolationLevel {get;}
```

Property Value

The IsolationLevel for this transaction. The default is ReadCommitted.

Implements

IDbTransaction.IsolationLevel

Remarks

Parallel transactions are not supported. Therefore, the IsolationLevel applies to the entire transaction.

See Also

MySqlTransaction Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.10.1.1.1.3. `MySqlTransaction.Commit` Method

Syntax: Visual Basic

```
NotOverridable Public Sub Commit() _
_ Implements IDbTransaction.Commit
```

Syntax: C#

```
public void Commit();
```

Implements

IDbTransaction.Commit

See Also

MySqlTransaction Class, MySql.Data.MySQLClient Namespace

20.2.7.1.2.1.1.3.1.1.10.1.1.1.4. `MySqlTransaction.Rollback` Method

Syntax: Visual Basic

```
NotOverridable Public Sub Rollback() _
_
 Implements IDbTransaction.Rollback
```

Syntax: C#

```
public void Rollback();
```

Implements

IDbTransaction.Rollback

See Also

MySqlTransaction Class, MySql.Data.MySQLClient Namespace

20.2.7.1.2.1.1.3.1.1.10.2. `MySqlConnection.BeginTransaction` Method

Syntax: Visual Basic

```
Overloads Public Function BeginTransaction( _
   ByVal iso As IsolationLevel _
) As MySqlTransaction
```

Syntax: C#

```
public MySqlTransaction BeginTransaction(
IsolationLeveliso
);
```

See Also

MySqlConnection Class, MySql.Data.MySQLClient Namespace, MySqlConnection.BeginTransaction Overload List

20.2.7.1.2.1.1.3.1.1.11. `MySqlConnection.ChangeDatabase` Method

Syntax: Visual Basic

```
NotOverridable Public Sub ChangeDatabase( _
   ByVal databaseName As String _
) _
_
 Implements IDbConnection.ChangeDatabase
```

Syntax: C#

```
public void ChangeDatabase(
stringdatabaseName
);
```

Implements

IDbConnection.ChangeDatabase

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.12. `MySqlConnection.Close` Method

Syntax: Visual Basic

```
NotOverridable Public Sub Close() _
_ Implements IDbConnection.Close
```

Syntax: C#

```
public void Close();
```

Implements

IDbConnection.Close

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.13. `MySqlConnection.CreateCommand` Method

Syntax: Visual Basic

```
Public Function CreateCommand() As MySqlCommand
```

Syntax: C#

```
public MySqlCommand CreateCommand();
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.14. `MySqlConnection.Open` Method

Syntax: Visual Basic

```
NotOverridable Public Sub Open() _
_ Implements IDbConnection.Open
```

Syntax: C#

```
public void Open();
```

Implements

IDbConnection.Open

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.15. `MySqlConnection.Ping` Method

Ping

Syntax: Visual Basic

```
Public Function Ping() As Boolean
```

Syntax: C#

```
public bool Ping();
```

Return Value

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16. `MySqlConnection.InfoMessage` Event

Syntax: Visual Basic

```
Public Event InfoMessage As MySqlInfoMessageEventHandler
```

Syntax: C#

```
public event MySqlInfoMessageEventHandler InfoMessage;
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1. `MySqlInfoMessageEventHandler` Delegate

Represents the method that will handle the InfoMessage event of a MySqlConnection .

Syntax: Visual Basic

```
Public Delegate Sub MySqlInfoMessageEventHandler( _
   ByVal sender As Object, _
   ByVal args As MySqlInfoMessageEventArgs _
)
```

Syntax: C#

```
public delegate void MySqlInfoMessageEventHandler(
objectsender,
MySqlInfoMessageEventArgsargs
);
```

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1. `MySqlInfoMessageEventArgs` Class

Provides data for the InfoMessage event. This class cannot be inherited.

For a list of all members of this type, see MySqlInfoMessageEventArgs Members .

Syntax: Visual Basic

```
Public Class MySqlInfoMessageEventArgs_
  Inherits EventArgs
```

Syntax: C#

```
public class MySqlInfoMessageEventArgs : EventArgs
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlInfoMessageEventArgs Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1. `MySqlInfoMessageEventArgs` Members

MySqlInfoMessageEventArgs overview

Public Instance Constructors

MySqlInfoMessageEventArgs Constructor	Initializes a new instance of the MySqlInfoMessageEventArgs class.

Public Instance Fields

errors	

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
ToString(inherited from Object)	Returns a Stringthat represents the current Object.

Protected Instance Methods

Finalize(inherited from Object)	Allows an Objectto attempt to free resources and perform other cleanup operations before the Objectis reclaimed by garbage collection.
MemberwiseClone(inherited from Object)	Creates a shallow copy of the current Object.

See Also

MySqlInfoMessageEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.1. `MySqlInfoMessageEventArgs` Constructor

Initializes a new instance of the MySqlInfoMessageEventArgs class.

Syntax: Visual Basic

```
Public Sub New()
```

Syntax: C#

```
public MySqlInfoMessageEventArgs();
```

See Also

MySqlInfoMessageEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.2. `MySqlInfoMessageEventArgs.errors` Field

Syntax: Visual Basic

```
Public errors As MySqlError()
```

Syntax: C#

```
public MySqlError[] errors;
```

See Also

MySqlInfoMessageEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.2.1. `MySqlError` Class

Collection of error codes that can be returned by the server

For a list of all members of this type, see MySqlError Members .

Syntax: Visual Basic

```
Public Class MySqlError
```

Syntax: C#

```
public class MySqlError
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlError Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.2.1.1. `MySqlError` Members

MySqlError overview

Public Instance Constructors

MySqlError Constructor	

Public Instance Properties

Code	Error code
Level	Error level
Message	Error message

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
ToString(inherited from Object)	Returns a Stringthat represents the current Object.

Protected Instance Methods

Finalize(inherited from Object)	Allows an Objectto attempt to free resources and perform other cleanup operations before the Objectis reclaimed by garbage collection.
MemberwiseClone(inherited from Object)	Creates a shallow copy of the current Object.

See Also

MySqlError Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.2.1.1.1. `MySqlError` Constructor

Syntax: Visual Basic

```
Public Sub New( _
   ByVal level As String, _
   ByVal code As Integer, _
   ByVal message As String _
)
```

Syntax: C#

```
public MySqlError(
stringlevel,
intcode,
stringmessage
);
```

Parameters

- `level`:
- `code`:
- `message`:

See Also

MySqlError Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.2.1.1.2. Code Property

Error code

Syntax: Visual Basic

```
Public ReadOnly Property Code As Integer
```

Syntax: C#

```
public int Code {get;}
```

See Also

MySqlError Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.2.1.1.3. Level Property

Error level

Syntax: Visual Basic

```
Public ReadOnly Property Level As String
```

Syntax: C#

```
public string Level {get;}
```

See Also

MySqlError Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.16.1.1.1.2.1.1.4. Message Property

Error message

Syntax: Visual Basic

```
Public ReadOnly Property Message As String
```

Syntax: C#

```
public string Message {get;}
```

See Also

MySqlError Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.3.1.1.17. `MySqlConnection.StateChange` Event

Syntax: Visual Basic

```
Public Event StateChange As StateChangeEventHandler
```

Syntax: C#

```
public event StateChangeEventHandler StateChange;
```

See Also

MySqlConnection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.1.4. `MySqlCommand` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal cmdText As String, _
   ByVal connection As MySqlConnection, _
   ByVal transaction As MySqlTransaction _
)
```

Syntax: C#

```
public MySqlCommand(
stringcmdText,
MySqlConnectionconnection,
MySqlTransactiontransaction
);
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace, MySqlCommand Constructor Overload List

20.2.7.1.2.1.2. CommandText Property

Syntax: Visual Basic

```
NotOverridable Public Property CommandText As String _
_
  Implements IDbCommand.CommandText
```

Syntax: C#

```
public string CommandText {get; set;}
```

Implements

IDbCommand.CommandText

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.3. CommandTimeout Property

Syntax: Visual Basic

```
NotOverridable Public Property CommandTimeout As Integer _
_ Implements IDbCommand.CommandTimeout
```

Syntax: C#

```
public int CommandTimeout {get; set;}
```

Implements

IDbCommand.CommandTimeout

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.4. CommandType Property

Syntax: Visual Basic

```
NotOverridable Public Property CommandType As CommandType _
_ Implements IDbCommand.CommandType
```

Syntax: C#

```
public System.Data.CommandType CommandType {get; set;}
```

Implements

IDbCommand.CommandType

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.5. Connection Property

Syntax: Visual Basic

```
Public Property Connection As MySqlConnection
```

Syntax: C#

```
public MySqlConnection Connection {get; set;}
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.6. IsPrepared Property

Syntax: Visual Basic

```
Public ReadOnly Property IsPrepared As Boolean
```

Syntax: C#

```
public bool IsPrepared {get;}
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7. Parameters Property

Syntax: Visual Basic

```
Public ReadOnly Property Parameters As MySqlParameterCollection
```

Syntax: C#

```
public MySqlParameterCollection Parameters {get;}
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1. `MySqlParameterCollection` Class

Represents a collection of parameters relevant to a MySqlCommand as well as their respective mappings to columns in a DataSet. This class cannot be inherited.

For a list of all members of this type, see MySqlParameterCollection Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlParameterCollection_
  Inherits MarshalByRefObject_
  Implements IDataParameterCollection, IList, ICollection, IEnumerable
```

Syntax: C#

```
public sealed class MySqlParameterCollection : MarshalByRefObject, IDataParameterCollection, IList, ICollection, IEnum
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlParameterCollection Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1. `MySqlParameterCollection` Members

MySqlParameterCollection overview

Public Instance Constructors

MySqlParameterCollection Constructor	Initializes a new instance of the MySqlParameterCollection class.

Public Instance Properties

Count	Gets the number of MySqlParameter objects in the collection.
Item	Overloaded. Gets the MySqlParameter with a specified attribute. In C#, this property is the indexer for the MySqlParameterCollection class.

Public Instance Methods

Add	Overloaded. Adds the specified MySqlParameter object to the MySqlParameterCollection .
Clear	Removes all items from the collection.
Contains	Overloaded. Gets a value indicating whether a MySqlParameter exists in the collection.

CopyTo	Copies MySqlParameter objects from the MySqlParameterCollection to the specified array.
CreateObjRef(inherited from MarshalByRefObject)	Creates an object that contains all the relevant information required to generate a proxy used to communicate with a remote object.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetLifetimeService(inherited from MarshalByRefObject)	Retrieves the current lifetime service object that controls the lifetime policy for this instance.
GetType(inherited from Object)	Gets the Typeof the current instance.
IndexOf	Overloaded. Gets the location of a MySqlParameter in the collection.
InitializeLifetimeService(inherited from MarshalByRefObject)	Obtains a lifetime service object to control the lifetime policy for this instance.
Insert	Inserts a MySqlParameter into the collection at the specified index.
Remove	Removes the specified MySqlParameter from the collection.
RemoveAt	Overloaded. Removes the specified MySqlParameter from the collection.
ToString(inherited from Object)	Returns a Stringthat represents the current Object.

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.1. `MySqlParameterCollection` Constructor

Initializes a new instance of the MySqlParameterCollection class.

Syntax: Visual Basic

```
Public Sub New()
```

Syntax: C#

```
public MySqlParameterCollection();
```

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.2. Count Property

Gets the number of MySqlParameter objects in the collection.

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property Count As Integer _
_ Implements ICollection.Count
```

Syntax: C#

```
public int Count {get;}
```

Implements

ICollection.Count

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3. Item Property

Gets the MySqlParameter with a specified attribute. In C#, this property is the indexer for the MySqlParameterCollection class.

Overload List

Gets the MySqlParameter at the specified index.

- public MySqlParameter this[int] {get; set;}

Gets the MySqlParameter with the specified name.

- public MySqlParameter this[string] {get; set;}

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1. `MySqlParameter` Class

Represents a parameter to a MySqlCommand , and optionally, its mapping to DataSetcolumns. This class cannot be inherited.

For a list of all members of this type, see MySqlParameter Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlParameter_
  Inherits MarshalByRefObject_
  Implements IDataParameter, IDbDataParameter, ICloneable
```

Syntax: C#

```
public sealed class MySqlParameter : MarshalByRefObject, IDataParameter, IDbDataParameter, ICloneable
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlParameter Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1. `MySqlParameter` Members

MySqlParameter overview

Public Instance Constructors

MySqlParameter	Overloaded. Initializes a new instance of the MySqlParameter class.

Public Instance Properties

DbType	Gets or sets the DbTypeof the parameter.
Direction	Gets or sets a value indicating whether the parameter is input-only, output-only, bidirectional, or a stored procedure return

	value parameter. As of MySQL version 4.1 and earlier, input-only is the only valid choice.
IsNullable	Gets or sets a value indicating whether the parameter accepts null values.
IsUnsigned	
MySqlDbType	Gets or sets the MySqlDbType of the parameter.
ParameterName	Gets or sets the name of the MySqlParameter.
Precision	Gets or sets the maximum number of digits used to represent the Value property.
Scale	Gets or sets the number of decimal places to which Value is resolved.
Size	Gets or sets the maximum size, in bytes, of the data within the column.
SourceColumn	Gets or sets the name of the source column that is mapped to the DataSetand used for loading or returning the Value .
SourceVersion	Gets or sets the DataRowVersionto use when loading Value .
Value	Gets or sets the value of the parameter.

Public Instance Methods

CreateObjRef(inherited from MarshalByRefObject)	Creates an object that contains all the relevant information required to generate a proxy used to communicate with a remote object.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetLifetimeService(inherited from MarshalByRefObject)	Retrieves the current lifetime service object that controls the lifetime policy for this instance.
GetType(inherited from Object)	Gets the Typeof the current instance.
InitializeLifetimeService(inherited from MarshalByRefObject)	Obtains a lifetime service object to control the lifetime policy for this instance.
ToString	Overridden. Gets a string containing the ParameterName .

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.1. `MySqlParameter` Constructor

Initializes a new instance of the MySqlParameter class.

Overload List

Initializes a new instance of the MySqlParameter class.

- public MySqlParameter();

Initializes a new instance of the MySqlParameter class with the parameter name and the data type.

- public MySqlParameter(string,MySqlDbType);

Initializes a new instance of the MySqlParameter class with the parameter name, the MySqlDbType , and the size.

- public MySqlParameter(string,MySqlDbType,int);

Initializes a new instance of the MySqlParameter class with the parameter name, the type of the parameter, the size of the parameter, a ParameterDirection, the precision of the parameter, the scale of the parameter, the source column, a DataRowVersionto use, and the value of the parameter.

- public MySqlParameter(string,MySqlDbType,int,ParameterDirection,bool,byte,byte,string,DataRowVersion,object);

Initializes a new instance of the MySqlParameter class with the parameter name, the MySqlDbType , the size, and the source column name.

- public MySqlParameter(string,MySqlDbType,int,string);

Initializes a new instance of the MySqlParameter class with the parameter name and a value of the new MySqlParameter.

- public MySqlParameter(string,object);

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.1.1. `MySqlParameter` Constructor ()

Initializes a new instance of the MySqlParameter class.

Syntax: Visual Basic

```
Overloads Public Sub New()
```

Syntax: C#

```
public MySqlParameter();
```

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace, MySqlParameter Constructor Overload List

20.2.7.1.2.1.7.1.1.3.1.1.1.2. `MySqlParameter` Constructor

Initializes a new instance of the MySqlParameter class with the parameter name and the data type.

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal parameterName As String, _
   ByVal dbType As MySqlDbType _
)
```

Syntax: C#

```
public MySqlParameter(
stringparameterName,
MySqlDbTypedbType
);
```

Parameters

- `parameterName`: The name of the parameter to map.
- `dbType`: One of the MySqlDbType values.

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace, MySqlParameter Constructor Overload List

20.2.7.1.2.1.7.1.1.3.1.1.1.2.1. `MySqlDbType` Enumeration

Specifies MySQL specific data type of a field, property, for use in a MySqlParameter .

Syntax: Visual Basic

```
Public Enum MySqlDbType
```

Syntax: C#

```
public enum MySqlDbType
```

Members

Member Name	Description
Newdate	Obsolete. Use Datetime or Date type.
Timestamp	A timestamp. The range is '1970-01-01 00:00:01' to sometime in the year 2038.
Time	The range is '-838:59:59' to '838:59:59'
Date	Date The supported range is '1000-01-01' to '9999-12-31'
Datetime	The supported range is '1000-01-01 00:00:00' to '9999-12-31 23:59:59'
Year	A year in 2- or 4-digit format (default is 4-digit). The allowable values are 1901 to 2155, 0000 in the 4-digit year format, and 1970-2069 if you use the 2-digit format (70-69).
TinyBlob	A BLOB column with a maximum length of 255 (2^8 - 1) characters
Blob	A BLOB column with a maximum length of 65535 (2^16 - 1) characters
MediumBlob	A BLOB column with a maximum length of 16777215 (2^24 - 1) characters
LongBlob	A BLOB column with a maximum length of 4294967295 or 4G (2^32 - 1) characters
Int16	A 16-bit signed integer. The signed range is -32768 to 32767. The unsigned range is 0 to 65535
Int24	Specifies a 24 (3 byte) signed or unsigned value
Int32	A 32-bit signed integer
Int64	A 64-bit signed integer
Byte	The signed range is -128 to 127. The unsigned range is 0 to 255.
Float	A small (single-precision) floating-point number. Allowable values are -3.402823466E+38 to -1.175494351E-38, 0, and 1.175494351E-38 to 3.402823466E+38.
Double	A normal-size (double-precision) floating-point number. Allowable values are -1.7976931348623157E+308 to -2.2250738585072014E-308, 0, and 2.2250738585072014E-308 to 1.7976931348623157E+308.
UByte	An 8-bit unsigned value
UInt16	A 16-bit unsigned value
UInt24	A 24-bit unsigned value
UInt32	A 32-bit unsigned value
UInt64	A 64-bit unsigned value
Decimal	A fixed precision and scale numeric value between -1038 -1 and 10 38 -1

NewDecimal	New Decimal
Set	A set. A string object that can have zero or more values, each of which must be chosen from the list of values 'value1', 'value2', ... A SET can have a maximum of 64 members.
String	Obsolete Use VarChar type
VarChar	A variable-length string containing 0 to 255 characters
VarString	A variable-length string containing 0 to 65535 characters
Enum	An enumeration. A string object that can have only one value, chosen from the list of values 'value1', 'value2', ..., NULL or the special "" error value. An ENUM can have a maximum of 65535 distinct values.
Geometry	
Bit	Bit-field data type
TinyText	A nonbinary string column supporting a maximum length of 255 (2^8 - 1) characters
Text	A nonbinary string column supporting a maximum length of 65535 (2^16 - 1) characters
MediumText	A nonbinary string column supporting a maximum length of 16777215 (2^24 - 1) characters
LongText	A nonbinary string column supporting a maximum length of 4294967295 (2^32 - 1) characters

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.1.3. `MySqlParameter` Constructor (String, MySqlDbType, Int32)

Initializes a new instance of the MySqlParameter class with the parameter name, the MySqlDbType , and the size.

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal parameterName As String, _
   ByVal dbType As MySqlDbType, _
   ByVal size As Integer _
)
```

Syntax: C#

```
public MySqlParameter(
stringparameterName,
MySqlDbTypedbType,
intsize
);
```

Parameters

- `parameterName`: The name of the parameter to map.
- `dbType`: One of the MySqlDbType values.
- `size`: The length of the parameter.

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace, MySqlParameter Constructor Overload List

20.2.7.1.2.1.7.1.1.3.1.1.1.4. `MySqlParameter` Constructor

Initializes a new instance of the MySqlParameter class with the parameter name, the type of the parameter, the size of the parameter, a ParameterDirection, the precision of the parameter, the scale of the parameter, the source column, a DataRowVersionto use, and the value of the parameter.

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal parameterName As String, _
   ByVal dbType As MySqlDbType, _
   ByVal size As Integer, _
   ByVal direction As ParameterDirection, _
   ByVal isNullable As Boolean, _
   ByVal precision As Byte, _
   ByVal scale As Byte, _
   ByVal sourceColumn As String, _
   ByVal sourceVersion As DataRowVersion, _
   ByVal value As Object _
)
```

Syntax: C#

```
public MySqlParameter(
stringparameterName,
MySqlDbTypedbType,
intsize,
ParameterDirectiondirection,
boolisNullable,
byteprecision,
bytescale,
stringsourceColumn,
DataRowVersionsourceVersion,
objectvalue
);
```

Parameters

- `parameterName`: The name of the parameter to map.
- `dbType`: One of the MySqlDbType values.
- `size`: The length of the parameter.
- `direction`: One of the ParameterDirectionvalues.
- `isNullable`: true if the value of the field can be null, otherwise false.
- `precision`: The total number of digits to the left and right of the decimal point to which Value is resolved.
- `scale`: The total number of decimal places to which Value is resolved.
- `sourceColumn`: The name of the source column.
- `sourceVersion`: One of the DataRowVersionvalues.
- `value`: An Objectthat is the value of the MySqlParameter .

Exceptions

Exception Type	Condition
ArgumentException	

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace, MySqlParameter Constructor Overload List

20.2.7.1.2.1.7.1.1.3.1.1.1.4.1. Value Property

Gets or sets the value of the parameter.

Syntax: Visual Basic

```
NotOverridable Public Property Value As Object _
_
 Implements IDataParameter.Value
```

Syntax: C#

```
public object Value {get; set;}
```

Implements

IDataParameter.Value

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.1.5. `MySqlParameter` Constructor

Initializes a new instance of the MySqlParameter class with the parameter name, the MySqlDbType , the size, and the source column name.

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal parameterName As String, _
   ByVal dbType As MySqlDbType, _
   ByVal size As Integer, _
   ByVal sourceColumn As String _
)
```

Syntax: C#

```
public MySqlParameter(
stringparameterName,
MySqlDbTypedbType,
intsize,
stringsourceColumn
);
```

Parameters

- `parameterName`: The name of the parameter to map.
- `dbType`: One of the MySqlDbType values.
- `size`: The length of the parameter.
- `sourceColumn`: The name of the source column.

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace, MySqlParameter Constructor Overload List

20.2.7.1.2.1.7.1.1.3.1.1.1.6. `MySqlParameter` Constructor

Initializes a new instance of the MySqlParameter class with the parameter name and a value of the new MySqlParameter.

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal parameterName As String, _
   ByVal value As Object _
)
```

Syntax: C#

```
public MySqlParameter(
stringparameterName,
objectvalue
);
```

Parameters

- `parameterName`: The name of the parameter to map.
- `value`: An Objectthat is the value of the MySqlParameter .

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace, MySqlParameter Constructor Overload List

20.2.7.1.2.1.7.1.1.3.1.1.2. DbType Property

Gets or sets the DbTypeof the parameter.

Syntax: Visual Basic

```
NotOverridable Public Property DbType As DbType _
_ Implements IDataParameter.DbType
```

Syntax: C#

```
public System.Data.DbType DbType {get; set;}
```

Implements

IDataParameter.DbType

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.3. Direction Property

Gets or sets a value indicating whether the parameter is input-only, output-only, bidirectional, or a stored procedure return value parameter. As of MySQL version 4.1 and earlier, input-only is the only valid choice.

Syntax: Visual Basic

```
NotOverridable Public Property Direction As ParameterDirection _
_ Implements IDataParameter.Direction
```

Syntax: C#

```
public System.Data.ParameterDirection Direction {get; set;}
```

Implements

IDataParameter.Direction

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.4. IsNullable Property

Gets or sets a value indicating whether the parameter accepts null values.

Syntax: Visual Basic

```
NotOverridable Public Property IsNullable As Boolean _
_ Implements IDataParameter.IsNullable
```

Syntax: C#

```
public bool IsNullable {get; set;}
```

Implements

IDataParameter.IsNullable

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.5. IsUnsigned Property

Syntax: Visual Basic

```
Public Property IsUnsigned As Boolean
```

Syntax: C#

```
public bool IsUnsigned {get; set;}
```

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.6. `MySqlDbType` Property

Gets or sets the MySqlDbType of the parameter.

Syntax: Visual Basic

```
Public Property MySqlDbType As MySqlDbType
```

Syntax: C#

```
public MySqlDbType MySqlDbType {get; set;}
```

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.7. ParameterName Property

Gets or sets the name of the MySqlParameter.

Syntax: Visual Basic

```
NotOverridable Public Property ParameterName As String _
_ Implements IDataParameter.ParameterName
```

Syntax: C#

```
public string ParameterName {get; set;}
```

Implements

IDataParameter.ParameterName

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.8. Precision Property

Gets or sets the maximum number of digits used to represent the Value property.

Syntax: Visual Basic

```
NotOverridable Public Property Precision As Byte _
_ Implements IDbDataParameter.Precision
```

Syntax: C#

```
public byte Precision {get; set;}
```

Implements

IDbDataParameter.Precision

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.9. Scale Property

Gets or sets the number of decimal places to which Value is resolved.

Syntax: Visual Basic

```
NotOverridable Public Property Scale As Byte _
_ Implements IDbDataParameter.Scale
```

Syntax: C#

```
public byte Scale {get; set;}
```

Implements

IDbDataParameter.Scale

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.10. Size Property

Gets or sets the maximum size, in bytes, of the data within the column.

Syntax: Visual Basic

```
NotOverridable Public Property Size As Integer _
_ Implements IDbDataParameter.Size
```

Syntax: C#

```
public int Size {get; set;}
```

Implements

IDbDataParameter.Size

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.11. SourceColumn Property

Gets or sets the name of the source column that is mapped to the DataSetand used for loading or returning the Value .

Syntax: Visual Basic

```
NotOverridable Public Property SourceColumn As String _
_ Implements IDataParameter.SourceColumn
```

Syntax: C#

```
public string SourceColumn {get; set;}
```

Implements

IDataParameter.SourceColumn

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.12. SourceVersion Property

Gets or sets the DataRowVersionto use when loading Value .

Syntax: Visual Basic

```
NotOverridable Public Property SourceVersion As DataRowVersion _
_ Implements IDataParameter.SourceVersion
```

Syntax: C#

```
public System.Data.DataRowVersion SourceVersion {get; set;}
```

Implements

IDataParameter.SourceVersion

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.1.1.13. `MySqlParameter.ToString` Method

Overridden. Gets a string containing the ParameterName .

Syntax: Visual Basic

```
Overrides Public Function ToString() As String
```

Syntax: C#

```
public override string ToString();
```

Return Value

See Also

MySqlParameter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.3.2. Item Property (Int32)

Gets the MySqlParameter at the specified index.

Syntax: Visual Basic

```
Overloads Public Default Property Item( _
   ByVal index As Integer _
) As MySqlParameter
```

Syntax: C#

```
public MySqlParameter this[
intindex
] {get; set;}
```

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Item Overload List

20.2.7.1.2.1.7.1.1.3.3. Item Property (String)

Gets the MySqlParameter with the specified name.

Syntax: Visual Basic

```
Overloads Public Default Property Item( _
   ByVal name As String _
) As MySqlParameter
```

Syntax: C#

```
public MySqlParameter this[
stringname
] {get; set;}
```

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Item Overload List

20.2.7.1.2.1.7.1.1.4. Add Method

Adds the specified MySqlParameter object to the MySqlParameterCollection .

Overload List

Adds the specified MySqlParameter object to the MySqlParameterCollection .

- public MySqlParameter Add(MySqlParameter);

Adds the specified MySqlParameter object to the MySqlParameterCollection .

- public int Add(object);

Adds a MySqlParameter to the MySqlParameterCollection given the parameter name and the data type.

- public MySqlParameter Add(string,MySqlDbType);

Adds a MySqlParameter to the MySqlParameterCollection with the parameter name, the data type, and the column length.

- public MySqlParameter Add(string,MySqlDbType,int);

Adds a MySqlParameter to the MySqlParameterCollection with the parameter name, the data type, the column length, and the source column name.

- public MySqlParameter Add(string,MySqlDbType,int,string);

Adds a MySqlParameter to the MySqlParameterCollection given the specified parameter name and value.

- public MySqlParameter Add(string,object);

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.4.1. `MySqlParameterCollection.Add` Method

Adds the specified MySqlParameter object to the MySqlParameterCollection .

Syntax: Visual Basic

```
Overloads Public Function Add( _
   ByVal value As MySqlParameter _
) As MySqlParameter
```

Syntax: C#

```
public MySqlParameter Add(
MySqlParametervalue
);
```

Parameters

- `value`: The MySqlParameter to add to the collection.

Return Value

The newly added MySqlParameter object.

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Add Overload List

20.2.7.1.2.1.7.1.1.4.2. `MySqlParameterCollection.Add` Method

Adds the specified MySqlParameter object to the MySqlParameterCollection .

Syntax: Visual Basic

```
NotOverridable Overloads Public Function Add( _
   ByVal value As Object _
) As Integer _
_
 Implements IList.Add
```

Syntax: C#

```
public int Add(
objectvalue
);
```

Parameters

- `value`: The MySqlParameter to add to the collection.

Return Value

The index of the new MySqlParameter object.

Implements

IList.Add

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Add Overload List

20.2.7.1.2.1.7.1.1.4.3. `MySqlParameterCollection.Add` Method

Adds a MySqlParameter to the MySqlParameterCollection given the parameter name and the data type.

Syntax: Visual Basic

```
Overloads Public Function Add( _
   ByVal parameterName As String, _
   ByVal dbType As MySqlDbType _
) As MySqlParameter
```

Syntax: C#

```
public MySqlParameter Add(
stringparameterName,
MySqlDbTypedbType
);
```

Parameters

- `parameterName`: The name of the parameter.
- `dbType`: One of the MySqlDbType values.

Return Value

The newly added MySqlParameter object.

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Add Overload List

20.2.7.1.2.1.7.1.1.4.4. `MySqlParameterCollection.Add` Method

Adds a MySqlParameter to the MySqlParameterCollection with the parameter name, the data type, and the column length.

Syntax: Visual Basic

```
Overloads Public Function Add( _
   ByVal parameterName As String, _
   ByVal dbType As MySqlDbType, _
   ByVal size As Integer _
) As MySqlParameter
```

Syntax: C#

```
public MySqlParameter Add(
stringparameterName,
MySqlDbTypedbType,
intsize
);
```

Parameters

- `parameterName`: The name of the parameter.
- `dbType`: One of the MySqlDbType values.
- `size`: The length of the column.

Return Value

The newly added MySqlParameter object.

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Add Overload List

20.2.7.1.2.1.7.1.1.4.5. `MySqlParameterCollection.Add` Method

Adds a MySqlParameter to the MySqlParameterCollection with the parameter name, the data type, the column length, and the source column name.

Syntax: Visual Basic

```
Overloads Public Function Add( _
   ByVal parameterName As String, _
   ByVal dbType As MySqlDbType, _
   ByVal size As Integer, _
   ByVal sourceColumn As String _
) As MySqlParameter
```

Syntax: C#

```
public MySqlParameter Add(
stringparameterName,
MySqlDbTypedbType,
intsize,
stringsourceColumn
);
```

Parameters

- `parameterName`: The name of the parameter.
- `dbType`: One of the MySqlDbType values.
- `size`: The length of the column.
- `sourceColumn`: The name of the source column.

Return Value

The newly added MySqlParameter object.

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Add Overload List

20.2.7.1.2.1.7.1.1.4.6. `MySqlParameterCollection.Add` Method

Adds a MySqlParameter to the MySqlParameterCollection given the specified parameter name and value.

Syntax: Visual Basic

```
Overloads Public Function Add( _
   ByVal parameterName As String, _
   ByVal value As Object _
) As MySqlParameter
```

Syntax: C#

```
public MySqlParameter Add(
stringparameterName,
objectvalue
);
```

Parameters

- `parameterName`: The name of the parameter.
- `value`: The Value of the MySqlParameter to add to the collection.

Return Value

The newly added MySqlParameter object.

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Add Overload List

20.2.7.1.2.1.7.1.1.5. `MySqlParameterCollection.Clear` Method

Removes all items from the collection.

Syntax: Visual Basic

```
NotOverridable Public Sub Clear() _
_
  Implements IList.Clear
```

Syntax: C#

```
public void Clear();
```

Implements

IList.Clear

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.6. Contains Method

Gets a value indicating whether a MySqlParameter exists in the collection.

Overload List

Gets a value indicating whether a MySqlParameter exists in the collection.

- public bool Contains(object);

Gets a value indicating whether a MySqlParameter with the specified parameter name exists in the collection.

- public bool Contains(string);

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.6.1. `MySqlParameterCollection.Contains` Method

Gets a value indicating whether a MySqlParameter exists in the collection.

Syntax: Visual Basic

```
NotOverridable Overloads Public Function Contains( _
   ByVal value As Object _
) As Boolean _
_
 Implements IList.Contains
```

Syntax: C#

```
public bool Contains(
objectvalue
);
```

Parameters

- `value`: The value of the MySqlParameter object to find.

Return Value

true if the collection contains the MySqlParameter object; otherwise, false.

Implements

IList.Contains

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Contains Overload List

20.2.7.1.2.1.7.1.1.6.2. `MySqlParameterCollection.Contains` Method

Gets a value indicating whether a MySqlParameter with the specified parameter name exists in the collection.

Syntax: Visual Basic

```
NotOverridable Overloads Public Function Contains( _
   ByVal name As String _
) As Boolean _
_
 Implements IDataParameterCollection.Contains
```

Syntax: C#

```
public bool Contains(
stringname
);
```

Parameters

- `name`: The name of the MySqlParameter object to find.

Return Value

true if the collection contains the parameter; otherwise, false.

Implements

IDataParameterCollection.Contains

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.Contains Overload List

20.2.7.1.2.1.7.1.1.7. `MySqlParameterCollection.CopyTo` Method

Copies MySqlParameter objects from the MySqlParameterCollection to the specified array.

Syntax: Visual Basic

```
NotOverridable Public Sub CopyTo( _
   ByVal array As Array, _
   ByVal index As Integer _
) _
_
  Implements ICollection.CopyTo
```

Syntax: C#

```
public void CopyTo(
Arrayarray,
intindex
);
```

Parameters

- `array`:
- `index`:

Implements

ICollection.CopyTo

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.8. IndexOf Method

Gets the location of a MySqlParameter in the collection.

Overload List

Gets the location of a MySqlParameter in the collection.

- public int IndexOf(object);

Gets the location of the MySqlParameter in the collection with a specific parameter name.

- public int IndexOf(string);

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.8.1. `MySqlParameterCollection.IndexOf` Method

Gets the location of a MySqlParameter in the collection.

Syntax: Visual Basic

```
NotOverridable Overloads Public Function IndexOf( _
   ByVal value As Object _
) As Integer _
_
  Implements IList.IndexOf
```

Syntax: C#

```
public int IndexOf(
objectvalue
);
```

Parameters

- `value`: The MySqlParameter object to locate.

Return Value

The zero-based location of the MySqlParameter in the collection.

Implements

IList.IndexOf

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.IndexOf Overload List

20.2.7.1.2.1.7.1.1.8.2. `MySqlParameterCollection.IndexOf` Method

Gets the location of the MySqlParameter in the collection with a specific parameter name.

Syntax: Visual Basic

```
NotOverridable Overloads Public Function IndexOf( _
   ByVal parameterName As String _
) As Integer _
_
  Implements IDataParameterCollection.IndexOf
```

Syntax: C#

```
public int IndexOf(
stringparameterName
);
```

Parameters

- `parameterName`: The name of the MySqlParameter object to retrieve.

Return Value

The zero-based location of the MySqlParameter in the collection.

Implements

IDataParameterCollection.IndexOf

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.IndexOf Overload List

20.2.7.1.2.1.7.1.1.9. `MySqlParameterCollection.Insert` Method

Inserts a MySqlParameter into the collection at the specified index.

Syntax: Visual Basic

```
NotOverridable Public Sub Insert( _
   ByVal index As Integer, _
   ByVal value As Object _
) _
_
 Implements IList.Insert
```

Syntax: C#

```
public void Insert(
intindex,
objectvalue
);
```

Parameters

- `index`:
- `value`:

Implements

IList.Insert

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.10. `MySqlParameterCollection.Remove` Method

Removes the specified MySqlParameter from the collection.

Syntax: Visual Basic

```
NotOverridable Public Sub Remove( _
   ByVal value As Object _
) _
_
 Implements IList.Remove
```

Syntax: C#

```
public void Remove(
objectvalue
);
```

Parameters

- `value`:

Implements

IList.Remove

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.11. RemoveAt Method

Removes the specified MySqlParameter from the collection.

Overload List

Removes the specified MySqlParameter from the collection using a specific index.

- public void RemoveAt(int);

Removes the specified MySqlParameter from the collection using the parameter name.

- public void RemoveAt(string);

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.7.1.1.11.1. `MySqlParameterCollection.RemoveAt` Method

Removes the specified MySqlParameter from the collection using a specific index.

Syntax: Visual Basic

```
NotOverridable Overloads Public Sub RemoveAt( _
   ByVal index As Integer _
) _
_
 Implements IList.RemoveAt
```

Syntax: C#

```
public void RemoveAt(
intindex
);
```

Parameters

- `index`: The zero-based index of the parameter.

Implements

IList.RemoveAt

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.RemoveAt Overload List

20.2.7.1.2.1.7.1.1.11.2. `MySqlParameterCollection.RemoveAt` Method

Removes the specified MySqlParameter from the collection using the parameter name.

Syntax: Visual Basic

```
NotOverridable Overloads Public Sub RemoveAt( _
   ByVal name As String _
) _
_
 Implements IDataParameterCollection.RemoveAt
```

Syntax: C#

```
public void RemoveAt(
stringname
);
```

Parameters

- `name`: The name of the MySqlParameter object to retrieve.

Implements

IDataParameterCollection.RemoveAt

See Also

MySqlParameterCollection Class, MySql.Data.MySqlClient Namespace, MySqlParameterCollection.RemoveAt Overload List

20.2.7.1.2.1.8. Transaction Property

Syntax: Visual Basic

```
Public Property Transaction As MySqlTransaction
```

Syntax: C#

```
public MySqlTransaction Transaction {get; set;}
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.9. UpdatedRowSource Property

Syntax: Visual Basic

```
NotOverridable Public Property UpdatedRowSource As UpdateRowSource _
_ Implements IDbCommand.UpdatedRowSource
```

Syntax: C#

```
public System.Data.UpdateRowSource UpdatedRowSource {get; set;}
```

Implements

IDbCommand.UpdatedRowSource

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.10. `MySqlCommand.Cancel` Method

Attempts to cancel the execution of a MySqlCommand. This operation is not supported.

Syntax: Visual Basic

```
NotOverridable Public Sub Cancel() _
_ Implements IDbCommand.Cancel
```

Syntax: C#

```
public void Cancel();
```

Implements

IDbCommand.Cancel

Remarks

Cancelling an executing command is currently not supported on any version of MySQL.

Exceptions

Exception Type	Condition

NotSupportedException	This operation is not supported.

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.11. `MySqlCommand.CreateParameter` Method

Creates a new instance of a MySqlParameter object.

Syntax: Visual Basic

```
Public Function CreateParameter() As MySqlParameter
```

Syntax: C#

```
public MySqlParameter CreateParameter();
```

Return Value

A MySqlParameter object.

Remarks

This method is a strongly-typed version of CreateParameter.

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.12. `MySqlCommand.ExecuteNonQuery` Method

Syntax: Visual Basic

```
NotOverridable Public Function ExecuteNonQuery() As Integer _
_ Implements IDbCommand.ExecuteNonQuery
```

Syntax: C#

```
public int ExecuteNonQuery();
```

Implements

IDbCommand.ExecuteNonQuery

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13. ExecuteReader Method

Overload List

- public MySqlDataReader ExecuteReader();
- public MySqlDataReader ExecuteReader(CommandBehavior);

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1. `MySqlCommand.ExecuteReader` Method

Syntax: Visual Basic

```
Overloads Public Function ExecuteReader() As MySqlDataReader
```

Syntax: C#

```
public MySqlDataReader ExecuteReader();
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace, MySqlCommand.ExecuteReader Overload List

20.2.7.1.2.1.13.1.1. `MySqlDataReader` Class

Provides a means of reading a forward-only stream of rows from a MySQL database. This class cannot be inherited.

For a list of all members of this type, see MySqlDataReader Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlDataReader_
  Inherits MarshalByRefObject_
  Implements IEnumerable, IDataReader, IDisposable, IDataRecord
```

Syntax: C#

```
public sealed class MySqlDataReader : MarshalByRefObject, IEnumerable, IDataReader, IDisposable, IDataRecord
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlDataReader Members, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1. `MySqlDataReader` Members

MySqlDataReader overview

Public Instance Properties

Depth	Gets a value indicating the depth of nesting for the current row. This method is not supported currently and always returns 0.
FieldCount	Gets the number of columns in the current row.
HasRows	Gets a value indicating whether the MySqlDataReader contains one or more rows.
IsClosed	Gets a value indicating whether the data reader is closed.
Item	Overloaded. Overloaded. Gets the value of a column in its native format. In C#, this property is the indexer for the MySqlDataReader class.
RecordsAffected	Gets the number of rows changed, inserted, or deleted by execution of the SQL statement.

Public Instance Methods

Close	Closes the MySqlDataReader object.
CreateObjRef(inherited from MarshalByRefObject)	Creates an object that contains all the relevant information required to generate a proxy used to communicate with a remote object.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.

GetBoolean	Gets the value of the specified column as a Boolean.
GetByte	Gets the value of the specified column as a byte.
GetBytes	Reads a stream of bytes from the specified column offset into the buffer an array starting at the given buffer offset.
GetChar	Gets the value of the specified column as a single character.
GetChars	Reads a stream of characters from the specified column offset into the buffer as an array starting at the given buffer offset.
GetDataTypeName	Gets the name of the source data type.
GetDateTime	
GetDecimal	
GetDouble	
GetFieldType	Gets the Type that is the data type of the object.
GetFloat	
GetGuid	
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetInt16	
GetInt32	
GetInt64	
GetLifetimeService(inherited from MarshalByRefObject)	Retrieves the current lifetime service object that controls the lifetime policy for this instance.
GetMySqlDateTime	
GetName	Gets the name of the specified column.
GetOrdinal	Gets the column ordinal, given the name of the column.
GetSchemaTable	Returns a DataTable that describes the column metadata of the MySqlDataReader.
GetString	
GetTimeSpan	
GetType(inherited from Object)	Gets the Typeof the current instance.
GetUInt16	
GetUInt32	
GetUInt64	
GetValue	Gets the value of the specified column in its native format.
GetValues	Gets all attribute columns in the collection for the current row.
InitializeLifetimeService(inherited from MarshalByRefObject)	Obtains a lifetime service object to control the lifetime policy for this instance.
IsDBNull	Gets a value indicating whether the column contains non-existent or missing values.
NextResult	Advances the data reader to the next result, when reading the results of batch SQL statements.
Read	Advances the MySqlDataReader to the next record.
ToString(inherited from Object)	Returns a Stringthat represents the current Object.

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.1. Depth Property

Gets a value indicating the depth of nesting for the current row. This method is not supported currently and always returns 0.

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property Depth As Integer _
_ Implements IDataReader.Depth
```

Syntax: C#

```
public int Depth {get;}
```

Implements

IDataReader.Depth

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.2. FieldCount Property

Gets the number of columns in the current row.

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property FieldCount As Integer _
_ Implements IDataRecord.FieldCount
```

Syntax: C#

```
public int FieldCount {get;}
```

Implements

IDataRecord.FieldCount

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.3. HasRows Property

Gets a value indicating whether the MySqlDataReader contains one or more rows.

Syntax: Visual Basic

```
Public ReadOnly Property HasRows As Boolean
```

Syntax: C#

```
public bool HasRows {get;}
```

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.4. IsClosed Property

Gets a value indicating whether the data reader is closed.

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property IsClosed As Boolean _
_ Implements IDataReader.IsClosed
```

Syntax: C#

```
public bool IsClosed {get;}
```

Implements

IDataReader.IsClosed

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.5. Item Property

Overloaded. Gets the value of a column in its native format. In C#, this property is the indexer for the MySqlDataReader class.

Overload List

Overloaded. Gets the value of a column in its native format. In C#, this property is the indexer for the MySqlDataReader class.

- public object this[int] {get;}

Gets the value of a column in its native format. In C#, this property is the indexer for the MySqlDataReader class.

- public object this[string] {get;}

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.5.1. Item Property (Int32)

Overloaded. Gets the value of a column in its native format. In C#, this property is the indexer for the MySqlDataReader class.

Syntax: Visual Basic

```
NotOverridable Overloads Public Default ReadOnly Property Item( _
   ByVal i As Integer _
) _
_
  Implements IDataRecord.Item As Object _
_
  Implements IDataRecord.Item
```

Syntax: C#

```
public object this[
inti
] {get;}
```

Implements

IDataRecord.Item

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace, MySqlDataReader.Item Overload List

20.2.7.1.2.1.13.1.1.1.5.2. Item Property (String)

Gets the value of a column in its native format. In C#, this property is the indexer for the MySqlDataReader class.

Syntax: Visual Basic

```
NotOverridable Overloads Public Default ReadOnly Property Item( _
   ByVal name As String _
) _
_
  Implements IDataRecord.Item As Object _
_
  Implements IDataRecord.Item
```

Syntax: C#

```
public object this[
stringname
] {get;}
```

Implements

IDataRecord.Item

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace, MySqlDataReader.Item Overload List

20.2.7.1.2.1.13.1.1.1.6. RecordsAffected Property

Gets the number of rows changed, inserted, or deleted by execution of the SQL statement.

Syntax: Visual Basic

```
NotOverridable Public ReadOnly Property RecordsAffected As Integer _
_ Implements IDataReader.RecordsAffected
```

Syntax: C#

```
public int RecordsAffected {get;}
```

Implements

IDataReader.RecordsAffected

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.7. `MySqlDataReader.Close` Method

Closes the MySqlDataReader object.

Syntax: Visual Basic

```
NotOverridable Public Sub Close() _
_ Implements IDataReader.Close
```

Syntax: C#

```
public void Close();
```

Implements

IDataReader.Close

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.8. `MySqlDataReader.GetBoolean` Method

Gets the value of the specified column as a Boolean.

Syntax: Visual Basic

```
NotOverridable Public Function GetBoolean( _
   ByVal i As Integer _
) As Boolean _
_ Implements IDataRecord.GetBoolean
```

Syntax: C#

```
public bool GetBoolean(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.GetBoolean

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.9. `MySqlDataReader.GetByte` Method

Gets the value of the specified column as a byte.

Syntax: Visual Basic

```
NotOverridable Public Function GetByte( _
   ByVal i As Integer _
) As Byte _
_
  Implements IDataRecord.GetByte
```

Syntax: C#

```
public byte GetByte(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.GetByte

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.10. `MySqlDataReader.GetBytes` Method

Reads a stream of bytes from the specified column offset into the buffer an array starting at the given buffer offset.

Syntax: Visual Basic

```
NotOverridable Public Function GetBytes( _
   ByVal i As Integer, _
   ByVal dataIndex As Long, _
   ByVal buffer As Byte(), _
   ByVal bufferIndex As Integer, _
   ByVal length As Integer _
) As Long _
_
  Implements IDataRecord.GetBytes
```

Syntax: C#

```
public long GetBytes(
inti,
longdataIndex,
byte[]buffer,
intbufferIndex,
intlength
);
```

Parameters

- `i`: The zero-based column ordinal.
- `dataIndex`: The index within the field from which to begin the read operation.
- `buffer`: The buffer into which to read the stream of bytes.
- `bufferIndex`: The index for buffer to begin the read operation.
- `length`: The maximum length to copy into the buffer.

Return Value

The actual number of bytes read.

Implements

IDataRecord.GetBytes

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.11. `MySqlDataReader.GetChar` Method

Gets the value of the specified column as a single character.

Syntax: Visual Basic

```
NotOverridable Public Function GetChar( _
   ByVal i As Integer _
) As Char _
_
 Implements IDataRecord.GetChar
```

Syntax: C#

```
public char GetChar(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.GetChar

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.12. `MySqlDataReader.GetChars` Method

Reads a stream of characters from the specified column offset into the buffer as an array starting at the given buffer offset.

Syntax: Visual Basic

```
NotOverridable Public Function GetChars( _
   ByVal i As Integer, _
   ByVal fieldOffset As Long, _
   ByVal buffer As Char(), _
   ByVal bufferoffset As Integer, _
   ByVal length As Integer _
) As Long _
_
 Implements IDataRecord.GetChars
```

Syntax: C#

```
public long GetChars(
inti,
longfieldOffset,
char[]buffer,
intbufferoffset,
intlength
);
```

Parameters

- `i`:
- `fieldOffset`:
- `buffer`:
- `bufferoffset`:
- `length`:

Return Value

Implements

IDataRecord.GetChars

See Also

MySqlDataReader Class, MySql.Data.MySQLClient Namespace

20.2.7.1.2.1.13.1.1.1.13. `MySqlDataReader.GetDataTypeName` Method

Gets the name of the source data type.

Syntax: Visual Basic

```
NotOverridable Public Function GetDataTypeName( _
   ByVal i As Integer _
) As String _
_
  Implements IDataRecord.GetDataTypeName
```

Syntax: C#

```
public string GetDataTypeName(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.GetDataTypeName

See Also

MySqlDataReader Class, MySql.Data.MySQLClient Namespace

20.2.7.1.2.1.13.1.1.1.14. `MySqlDataReader.GetDateTime` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetDateTime( _
   ByVal index As Integer _
) As Date _
_
  Implements IDataRecord.GetDateTime
```

Syntax: C#

```
public DateTime GetDateTime(
intindex
);
```

Implements

IDataRecord.GetDateTime

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.15. `MySqlDataReader.GetDecimal` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetDecimal( _
   ByVal index As Integer _
) As Decimal _
_
  Implements IDataRecord.GetDecimal
```

Syntax: C#

```
public decimal GetDecimal(
intindex
);
```

Implements

IDataRecord.GetDecimal

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.16. `MySqlDataReader.GetDouble` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetDouble( _
   ByVal index As Integer _
) As Double _
_
  Implements IDataRecord.GetDouble
```

Syntax: C#

```
public double GetDouble(
intindex
);
```

Implements

IDataRecord.GetDouble

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.17. `MySqlDataReader.GetFieldType` Method

Gets the Type that is the data type of the object.

Syntax: Visual Basic

```
NotOverridable Public Function GetFieldType( _
   ByVal i As Integer _
) As Type _
_
  Implements IDataRecord.GetFieldType
```

Syntax: C#

```
public Type GetFieldType(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.GetFieldType

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.18. `MySqlDataReader.GetFloat` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetFloat( _
   ByVal index As Integer _
) As Single _
_
 Implements IDataRecord.GetFloat
```

Syntax: C#

```
public float GetFloat(
intindex
);
```

Implements

IDataRecord.GetFloat

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.19. `MySqlDataReader.GetGuid` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetGuid( _
   ByVal index As Integer _
) As Guid _
_
 Implements IDataRecord.GetGuid
```

Syntax: C#

```
public Guid GetGuid(
intindex
);
```

Implements

IDataRecord.GetGuid

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.20. `MySqlDataReader.GetInt16` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetInt16( _
   ByVal index As Integer _
) As Short _
_
 Implements IDataRecord.GetInt16
```

Syntax: C#

```
public short GetInt16(
intindex
);
```

Implements

IDataRecord.GetInt16

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.21. `MySqlDataReader.GetInt32` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetInt32( _
   ByVal index As Integer _
) As Integer _
_
 Implements IDataRecord.GetInt32
```

Syntax: C#

```
public int GetInt32(
intindex
);
```

Implements

IDataRecord.GetInt32

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.22. `MySqlDataReader.GetInt64` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetInt64( _
   ByVal index As Integer _
) As Long _
_
 Implements IDataRecord.GetInt64
```

Syntax: C#

```
public long GetInt64(
intindex
);
```

Implements

IDataRecord.GetInt64

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.23. `MySqlDataReader.GetMySqlDateTime` Method

Syntax: Visual Basic

```
Public Function GetMySqlDateTime( _
   ByVal index As Integer _
) As MySqlDateTime
```

Syntax: C#

```
public MySqlDateTime GetMySqlDateTime(
intindex
);
```

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.24. `MySqlDataReader.GetName` Method

Gets the name of the specified column.

Syntax: Visual Basic

```
NotOverridable Public Function GetName( _
   ByVal i As Integer _
) As String _
_
  Implements IDataRecord.GetName
```

Syntax: C#

```
public string GetName(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.GetName

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.25. `MySqlDataReader.GetOrdinal` Method

Gets the column ordinal, given the name of the column.

Syntax: Visual Basic

```
NotOverridable Public Function GetOrdinal( _
   ByVal name As String _
) As Integer _
_
  Implements IDataRecord.GetOrdinal
```

Syntax: C#

```
public int GetOrdinal(
stringname
);
```

Parameters

- `name`:

Return Value

Implements

IDataRecord.GetOrdinal

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.26. `MySqlDataReader.GetSchemaTable` Method

Returns a DataTable that describes the column metadata of the MySqlDataReader.

Syntax: Visual Basic

```
NotOverridable Public Function GetSchemaTable() As DataTable _
_
 Implements IDataReader.GetSchemaTable
```

Syntax: C#

```
public DataTable GetSchemaTable();
```

Return Value

Implements

IDataReader.GetSchemaTable

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.27. `MySqlDataReader.GetString` Method

Syntax: Visual Basic

```
NotOverridable Public Function GetString( _
   ByVal index As Integer _
) As String _
_
 Implements IDataRecord.GetString
```

Syntax: C#

```
public string GetString(
intindex
);
```

Implements

IDataRecord.GetString

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.28. `MySqlDataReader.GetTimeSpan` Method

Syntax: Visual Basic

```
Public Function GetTimeSpan( _
   ByVal index As Integer _
) As TimeSpan
```

Syntax: C#

```
public TimeSpan GetTimeSpan(
intindex
);
```

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.29. `MySqlDataReader.GetUInt16` Method

Syntax: Visual Basic

```
Public Function GetUInt16( _
   ByVal index As Integer _
) As UInt16
```

Syntax: C#

```
public ushort GetUInt16(
intindex
);
```

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.30. `MySqlDataReader.GetUInt32` Method

Syntax: Visual Basic

```
Public Function GetUInt32( _
   ByVal index As Integer _
) As UInt32
```

Syntax: C#

```
public uint GetUInt32(
intindex
);
```

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.31. `MySqlDataReader.GetUInt64` Method

Syntax: Visual Basic

```
Public Function GetUInt64( _
   ByVal index As Integer _
) As UInt64
```

Syntax: C#

```
public ulong GetUInt64(
intindex
);
```

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.32. `MySqlDataReader.GetValue` Method

Gets the value of the specified column in its native format.

Syntax: Visual Basic

```
NotOverridable Public Function GetValue( _
   ByVal i As Integer _
) As Object _
_
  Implements IDataRecord.GetValue
```

Syntax: C#

```
public object GetValue(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.GetValue

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.33. `MySqlDataReader.GetValues` Method

Gets all attribute columns in the collection for the current row.

Syntax: Visual Basic

```
NotOverridable Public Function GetValues( _
   ByVal values As Object() _
) As Integer _
_
 Implements IDataRecord.GetValues
```

Syntax: C#

```
public int GetValues(
object[]values
);
```

Parameters

- `values`:

Return Value

Implements

IDataRecord.GetValues

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.34. `MySqlDataReader.IsDBNull` Method

Gets a value indicating whether the column contains non-existent or missing values.

Syntax: Visual Basic

```
NotOverridable Public Function IsDBNull( _
   ByVal i As Integer _
) As Boolean _
_
 Implements IDataRecord.IsDBNull
```

Syntax: C#

```
public bool IsDBNull(
inti
);
```

Parameters

- `i`:

Return Value

Implements

IDataRecord.IsDBNull

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.35. `MySqlDataReader.NextResult` Method

Advances the data reader to the next result, when reading the results of batch SQL statements.

Syntax: Visual Basic

```
NotOverridable Public Function NextResult() As Boolean _
_
 Implements IDataReader.NextResult
```

Syntax: C#

```
public bool NextResult();
```

Return Value

Implements

IDataReader.NextResult

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.1.1.1.36. `MySqlDataReader.Read` Method

Advances the MySqlDataReader to the next record.

Syntax: Visual Basic

```
NotOverridable Public Function Read() As Boolean _
_
 Implements IDataReader.Read
```

Syntax: C#

```
public bool Read();
```

Return Value

Implements

IDataReader.Read

See Also

MySqlDataReader Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.13.2. `MySqlCommand.ExecuteReader` Method

Syntax: Visual Basic

```
Overloads Public Function ExecuteReader( _
   ByVal behavior As CommandBehavior _
) As MySqlDataReader
```

Syntax: C#

```
public MySqlDataReader ExecuteReader(
CommandBehaviorbehavior
);
```

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace, MySqlCommand.ExecuteReader Overload List

20.2.7.1.2.1.14. `MySqlCommand.ExecuteScalar` Method

Syntax: Visual Basic

```
NotOverridable Public Function ExecuteScalar() As Object _
_
  Implements IDbCommand.ExecuteScalar
```

Syntax: C#

```
public object ExecuteScalar();
```

Implements

IDbCommand.ExecuteScalar

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.2.1.15. `MySqlCommand.Prepare` Method

Syntax: Visual Basic

```
NotOverridable Public Sub Prepare() _
_
  Implements IDbCommand.Prepare
```

Syntax: C#

```
public void Prepare();
```

Implements

IDbCommand.Prepare

See Also

MySqlCommand Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3. `MySqlCommandBuilder` Class

For a list of all members of this type, see MySqlCommandBuilder Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlCommandBuilder_
  Inherits Component
```

Syntax: C#

```
public sealed class MySqlCommandBuilder : Component
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlCommandBuilder Members, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1. `MySqlCommandBuilder` Members

MySqlCommandBuilder overview

Public Static (Shared) Methods

DeriveParameters	Overloaded. Retrieves parameter information from the stored procedure specified in the MySqlCommand and populates the Parameters collection of the specified MySqlCommand object. This method is not currently supported since stored procedures are not available in MySql.

Public Instance Constructors

MySqlCommandBuilder	Overloaded. Initializes a new instance of the MySqlCommandBuilder class.

Public Instance Properties

Container(inherited from Component)	Gets the IContainerthat contains the Component.
DataAdapter	
QuotePrefix	
QuoteSuffix	
Site(inherited from Component)	Gets or sets the ISiteof the Component.

Public Instance Methods

CreateObjRef(inherited from MarshalByRefObject)	Creates an object that contains all the relevant information required to generate a proxy used to communicate with a remote object.
Dispose(inherited from Component)	Releases all resources used by the Component.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetDeleteCommand	
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetInsertCommand	
GetLifetimeService(inherited from MarshalByRefObject)	Retrieves the current lifetime service object that controls the lifetime policy for this instance.
GetType(inherited from Object)	Gets the Typeof the current instance.
GetUpdateCommand	
InitializeLifetimeService(inherited from MarshalByRefObject)	Obtains a lifetime service object to control the lifetime policy for this instance.
RefreshSchema	
ToString(inherited from Component)	Returns a Stringcontaining the name of the Component, if any. This method should not be overridden.

Public Instance Events

Disposed(inherited from Component)	Adds an event handler to listen to the Disposedevent on the component.

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.1. DeriveParameters Method

Retrieves parameter information from the stored procedure specified in the MySqlCommand and populates the Parameters collection of the specified MySqlCommand object. This method is not currently supported since stored procedures are not available in MySql.

Overload List

Retrieves parameter information from the stored procedure specified in the MySqlCommand and populates the Parameters collection of the specified MySqlCommand object. This method is not currently supported since stored procedures are not available in MySql.

- public static void DeriveParameters(MySqlCommand);
- public static void DeriveParameters(MySqlCommand,bool);

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.1.1. `MySqlCommandBuilder.DeriveParameters` Method

Retrieves parameter information from the stored procedure specified in the MySqlCommand and populates the Parameters collection of the specified MySqlCommand object. This method is not currently supported since stored procedures are not available in MySql.

Syntax: Visual Basic

```
Overloads Public Shared Sub DeriveParameters( _
   ByVal command As MySqlCommand _
)
```

Syntax: C#

```
public static void DeriveParameters(
MySqlCommandcommand
);
```

Parameters

- `command`: The MySqlCommand referencing the stored procedure from which the parameter information is to be derived. The derived parameters are added to the Parameters collection of the MySqlCommand.

Exceptions

Exception Type	Condition
InvalidOperationException	The command text is not a valid stored procedure name.

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace, MySqlCommandBuilder.DeriveParameters Overload List

20.2.7.1.3.1.1.2. `MySqlCommandBuilder.DeriveParameters` Method

Syntax: Visual Basic

```
Overloads Public Shared Sub DeriveParameters( _
   ByVal command As MySqlCommand, _
   ByVal useProc As Boolean _
)
```

Syntax: C#

```
public static void DeriveParameters(
MySqlCommandcommand,
booluseProc
);
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace, MySqlCommandBuilder.DeriveParameters Overload List

20.2.7.1.3.1.2. `MySqlCommandBuilder` Constructor

Initializes a new instance of the MySqlCommandBuilder class.

Overload List

Initializes a new instance of the MySqlCommandBuilder class.

- public MySqlCommandBuilder();
- public MySqlCommandBuilder(MySqlDataAdapter);
- public MySqlCommandBuilder(MySqlDataAdapter,bool);
- public MySqlCommandBuilder(bool);

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.1. `MySqlCommandBuilder` Constructor

Initializes a new instance of the MySqlCommandBuilder class.

Syntax: Visual Basic

```
Overloads Public Sub New()
```

Syntax: C#

```
public MySqlCommandBuilder();
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace, MySqlCommandBuilder Constructor Overload List

20.2.7.1.3.1.2.2. `MySqlCommandBuilder` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal adapter As MySqlDataAdapter _
)
```

Syntax: C#

```
public MySqlCommandBuilder(
MySqlDataAdapteradapter
);
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace, MySqlCommandBuilder Constructor Overload List

20.2.7.1.3.1.2.2.1. `MySqlDataAdapter` Class

For a list of all members of this type, see MySqlDataAdapter Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlDataAdapter_
  Inherits DbDataAdapter
```

Syntax: C#

```
public sealed class MySqlDataAdapter : DbDataAdapter
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlDataAdapter Members, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1. `MySqlDataAdapter` Members

MySqlDataAdapter overview

Public Instance Constructors

MySqlDataAdapter	Overloaded. Initializes a new instance of the MySqlDataAdapter class.

Public Instance Properties

AcceptChangesDuringFill(inherited from DataAdapter)	Gets or sets a value indicating whether AcceptChangesis called on a DataRowafter it is added to the DataTableduring any of the Fill operations.
AcceptChangesDuringUpdate(inherited from DataAdapter)	Gets or sets whether AcceptChangesis called during a Update.
Container(inherited from Component)	Gets the IContainerthat contains the Component.
ContinueUpdateOnError(inherited from DataAdapter)	Gets or sets a value that specifies whether to generate an exception when an error is encountered during a row update.
DeleteCommand	Overloaded.
FillLoadOption(inherited from DataAdapter)	Gets or sets the LoadOptionthat determines how the adapter fills the DataTablefrom the DbDataReader.
InsertCommand	Overloaded.
MissingMappingAction(inherited from DataAdapter)	Determines the action to take when incoming data does not have a matching table or column.
MissingSchemaAction(inherited from DataAdapter)	Determines the action to take when existing DataSetschema does not match incoming data.
ReturnProviderSpecificTypes(inherited from DataAdapter)	Gets or sets whether the Fillmethod should return provider-specific values or common CLS-compliant values.
SelectCommand	Overloaded.
Site(inherited from Component)	Gets or sets the ISiteof the Component.
TableMappings(inherited from DataAdapter)	Gets a collection that provides the master mapping between a source table and a DataTable.
UpdateBatchSize(inherited from DbDataAdapter)	Gets or sets a value that enables or disables batch processing support, and specifies the number of commands that can be executed in a batch.
UpdateCommand	Overloaded.

Public Instance Methods

CreateObjRef(inherited from MarshalByRefObject)	Creates an object that contains all the relevant information required to generate a proxy used to communicate with a remote object.

Dispose(inherited from Component)	Releases all resources used by the Component.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
Fill(inherited from DbDataAdapter)	Overloaded. Adds or refreshes rows in the DataSetto match those in the data source using the DataSetname, and creates a DataTablenamed "Table."
FillSchema(inherited from DbDataAdapter)	Overloaded. Configures the schema of the specified DataTable-based on the specified SchemaType.
GetFillParameters(inherited from DbDataAdapter)	Gets the parameters set by the user when executing an SQL `SELECT` statement.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetLifetimeService(inherited from MarshalByRefObject)	Retrieves the current lifetime service object that controls the lifetime policy for this instance.
GetType(inherited from Object)	Gets the Typeof the current instance.
InitializeLifetimeService(inherited from MarshalByRefObject)	Obtains a lifetime service object to control the lifetime policy for this instance.
ResetFillLoadOption(inherited from DataAdapter)	Resets FillLoadOptionto its default state and causes Fillto honor AcceptChangesDuringFill.
ShouldSerializeAcceptChangesDuringFill(inherited from DataAdapter)	Determines whether the AcceptChangesDuringFillproperty should be persisted.
ShouldSerializeFillLoadOption(inherited from DataAdapter)	Determines whether the FillLoadOptionproperty should be persisted.
ToString(inherited from Component)	Returns a Stringcontaining the name of the Component, if any. This method should not be overridden.
Update(inherited from DbDataAdapter)	Overloaded. Calls the respective INSERT, UPDATE, or DELETE statements for each inserted, updated, or deleted row in the specified DataSet.

Public Instance Events

Disposed(inherited from Component)	Adds an event handler to listen to the Disposedevent on the component.
FillError(inherited from DataAdapter)	Returned when an error occurs during a fill operation.
RowUpdated	Occurs during Update after a command is executed against the data source. The attempt to update is made, so the event fires.
RowUpdating	Occurs during Update before a command is executed against the data source. The attempt to update is made, so the event fires.

Protected Internal Instance Properties

FillCommandBehavior(inherited from DbDataAdapter)	Gets or sets the behavior of the command used to fill the data adapter.

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.1. `MySqlDataAdapter` Constructor

Initializes a new instance of the MySqlDataAdapter class.

Overload List

Initializes a new instance of the MySqlDataAdapter class.

- public MySqlDataAdapter();

- public MySqlDataAdapter(MySqlCommand);
- public MySqlDataAdapter(string,MySqlConnection);
- public MySqlDataAdapter(string,string);

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.1.1. `MySqlDataAdapter` Constructor

Initializes a new instance of the MySqlDataAdapter class.

Syntax: Visual Basic

```
Overloads Public Sub New()
```

Syntax: C#

```
public MySqlDataAdapter();
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace, MySqlDataAdapter Constructor Overload List

20.2.7.1.3.1.2.2.1.1.1.2. `MySqlDataAdapter` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal selectCommand As MySqlCommand _
)
```

Syntax: C#

```
public MySqlDataAdapter(
MySqlCommandselectCommand
);
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace, MySqlDataAdapter Constructor Overload List

20.2.7.1.3.1.2.2.1.1.1.3. `MySqlDataAdapter` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal selectCommandText As String, _
   ByVal connection As MySqlConnection _
)
```

Syntax: C#

```
public MySqlDataAdapter(
stringselectCommandText,
MySqlConnectionconnection
);
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace, MySqlDataAdapter Constructor Overload List

20.2.7.1.3.1.2.2.1.1.1.4. `MySqlDataAdapter` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal selectCommandText As String, _
   ByVal selectConnString As String _
)
```

Syntax: C#

```
public MySqlDataAdapter(
stringselectCommandText,
stringselectConnString
);
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace, MySqlDataAdapter Constructor Overload List

20.2.7.1.3.1.2.2.1.1.2. DeleteCommand Property

Syntax: Visual Basic

```
Overloads Public Property DeleteCommand As MySqlCommand
```

Syntax: C#

```
new public MySqlCommand DeleteCommand {get; set;}
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.3. InsertCommand Property

Syntax: Visual Basic

```
Overloads Public Property InsertCommand As MySqlCommand
```

Syntax: C#

```
new public MySqlCommand InsertCommand {get; set;}
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.4. SelectCommand Property

Syntax: Visual Basic

```
Overloads Public Property SelectCommand As MySqlCommand
```

Syntax: C#

```
new public MySqlCommand SelectCommand {get; set;}
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.5. UpdateCommand Property

Syntax: Visual Basic

```
Overloads Public Property UpdateCommand As MySqlCommand
```

Syntax: C#

```
new public MySqlCommand UpdateCommand {get; set;}
```

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.6. `MySqlDataAdapter.RowUpdated` Event

Occurs during Update after a command is executed against the data source. The attempt to update is made, so the event fires.

Syntax: Visual Basic

```
Public Event RowUpdated As MySqlRowUpdatedEventHandler
```

Syntax: C#

```
public event MySqlRowUpdatedEventHandler RowUpdated;
```

Event Data

The event handler receives an argument of type MySqlRowUpdatedEventArgs containing data related to this event. The following MySqlRowUpdatedEventArgsproperties provide information specific to this event.

Property	Description
Command	Gets or sets the MySqlCommand executed when Update is called.
Errors	Gets any errors generated by the .NET Framework data provider when the Commandwas executed.
RecordsAffected	Gets the number of rows changed, inserted, or deleted by execution of the SQL statement.
Row	Gets the DataRowsent through an Update.
RowCount	Gets the number of rows processed in a batch of updated records.
StatementType	Gets the type of SQL statement executed.
Status	Gets the UpdateStatusof the Commandproperty.
TableMapping	Gets the DataTableMappingsent through an Update.

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.6.1. `MySqlRowUpdatedEventHandler` Delegate

Represents the method that will handle the RowUpdatedevent of a MySqlDataAdapter .

Syntax: Visual Basic

```
Public Delegate Sub MySqlRowUpdatedEventHandler( _
   ByVal sender As Object, _
   ByVal e As MySqlRowUpdatedEventArgs _
)
```

Syntax: C#

```
public delegate void MySqlRowUpdatedEventHandler(
objectsender,
MySqlRowUpdatedEventArgse
);
```

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.6.1.1. `MySqlRowUpdatedEventArgs` Class

Provides data for the RowUpdated event. This class cannot be inherited.

For a list of all members of this type, see MySqlRowUpdatedEventArgs Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlRowUpdatedEventArgs_
  Inherits RowUpdatedEventArgs
```

Syntax: C#

```
public sealed class MySqlRowUpdatedEventArgs : RowUpdatedEventArgs
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlRowUpdatedEventArgs Members, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.6.1.1.1. `MySqlRowUpdatedEventArgs` Members

MySqlRowUpdatedEventArgs overview

Public Instance Constructors

MySqlRowUpdatedEventArgs Constructor	Initializes a new instance of the MySqlRowUpdatedEventArgs class.

Public Instance Properties

Command	Overloaded. Gets or sets the MySqlCommand executed when Update is called.
Errors(inherited from RowUpdatedEventArgs)	Gets any errors generated by the .NET Framework data provider when the Commandwas executed.
RecordsAffected(inherited from RowUpdatedEventArgs)	Gets the number of rows changed, inserted, or deleted by execution of the SQL statement.
Row(inherited from RowUpdatedEventArgs)	Gets the DataRowsent through an Update.
RowCount(inherited from RowUpdatedEventArgs)	Gets the number of rows processed in a batch of updated records.
StatementType(inherited from RowUpdatedEventArgs)	Gets the type of SQL statement executed.
Status(inherited from RowUpdatedEventArgs)	Gets the UpdateStatusof the Commandproperty.
TableMapping(inherited from RowUpdatedEventArgs)	Gets the DataTableMappingsent through an Update.

Public Instance Methods

CopyToRows(inherited from RowUpdatedEventArgs)	Overloaded. Copies references to the modified rows into the provided array.
Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
ToString(inherited from Object)	Returns a Stringthat represents the current Object.

See Also

MySqlRowUpdatedEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.6.1.1.1.1. `MySqlRowUpdatedEventArgs` Constructor

Initializes a new instance of the MySqlRowUpdatedEventArgs class.

Syntax: Visual Basic

```
Public Sub New( _
   ByVal row As DataRow, _
   ByVal command As IDbCommand, _
   ByVal statementType As StatementType, _
   ByVal tableMapping As DataTableMapping _
)
```

Syntax: C#

```
public MySqlRowUpdatedEventArgs(
DataRowrow,
IDbCommandcommand,
StatementTypestatementType,
DataTableMappingtableMapping
);
```

Parameters

- `row`: The DataRowsent through an Update.
- `command`: The IDbCommandexecuted when Updateis called.
- `statementType`: One of the StatementTypevalues that specifies the type of query executed.
- `tableMapping`: The DataTableMappingsent through an Update.

See Also

MySqlRowUpdatedEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.6.1.1.1.2. Command Property

Gets or sets the MySqlCommand executed when Update is called.

Syntax: Visual Basic

```
Overloads Public ReadOnly Property Command As MySqlCommand
```

Syntax: C#

```
new public MySqlCommand Command {get;}
```

See Also

MySqlRowUpdatedEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.7. `MySqlDataAdapter.RowUpdating` Event

Occurs during Update before a command is executed against the data source. The attempt to update is made, so the event fires.

Syntax: Visual Basic

```
Public Event RowUpdating As MySqlRowUpdatingEventHandler
```

Syntax: C#

```
public event MySqlRowUpdatingEventHandler RowUpdating;
```

Event Data

The event handler receives an argument of type MySqlRowUpdatingEventArgs containing data related to this event. The following MySqlRowUpdatingEventArgsproperties provide information specific to this event.

Property	Description
Command	Gets or sets the MySqlCommand to execute when performing the Update.
Errors	Gets any errors generated by the .NET Framework data provider when the Commandexecutes.
Row	Gets the DataRowthat will be sent to the server as part of an insert, update, or delete operation.
StatementType	Gets the type of SQL statement to execute.
Status	Gets or sets the UpdateStatusof the Commandproperty.
TableMapping	Gets the DataTableMappingto send through the Update.

See Also

MySqlDataAdapter Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.7.1. `MySqlRowUpdatingEventHandler` Delegate

Represents the method that will handle the RowUpdatingevent of a MySqlDataAdapter .

Syntax: Visual Basic

```
Public Delegate Sub MySqlRowUpdatingEventHandler( _
   ByVal sender As Object, _
   ByVal e As MySqlRowUpdatingEventArgs _
)
```

Syntax: C#

```
public delegate void MySqlRowUpdatingEventHandler(
objectsender,
MySqlRowUpdatingEventArgse
);
```

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.7.1.1. `MySqlRowUpdatingEventArgs` Class

Provides data for the RowUpdating event. This class cannot be inherited.

For a list of all members of this type, see MySqlRowUpdatingEventArgs Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlRowUpdatingEventArgs_
  Inherits RowUpdatingEventArgs
```

Syntax: C#

```
public sealed class MySqlRowUpdatingEventArgs : RowUpdatingEventArgs
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlRowUpdatingEventArgs Members, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.7.1.1.1. `MySqlRowUpdatingEventArgs` Members

MySqlRowUpdatingEventArgs overview

Public Instance Constructors

MySqlRowUpdatingEventArgs Constructor	Initializes a new instance of the MySqlRowUpdatingEventArgs class.

Public Instance Properties

Command	Overloaded. Gets or sets the MySqlCommand to execute when performing the Update.
Errors(inherited from RowUpdatingEventArgs)	Gets any errors generated by the .NET Framework data provider when the Commandexecutes.
Row(inherited from RowUpdatingEventArgs)	Gets the DataRowthat will be sent to the server as part of an insert, update, or delete operation.
StatementType(inherited from RowUpdatingEventArgs)	Gets the type of SQL statement to execute.
Status(inherited from RowUpdatingEventArgs)	Gets or sets the UpdateStatusof the Commandproperty.
TableMapping(inherited from RowUpdatingEventArgs)	Gets the DataTableMappingto send through the Update.

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
ToString(inherited from Object)	Returns a Stringthat represents the current Object.

See Also

MySqlRowUpdatingEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.7.1.1.1.1. `MySqlRowUpdatingEventArgs` Constructor

Initializes a new instance of the MySqlRowUpdatingEventArgs class.

Syntax: Visual Basic

```
Public Sub New( _
   ByVal row As DataRow, _
   ByVal command As IDbCommand, _
   ByVal statementType As StatementType, _
   ByVal tableMapping As DataTableMapping _
)
```

Syntax: C#

```
public MySqlRowUpdatingEventArgs(
DataRowrow,
IDbCommandcommand,
StatementTypestatementType,
DataTableMappingtableMapping
);
```

Parameters

- `row`: The DataRowto Update.
- `command`: The IDbCommandto execute during Update.
- `statementType`: One of the StatementTypevalues that specifies the type of query executed.
- `tableMapping`: The DataTableMappingsent through an Update.

See Also

MySqlRowUpdatingEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.2.1.1.7.1.1.1.2. Command Property

Gets or sets the MySqlCommand to execute when performing the Update.

Syntax: Visual Basic

```
Overloads Public Property Command As MySqlCommand
```

Syntax: C#

```
new public MySqlCommand Command {get; set;}
```

See Also

MySqlRowUpdatingEventArgs Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.2.3. `MySqlCommandBuilder` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal adapter As MySqlDataAdapter, _
   ByVal lastOneWins As Boolean _
)
```

Syntax: C#

```
public MySqlCommandBuilder(
MySqlDataAdapteradapter,
boollastOneWins
);
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace, MySqlCommandBuilder Constructor Overload List

20.2.7.1.3.1.2.4. `MySqlCommandBuilder` Constructor

Syntax: Visual Basic

```
Overloads Public Sub New( _
   ByVal lastOneWins As Boolean _
)
```

Syntax: C#

```
public MySqlCommandBuilder(
boollastOneWins
);
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace, MySqlCommandBuilder Constructor Overload List

20.2.7.1.3.1.3. DataAdapter Property

Syntax: Visual Basic

```
Public Property DataAdapter As MySqlDataAdapter
```

Syntax: C#

```
public MySqlDataAdapter DataAdapter {get; set;}
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.4. QuotePrefix Property

Syntax: Visual Basic

```
Public Property QuotePrefix As String
```

Syntax: C#

```
public string QuotePrefix {get; set;}
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.5. QuoteSuffix Property

Syntax: Visual Basic

```
Public Property QuoteSuffix As String
```

Syntax: C#

```
public string QuoteSuffix {get; set;}
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.6. `MySqlCommandBuilder.GetDeleteCommand` Method

Syntax: Visual Basic

```
Public Function GetDeleteCommand() As MySqlCommand
```

Syntax: C#

```
public MySqlCommand GetDeleteCommand();
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.7. `MySqlCommandBuilder.GetInsertCommand` Method

Syntax: Visual Basic

```
Public Function GetInsertCommand() As MySqlCommand
```

Syntax: C#

```
public MySqlCommand GetInsertCommand();
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.8. `MySqlCommandBuilder.GetUpdateCommand` Method

Syntax: Visual Basic

```
Public Function GetUpdateCommand() As MySqlCommand
```

Syntax: C#

```
public MySqlCommand GetUpdateCommand();
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.3.1.9. `MySqlCommandBuilder.RefreshSchema` Method

Syntax: Visual Basic

```
Public Sub RefreshSchema()
```

Syntax: C#

```
public void RefreshSchema();
```

See Also

MySqlCommandBuilder Class, MySql.Data.MySqlClient Namespace

20.2.7.1.4. `MySqlException` Class

The exception that is thrown when MySQL returns an error. This class cannot be inherited.

For a list of all members of this type, see MySqlException Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlException_
  Inherits SystemException
```

Syntax: C#

```
public sealed class MySqlException : SystemException
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlException Members, MySql.Data.MySqlClient Namespace

20.2.7.1.4.1. `MySqlException` Members

MySqlException overview

Public Instance Properties

Data(inherited from Exception)	Gets a collection of key/value pairs that provide additional, user-defined information about the exception.
HelpLink(inherited from Exception)	Gets or sets a link to the help file associated with this exception.
InnerException(inherited from Exception)	Gets the Exceptioninstance that caused the current exception.

Message(inherited from Exception)	Gets a message that describes the current exception.
Number	Gets a number that identifies the type of error. This number corresponds to the error numbers given in Section C.3, “Server Error Codes and Messages”.
Source(inherited from Exception)	Gets or sets the name of the application or the object that causes the error.
StackTrace(inherited from Exception)	Gets a string representation of the frames on the call stack at the time the current exception was thrown.
TargetSite(inherited from Exception)	Gets the method that throws the current exception.

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetBaseException(inherited from Exception)	When overridden in a derived class, returns the Exceptionthat is the root cause of one or more subsequent exceptions.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetObjectData(inherited from Exception)	When overridden in a derived class, sets the SerializationInfowith information about the exception.
GetType(inherited from Exception)	Gets the runtime type of the current instance.
ToString(inherited from Exception)	Creates and returns a string representation of the current exception.

See Also

MySqlException Class, MySql.Data.MySqlClient Namespace

20.2.7.1.4.1.1. Number Property

Gets a number that identifies the type of error.

Syntax: Visual Basic

```
Public ReadOnly Property Number As Integer
```

Syntax: C#

```
public int Number {get;}
```

See Also

MySqlException Class, MySql.Data.MySqlClient Namespace

20.2.7.1.5. `MySqlHelper` Class

Helper class that makes it easier to work with the provider.

For a list of all members of this type, see MySqlHelper Members .

Syntax: Visual Basic

```
NotInheritable Public Class MySqlHelper
```

Syntax: C#

```
public sealed class MySqlHelper
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlHelper Members, MySql.Data.MySqlClient Namespace

20.2.7.1.5.1. `MySqlHelper` Members

MySqlHelper overview

Public Static (Shared) Methods

ExecuteDataRow	Executes a single SQL statement and returns the first row of the resultset. A new MySqlConnection object is created, opened, and closed during this method.
ExecuteDataset	Overloaded. Executes a single SQL statement and returns the resultset in a DataSet. A new MySqlConnection object is created, opened, and closed during this method.
ExecuteNonQuery	Overloaded. Executes a single command against a MySQL database. The MySqlConnection is assumed to be open when the method is called and remains open after the method completes.
ExecuteReader	Overloaded. Executes a single command against a MySQL database.
ExecuteScalar	Overloaded. Execute a single command against a MySQL database.
UpdateDataSet	Updates the given table with data from the given DataSet

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
ToString(inherited from Object)	Returns a Stringthat represents the current Object.

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace

20.2.7.1.5.1.1. `MySqlHelper.ExecuteDataRow` Method

Executes a single SQL statement and returns the first row of the resultset. A new MySqlConnection object is created, opened, and closed during this method.

Syntax: Visual Basic

```
Public Shared Function ExecuteDataRow( _
   ByVal connectionString As String, _
   ByVal commandText As String, _
   ParamArray parms As MySqlParameter() _
) As DataRow
```

Syntax: C#

```
public static DataRow ExecuteDataRow(
stringconnectionString,
stringcommandText,
   params MySqlParameter[]parms
);
```

Parameters

- `connectionString`: Settings to be used for the connection
- `commandText`: Command to execute
- `parms`: Parameters to use for the command

Return Value

DataRow containing the first row of the resultset

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace

20.2.7.1.5.1.2. ExecuteDataset Method

Executes a single SQL statement and returns the resultset in a DataSet. The state of the MySqlConnection object remains unchanged after execution of this method.

Overload List

Executes a single SQL statement and returns the resultset in a DataSet. The state of the MySqlConnection object remains unchanged after execution of this method.

- public static DataSet ExecuteDataset(MySqlConnection,string);

Executes a single SQL statement and returns the resultset in a DataSet. The state of the MySqlConnection object remains unchanged after execution of this method.

- public static DataSet ExecuteDataset(MySqlConnection,string,params MySqlParameter[]);

Executes a single SQL statement and returns the resultset in a DataSet. A new MySqlConnection object is created, opened, and closed during this method.

- public static DataSet ExecuteDataset(string,string);

Executes a single SQL statement and returns the resultset in a DataSet. A new MySqlConnection object is created, opened, and closed during this method.

- public static DataSet ExecuteDataset(string,string,params MySqlParameter[]);

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace

20.2.7.1.5.1.2.1. `MySqlHelper.ExecuteDataset` Method

Executes a single SQL statement and returns the resultset in a DataSet. The state of the MySqlConnection object remains unchanged after execution of this method.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteDataset( _
   ByVal connection As MySqlConnection, _
   ByVal commandText As String _
) As DataSet
```

Syntax: C#

```
public static DataSet ExecuteDataset(
MySqlConnectionconnection,
stringcommandText
);
```

Parameters

- `connection`: MySqlConnection object to use
- `commandText`: Command to execute

Return Value

DataSetcontaining the resultset

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteDataset Overload List

20.2.7.1.5.1.2.2. `MySqlHelper.ExecuteDataset` Method

Executes a single SQL statement and returns the resultset in a DataSet. The state of the MySqlConnection object remains unchanged after execution of this method.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteDataset( _
   ByVal connection As MySqlConnection, _
   ByVal commandText As String, _
   ParamArray commandParameters As MySqlParameter() _
) As DataSet
```

Syntax: C#

```
public static DataSet ExecuteDataset(
MySqlConnectionconnection,
stringcommandText,
   params MySqlParameter[]commandParameters
);
```

Parameters

- `connection`: MySqlConnection object to use
- `commandText`: Command to execute
- `commandParameters`: Parameters to use for the command

Return Value

DataSetcontaining the resultset

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteDataset Overload List

20.2.7.1.5.1.2.3. `MySqlHelper.ExecuteDataset` Method

Executes a single SQL statement and returns the resultset in a DataSet. A new MySqlConnection object is created, opened, and closed during this method.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteDataset( _
   ByVal connectionString As String, _
   ByVal commandText As String _
) As DataSet
```

Syntax: C#

```
public static DataSet ExecuteDataset(
stringconnectionString,
stringcommandText
);
```

Parameters

- `connectionString`: Settings to be used for the connection
- `commandText`: Command to execute

Return Value

DataSetcontaining the resultset

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteDataset Overload List

20.2.7.1.5.1.2.4. `MySqlHelper.ExecuteDataset` Method

Executes a single SQL statement and returns the resultset in a DataSet. A new MySqlConnection object is created, opened, and closed during this method.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteDataset( _
   ByVal connectionString As String, _
   ByVal commandText As String, _
   ParamArray commandParameters As MySqlParameter() _
) As DataSet
```

Syntax: C#

```
public static DataSet ExecuteDataset(
stringconnectionString,
stringcommandText,
   params MySqlParameter[]commandParameters
);
```

Parameters

- `connectionString`: Settings to be used for the connection
- `commandText`: Command to execute
- `commandParameters`: Parameters to use for the command

Return Value

DataSetcontaining the resultset

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteDataset Overload List

20.2.7.1.5.1.3. ExecuteNonQuery Method

Executes a single command against a MySQL database. The MySqlConnection is assumed to be open when the method is called and remains open after the method completes.

Overload List

Executes a single command against a MySQL database. The MySqlConnection is assumed to be open when the method is called and remains open after the method completes.

- public static int ExecuteNonQuery(MySqlConnection,string,params MySqlParameter[]);

Executes a single command against a MySQL database. A new MySqlConnection is created using the ConnectionString given.

- public static int ExecuteNonQuery(string,string,params MySqlParameter[]);

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace

20.2.7.1.5.1.3.1. `MySqlHelper.ExecuteNonQuery` Method

Executes a single command against a MySQL database. The MySqlConnection is assumed to be open when the method is called and remains open after the method completes.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteNonQuery( _
   ByVal connection As MySqlConnection, _
   ByVal commandText As String, _
   ParamArray commandParameters As MySqlParameter() _
) As Integer
```

Syntax: C#

```
public static int ExecuteNonQuery(
MySqlConnectionconnection,
stringcommandText,
   params MySqlParameter[]commandParameters
);
```

Parameters

- `connection`: MySqlConnection object to use
- `commandText`: SQL statement to be executed
- `commandParameters`: Array of MySqlParameter objects to use with the command.

Return Value

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteNonQuery Overload List

20.2.7.1.5.1.3.2. `MySqlHelper.ExecuteNonQuery` Method

Executes a single command against a MySQL database. A new MySqlConnection is created using the ConnectionString given.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteNonQuery( _
   ByVal connectionString As String, _
   ByVal commandText As String, _
   ParamArray parms As MySqlParameter() _
) As Integer
```

Syntax: C#

```
public static int ExecuteNonQuery(
stringconnectionString,
stringcommandText,
   params MySqlParameter[]parms
);
```

Parameters

- `connectionString`: ConnectionString to use
- `commandText`: SQL statement to be executed

- `parms`: Array of MySqlParameter objects to use with the command.

Return Value

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteNonQuery Overload List

20.2.7.1.5.1.4. ExecuteReader Method

Executes a single command against a MySQL database.

Overload List

Executes a single command against a MySQL database.

- public static MySqlDataReader ExecuteReader(string,string);

Executes a single command against a MySQL database.

- public static MySqlDataReader ExecuteReader(string,string,params MySqlParameter[]);

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace

20.2.7.1.5.1.4.1. `MySqlHelper.ExecuteReader` Method

Executes a single command against a MySQL database.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteReader( _
   ByVal connectionString As String, _
   ByVal commandText As String _
) As MySqlDataReader
```

Syntax: C#

```
public static MySqlDataReader ExecuteReader(
stringconnectionString,
stringcommandText
);
```

Parameters

- `connectionString`: Settings to use for this command
- `commandText`: Command text to use

Return Value

MySqlDataReader object ready to read the results of the command

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteReader Overload List

20.2.7.1.5.1.4.2. `MySqlHelper.ExecuteReader` Method

Executes a single command against a MySQL database.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteReader( _
   ByVal connectionString As String, _
   ByVal commandText As String, _
   ParamArray commandParameters As MySqlParameter() _
) As MySqlDataReader
```

Syntax: C#

```
public static MySqlDataReader ExecuteReader(
stringconnectionString,
stringcommandText,
   params MySqlParameter[]commandParameters
);
```

Parameters

- `connectionString`: Settings to use for this command
- `commandText`: Command text to use
- `commandParameters`: Array of MySqlParameter objects to use with the command

Return Value

MySqlDataReader object ready to read the results of the command

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteReader Overload List

20.2.7.1.5.1.5. ExecuteScalar Method

Execute a single command against a MySQL database.

Overload List

Execute a single command against a MySQL database.

- public static object ExecuteScalar(MySqlConnection,string);

Execute a single command against a MySQL database.

- public static object ExecuteScalar(MySqlConnection,string,params MySqlParameter[]);

Execute a single command against a MySQL database.

- public static object ExecuteScalar(string,string);

Execute a single command against a MySQL database.

- public static object ExecuteScalar(string,string,params MySqlParameter[]);

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace

20.2.7.1.5.1.5.1. `MySqlHelper.ExecuteScalar` Method

Execute a single command against a MySQL database.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteScalar( _
   ByVal connection As MySqlConnection, _
   ByVal commandText As String _
) As Object
```

Syntax: C#

```
public static object ExecuteScalar(
MySqlConnectionconnection,
stringcommandText
);
```

Parameters

- `connection`: MySqlConnection object to use
- `commandText`: Command text to use for the command

Return Value

The first column of the first row in the result set, or a null reference if the result set is empty.

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteScalar Overload List

20.2.7.1.5.1.5.2. `MySqlHelper.ExecuteScalar` Method

Execute a single command against a MySQL database.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteScalar( _
   ByVal connection As MySqlConnection, _
   ByVal commandText As String, _
   ParamArray commandParameters As MySqlParameter() _
) As Object
```

Syntax: C#

```
public static object ExecuteScalar(
MySqlConnectionconnection,
stringcommandText,
   params MySqlParameter[]commandParameters
);
```

Parameters

- `connection`: MySqlConnection object to use
- `commandText`: Command text to use for the command
- `commandParameters`: Parameters to use for the command

Return Value

The first column of the first row in the result set, or a null reference if the result set is empty.

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteScalar Overload List

20.2.7.1.5.1.5.3. `MySqlHelper.ExecuteScalar` Method

Execute a single command against a MySQL database.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteScalar( _
   ByVal connectionString As String, _
   ByVal commandText As String _
) As Object
```

Syntax: C#

```
public static object ExecuteScalar(
stringconnectionString,
stringcommandText
);
```

Parameters

- `connectionString`: Settings to use for the update
- `commandText`: Command text to use for the update

Return Value

The first column of the first row in the result set, or a null reference if the result set is empty.

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteScalar Overload List

20.2.7.1.5.1.5.4. `MySqlHelper.ExecuteScalar` Method

Execute a single command against a MySQL database.

Syntax: Visual Basic

```
Overloads Public Shared Function ExecuteScalar( _
   ByVal connectionString As String, _
   ByVal commandText As String, _
   ParamArray commandParameters As MySqlParameter() _
) As Object
```

Syntax: C#

```
public static object ExecuteScalar(
stringconnectionString,
stringcommandText,
   params MySqlParameter[]commandParameters
);
```

Parameters

- `connectionString`: Settings to use for the command
- `commandText`: Command text to use for the command
- `commandParameters`: Parameters to use for the command

Return Value

The first column of the first row in the result set, or a null reference if the result set is empty.

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace, MySqlHelper.ExecuteScalar Overload List

20.2.7.1.5.1.6. `MySqlHelper.UpdateDataSet` Method

Updates the given table with data from the given DataSet

Syntax: Visual Basic

```
Public Shared Sub UpdateDataSet( _
   ByVal connectionString As String, _
   ByVal commandText As String, _
   ByVal ds As DataSet, _
   ByVal tablename As String _
)
```

Syntax: C#

```
public static void UpdateDataSet(
stringconnectionString,
stringcommandText,
DataSetds,
stringtablename
);
```

Parameters

- `connectionString`: Settings to use for the update
- `commandText`: Command text to use for the update
- `ds`: DataSetcontaining the new data to use in the update
- `tablename`: Tablename in the data set to update

See Also

MySqlHelper Class, MySql.Data.MySqlClient Namespace

20.2.7.1.6. `MySqlErrorCode` Enumeration

Syntax: Visual Basic

```
Public Enum MySqlErrorCode
```

Syntax: C#

```
public enum MySqlErrorCode
```

Members

Member Name	Description
PacketTooLarge	
PasswordNotAllowed	
DuplicateKeyEntry	
HostNotPrivileged	
PasswordNoMatch	
AnonymousUser	
DuplicateKey	
KeyNotFound	
DuplicateKeyName	

Requirements

Namespace: MySql.Data.MySqlClient

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySql.Data.MySqlClient Namespace

20.2.7.2. `MySql.Data.Types`

Namespace hierarchy

Classes

Class	Description
MySqlConversionException	Summary description for MySqlConversionException.
MySqlDateTime	Summary description for MySqlDateTime.

MySqlValue	

20.2.7.2.1. `MySql.Data.TypesHierarchy`

See Also

MySql.Data.Types Namespace

20.2.7.2.2. `MySqlConversionException` Class

Summary description for MySqlConversionException.

For a list of all members of this type, see MySqlConversionException Members .

Syntax: Visual Basic

```
Public Class MySqlConversionException_
  Inherits ApplicationException
```

Syntax: C#

```
public class MySqlConversionException : ApplicationException
```

Thread Safety

Public static (Sharedin Visual Basic) members of this type are safe for multithreaded operations. Instance members are notguaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.Types

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlConversionException Members, MySql.Data.Types Namespace

20.2.7.2.2.1. `MySqlConversionException` Members

MySqlConversionException overview

Public Instance Constructors

MySqlConversionException Constructor	Ctor

Public Instance Properties

Data(inherited from Exception)	Gets a collection of key/value pairs that provide additional, user-defined information about the exception.
HelpLink(inherited from Exception)	Gets or sets a link to the help file associated with this exception.
InnerException(inherited from Exception)	Gets the Exceptioninstance that caused the current exception.
Message(inherited from Exception)	Gets a message that describes the current exception.
Source(inherited from Exception)	Gets or sets the name of the application or the object that causes the error.
StackTrace(inherited from Exception)	Gets a string representation of the frames on the call stack at the time the current exception was thrown.
TargetSite(inherited from Exception)	Gets the method that throws the current exception.

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.

GetBaseException(inherited from Exception)	When overridden in a derived class, returns the Exceptionthat is the root cause of one or more subsequent exceptions.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetObjectData(inherited from Exception)	When overridden in a derived class, sets the SerializationInfowith information about the exception.
GetType(inherited from Exception)	Gets the runtime type of the current instance.
ToString(inherited from Exception)	Creates and returns a string representation of the current exception.

Protected Instance Properties

HResult(inherited from Exception)	Gets or sets HRESULT, a coded numeric value that is assigned to a specific exception.

Protected Instance Methods

Finalize(inherited from Object)	Allows an Objectto attempt to free resources and perform other cleanup operations before the Objectis reclaimed by garbage collection.
MemberwiseClone(inherited from Object)	Creates a shallow copy of the current Object.

See Also

MySqlConversionException Class, MySql.Data.Types Namespace

20.2.7.2.2.1.1. `MySqlConversionException` Constructor

Syntax: Visual Basic

```
Public Sub New( _
   ByVal msg As String _
)
```

Syntax: C#

```
public MySqlConversionException(
stringmsg
);
```

See Also

MySqlConversionException Class, MySql.Data.Types Namespace

20.2.7.2.3. `MySqlDateTime` Class

Summary description for MySqlDateTime.

For a list of all members of this type, see MySqlDateTime Members .

Syntax: Visual Basic

```
Public Class MySqlDateTime_
  Inherits MySqlValue_
  Implements IConvertible, IComparable
```

Syntax: C#

```
public class MySqlDateTime : MySqlValue, IConvertible, IComparable
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.Types

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlDateTime Members, MySql.Data.Types Namespace

20.2.7.2.3.1. `MySqlDateTime` Members

MySqlDateTime overview

Public Static (Shared) Type Conversions

Explicit MySqlDateTime to DateTime Conversion	

Public Instance Properties

Day	Returns the day portion of this datetime
Hour	Returns the hour portion of this datetime
IsNull (inherited from MySqlValue)	
IsValidDateTime	Indicates if this object contains a value that can be represented as a DateTime
Minute	Returns the minute portion of this datetime
Month	Returns the month portion of this datetime
Second	Returns the second portion of this datetime
ValueAsObject (inherited from MySqlValue)	Returns the value of this field as an object
Year	Returns the year portion of this datetime

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetDateTime	Returns this value as a DateTime
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
ToString	Returns a MySQL specific string representation of this value

Protected Instance Fields

classType (inherited from MySqlValue)	The system type represented by this value
dbType (inherited from MySqlValue)	The generic dbtype of this value
isNull (inherited from MySqlValue)	Is this value null
mySqlDbType (inherited from MySqlValue)	The specific MySQL db type
mySqlTypeName (inherited from MySqlValue)	The MySQL specific typename of this value
objectValue (inherited from MySqlValue)	

Protected Instance Methods

Finalize(inherited from Object)	Allows an Objectto attempt to free resources and perform other cleanup operations before the Objectis reclaimed by garbage

	collection.
MemberwiseClone(inherited from Object)	Creates a shallow copy of the current Object.

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.1. `MySqlDateTime` Explicit `MySqlDateTime` to `DateTime` Conversion

Syntax: Visual Basic

```
MySqlDateTime.op_Explicit(val)
```

Syntax: C#

```
public static explicit operator DateTime(
MySqlDateTimeval
);
```

Parameters

- `val`:

Return Value

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.2. Day Property

Returns the day portion of this datetime

Syntax: Visual Basic

```
Public Property Day As Integer
```

Syntax: C#

```
public int Day {get; set;}
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.3. Hour Property

Returns the hour portion of this datetime

Syntax: Visual Basic

```
Public Property Hour As Integer
```

Syntax: C#

```
public int Hour {get; set;}
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4. IsNull Property

Syntax: Visual Basic

```
Public Property IsNull As Boolean
```

Syntax: C#

```
public bool IsNull {get; set;}
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1. `MySqlValue` Class

For a list of all members of this type, see MySqlValue Members .

Syntax: Visual Basic

```
MustInherit Public Class MySqlValue
```

Syntax: C#

```
public abstract class MySqlValue
```

Thread Safety

Public static (Shared in Visual Basic) members of this type are safe for multithreaded operations. Instance members are not guaranteed to be thread-safe.

Requirements

Namespace: MySql.Data.Types

Assembly: MySql.Data (in MySql.Data.dll)

See Also

MySqlValue Members, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1. `MySqlValue` Members

MySqlValue overview

Protected Static (Shared) Fields

numberFormat	

Public Instance Constructors

MySqlValue Constructor	Initializes a new instance of the MySqlValue class.

Public Instance Properties

IsNull	
ValueAsObject	Returns the value of this field as an object

Public Instance Methods

Equals(inherited from Object)	Determines whether the specified Objectis equal to the current Object.
GetHashCode(inherited from Object)	Serves as a hash function for a particular type. GetHashCodeis suitable for use in hashing algorithms and data structures like a hash table.
GetType(inherited from Object)	Gets the Typeof the current instance.
ToString	Returns a string representation of this value

Protected Instance Fields

classType	The system type represented by this value
dbType	The generic dbtype of this value
isNull	Is this value null
mySqlDbType	The specific MySQL db type
mySqlTypeName	The MySQL specific typename of this value
objectValue	

Protected Instance Methods

Finalize(inherited from Object)	Allows an Objectto attempt to free resources and perform other cleanup operations before the Objectis reclaimed by garbage collection.
MemberwiseClone(inherited from Object)	Creates a shallow copy of the current Object.

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.1. `MySqlValue.numberFormat` Field

Syntax: Visual Basic

```
Protected Shared numberFormat As NumberFormatInfo
```

Syntax: C#

```
protected static NumberFormatInfo numberFormat;
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.2. `MySqlValue` Constructor

Initializes a new instance of the MySqlValue class.

Syntax: Visual Basic

```
Public Sub New()
```

Syntax: C#

```
public MySqlValue();
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.3. ValueAsObject Property

Returns the value of this field as an object

Syntax: Visual Basic

```
Public ReadOnly Property ValueAsObject As Object
```

Syntax: C#

```
public object ValueAsObject {get;}
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.4. `MySqlValue.ToString` Method

Returns a string representation of this value

Syntax: Visual Basic

```
Overrides Public Function ToString() As String
```

Syntax: C#

```
public override string ToString();
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.5. `MySqlValue.classType` Field

The system type represented by this value

Syntax: Visual Basic

```
Protected classType As Type
```

Syntax: C#

```
protected Type classType;
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.6. `MySqlValue.dbType` Field

The generic dbtype of this value

Syntax: Visual Basic

```
Protected dbType As DbType
```

Syntax: C#

```
protected DbType dbType;
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.7. `MySqlValue.mySqlDbType` Field

The specific MySQL db type

Syntax: Visual Basic

```
Protected mySqlDbType As MySqlDbType
```

Syntax: C#

```
protected MySqlDbType mySqlDbType;
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.8. `MySqlValue.mySqlTypeName` Field

The MySQL specific typename of this value

Syntax: Visual Basic

```
Protected mySqlTypeName As String
```

Syntax: C#

```
protected string mySqlTypeName;
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.4.1.1.9. `MySqlValue.objectValue` Field

Syntax: Visual Basic

```
Protected objectValue As Object
```

Syntax: C#

```
protected object objectValue;
```

See Also

MySqlValue Class, MySql.Data.Types Namespace

20.2.7.2.3.1.5. IsValidDateTime Property

Indicates if this object contains a value that can be represented as a DateTime

Syntax: Visual Basic

```
Public ReadOnly Property IsValidDateTime As Boolean
```

Syntax: C#

```
public bool IsValidDateTime {get;}
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.6. Minute Property

Returns the minute portion of this datetime

Syntax: Visual Basic

```
Public Property Minute As Integer
```

Syntax: C#

```
public int Minute {get; set;}
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.7. Month Property

Returns the month portion of this datetime

Syntax: Visual Basic

```
Public Property Month As Integer
```

Syntax: C#

```
public int Month {get; set;}
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.8. Second Property

Returns the second portion of this datetime

Syntax: Visual Basic

```
Public Property Second As Integer
```

Syntax: C#

```
public int Second {get; set;}
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.9. Year Property

Returns the year portion of this datetime

Syntax: Visual Basic

```
Public Property Year As Integer
```

Syntax: C#

```
public int Year {get; set;}
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.10. `MySqlDateTime.GetDateTime` Method

Returns this value as a DateTime

Syntax: Visual Basic

```
Public Function GetDateTime() As Date
```

Syntax: C#

```
public DateTime GetDateTime();
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.7.2.3.1.11. `MySqlDateTime.ToString` Method

Returns a MySQL specific string representation of this value

Syntax: Visual Basic

```
Overrides Public Function ToString() As String
```

Syntax: C#

```
public override string ToString();
```

See Also

MySqlDateTime Class, MySql.Data.Types Namespace

20.2.8. Connector/Net Support

The developers of Connector/Net greatly value the input of our users in the software development process. If you find Connector/Net lacking some feature important to you, or if you discover a bug and need to file a bug report, please use the instructions in Section 1.7, “How to Report Bugs or Problems”.

20.2.8.1. Connector/Net Community Support

- Community support for Connector/Net can be found through the forums at http://forums.mysql.com.
- Community support for Connector/Net can also be found through the mailing lists at http://lists.mysql.com.
- Paid support is available from Oracle. Additional information is available at http://dev.mysql.com/support/.

20.2.8.2. How to report Connector/Net Problems or Bugs

If you encounter difficulties or problems with Connector/Net, contact the Connector/Net community Section 20.2.8.1, “Connector/Net Community Support”.

You should first try to execute the same SQL statements and commands from the `mysql` client program or from `admndemo`. This helps you determine whether the error is in Connector/Net or MySQL.

If reporting a problem, you should ideally include the following information with the email:

- Operating system and version
- Connector/Net version
- MySQL server version
- Copies of error messages or other unexpected output
- Simple reproducible sample

Remember that the more information you can supply to us, the more likely it is that we can fix the problem.

If you believe the problem to be a bug, then you must report the bug through http://bugs.mysql.com/.

20.2.8.3. Connector/Net Change History

The Connector/Net Change History (Changelog) is located with the main Changelog for MySQL. See Section D.3, “MySQL Connector/Net Change History”.

20.2.9. Connector/Net FAQ

Questions

- 21.2.9.1: How do I obtain the value of an auto-incremented column?

Questions and Answers

21.2.9.1: How do I obtain the value of an auto-incremented column?

When using `CommandBuilder`, setting `ReturnGeneratedIdentifiers` property to `true` no longer works, as `CommandBuilder` does not add `last_insert_id()` by default.

CommandBuilder hooks up to the `DataAdapter.RowUpdating` event handler, which means it will get called for every row. It examines the command object and, if it is the same referenced object, it essentially rebuilds the object, thereby destroying your command text changes.

One approach to solving this problem is to clone the command object so you have a different actual reference:

```
dataAdapter.InsertCommand = cb.GetInsertCommand().Clone()
```

This will work, but since the CommandBuilder is still connected to the DataAdapter, the RowUpdating event will still fire and performance will be hit. To stop that, once all your commands have been added you need to disconnect the CommandBuilder from the DataAdapter:

```
cb.DataAdapter = null;
```

The last requirement is to make sure the `id` that is returned by `last_insert_id()` has the correct name. For example:

```
SELECT last_insert_id() AS id
```

A complete working example is shown here:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using System.Data;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace GetAutoIncId
{
    class Program
    {
        static void Main(string[] args)
        {
            string connStr = "server=localhost;user=root;database=TestDB;port=3306;password=******;";
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql = "SELECT * FROM TestTable";

                MySqlDataAdapter da = new MySqlDataAdapter(sql, conn);
                MySqlCommandBuilder cb = new MySqlCommandBuilder(da);

                MySqlCommand cmd = new MySqlCommand();
                cmd.Connection = conn;
                cmd.CommandText = sql;
                // use Cloned object to avoid .NET rebuilding the object, and
                // thereby throwing away our command text additions.
                MySqlCommand insertCmd = cb.GetInsertCommand().Clone();
                insertCmd.CommandText = insertCmd.CommandText + ";SELECT last_insert_id() AS id";
                insertCmd.UpdatedRowSource = UpdateRowSource.FirstReturnedRecord;
                da.InsertCommand = insertCmd;
                cb.DataAdapter = null; // Unhook RowUpdating event handler

                DataTable dt = new DataTable();
                da.Fill(dt);

                DataRow row = dt.NewRow();
                row["name"] = "Joe Smith";

                dt.Rows.Add(row);
                da.Update(dt);

                System.Console.WriteLine("ID after update: " + row["id"]);
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }

            conn.Close();
            Console.WriteLine("Done.");
        }
    }
}
```

20.3. MySQL Connector/J

MySQL provides connectivity for client applications developed in the Java programming language through a JDBC driver, which is called MySQL Connector/J.

MySQL Connector/J is a JDBC Type 4 driver. Different versions are available that are compatible with the JDBC 3.0 and JDBC 4.0 specifications. The Type 4 designation means that the driver is pure-Java implementation of the MySQL protocol and does not rely on the MySQL client libraries.

Although JDBC is useful by itself, we would hope that if you are not familiar with JDBC that after reading the first few sections of this manual, that you would avoid using naked JDBC for all but the most trivial problems and consider using one of the popular persistence frameworks such as Hibernate, Spring's JDBC templates or Ibatis SQL Maps to do the majority of repetitive work and heavier lifting that is sometimes required with JDBC.

This section is not designed to be a complete JDBC tutorial. If you need more information about using JDBC you might be interested in the following online tutorials that are more in-depth than the information presented here:

- JDBC Basics: A tutorial from Sun covering beginner topics in JDBC
- JDBC Short Course: A more in-depth tutorial from Sun and JGuru

Key topics:

- For help with connection strings, connection options setting up your connection through JDBC, see Section 20.3.4.1, “Driver/Datasource Class Names, URL Syntax and Configuration Properties for Connector/J”.
- For tips on using Connector/J and JDBC with generic J2EE toolkits, see Section 20.3.5.2, “Using Connector/J with J2EE and Other Java Frameworks”.
- Developers using the Tomcat server platform, see Section 20.3.5.2.2, “Using Connector/J with Tomcat”.
- Developers using JBoss, see Section 20.3.5.2.3, “Using Connector/J with JBoss”.
- Developers using Spring, see Section 20.3.5.2.4, “Using Connector/J with Spring”.
- Developers using GlassFish (Sun Application Server), see Section 20.3.5.2.5, “Using Connector/J with GlassFish”.

20.3.1. Connector/J Versions

There are currently four versions of MySQL Connector/J available:

- Connector/J 5.1 is the Type 4 pure Java JDBC driver, which conforms to the JDBC 3.0 and JDBC 4.0 specifications. It provides compatibility with all the functionality of MySQL, including 4.1, 5.0, 5.1, 5.4 and 5.5. Connector/J 5.1 provides ease of development features, including auto-registration with the Driver Manager, standardized validity checks, categorized SQLExceptions, support for the JDBC-4.0 XML processing, per connection client information, `NCHAR`, `NVARCHAR` and `NCLOB` types. This release also includes all bug fixes up to and including Connector/J 5.0.6.
- Connector/J 5.0 provides support for all the functionality offered by Connector/J 3.1 and includes distributed transaction (XA) support.
- Connector/J 3.1 was designed for connectivity to MySQL 4.1 and MySQL 5.0 servers and provides support for all the functionality in MySQL 5.0 except distributed transaction (XA) support.
- Connector/J 3.0 provides core functionality and was designed with connectivity to MySQL 3.x or MySQL 4.1 servers, although it will provide basic compatibility with later versions of MySQL. Connector/J 3.0 does not support server-side prepared statements, and does not support any of the features in versions of MySQL later than 4.1.

The following table summarizes the Connector/J versions available:

Connector/J version	Driver Type	JDBC version	MySQL Server version	Status
5.1	4	3.0, 4.0	4.1, 5.0, 5.1, 5.4, 5.5	Recommended version
5.0	4	3.0	4.1, 5.0	Released version
3.1	4	3.0	4.1, 5.0	Obsolete
3.0	4	3.0	3.x, 4.1	Obsolete

The current recommended version for Connector/J is 5.1. This guide covers all four connector versions, with specific notes given where a setting applies to a specific option.

20.3.1.1. Java Versions Supported

The following table summarizes Connector/J Java dependencies:

Connector/J version	Java RTE required	JDK required (to build source code)
5.1	1.5.x, 1.6.x	1.6.x and 1.5.x
5.0	1.3.x, 1.4.x, 1.5.x, 1.6.x	1.4.2, 1.5.x, 1.6.x
3.1	1.2.x, 1.3.x, 1.4.x, 1.5.x, 1.6.x	1.4.2, 1.5.x, 1.6.x
3.0	1.2.x, 1.3.x, 1.4.x, 1.5.x, 1.6.x	1.4.2, 1.5.x, 1.6.x

MySQL Connector/J does not support JDK-1.1.x or JDK-1.0.x.

Because of the implementation of `java.sql.Savepoint`, Connector/J 3.1.0 and newer will not run on a Java runtime older than 1.4 unless the class verifier is turned off (by setting the `-Xverify:none` option to the Java runtime). This is because the class verifier will try to load the class definition for `java.sql.Savepoint` even though it is not accessed by the driver unless you actually use savepoint functionality.

Caching functionality provided by Connector/J 3.1.0 or newer is also not available on JVMs older than 1.4.x, as it relies on `java.util.LinkedHashMap` which was first available in JDK-1.4.0.

If you are building Connector/J from source code using the source distribution (see Section 20.3.2.4, “Installing from the Development Source Tree”) then you must use JDK 1.4.2 or newer to compile the Connector package. For Connector/J 5.1 you must have both JDK-1.6.x. and JDK-1.5.x installed to be able to build the source code.

20.3.2. Connector/J Installation

You can install the Connector/J package using either the binary or source distribution. The binary distribution provides the easiest method for installation; the source distribution enables you to customize your installation further. With either solution, you must manually add the Connector/J location to your Java `CLASSPATH`.

If you are upgrading from a previous version, read the upgrade information before continuing. See Section 20.3.2.3, “Upgrading from an Older Version”.

Connector/J is also available as part of the Maven project. More information, and the Connector/J JAR files can be found at the Maven repository.

20.3.2.1. Installing Connector/J from a Binary Distribution

The easiest method of installation is to use the binary distribution of the Connector/J package. The binary distribution is available either as a Tar/Gzip or Zip file which you must extract to a suitable location and then optionally make the information about the package available by changing your `CLASSPATH` (see Section 20.3.2.2, “Installing the Driver and Configuring the `CLASSPATH`”).

MySQL Connector/J is distributed as a .zip or .tar.gz archive containing the sources, the class files, and the JAR archive named `mysql-connector-java-[version]-bin.jar`, and starting with Connector/J 3.1.8 a debug build of the driver in a file named `mysql-connector-java-[version]-bin-g.jar`.

Starting with Connector/J 3.1.9, the `.class` files that constitute the JAR files are only included as part of the driver JAR file.

You should not use the debug build of the driver unless instructed to do so when reporting a problem or a bug, as it is not designed to be run in production environments, and will have adverse performance impact when used. The debug binary also depends on the Aspect/J runtime library, which is located in the `src/lib/aspectjrt.jar` file that comes with the Connector/J distribution.

You will need to use the appropriate graphical or command-line utility to extract the distribution (for example, WinZip for the .zip archive, and `tar` for the .tar.gz archive). Because there are potentially long file names in the distribution, we use the GNU tar archive format. You will need to use GNU tar (or an application that understands the GNU tar archive format) to unpack the .tar.gz variant of the distribution.

20.3.2.2. Installing the Driver and Configuring the `CLASSPATH`

Once you have extracted the distribution archive, you can install the driver by placing `mysql-connector-java-[version]-bin.jar` in your classpath, either by adding the full path to it to your `CLASSPATH` environment variable, or by directly specifying it with the command line switch -cp when starting your JVM.

If you are going to use the driver with the JDBC DriverManager, you would use `com.mysql.jdbc.Driver` as the class that implements `java.sql.Driver`.

You can set the `CLASSPATH` environment variable under UNIX, Linux or Mac OS X either locally for a user within their `.profile`, `.login` or other login file. You can also set it globally by editing the global `/etc/profile` file.

For example, under a C shell (csh, tcsh) you would add the Connector/J driver to your `CLASSPATH` using the following:

```
shell> setenv CLASSPATH /path/mysql-connector-java-[ver]-bin.jar:$CLASSPATH
```

Or with a Bourne-compatible shell (sh, ksh, bash):

```
shell> export set CLASSPATH=/path/mysql-connector-java-[ver]-bin.jar:$CLASSPATH
```

Within Windows 2000, Windows XP, Windows Server 2003 and Windows Vista, you must set the environment variable through the System Control Panel.

If you want to use MySQL Connector/J with an application server such as GlassFish, Tomcat or JBoss, you will have to read your vendor's documentation for more information on how to configure third-party class libraries, as most application servers ignore the `CLASSPATH` environment variable. For configuration examples for some J2EE application servers, see Section 20.3.5.2, “Using Connector/J with J2EE and Other Java Frameworks”. However, the authoritative source for JDBC connection pool configuration information for your particular application server is the documentation for that application server.

If you are developing servlets or JSPs, and your application server is J2EE-compliant, you can put the driver's .jar file in the WEB-INF/lib subdirectory of your webapp, as this is a standard location for third party class libraries in J2EE web applications.

You can also use the `MysqlDataSource` or `MysqlConnectionPoolDataSource` classes in the `com.mysql.jdbc.jdbc2.optional` package, if your J2EE application server supports or requires them. Starting with Connector/J 5.0.0, the `javax.sql.XADataSource` interface is implemented using the `com.mysql.jdbc.jdbc2.optional.MysqlXADataSource` class, which supports XA distributed transactions when used in combination with MySQL server version 5.0.

The various `MysqlDataSource` classes support the following parameters (through standard set mutators):

- user
- password
- serverName (see the previous section about fail-over hosts)
- databaseName
- port

20.3.2.3. Upgrading from an Older Version

We try to keep the upgrade process as easy as possible, however as is the case with any software, sometimes changes need to be made in new versions to support new features, improve existing functionality, or comply with new standards.

This section has information about what users who are upgrading from one version of Connector/J to another (or to a new version of the MySQL server, with respect to JDBC functionality) should be aware of.

20.3.2.3.1. Upgrading from MySQL Connector/J 3.0 to 3.1

Connector/J 3.1 is designed to be backward-compatible with Connector/J 3.0 as much as possible. Major changes are isolated to new functionality exposed in MySQL-4.1 and newer, which includes Unicode character sets, server-side prepared statements, SQL-State codes returned in error messages by the server and various performance enhancements that can be enabled or disabled using configuration properties.

- **Unicode Character Sets**: See the next section, as well as Section 9.1, “Character Set Support”, for information on this new feature of MySQL. If you have something misconfigured, it will usually show up as an error with a message similar to `Illegal mix of collations`.
- **Server-side Prepared Statements**: Connector/J 3.1 will automatically detect and use server-side prepared statements when they are available (MySQL server version 4.1.0 and newer).

  Starting with version 3.1.7, the driver scans SQL you are preparing using all variants of `Connection.prepareStatement()` to determine if it is a supported type of statement to prepare on the server side, and if it is not supported by the server, it instead prepares it as a client-side emulated prepared statement. You can disable this feature by passing emulateUnsupportedPstmts=false in your JDBC URL.

If your application encounters issues with server-side prepared statements, you can revert to the older client-side emulated prepared statement code that is still presently used for MySQL servers older than 4.1.0 with the connection property useServerPrepStmts=false

- **Datetimes** with all-zero components (`0000-00-00 ...`): These values can not be represented reliably in Java. Connector/J 3.0.x always converted them to `NULL` when being read from a ResultSet.

  Connector/J 3.1 throws an exception by default when these values are encountered as this is the most correct behavior according to the JDBC and SQL standards. This behavior can be modified using the zeroDateTimeBehavior configuration property. The permissible values are:

  - `exception` (the default), which throws an SQLException with an SQLState of `S1009`.
  - `convertToNull`, which returns `NULL` instead of the date.
  - `round`, which rounds the date to the nearest closest value which is `0001-01-01`.

  Starting with Connector/J 3.1.7, `ResultSet.getString()` can be decoupled from this behavior using noDatetimeStringSync=true (the default value is `false`) so that you can retrieve the unaltered all-zero value as a String. It should be noted that this also precludes using any time zone conversions, therefore the driver will not allow you to enable noDatetimeStringSync and useTimezone at the same time.

- **New SQLState Codes**: Connector/J 3.1 uses SQL:1999 SQLState codes returned by the MySQL server (if supported), which are different from the legacy X/Open state codes that Connector/J 3.0 uses. If connected to a MySQL server older than MySQL-4.1.0 (the oldest version to return SQLStates as part of the error code), the driver will use a built-in mapping. You can revert to the old mapping by using the configuration property useSqlStateCodes=false.

- **`ResultSet.getString()`**: Calling `ResultSet.getString()` on a `BLOB` column will now return the address of the `byte[]` array that represents it, instead of a `String` representation of the `BLOB`. `BLOB` values have no character set, so they cannot be converted to `java.lang.String`s without data loss or corruption.

  To store strings in MySQL with LOB behavior, use one of the `TEXT` types, which the driver will treat as a `java.sql.Clob`.

- **Debug builds**: Starting with Connector/J 3.1.8 a debug build of the driver in a file named `mysql-connector-java-[version]-bin-g.jar` is shipped alongside the normal binary jar file that is named `mysql-connector-java-[version]-bin.jar`.

  Starting with Connector/J 3.1.9, we do not ship the .class files unbundled, they are only available in the JAR archives that ship with the driver.

  You should not use the debug build of the driver unless instructed to do so when reporting a problem or bug, as it is not designed to be run in production environments, and will have adverse performance impact when used. The debug binary also depends on the Aspect/J runtime library, which is located in the `src/lib/aspectjrt.jar` file that comes with the Connector/J distribution.

20.3.2.3.2. Upgrading to MySQL Connector/J 5.1.x

- In Connector/J 5.0.x and earlier, the alias for a table in a `SELECT` statement is returned when accessing the result set metadata using `ResultSetMetaData.getColumnName()`. This behavior however is not JDBC compliant, and in Connector/J 5.1 this behavior was changed so that the original table name, rather than the alias, is returned.

  The JDBC-compliant behavior is designed to let API users reconstruct the DML statement based on the metadata within `ResultSet` and `ResultSetMetaData`.

  You can get the alias for a column in a result set by calling `ResultSetMetaData.getColumnLabel()`. If you want to use the old noncompliant behavior with `ResultSetMetaData.getColumnName()`, use the `useOldAliasMetadataBehavior` option and set the value to `true`.

  In Connector/J 5.0.x the default value of `useOldAliasMetadataBehavior` was true, but in Connector/J 5.1 this was changed to a default value of false.

20.3.2.3.3. JDBC-Specific Issues When Upgrading to MySQL Server 4.1 or Newer

- *Using the UTF-8 Character Encoding* - Prior to MySQL server version 4.1, the UTF-8 character encoding was not supported by the server, however the JDBC driver could use it, allowing storage of multiple character sets in latin1 tables on the server.

Starting with MySQL-4.1, this functionality is deprecated. If you have applications that rely on this functionality, and can not upgrade them to use the official Unicode character support in MySQL server version 4.1 or newer, you should add the following property to your connection URL:

```
useOldUTF8Behavior=true
```

- *Server-side Prepared Statements* - Connector/J 3.1 will automatically detect and use server-side prepared statements when they are available (MySQL server version 4.1.0 and newer). If your application encounters issues with server-side prepared statements, you can revert to the older client-side emulated prepared statement code that is still presently used for MySQL servers older than 4.1.0 with the following connection property:

  ```
  useServerPrepStmts=false
  ```

20.3.2.4. Installing from the Development Source Tree

> **Caution**
>
> You should read this section only if you are interested in helping us test our new code. If you just want to get MySQL Connector/J up and running on your system, you should use a standard binary release distribution.

To install MySQL Connector/J from the development source tree, make sure that you have the following prerequisites:

- A Bazaar client, to check out the sources from our Launchpad repository (available from http://bazaar-vcs.org/).
- Apache Ant version 1.7 or newer (available from http://ant.apache.org/).
- JDK 1.4.2 or later. Although MySQL Connector/J can be be used with older JDKs, to compile it from source you must have at least JDK 1.4.2. If you are building Connector/J 5.1 you will need JDK 1.6.x and an older JDK such as JDK 1.5.x. You will then need to point your JAVA_HOME environment variable at the older installation.

The source code repository for MySQL Connector/J is located on Launchpad at https://code.launchpad.net/connectorj.

To check out and compile a specific branch of MySQL Connector/J, follow these steps:

1. Check out the latest code from the branch that you want with one of the following commands.

   To check out the latest development branch use:

   ```
   shell> bzr branch lp:connectorj
   ```

   This creates a `connectorj` subdirectory in the current directory that contains the latest sources for the requested branch.

   To check out the latest 5.1 code use:

   ```
   shell> bzr branch lp:connectorj/5.1
   ```

   This will create a `5.1` subdirectory in the current directory containing the latest 5.1 code.

2. If you are building Connector/J 5.1 make sure that you have both JDK 1.6.x installed and an older JDK such as JDK 1.5.x. This is because Connector/J supports both JDBC 3.0 (which was prior to JDK 1.6.x) and JDBC 4.0. Set your JAVA_HOME environment variable to the path of the older JDK installation.

3. Change location to either the `connectorj` or `5.1` directory, depending on which branch you want to build, to make it your current working directory. For example:

   ```
   shell> cd connectorj
   ```

4. If you are building Connector/J 5.1 you need to edit the `build.xml` to reflect the location of your JDK 1.6.x installation. The lines that you need to change are:

   ```
               <property name="com.mysql.jdbc.java6.javac" value="C:\jvms\jdk1.6.0\bin\javac.exe" />
               <property name="com.mysql.jdbc.java6.rtjar" value="C:\jvms\jdk1.6.0\jre\lib\rt.jar" />
   ```

   Alternatively, you can set the value of these property names through the Ant `-D` option.

5. Issue the following command to compile the driver and create a `.jar` file suitable for installation:

   ```
   shell> ant dist
   ```

   This creates a `build` directory in the current directory, where all build output will go. A directory is created in the `build` directory that includes the version number of the sources you are building from. This directory contains the sources, compiled `.class` files, and a `.jar` file suitable for deployment. For other possible targets, including ones that will create a fully packaged distribution, issue the following command:

   ```
   shell> ant -projecthelp
   ```

6. A newly created `.jar` file containing the JDBC driver will be placed in the directory `build/mysql-connector-java-[version]`.

   Install the newly created JDBC driver as you would a binary `.jar` file that you download from MySQL by following the instructions in Section 20.3.2.2, “Installing the Driver and Configuring the `CLASSPATH`”.

A package containing both the binary and source code for Connector/J 5.1 can also be found at the following location: Connector/J 5.1 Download

20.3.3. Connector/J Examples

Examples of using Connector/J are located throughout this document, this section provides a summary and links to these examples.

- Example 20.1, “Connector/J: Obtaining a connection from the `DriverManager`”
- Example 20.2, “Connector/J: Using java.sql.Statement to execute a `SELECT` query”
- Example 20.3, “Connector/J: Calling Stored Procedures”
- Example 20.4, “Connector/J: Using `Connection.prepareCall()`”
- Example 20.5, “Connector/J: Registering output parameters”
- Example 20.6, “Connector/J: Setting `CallableStatement` input parameters”
- Example 20.7, “Connector/J: Retrieving results and output parameter values”
- Example 20.8, “Connector/J: Retrieving `AUTO_INCREMENT` column values using `Statement.getGeneratedKeys()`”
- Example 20.9, “Connector/J: Retrieving `AUTO_INCREMENT` column values using `SELECT LAST_INSERT_ID()`”
- Example 20.10, “Connector/J: Retrieving `AUTO_INCREMENT` column values in `Updatable ResultSets`”
- Example 20.11, “Connector/J: Using a connection pool with a J2EE application server”
- Example 20.12, “Connector/J: Example of transaction with retry logic”

20.3.4. Connector/J (JDBC) Reference

This section of the manual contains reference material for MySQL Connector/J, some of which is automatically generated during the Connector/J build process.

20.3.4.1. Driver/Datasource Class Names, URL Syntax and Configuration Properties for Connector/J

The name of the class that implements java.sql.Driver in MySQL Connector/J is `com.mysql.jdbc.Driver`. The `org.gjt.mm.mysql.Driver` class name is also usable to remain backward-compatible with MM.MySQL. You should use this class name when registering the driver, or when otherwise configuring software to use MySQL Connector/J.

The JDBC URL format for MySQL Connector/J is as follows, with items in square brackets ([,]) being optional:

```
jdbc:mysql://[host][,failoverhost...][:port]/[database] »
[?propertyName1][=propertyValue1][&propertyName2][=propertyValue2]...
```

If the host name is not specified, it defaults to 127.0.0.1. If the port is not specified, it defaults to 3306, the default port number for

MySQL servers.

```
jdbc:mysql://[host:port],[host:port].../[database] »
[?propertyName1][=propertyValue1][&propertyName2][=propertyValue2]...
```

If the database is not specified, the connection will be made with no default database. In this case, you will need to either call the `setCatalog()` method on the Connection instance or fully specify table names using the database name (that is, `SELECT dbname.tablename.colname FROM dbname.tablename...`) in your SQL. Not specifying the database to use upon connection is generally only useful when building tools that work with multiple databases, such as GUI database managers.

> **Note**
>
> JDBC clients should never employ the `USE database` statement to specify the desired database, they should always use the `Connection.setCatalog()` method instead.

MySQL Connector/J has fail-over support. This enables the driver to fail-over to any number of slave hosts and still perform read-only queries. Fail-over only happens when the connection is in an `autoCommit(true)` state, because fail-over can not happen reliably when a transaction is in progress. Most application servers and connection pools set `autoCommit` to `true` at the end of every transaction/connection use.

The fail-over functionality has the following behavior:

- If the URL property autoReconnect is false: Failover only happens at connection initialization, and failback occurs when the driver determines that the first host has become available again.
- If the URL property autoReconnect is true: Failover happens when the driver determines that the connection has failed (before *every* query), and falls back to the first host when it determines that the host has become available again (after `queriesBeforeRetryMaster` queries have been issued).

In either case, whenever you are connected to a "failed-over" server, the connection will be set to read-only state, so queries that would modify data will have exceptions thrown (the query will **never** be processed by the MySQL server).

Configuration properties define how Connector/J will make a connection to a MySQL server. Unless otherwise noted, properties can be set for a DataSource object or for a Connection object.

Configuration Properties can be set in one of the following ways:

- Using the set*() methods on MySQL implementations of java.sql.DataSource (which is the preferred method when using implementations of java.sql.DataSource):
  - com.mysql.jdbc.jdbc2.optional.MysqlDataSource
  - com.mysql.jdbc.jdbc2.optional.MysqlConnectionPoolDataSource
- As a key/value pair in the java.util.Properties instance passed to `DriverManager.getConnection()` or `Driver.connect()`
- As a JDBC URL parameter in the URL given to `java.sql.DriverManager.getConnection()`, `java.sql.Driver.connect()` or the MySQL implementations of the `javax.sql.DataSource` `setURL()` method.

  > **Note**
  >
  > If the mechanism you use to configure a JDBC URL is XML-based, you will need to use the XML character literal &amp; to separate configuration parameters, as the ampersand is a reserved character for XML.

The properties are listed in the following tables.

Connection/Authentication.

Property Name	**Definition**	**Default Value**	**Since Version**
user	The user to connect as		all versions
password	The password to use when connecting		all versions
socketFactory	The name of the class that the driver should use for creating socket connections to the server. This class must implement the	com.mysql.jd-	3.0.3

	interface 'com.mysql.jdbc.SocketFactory' and have public no-args constructor.	bc.Standard SocketFactory	
connectTimeout	Timeout for socket connect (in milliseconds), with 0 being no timeout. Only works on JDK-1.4 or newer. Defaults to '0'.	0	3.0.1
socketTimeout	Timeout on network socket operations (0, the default means no timeout).	0	3.0.1
connectionLifecycleInterceptors	A comma-delimited list of classes that implement "com.mysql.jdbc.ConnectionLifecycleInterceptor" that should notified of connection lifecycle events (creation, destruction, commit, rollback, setCatalog and setAutoCommit) and potentially alter the execution of these commands. ConnectionLifecycleInterceptors are "stackable", more than one interceptor may be specified via the configuration property as a comma-delimited list, with the interceptors executed in order from left to right.		5.1.4
useConfigs	Load the comma-delimited list of configuration properties before parsing the URL or applying user-specified properties. These configurations are explained in the 'Configurations' of the documentation.		3.1.5
interactiveClient	Set the CLIENT_INTERACTIVE flag, which tells MySQL to timeout connections based on INTERACTIVE_TIMEOUT instead of WAIT_TIMEOUT	false	3.1.0
localSocketAddress	Hostname or IP address given to explicitly configure the interface that the driver will bind the client side of the TCP/IP connection to when connecting.		5.0.5
propertiesTransform	An implementation of com.mysql.jdbc.ConnectionPropertiesTransform that the driver will use to modify URL properties passed to the driver before attempting a connection		3.1.4
useCompression	Use zlib compression when communicating with the server (true/false)? Defaults to 'false'.	false	3.0.17

Networking.

Property Name	Definition	Default Value	Since Version
maxAllowedPacket	Maximum allowed packet size to send to server. If not set, the value of system variable 'max_allowed_packet' will be used to initialize this upon connecting. This value will not take effect if set larger than the value of 'max_allowed_packet'.	-1	5.1.8
tcpKeepAlive	If connecting using TCP/IP, should the driver set SO_KEEPALIVE?	true	5.0.7
tcpNoDelay	If connecting using TCP/IP, should the driver set SO_TCP_NODELAY (disabling the Nagle Algorithm)?	true	5.0.7
tcpRcvBuf	If connecting using TCP/IP, should the driver set SO_RCV_BUF to the given value? The default value of '0', means use the platform default value for this property)	0	5.0.7
tcpSndBuf	If connecting using TCP/IP, shuold the driver set SO_SND_BUF to the given value? The default value of '0', means use the platform default value for this property)	0	5.0.7
tcpTrafficClass	If connecting using TCP/IP, should the driver set traffic class or type-of-service fields ?See the documentation for java.net.Socket.setTrafficClass() for more information.	0	5.0.7

High Availability and Clustering.

Property Name	Definition	Default Value	Since Version
autoReconnect	Should the driver try to re-establish stale and/or dead connec-	false	1.1

	tions? If enabled the driver will throw an exception for a queries issued on a stale or dead connection, which belong to the current transaction, but will attempt reconnect before the next query issued on the connection in a new transaction. The use of this feature is not recommended, because it has side effects related to session state and data consistency when applications don't handle SQLExceptions properly, and is only designed to be used when you are unable to configure your application to handle SQLExceptions resulting from dead and stale connections properly. Alternatively, investigate setting the MySQL server variable "wait_timeout" to some high value rather than the default of 8 hours.		
autoReconnectForPools	Use a reconnection strategy appropriate for connection pools (defaults to 'false')	false	3.1.3
failOverReadOnly	When failing over in autoReconnect mode, should the connection be set to 'read-only'?	true	3.0.12
maxReconnects	Maximum number of reconnects to attempt if autoReconnect is true, default is '3'.	3	1.1
reconnectAtTxEnd	If autoReconnect is set to true, should the driver attempt reconnections at the end of every transaction?	false	3.0.10
retriesAllDown	When using loadbalancing, the number of times the driver should cycle through available hosts, attempting to connect. Between cycles, the driver will pause for 250ms if no servers are available.	120	5.1.6
initialTimeout	If autoReconnect is enabled, the initial time to wait between reconnect attempts (in seconds, defaults to '2').	2	1.1
roundRobinLoadBalance	When autoReconnect is enabled, and failoverReadonly is false, should we pick hosts to connect to on a round-robin basis?	false	3.1.2
queriesBeforeRetryMaster	Number of queries to issue before falling back to master when failed over (when using multi-host failover). Whichever condition is met first, 'queriesBeforeRetryMaster' or 'secondsBeforeRetryMaster' will cause an attempt to be made to reconnect to the master. Defaults to 50.	50	3.0.2
secondsBeforeRetryMaster	How long should the driver wait, when failed over, before attempting	30	3.0.2
selfDestructOnPingMaxOperations	=If set to a non-zero value, the driver will report close the connection and report failure when Connection.ping() or Connection.isValid(int) is called if the connnection's count of commands sent to the server exceeds this value.	0	5.1.6
selfDestructOnPingSecondsLifetime	If set to a non-zero value, the driver will report close the connection and report failure when Connection.ping() or Connection.isValid(int) is called if the connnection's lifetime exceeds this value.	0	5.1.6
resourceId	A globally unique name that identifies the resource that this datasource or connection is connected to, used for XAResource.isSameRM() when the driver can't determine this value based on hostnames used in the URL		5.0.1

Security.

Property Name	Definition	Default Value	Since Version
allowMultiQueries	Allow the use of ';' to delimit multiple queries during one statement (true/false), defaults to 'false'	false	3.1.1
useSSL	Use SSL when communicating with the server (true/false), defaults to 'false'	false	3.0.2
requireSSL	Require SSL connection if useSSL=true? (defaults to 'false').	false	3.1.0
verifyServerCertificate	If "useSSL" is set to "true", should the driver verify the server's certificate? When using this feature, the keystore parameters should be specified by the "clientCertificateKeyStore*" properties, rather than system properties.	true	5.1.6

clientCertificateKeyStoreUrl	URL to the client certificate KeyStore (if not specified, use defaults)		5.1.0
clientCertificateKeyStoreType	KeyStore type for client certificates (NULL or empty means use the default, which is "JKS". Standard keystore types supported by the JVM are "JKS" and "PKCS12", your environment may have more available depending on what security products are installed and available to the JVM.	JKS	5.1.0
clientCertificateKeyStorePassword	Password for the client certificates KeyStore		5.1.0
trustCertificateKeyStoreUrl	URL to the trusted root certificate KeyStore (if not specified, use defaults)		5.1.0
trustCertificateKeyStoreType	KeyStore type for trusted root certificates (NULL or empty means use the default, which is "JKS". Standard keystore types supported by the JVM are "JKS" and "PKCS12", your environment may have more available depending on what security products are installed and available to the JVM.	JKS	5.1.0
trustCertificateKeyStorePassword	Password for the trusted root certificates KeyStore		5.1.0
allowLoadLocalInfile	Should the driver allow use of 'LOAD DATA LOCAL INFILE...' (defaults to 'true').	true	3.0.3
allowUrlInLocalInfile	Should the driver allow URLs in 'LOAD DATA LOCAL INFILE' statements?	false	3.1.4
paranoid	Take measures to prevent exposure sensitive information in error messages and clear data structures holding sensitive data when possible? (defaults to 'false')	false	3.0.1
passwordCharacterEncoding	What character encoding is used for passwords? Leaving this set to the default value (null), uses the platform character set, which works for ISO8859_1 (i.e. "latin1") passwords. For passwords in other character encodings, the encoding will have to be specified with this property, as it's not possible for the driver to auto-detect this.		5.1.7

Performance Extensions.

Property Name	Definition	Default Value	Since Version
callableStmtCacheSize	If 'cacheCallableStmts' is enabled, how many callable statements should be cached?	100	3.1.2
metadataCacheSize	The number of queries to cache ResultSetMetadata for if cacheResultSetMetaData is set to 'true' (default 50)	50	3.1.1
useLocalSessionState	Should the driver refer to the internal values of autocommit and transaction isolation that are set by Connection.setAutoCommit() and Connection.setTransactionIsolation() and transaction state as maintained by the protocol, rather than querying the database or blindly sending commands to the database for commit() or rollback() method calls?	false	3.1.7
useLocalTransactionState	Should the driver use the in-transaction state provided by the MySQL protocol to determine if a commit() or rollback() should actually be sent to the database?	false	5.1.7
prepStmtCacheSize	If prepared statement caching is enabled, how many prepared statements should be cached?	25	3.0.10
prepStmtCacheSqlLimit	If prepared statement caching is enabled, what's the largest SQL the driver will cache the parsing for?	256	3.0.10
alwaysSendSetIsolation	Should the driver always communicate with the database when Connection.setTransactionIsolation() is called? If set to false, the driver will only communicate with the database when the requested transaction isolation is different than the whichever is newer, the last value that was set via Connection.setTransactionIsolation(), or the value that was read from the server when the connection was established.	true	3.1.7
maintainTimeStats	Should the driver maintain various internal timers to enable idle time calculations as well as more verbose error messages when	true	3.1.9

	the connection to the server fails? Setting this property to false removes at least two calls to System.getCurrentTimeMillis() per query.		
useCursorFetch	If connected to MySQL > 5.0.2, and setFetchSize() > 0 on a statement, should that statement use cursor-based fetching to retrieve rows?	false	5.0.0
blobSendChunkSize	Chunk to use when sending BLOB/CLOBs via ServerPreparedStatements	1048576	3.1.9
cacheCallableStmts	Should the driver cache the parsing stage of CallableStatements	false	3.1.2
cachePrepStmts	Should the driver cache the parsing stage of PreparedStatements of client-side prepared statements, the "check" for suitability of server-side prepared and server-side prepared statements themselves?	false	3.0.10
cacheResultSetMetadata	Should the driver cache ResultSetMetaData for Statements and PreparedStatements? (Req. JDK-1.4+, true/false, default 'false')	false	3.1.1
cacheServerConfiguration	Should the driver cache the results of 'SHOW VARIABLES' and 'SHOW COLLATION' on a per-URL basis?	false	3.1.5
defaultFetchSize	The driver will call setFetchSize(n) with this value on all newly-created Statements	0	3.1.9
dontTrackOpenResources	The JDBC specification requires the driver to automatically track and close resources, however if your application doesn't do a good job of explicitly calling close() on statements or result sets, this can cause memory leakage. Setting this property to true relaxes this constraint, and can be more memory efficient for some applications.	false	3.1.7
dynamicCalendars	Should the driver retrieve the default calendar when required, or cache it per connection/session?	false	3.1.5
elideSetAutoCommits	If using MySQL-4.1 or newer, should the driver only issue 'set autocommit=n' queries when the server's state doesn't match the requested state by Connection.setAutoCommit(boolean)?	false	3.1.3
enableQueryTimeouts	When enabled, query timeouts set via Statement.setQueryTimeout() use a shared java.util.Timer instance for scheduling. Even if the timeout doesn't expire before the query is processed, there will be memory used by the TimerTask for the given timeout which won't be reclaimed until the time the timeout would have expired if it hadn't been cancelled by the driver. High-load environments might want to consider disabling this functionality.	true	5.0.6
holdResultsOpenOverStatementClose	Should the driver leave the result sets open on Statement.close() (enabling violates JDBC specification)	false	3.1.7
largeRowSizeThreshold	What size result set row should the JDBC driver consider "large", and thus use a more memory-efficient way of representing the row internally?	2048	5.1.1
loadBalanceStrategy	If using a load-balanced connection to connect to SQL nodes in a MySQL Cluster/NDB configuration (by using the URL prefix "jdbc:mysql:loadbalance://"), which load balancing algorithm should the driver use: (1) "random" - the driver will pick a random host for each request. This tends to work better than round-robin, as the randomness will somewhat account for spreading loads where requests vary in response time, while round-robin can sometimes lead to overloaded nodes if there are variations in response times across the workload. (2) "bestResponseTime" - the driver will route the request to the host that had the best response time for the previous transaction.	random	5.0.6
locatorFetchBufferSize	If 'emulateLocators' is configured to 'true', what size buffer should be used when fetching BLOB data for getBinaryInputStream?	1048576	3.2.1
rewriteBatchedStatements	Should the driver use multiqueries (irregardless of the setting of "allowMultiQueries") as well as rewriting of prepared statements for INSERT into multi-value inserts when executeBatch() is called? Notice that this has the potential for SQL injection if using plain java.sql.Statements and your code doesn't sanitize	false	3.1.13

	input correctly. Notice that for prepared statements, server-side prepared statements can not currently take advantage of this rewrite option, and that if you don't specify stream lengths when using PreparedStatement.set*Stream(), the driver won't be able to determine the optimum number of parameters per batch and you might receive an error from the driver that the resultant packet is too large. Statement.getGeneratedKeys() for these rewritten statements only works when the entire batch includes INSERT statements.		
useDirectRowUnpack	Use newer result set row unpacking code that skips a copy from network buffers to a MySQL packet instance and instead reads directly into the result set row data buffers.	true	5.1.1
useDynamicCharsetInfo	Should the driver use a per-connection cache of character set information queried from the server when necessary, or use a built-in static mapping that is more efficient, but isn't aware of custom character sets or character sets implemented after the release of the JDBC driver?	true	5.0.6
useFastDateParsing	Use internal String->Date/Time/Timestamp conversion routines to avoid excessive object creation?	true	5.0.5
useFastIntParsing	Use internal String->Integer conversion routines to avoid excessive object creation?	true	3.1.4
useJvmCharsetConverters	Always use the character encoding routines built into the JVM, rather than using lookup tables for single-byte character sets?	false	5.0.1
useReadAheadInput	Use newer, optimized non-blocking, buffered input stream when reading from the server?	true	3.1.5

Debugging/Profiling.

Property Name	**Definition**	**Default Value**	**Since Version**
logger	The name of a class that implements "com.mysql.jdbc.log.Log" that will be used to log messages to. (default is "com.mysql.jdbc.log.StandardLogger", which logs to STDERR)	com.mysql.jdbc.log.StandardLogger	3.1.1
gatherPerfMetrics	Should the driver gather performance metrics, and report them via the configured logger every 'reportMetricsIntervalMillis' milliseconds?	false	3.1.2
profileSQL	Trace queries and their execution/fetch times to the configured logger (true/false) defaults to 'false'	false	3.1.0
profileSql	Deprecated, use 'profileSQL' instead. Trace queries and their execution/fetch times on STDERR (true/false) defaults to 'false'		2.0.14
reportMetricsIntervalMillis	If 'gatherPerfMetrics' is enabled, how often should they be logged (in ms)?	30000	3.1.2
maxQuerySizeToLog	Controls the maximum length/size of a query that will get logged when profiling or tracing	2048	3.1.3
packetDebugBufferSize	The maximum number of packets to retain when 'enablePacketDebug' is true	20	3.1.3
slowQueryThresholdMillis	If 'logSlowQueries' is enabled, how long should a query (in ms) before it is logged as 'slow'?	2000	3.1.2
slowQueryThresholdNanos	If 'useNanosForElapsedTime' is set to true, and this property is set to a non-zero value, the driver will use this threshold (in nanosecond units) to determine if a query was slow.	0	5.0.7
useUsageAdvisor	Should the driver issue 'usage' warnings advising proper and efficient usage of JDBC and MySQL Connector/J to the log (true/false, defaults to 'false')?	false	3.1.1
autoGenerateTestcaseScript	Should the driver dump the SQL it is executing, including server-side prepared statements to STDERR?	false	3.1.9
autoSlowLog	Instead of using slowQueryThreshold* to determine if a query is slow enough to be logged, maintain statistics that allow the driver to determine queries that are outside the 99th percentile?	true	5.1.4

clientInfoProvider	The name of a class that implements the com.mysql.jdbc.JDBC4ClientInfoProvider interface in order to support JDBC-4.0's Connection.get/setClientInfo() methods	com.mysql.jdbc.JDBC4CommentClientInfoProvider	5.1.0
dumpMetadataOnColumnNotFound	Should the driver dump the field-level metadata of a result set into the exception message when ResultSet.findColumn() fails?	false	3.1.13
dumpQueriesOnException	Should the driver dump the contents of the query sent to the server in the message for SQLExceptions?	false	3.1.3
enablePacketDebug	When enabled, a ring-buffer of 'packetDebugBufferSize' packets will be kept, and dumped when exceptions are thrown in key areas in the driver's code	false	3.1.3
explainSlowQueries	If 'logSlowQueries' is enabled, should the driver automatically issue an 'EXPLAIN' on the server and send the results to the configured log at a WARN level?	false	3.1.2
includeInnodbStatusInDeadlockExceptions	Include the output of "SHOW ENGINE INNODB STATUS" in exception messages when deadlock exceptions are detected?	false	5.0.7
includeThreadDumpInDeadlockExceptions	Include a current Java thread dump in exception messages when deadlock exceptions are detected?	false	5.1.15
includeThreadNamesAsStatementComment	Include the name of the current thread as a comment visible in "SHOW PROCESSLIST", or in Innodb deadlock dumps, useful in correlation with "includeInnodbStatusInDeadlockExceptions=true" and "includeThreadDumpInDeadlockExceptions=true".	false	5.1.15
logSlowQueries	Should queries that take longer than 'slowQueryThresholdMillis' be logged?	false	3.1.2
logXaCommands	Should the driver log XA commands sent by MysqlXaConnection to the server, at the DEBUG level of logging?	false	5.0.5
profilerEventHandler	Name of a class that implements the interface com.mysql.jdbc.profiler.ProfilerEventHandler that will be used to handle profiling/tracing events.	com.mysql.jdbc.profiler.LoggingProfilerEventHandler	5.1.6
resultSetSizeThreshold	If the usage advisor is enabled, how many rows should a result set contain before the driver warns that it is suspiciously large?	100	5.0.5
traceProtocol	Should trace-level network protocol be logged?	false	3.1.2
useNanosForElapsedTime	For profiling/debugging functionality that measures elapsed time, should the driver try to use nanoseconds resolution if available (JDK >= 1.5)?	false	5.0.7

Miscellaneous.

Property Name	**Definition**	**Default Value**	**Since Version**
useUnicode	Forces the driver to use Unicode character encodings. Should only be set to false either when the driver can't determine the character set mapping (in which case, specify the Java character encoding in the characterEncoding property), or you are trying to force the driver to use a character set that MySQL doesn't natively support. Should be 'true' for all versions of MySQL 4.1 or higher unless you are trying to emulate the character set handling support provided in MySQL 4.0. Value is true/false, defaults to 'true'	true	1.1g
characterEncoding	If 'useUnicode' is set to true, what Java character encoding should the driver use when dealing with strings? (defaults is to 'autodetect'). If the encoding cannot be determined, then an exception will be raised.		1.1g

characterSetResults	Character set to tell the server to return results as.		3.0.13
connectionCollation	If set, tells the server to use this collation via 'set collation_connection'		3.0.13
useBlobToStoreUTF8OutsideBMP	Tells the driver to treat [MEDIUM/LONG]BLOB columns as [LONG]VARCHAR columns holding text encoded in UTF-8 that has characters outside the BMP (4-byte encodings), which MySQL server can't handle natively.	false	5.1.3
utf8OutsideBmpExcludedColumnNamePattern	When "useBlobToStoreUTF8OutsideBMP" is set to "true", column names matching the given regex will still be treated as BLOBs unless they match the regex specified for "utf8OutsideBmpIncludedColumnNamePattern". The regex must follow the patterns used for the java.util.regex package.		5.1.3
utf8OutsideBmpIncludedColumnNamePattern	Used to specify exclusion rules to "utf8OutsideBmpExcludedColumnNamePattern". The regex must follow the patterns used for the java.util.regex package.		5.1.3
loadBalanceEnableJMX	Enables JMX-based management of load-balanced connection groups, including live addition/removal of hosts from load-balancing pool.	false	5.1.13
sessionVariables	A comma-separated list of name/value pairs to be sent as SET SESSION ... to the server when the driver connects.		3.1.8
useColumnNamesInFindColumn	Prior to JDBC-4.0, the JDBC specification had a bug related to what could be given as a "column name" to ResultSet methods like findColumn(), or getters that took a String property. JDBC-4.0 clarified "column name" to mean the label, as given in an "AS" clause and returned by ResultSetMetaData.getColumnLabel(), and if no AS clause, the column name. Setting this property to "true" will give behavior that is congruent to JDBC-3.0 and earlier versions of the JDBC specification, but which because of the specification bug could give unexpected results. This property is preferred over "useOldAliasMetadataBehavior" unless you need the specific behavior that it provides with respect to ResultSetMetadata.	false	5.1.7
allowNanAndInf	Should the driver allow NaN or +/- INF values in PreparedStatement.setDouble()?	false	3.1.5
autoClosePStmtStreams	Should the driver automatically call .close() on streams/readers passed as arguments via set*() methods?	false	3.1.12
autoDeserialize	Should the driver automatically detect and de-serialize objects stored in BLOB fields?	false	3.1.5
blobsAreStrings	Should the driver always treat BLOBs as Strings - specifically to work around dubious metadata returned by the server for GROUP BY clauses?	false	5.0.8
capitalizeTypeNames	Capitalize type names in DatabaseMetaData? (usually only useful when using WebObjects, true/false, defaults to 'false')	true	2.0.7
clobCharacterEncoding	The character encoding to use for sending and retrieving TEXT, MEDIUMTEXT and LONGTEXT values instead of the configured connection characterEncoding		5.0.0
clobberStreamingResults	This will cause a 'streaming' ResultSet to be automatically closed, and any outstanding data still streaming from the server to be discarded if another query is executed before all the data has been read from the server.	false	3.0.9
compensateOnDuplicateKeyUpdateCounts	Should the driver compensate for the update counts of "ON DUPLICATE KEY" INSERT statements (2 = 1, 0 = 1) when using prepared statements?	false	5.1.7
continueBatchOnError	Should the driver continue processing batch commands if one statement fails. The JDBC spec allows either way (defaults to 'true').	true	3.0.3
createDatabaseIfNotExist	Creates the database given in the URL if it doesn't yet exist. Assumes the configured user has permissions to create databases.	false	3.1.9
emptyStringsConvertToZero	Should the driver allow conversions from empty string fields to numeric values of '0'?	true	3.1.8
emulateLocators	Should the driver emulate java.sql.Blobs with locators? With	false	3.1.0

	this feature enabled, the driver will delay loading the actual Blob data until the one of the retrieval methods (getInputStream(), getBytes(), and so forth) on the blob data stream has been accessed. For this to work, you must use a column alias with the value of the column to the actual name of the Blob. The feature also has the following restrictions: The SELECT that created the result set must reference only one table, the table must have a primary key; the SELECT must alias the original blob column name, specified as a string, to an alternate name; the SELECT must cover all columns that make up the primary key.		
emulateUnsupportedPstmts	Should the driver detect prepared statements that are not supported by the server, and replace them with client-side emulated versions?	true	3.1.7
exceptionInterceptors	Comma-delimited list of classes that implement com.mysql.jdbc.ExceptionInterceptor. These classes will be instantiated one per Connection instance, and all SQLExceptions thrown by the driver will be allowed to be intercepted by these interceptors, in a chained fashion, with the first class listed as the head of the chain.		5.1.8
functionsNeverReturnBlobs	Should the driver always treat data from functions returning BLOBs as Strings - specifically to work around dubious metadata returned by the server for GROUP BY clauses?	false	5.0.8
generateSimpleParameterMetadata	Should the driver generate simplified parameter metadata for PreparedStatements when no metadata is available either because the server couldn't support preparing the statement, or server-side prepared statements are disabled?	false	5.0.5
ignoreNonTxTables	Ignore non-transactional table warning for rollback? (defaults to 'false').	false	3.0.9
jdbcCompliantTruncation	This sets whether Connector/J should throw java.sql.DataTruncation exceptions when data is truncated. This is required by the JDBC specification when connected to a server that supports warnings (MySQL 4.1.0 and newer). This property has no effect if the server sql-mode includes STRICT_TRANS_TABLES. Note that if STRICT_TRANS_TABLES is not set, it will be set as a result of using this connection string option.	true	3.1.2
loadBalanceAutoCommitStatementRegex	When load-balancing is enabled for auto-commit statements (via loadBalanceAutoCommitStatementThreshold), the statement counter will only increment when the SQL matches the regular expression. By default, every statement issued matches.		5.1.15
loadBalanceAutoCommitStatementThreshold	When auto-commit is enabled, the number of statements which should be executed before triggering load-balancing to rebalance. Default value of 0 causes load-balanced connections to only rebalance when exceptions are encountered, or auto-commit is disabled and transactions are explicitly committed or rolled back.	0	5.1.15
loadBalanceBlacklistTimeout	Time in milliseconds between checks of servers which are unavailable.	0	5.1.0
loadBalanceConnectionGroup	Logical group of load-balanced connections within a classloader, used to manage different groups independently. If not specified, live management of load-balanced connections is disabled.		5.1.13
loadBalanceExceptionChecker	Fully-qualified class name of custom exception checker. The class must implement com.mysql.jdbc.LoadBalanceExceptionChecker interface, and is used to inspect SQLExceptions and determine whether they should trigger fail-over to another host in a load-balanced deployment.	com.mysql.jdbc.StandardLoadBalanceExceptionChecker	5.1.13
loadBalancePingTimeout	Time in milliseconds to wait for ping response from each of load-balanced physical connections when using load-balanced Connection.	0	5.1.13

loadBalanceSQLExceptionSubclassFailover	Comma-delimited list of classes/interfaces used by default load-balanced exception checker to determine whether a given SQLException should trigger failover. The comparison is done using Class.isInstance(SQLException) using the thrown SQLException.		5.1.13
loadBalanceSQLStateFailover	Comma-delimited list of SQLState codes used by default load-balanced exception checker to determine whether a given SQLException should trigger failover. The SQLState of a given SQLException is evaluated to determine whether it begins with any value in the comma-delimited list.		5.1.13
loadBalanceValidateConnectionOnSwapServer	Should the load-balanced Connection explicitly check whether the connection is live when swapping to a new physical connection at commit/rollback?	false	5.1.13
maxRows	The maximum number of rows to return (0, the default means return all rows).	-1	all versions
netTimeoutForStreamingResults	What value should the driver automatically set the server setting 'net_write_timeout' to when the streaming result sets feature is in use? (value has unit of seconds, the value '0' means the driver will not try and adjust this value)	600	5.1.0
noAccessToProcedureBodies	When determining procedure parameter types for CallableStatements, and the connected user can't access procedure bodies through "SHOW CREATE PROCEDURE" or select on mysql.proc should the driver instead create basic metadata (all parameters reported as IN VARCHARs, but allowing registerOutParameter() to be called on them anyway) instead of throwing an exception?	false	5.0.3
noDatetimeStringSync	Don't ensure that ResultSet.getDatetimeType().toString().equals(ResultSet.getString())	false	3.1.7
noTimezoneConversionForTimeType	Don't convert TIME values using the server timezone if 'useTimezone'='true'	false	5.0.0
nullCatalogMeansCurrent	When DatabaseMetadataMethods ask for a 'catalog' parameter, does the value null mean use the current catalog? When nullCatalogMeansCurrent is true the current catalog will be used if the catalog parameter is null. If nullCatalogMeansCurrent is false and the catalog parameter is null then the catalog parameter is not used to restrict the catalog search. (This is not JDBC-compliant, but follows legacy behavior from earlier versions of the driver)	true	3.1.8
nullNamePatternMatchesAll	Should DatabaseMetaData methods that accept *pattern parameters treat null the same as '%' (this is not JDBC-compliant, however older versions of the driver accepted this departure from the specification)	true	3.1.8
overrideSupportsIntegrityEnhancementFacility	Should the driver return "true" for DatabaseMetaData.supportsIntegrityEnhancementFacility() even if the database doesn't support it to workaround applications that require this method to return "true" to signal support of foreign keys, even though the SQL specification states that this facility contains much more than just foreign key support (one such application being OpenOffice)?	false	3.1.12
padCharsWithSpace	If a result set column has the CHAR type and the value does not fill the amount of characters specified in the DDL for the column, should the driver pad the remaining characters with space (for ANSI compliance)?	false	5.0.6
pedantic	Follow the JDBC spec to the letter.	false	3.0.0
pinGlobalTxToPhysicalConnection	When using XAConnections, should the driver ensure that operations on a given XID are always routed to the same physical connection? This allows the XAConnection to support "XA START ... JOIN" after "XA END" has been called	false	5.0.1
populateInsertRowWithDefaultValues	When using ResultSets that are CONCUR_UPDATABLE, should the driver pre-populate the "insert" row with default values from the DDL for the table used in the query so those values are immediately available for ResultSet accessors? This functionality requires a call to the database for metadata each time a	false	5.0.5

	result set of this type is created. If disabled (the default), the default values will be populated by the an internal call to refreshRow() which pulls back default values and/or values changed by triggers.		
processEscapeCodesForPrepStmts	Should the driver process escape codes in queries that are prepared?	true	3.1.12
queryTimeoutKillsConnection	If the timeout given in Statement.setQueryTimeout() expires, should the driver forcibly abort the Connection instead of attempting to abort the query?	false	5.1.9
relaxAutoCommit	If the version of MySQL the driver connects to does not support transactions, still allow calls to commit(), rollback() and setAutoCommit() (true/false, defaults to 'false')?	false	2.0.13
retainStatementAfterResultSetClose	Should the driver retain the Statement reference in a ResultSet after ResultSet.close() has been called. This is not JDBC-compliant after JDBC-4.0.	false	3.1.11
rollbackOnPooledClose	Should the driver issue a rollback() when the logical connection in a pool is closed?	true	3.0.15
runningCTS13	Enables workarounds for bugs in Sun's JDBC compliance testsuite version 1.3	false	3.1.7
serverTimezone	Override detection/mapping of timezone. Used when timezone from server doesn't map to Java timezone		3.0.2
statementInterceptors	A comma-delimited list of classes that implement "com.mysql.jdbc.StatementInterceptor" that should be placed "in between" query execution to influence the results. StatementInterceptors are "chainable", the results returned by the "current" interceptor will be passed on to the next in in the chain, from left-to-right order, as specified in this property.		5.1.1
strictFloatingPoint	Used only in older versions of compliance test	false	3.0.0
strictUpdates	Should the driver do strict checking (all primary keys selected) of updatable result sets (true, false, defaults to 'true')?	true	3.0.4
tinyInt1isBit	Should the driver treat the datatype TINYINT(1) as the BIT type (because the server silently converts BIT -> TINYINT(1) when creating tables)?	true	3.0.16
transformedBitIsBoolean	If the driver converts TINYINT(1) to a different type, should it use BOOLEAN instead of BIT for future compatibility with MySQL-5.0, as MySQL-5.0 has a BIT type?	false	3.1.9
treatUtilDateAsTimestamp	Should the driver treat java.util.Date as a TIMESTAMP for the purposes of PreparedStatement.setObject()?	true	5.0.5
ultraDevHack	Create PreparedStatements for prepareCall() when required, because UltraDev is broken and issues a prepareCall() for _all_ statements? (true/false, defaults to 'false')	false	2.0.3
useAffectedRows	Don't set the CLIENT_FOUND_ROWS flag when connecting to the server (not JDBC-compliant, will break most applications that rely on "found" rows vs. "affected rows" for DML statements), but does cause "correct" update counts from "INSERT ... ON DUPLICATE KEY UPDATE" statements to be returned by the server.	false	5.1.7
useGmtMillisForDatetimes	Convert between session timezone and GMT before creating Date and Timestamp instances (value of "false" is legacy behavior, "true" leads to more JDBC-compliant behavior.	false	3.1.12
useHostsInPrivileges	Add '@hostname' to users in DatabaseMetaData.getColumn/TablePrivileges() (true/false), defaults to 'true'.	true	3.0.2
useInformationSchema	When connected to MySQL-5.0.7 or newer, should the driver use the INFORMATION_SCHEMA to derive information used by DatabaseMetaData?	false	5.0.0
useJDBCCompliantTimezoneShift	Should the driver use JDBC-compliant rules when converting TIME/TIMESTAMP/DATETIME values' timezone information for those JDBC arguments which take a java.util.Calendar argument? (Notice that this option is exclusive of the "useTimezone=true" configuration option.)	false	5.0.0

useLegacyDatetimeCode	Use code for DATE/TIME/DATETIME/TIMESTAMP handling in result sets and statements that consistently handles timezone conversions from client to server and back again, or use the legacy code for these datatypes that has been in the driver for backwards-compatibility?	true	5.1.6
useOldAliasMetadataBehavior	Should the driver use the legacy behavior for "AS" clauses on columns and tables, and only return aliases (if any) for ResultSetMetaData.getColumnName() or ResultSetMetaData.getTableName() rather than the original column/table name? In 5.0.x, the default value was true.	false	5.0.4
useOldUTF8Behavior	Use the UTF-8 behavior the driver did when communicating with 4.0 and older servers	false	3.1.6
useOnlyServerErrorMessages	Don't prepend 'standard' SQLState error messages to error messages returned by the server.	true	3.0.15
useSSPSCompatibleTimezoneShift	If migrating from an environment that was using server-side prepared statements, and the configuration property "useJDBCCompliantTimeZoneShift" set to "true", use compatible behavior when not using server-side prepared statements when sending TIMESTAMP values to the MySQL server.	false	5.0.5
useServerPrepStmts	Use server-side prepared statements if the server supports them?	false	3.1.0
useSqlStateCodes	Use SQL Standard state codes instead of 'legacy' X/Open/SQL state codes (true/false), default is 'true'	true	3.1.3
useStreamLengthsInPrepStmts	Honor stream length parameter in PreparedStatement/ResultSet.setXXXStream() method calls (true/false, defaults to 'true')?	true	3.0.2
useTimezone	Convert time/date types between client and server timezones (true/false, defaults to 'false')?	false	3.0.2
useUnbufferedInput	Don't use BufferedInputStream for reading data from the server	true	3.0.11
yearIsDateType	Should the JDBC driver treat the MySQL type "YEAR" as a java.sql.Date, or as a SHORT?	true	3.1.9
zeroDateTimeBehavior	What should happen when the driver encounters DATETIME values that are composed entirely of zeros (used by MySQL to represent invalid dates)? Valid values are "exception", "round" and "convertToNull".	exception	3.1.4

Connector/J also supports access to MySQL using named pipes on Windows NT/2000/XP using the NamedPipeSocketFactory as a plugin-socket factory using the socketFactory property. If you do not use a namedPipePath property, the default of '\\.\pipe\MySQL' will be used. If you use the `NamedPipeSocketFactory`, the host name and port number values in the JDBC url will be ignored. You can enable this feature using:

```
socketFactory=com.mysql.jdbc.NamedPipeSocketFactory
```

Named pipes only work when connecting to a MySQL server on the same physical machine as the one the JDBC driver is being used on. In simple performance tests, it appears that named pipe access is between 30%-50% faster than the standard TCP/IP access. However, this varies per system, and named pipes are slower than TCP/IP in many Windows configurations.

You can create your own socket factories by following the example code in `com.mysql.jdbc.NamedPipeSocketFactory`, or `com.mysql.jdbc.StandardSocketFactory`.

20.3.4.2. JDBC API Implementation Notes

MySQL Connector/J passes all of the tests in the publicly available version of Sun's JDBC compliance test suite. However, in many places the JDBC specification is vague about how certain functionality should be implemented, or the specification enables leeway in implementation.

This section gives details on a interface-by-interface level about how certain implementation decisions may affect how you use MySQL Connector/J.

- **Blob**

  Starting with Connector/J version 3.1.0, you can emulate Blobs with locators by adding the property 'emulateLocators=true' to your JDBC URL. Using this method, the driver will delay loading the actual Blob data until you retrieve the other data and then use retrieval methods (`getInputStream()`, `getBytes()`, and so forth) on the blob data stream.

For this to work, you must use a column alias with the value of the column to the actual name of the Blob, for example:

```
SELECT id, 'data' as blob_data from blobtable
```

For this to work, you must also follow these rules:

- The `SELECT` must also reference only one table, the table must have a primary key.
- The `SELECT` must alias the original blob column name, specified as a string, to an alternate name.
- The `SELECT` must cover all columns that make up the primary key.

The Blob implementation does not allow in-place modification (they are copies, as reported by the `DatabaseMetaData.locatorsUpdateCopies()` method). Because of this, you should use the corresponding `PreparedStatement.setBlob()` or `ResultSet.updateBlob()` (in the case of updatable result sets) methods to save changes back to the database.

- **CallableStatement**

  Starting with Connector/J 3.1.1, stored procedures are supported when connecting to MySQL version 5.0 or newer using the `CallableStatement` interface. Currently, the `getParameterMetaData()` method of `CallableStatement` is not supported.

- **Clob**

  The Clob implementation does not allow in-place modification (they are copies, as reported by the `DatabaseMetaData.locatorsUpdateCopies()` method). Because of this, you should use the `PreparedStatement.setClob()` method to save changes back to the database. The JDBC API does not have a `ResultSet.updateClob()` method.

- **Connection**

  Unlike older versions of MM.MySQL the `isClosed()` method does not ping the server to determine if it is available. In accordance with the JDBC specification, it only returns true if `closed()` has been called on the connection. If you need to determine if the connection is still valid, you should issue a simple query, such as `SELECT 1`. The driver will throw an exception if the connection is no longer valid.

- **DatabaseMetaData**

  Foreign Key information (`getImportedKeys()`/`getExportedKeys()` and `getCrossReference()`) is only available from InnoDB tables. However, the driver uses `SHOW CREATE TABLE` to retrieve this information, so when other storage engines support foreign keys, the driver will transparently support them as well.

- **PreparedStatement**

  PreparedStatements are implemented by the driver, as MySQL does not have a prepared statement feature. Because of this, the driver does not implement `getParameterMetaData()` or `getMetaData()` as it would require the driver to have a complete SQL parser in the client.

  Starting with version 3.1.0 MySQL Connector/J, server-side prepared statements and binary-encoded result sets are used when the server supports them.

  Take care when using a server-side prepared statement with **large** parameters that are set using `setBinaryStream()`, `setAsciiStream()`, `setUnicodeStream()`, `setBlob()`, or `setClob()`. If you want to re-execute the statement with any large parameter changed to a nonlarge parameter, it is necessary to call `clearParameters()` and set all parameters again. The reason for this is as follows:

  - During both server-side prepared statements and client-side emulation, large data is exchanged only when `PreparedStatement.execute()` is called.
  - Once that has been done, the stream used to read the data on the client side is closed (as per the JDBC spec), and cannot be read from again.
  - If a parameter changes from large to nonlarge, the driver must reset the server-side state of the prepared statement to allow the parameter that is being changed to take the place of the prior large value. This removes all of the large data that has already been sent to the server, thus requiring the data to be re-sent, using the `setBinaryStream()`, `setAsciiStream()`, `setUnicodeStream()`, `setBlob()` or `setClob()` method.

Consequently, if you want to change the type of a parameter to a nonlarge one, you must call `clearParameters()` and set all parameters of the prepared statement again before it can be re-executed.

- **ResultSet**

  By default, ResultSets are completely retrieved and stored in memory. In most cases this is the most efficient way to operate, and due to the design of the MySQL network protocol is easier to implement. If you are working with ResultSets that have a large number of rows or large values, and can not allocate heap space in your JVM for the memory required, you can tell the driver to stream the results back one row at a time.

  To enable this functionality, you need to create a Statement instance in the following manner:

  ```
  stmt = conn.createStatement(java.sql.ResultSet.TYPE_FORWARD_ONLY,
                java.sql.ResultSet.CONCUR_READ_ONLY);
  stmt.setFetchSize(Integer.MIN_VALUE);
  ```

  The combination of a forward-only, read-only result set, with a fetch size of `Integer.MIN_VALUE` serves as a signal to the driver to stream result sets row-by-row. After this any result sets created with the statement will be retrieved row-by-row.

  There are some caveats with this approach. You will have to read all of the rows in the result set (or close it) before you can issue any other queries on the connection, or an exception will be thrown.

  The earliest the locks these statements hold can be released (whether they be `MyISAM` table-level locks or row-level locks in some other storage engine such as `InnoDB`) is when the statement completes.

  If the statement is within scope of a transaction, then locks are released when the transaction completes (which implies that the statement needs to complete first). As with most other databases, statements are not complete until all the results pending on the statement are read or the active result set for the statement is closed.

  Therefore, if using streaming results, you should process them as quickly as possible if you want to maintain concurrent access to the tables referenced by the statement producing the result set.

- **ResultSetMetaData**

  The `isAutoIncrement()` method only works when using MySQL servers 4.0 and newer.

- **Statement**

  When using versions of the JDBC driver earlier than 3.2.1, and connected to server versions earlier than 5.0.3, the `setFetchSize()` method has no effect, other than to toggle result set streaming as described above.

  Connector/J 5.0.0 and later include support for both `Statement.cancel()` and `Statement.setQueryTimeout()`. Both require MySQL 5.0.0 or newer server, and require a separate connection to issue the `KILL QUERY` statement. In the case of `setQueryTimeout()`, the implementation creates an additional thread to handle the timeout functionality.

  > **Note**
  >
  > Failures to cancel the statement for `setQueryTimeout()` may manifest themselves as `RuntimeException` rather than failing silently, as there is currently no way to unblock the thread that is executing the query being cancelled due to timeout expiration and have it throw the exception instead.

  MySQL does not support SQL cursors, and the JDBC driver doesn't emulate them, so "setCursorName()" has no effect.

  Connector/J 5.1.3 and later include two additional methods:

  - `setLocalInfileInputStream()` sets an `InputStream` instance that will be used to send data to the MySQL server for a `LOAD DATA LOCAL INFILE` statement rather than a `FileInputStream` or `URLInputStream` that represents the path given as an argument to the statement.

    This stream will be read to completion upon execution of a `LOAD DATA LOCAL INFILE` statement, and will automatically be closed by the driver, so it needs to be reset before each call to `execute*()` that would cause the MySQL server to request data to fulfill the request for `LOAD DATA LOCAL INFILE`.

    If this value is set to `NULL`, the driver will revert to using a `FileInputStream` or `URLInputStream` as required.

  - `getLocalInfileInputStream()` returns the `InputStream` instance that will be used to send data in response to a `LOAD DATA LOCAL INFILE` statement.

    This method returns `NULL` if no such stream has been set using `setLocalInfileInputStream()`.

20.3.4.3. Java, JDBC and MySQL Types

MySQL Connector/J is flexible in the way it handles conversions between MySQL data types and Java data types.

In general, any MySQL data type can be converted to a java.lang.String, and any numeric type can be converted to any of the Java numeric types, although round-off, overflow, or loss of precision may occur.

Starting with Connector/J 3.1.0, the JDBC driver will issue warnings or throw DataTruncation exceptions as is required by the JDBC specification unless the connection was configured not to do so by using the property jdbcCompliantTruncation and setting it to `false`.

The conversions that are always guaranteed to work are listed in the following table:

Connection Properties - Miscellaneous.

These MySQL Data Types	Can always be converted to these Java types
`CHAR, VARCHAR, BLOB, TEXT, ENUM, and SET`	`java.lang.String, java.io.InputStream, java.io.Reader, java.sql.Blob, java.sql.Clob`
`FLOAT, REAL, DOUBLE PRECISION, NUMERIC, DECIMAL, TINYINT, SMALLINT, MEDIUMINT, INTEGER, BIGINT`	`java.lang.String, java.lang.Short, java.lang.Integer, java.lang.Long, java.lang.Double, java.math.BigDecimal`
`DATE, TIME, DATETIME, TIMESTAMP`	`java.lang.String, java.sql.Date, java.sql.Timestamp`

> **Note**
>
> Round-off, overflow or loss of precision may occur if you choose a Java numeric data type that has less precision or capacity than the MySQL data type you are converting to/from.

The `ResultSet.getObject()` method uses the type conversions between MySQL and Java types, following the JDBC specification where appropriate. The value returned by `ResultSetMetaData.GetColumnClassName()` is also shown below. For more information on the `java.sql.Types` classes see Java 2 Platform Types.

MySQL Types to Java Types for ResultSet.getObject().

MySQL Type Name	Return value of `GetColumnClassName`	Returned as Java Class
BIT(1) (new in MySQL-5.0)	BIT	`java.lang.Boolean`
BIT(> 1) (new in MySQL-5.0)	BIT	`byte[]`
TINYINT	TINYINT	`java.lang.Boolean` if the configuration property `tinyInt1isBit` is set to `true` (the default) and the storage size is 1, or `java.lang.Integer` if not.
BOOL, BOOLEAN	TINYINT	See TINYINT, above as these are aliases for TINYINT(1), currently.
SMALLINT[(M)] [UNSIGNED]	SMALLINT [UNSIGNED]	`java.lang.Integer` (regardless if UNSIGNED or not)
MEDIUMINT[(M)] [UNSIGNED]	MEDIUMINT [UNSIGNED]	`java.lang.Integer,` if UNSIGNED `java.lang.Long` (C/J 3.1 and earlier), or `java.lang.Integer` for C/J 5.0 and later
INT,INTEGER[(M)] [UNSIGNED]	INTEGER [UNSIGNED]	`java.lang.Integer`, if UNSIGNED `java.lang.Long`
BIGINT[(M)] [UNSIGNED]	BIGINT [UNSIGNED]	`java.lang.Long`, if UNSIGNED `java.math.BigInteger`
FLOAT[(M,D)]	FLOAT	`java.lang.Float`
DOUBLE[(M,B)]	DOUBLE	`java.lang.Double`
DECIMAL[(M[,D])]	DECIMAL	`java.math.BigDecimal`
DATE	DATE	`java.sql.Date`
DATETIME	DATETIME	`java.sql.Timestamp`
TIMESTAMP[(M)]	TIMESTAMP	`java.sql.Timestamp`

MySQL Type Name	Return value of `GetColumnClassName`	Returned as Java Class
TIME	TIME	`java.sql.Time`
YEAR[(2|4)]	YEAR	If `yearIsDateType` configuration property is set to false, then the returned object type is `java.sql.Short`. If set to true (the default) then an object of type `java.sql.Date` (with the date set to January 1st, at midnight).
CHAR(M)	CHAR	`java.lang.String` (unless the character set for the column is BINARY, then `byte[]` is returned.
VARCHAR(M) [BINARY]	VARCHAR	`java.lang.String` (unless the character set for the column is BINARY, then `byte[]` is returned.
BINARY(M)	BINARY	`byte[]`
VARBINARY(M)	VARBINARY	`byte[]`
TINYBLOB	TINYBLOB	`byte[]`
TINYTEXT	VARCHAR	`java.lang.String`
BLOB	BLOB	`byte[]`
TEXT	VARCHAR	`java.lang.String`
MEDIUMBLOB	MEDIUMBLOB	`byte[]`
MEDIUMTEXT	VARCHAR	`java.lang.String`
LONGBLOB	LONGBLOB	`byte[]`
LONGTEXT	VARCHAR	`java.lang.String`
ENUM('value1','value2',...)	CHAR	`java.lang.String`
SET('value1','value2',...)	CHAR	`java.lang.String`

20.3.4.4. Using Character Sets and Unicode

All strings sent from the JDBC driver to the server are converted automatically from native Java Unicode form to the client character encoding, including all queries sent using `Statement.execute()`, `Statement.executeUpdate()`, `Statement.executeQuery()` as well as all `PreparedStatement` and `CallableStatement` parameters with the exclusion of parameters set using `setBytes()`, `setBinaryStream()`, `setAsciiStream()`, `setUnicodeStream()` and `setBlob()`.

Prior to MySQL Server 4.1, Connector/J supported a single character encoding per connection, which could either be automatically detected from the server configuration, or could be configured by the user through the *`useUnicode`* and *`characterEncoding`* properties.

Starting with MySQL Server 4.1, Connector/J supports a single character encoding between client and server, and any number of character encodings for data returned by the server to the client in `ResultSets`.

The character encoding between client and server is automatically detected upon connection. The encoding used by the driver is specified on the server using the `character_set` system variable for server versions older than 4.1.0 and `character_set_server` for server versions 4.1.0 and newer. For more information, see Section 9.1.3.1, “Server Character Set and Collation”.

To override the automatically detected encoding on the client side, use the *`characterEncoding`* property in the URL used to connect to the server.

When specifying character encodings on the client side, Java-style names should be used. The following table lists Java-style names for MySQL character sets:

MySQL to Java Encoding Name Translations.

MySQL Character Set Name	Java-Style Character Encoding Name
ascii	US-ASCII
big5	Big5
gbk	GBK
sjis	SJIS (or Cp932 or MS932 for MySQL Server < 4.1.11)
cp932	Cp932 or MS932 (MySQL Server > 4.1.11)
gb2312	EUC_CN

MySQL Character Set Name	Java-Style Character Encoding Name
ujis	EUC_JP
euckr	EUC_KR
latin1	Cp1252
latin2	ISO8859_2
greek	ISO8859_7
hebrew	ISO8859_8
cp866	Cp866
tis620	TIS620
cp1250	Cp1250
cp1251	Cp1251
cp1257	Cp1257
macroman	MacRoman
macce	MacCentralEurope
utf8	UTF-8
ucs2	UnicodeBig

> **Warning**
>
> Do not issue the query 'set names' with Connector/J, as the driver will not detect that the character set has changed, and will continue to use the character set detected during the initial connection setup.

To allow multiple character sets to be sent from the client, the UTF-8 encoding should be used, either by configuring `utf8` as the default server character set, or by configuring the JDBC driver to use UTF-8 through the *`characterEncoding`* property.

20.3.4.5. Connecting Securely Using SSL

SSL in MySQL Connector/J encrypts all data (other than the initial handshake) between the JDBC driver and the server. The performance penalty for enabling SSL is an increase in query processing time between 35% and 50%, depending on the size of the query, and the amount of data it returns.

For SSL Support to work, you must have the following:

- A JDK that includes JSSE (Java Secure Sockets Extension), like JDK-1.4.1 or newer. SSL does not currently work with a JDK that you can add JSSE to, like JDK-1.2.x or JDK-1.3.x due to the following JSSE bug: http://developer.java.sun.com/developer/bugParade/bugs/4273544.html
- A MySQL server that supports SSL and has been compiled and configured to do so, which is MySQL-4.0.4 or later, see Section 5.5.8, “Using SSL for Secure Connections”, for more information.
- A client certificate (covered later in this section)

The system works through two Java truststore files, one file contains the certificate information for the server (`truststore` in the examples below). The other file contains the certificate for the client (`keystore` in the examples below). All Java truststore files are password protected by supplying a suitable password to the `keytool` when you create the files. You need the file names and associated passwords to create an SSL connection.

You will first need to import the MySQL server CA Certificate into a Java truststore. A sample MySQL server CA Certificate is located in the `SSL` subdirectory of the MySQL source distribution. This is what SSL will use to determine if you are communicating with a secure MySQL server. Alternatively, use the CA Certificate that you have generated or been provided with by your SSL provider.

To use Java's `keytool` to create a truststore in the current directory , and import the server's CA certificate (`cacert.pem`), you can do the following (assuming that `keytool` is in your path. The `keytool` should be located in the `bin` subdirectory of your JDK or JRE):

```
shell> keytool -import -alias mysqlServerCACert \
                                  -file cacert.pem -keystore truststore
```

You will need to enter the password when prompted for the keystore file. Interaction with `keytool` will look like this:

```
Enter keystore password:  *********
Owner: EMAILADDRESS=walrus@example.com, CN=Walrus,
       O=MySQL AB, L=Orenburg, ST=Some-State, C=RU
Issuer: EMAILADDRESS=walrus@example.com, CN=Walrus,
       O=MySQL AB, L=Orenburg, ST=Some-State, C=RU
Serial number: 0
Valid from:
   Fri Aug 02 16:55:53 CDT 2002 until: Sat Aug 02 16:55:53 CDT 2003
Certificate fingerprints:
    MD5:  61:91:A0:F2:03:07:61:7A:81:38:66:DA:19:C4:8D:AB
    SHA1: 25:77:41:05:D5:AD:99:8C:14:8C:CA:68:9C:2F:B8:89:C3:34:4D:6C
Trust this certificate? [no]:  yes
Certificate was added to keystore
```

You then have two options, you can either import the client certificate that matches the CA certificate you just imported, or you can create a new client certificate.

To import an existing certificate, the certificate should be in DER format. You can use `openssl` to convert an existing certificate into the new format. For example:

```
shell> openssl x509 -outform DER -in client-cert.pem -out client.cert
```

You now need to import the converted certificate into your keystore using `keytool`:

```
shell> keytool -import -file client.cert -keystore keystore -alias mysqlClientCertificate
```

To generate your own client certificate, use `keytool` to create a suitable certificate and add it to the `keystore` file:

```
 shell> keytool -genkey -keyalg rsa \
     -alias mysqlClientCertificate -keystore keystore
```

Keytool will prompt you for the following information, and create a keystore named `keystore` in the current directory.

You should respond with information that is appropriate for your situation:

```
Enter keystore password:  *********
What is your first and last name?
  [Unknown]:  Matthews
What is the name of your organizational unit?
  [Unknown]:  Software Development
What is the name of your organization?
  [Unknown]:  MySQL AB
What is the name of your City or Locality?
  [Unknown]:  Flossmoor
What is the name of your State or Province?
  [Unknown]:  IL
What is the two-letter country code for this unit?
  [Unknown]:  US
Is <CN=Matthews, OU=Software Development, O=MySQL AB,
 L=Flossmoor, ST=IL, C=US> correct?
  [no]:  y

Enter key password for <mysqlClientCertificate>
        (RETURN if same as keystore password):
```

Finally, to get JSSE to use the keystore and truststore that you have generated, you need to set the following system properties when you start your JVM, replacing path_to_keystore_file with the full path to the keystore file you created, path_to_truststore_file with the path to the truststore file you created, and using the appropriate password values for each property. You can do this either on the command line:

```
-Djavax.net.ssl.keyStore=path_to_keystore_file
-Djavax.net.ssl.keyStorePassword=password
-Djavax.net.ssl.trustStore=path_to_truststore_file
-Djavax.net.ssl.trustStorePassword=password
```

Or you can set the values directly within the application:

```
 System.setProperty("javax.net.ssl.keyStore","path_to_keystore_file");
System.setProperty("javax.net.ssl.keyStorePassword","password");
System.setProperty("javax.net.ssl.trustStore","path_to_truststore_file");
System.setProperty("javax.net.ssl.trustStorePassword","password");
```

You will also need to set useSSL to `true` in your connection parameters for MySQL Connector/J, either by adding `useSSL=true` to your URL, or by setting the property useSSL to `true` in the `java.util.Properties` instance you pass to `DriverManager.getConnection()`.

You can test that SSL is working by turning on JSSE debugging (as detailed below), and look for the following key events:

```
...
*** ClientHello, v3.1
RandomCookie:  GMT: 1018531834 bytes = { 199, 148, 180, 215, 74, 12, »
  54, 244, 0, 168, 55, 103, 215, 64, 16, 138, 225, 190, 132, 153, 2, »
  217, 219, 239, 202, 19, 121, 78 }
Session ID:  {}
Cipher Suites:  { 0, 5, 0, 4, 0, 9, 0, 10, 0, 18, 0, 19, 0, 3, 0, 17 }
Compression Methods:  { 0 }
***
[write] MD5 and SHA1 hashes:  len = 59
0000: 01 00 00 37 03 01 3D B6 90 FA C7 94 B4 D7 4A 0C  ...7..=.......J.
0010: 36 F4 00 A8 37 67 D7 40 10 8A E1 BE 84 99 02 D9  6...7g.@........
0020: DB EF CA 13 79 4E 00 00 10 00 05 00 04 00 09 00  ....yN..........
0030: 0A 00 12 00 13 00 03 00 11 01 00                 ...........
main, WRITE:  SSL v3.1 Handshake, length = 59
main, READ:  SSL v3.1 Handshake, length = 74
*** ServerHello, v3.1
RandomCookie:  GMT: 1018577560 bytes = { 116, 50, 4, 103, 25, 100, 58, »
   202, 79, 185, 178, 100, 215, 66, 254, 21, 83, 187, 190, 42, 170, 3, »
   132, 110, 82, 148, 160, 92 }
Session ID:  {163, 227, 84, 53, 81, 127, 252, 254, 178, 179, 68, 63, »
   182, 158, 30, 11, 150, 79, 170, 76, 255, 92, 15, 226, 24, 17, 177, »
   219, 158, 177, 187, 143}
Cipher Suite:  { 0, 5 }
Compression Method: 0
***
%% Created:  [Session-1, SSL_RSA_WITH_RC4_128_SHA]
** SSL_RSA_WITH_RC4_128_SHA
[read] MD5 and SHA1 hashes:  len = 74
0000: 02 00 00 46 03 01 3D B6 43 98 74 32 04 67 19 64  ...F..=.C.t2.g.d
0010: 3A CA 4F B9 B2 64 D7 42 FE 15 53 BB BE 2A AA 03  :.O..d.B..S..*..
0020: 84 6E 52 94 A0 5C 20 A3 E3 54 35 51 7F FC FE B2  .nR..\ ..T5Q....
0030: B3 44 3F B6 9E 1E 0B 96 4F AA 4C FF 5C 0F E2 18  .D?.....O.L.\...
0040: 11 B1 DB 9E B1 BB 8F 00 05 00                    ..........
main, READ:  SSL v3.1 Handshake, length = 1712
...
```

JSSE provides debugging (to STDOUT) when you set the following system property: `-Djavax.net.debug=all` This will tell you what keystores and truststores are being used, as well as what is going on during the SSL handshake and certificate exchange. It will be helpful when trying to determine what is not working when trying to get an SSL connection to happen.

20.3.4.6. Using Master/Slave Replication with ReplicationConnection

Starting with Connector/J 3.1.7, we've made available a variant of the driver that will automatically send queries to a read/write master, or a failover or round-robin loadbalanced set of slaves based on the state of `Connection.getReadOnly()` .

An application signals that it wants a transaction to be read-only by calling `Connection.setReadOnly(true)`, this replication-aware connection will use one of the slave connections, which are load-balanced per-vm using a round-robin scheme (a given connection is sticky to a slave unless that slave is removed from service). If you have a write transaction, or if you have a read that is time-sensitive (remember, replication in MySQL is asynchronous), set the connection to be not read-only, by calling `Connection.setReadOnly(false)` and the driver will ensure that further calls are sent to the master MySQL server. The driver takes care of propagating the current state of autocommit, isolation level, and catalog between all of the connections that it uses to accomplish this load balancing functionality.

To enable this functionality, use the " `com.mysql.jdbc.ReplicationDriver` " class when configuring your application server's connection pool or when creating an instance of a JDBC driver for your standalone application. Because it accepts the same URL format as the standard MySQL JDBC driver, `ReplicationDriver` does not currently work with `java.sql.DriverManager` -based connection creation unless it is the only MySQL JDBC driver registered with the `DriverManager` .

Here is a short, simple example of how ReplicationDriver might be used in a standalone application.

```
import java.sql.Connection;
import java.sql.ResultSet;
import java.util.Properties;

import com.mysql.jdbc.ReplicationDriver;

public class ReplicationDriverDemo {

  public static void main(String[] args) throws Exception {
    ReplicationDriver driver = new ReplicationDriver();

    Properties props = new Properties();

    // We want this for failover on the slaves
    props.put("autoReconnect", "true");

    // We want to load balance between the slaves
    props.put("roundRobinLoadBalance", "true");

    props.put("user", "foo");
    props.put("password", "bar");

    //
    // Looks like a normal MySQL JDBC url, with a
    // comma-separated list of hosts, the first
    // being the 'master', the rest being any number
    // of slaves that the driver will load balance against
    //

    Connection conn =
        driver.connect("jdbc:mysql:replication://master,slave1,slave2,slave3/test",
            props);

    //
    // Perform read/write work on the master
    // by setting the read-only flag to "false"
    //

    conn.setReadOnly(false);
    conn.setAutoCommit(false);
    conn.createStatement().executeUpdate("UPDATE some_table ....");
    conn.commit();

    //
    // Now, do a query from a slave, the driver automatically picks one
    // from the list
    //

    conn.setReadOnly(true);

    ResultSet rs =
      conn.createStatement().executeQuery("SELECT a,b FROM alt_table");

     .......
  }
}
```

You may also want to investigate the Load Balancing JDBC Pool (lbpol) tool, which provides a wrapper around the standard JDBC driver and enables you to use DB connection pools that includes checks for system failures and uneven load distribution. For more information, see Load Balancing JDBC Pool (lbpool).

20.3.4.7. Mapping MySQL Error Numbers to SQLStates

The table below provides a mapping of the MySQL Error Numbers to `SQL States`

Table 20.3. Mapping of MySQL Error Numbers to SQLStates

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
1022	ER_DUP_KEY	S1000	23000
1037	ER_OUTOFMEMORY	S1001	HY001
1038	ER_OUT_OF_SORT-MEMORY	S1001	HY001
1040	ER_CON_COUNT_ERROR	08004	08004
1042	ER_BAD_HOST_ERROR	08004	08S01
1043	ER_HANDSHAKE_ERROR	08004	08S01
1044	ER_DBACCESS_DENIED	S1000	42000

MySQL Error Number	**MySQL Error Name**	**Legacy (X/Open) SQLState**	**SQL Standard SQLState**
	_ERROR		
1045	ER_ACCESS_DENIED_ERROR	28000	28000
1047	ER_UNKNOWN_COM_ERROR	08S01	HY000
1050	ER_TABLE_EXISTS_ERROR	S1000	42S01
1051	ER_BAD_TABLE_ERROR	42S02	42S02
1052	ER_NON_UNIQ_ERROR	S1000	23000
1053	ER_SERVER_SHUTDOWN	S1000	08S01
1054	ER_BAD_FIELD_ERROR	S0022	42S22
1055	ER_WRONG_FIELD_WITH_GROUP	S1009	42000
1056	ER_WRONG_GROUP_FIELD	S1009	42000
1057	ER_WRONG_SUM_SELECT	S1009	42000
1058	ER_WRONG_VALUE_COUNT	21S01	21S01
1059	ER_TOO_LONG_IDENT	S1009	42000
1060	ER_DUP_FIELDNAME	S1009	42S21
1061	ER_DUP_KEYNAME	S1009	42000
1062	ER_DUP_ENTRY	S1009	23000
106	ER_WR	S10	420

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
3	ONG_FIELD_SPEC	09	00
1064	ER_PARSE_ERROR	42000	42000
1065	ER_EMPTY_QUERY	42000	42000
1066	ER_NONUNIQ_TABLE	S1009	42000
1067	ER_INVALID_DEFAULT	S1009	42000
1068	ER_MULTIPLE_PRI_KEY	S1009	42000
1069	ER_TOO_MANY_KEYS	S1009	42000
1070	ER_TOO_MANY_KEY_PARTS	S1009	42000
1071	ER_TOO_LONG_KEY	S1009	42000
1072	ER_KEY_COLUMN_DOES_NOT_EXITS	S1009	42000
1073	ER_BLOB_USED_AS_KEY	S1009	42000
1074	ER_TOO_BIG_FIELDLENGTH	S1009	42000
1075	ER_WRONG_AUTO_KEY	S1009	42000
1080	ER_FORCING_CLOSE	S1000	08S01
1081	ER_IPSOCK_ERROR	08S01	08S01
1082	ER_NO_SUCH_I	S1009	42S12

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
	NDEX		
1083	ER_WRONG_FIELD_TERMINATORS	S1009	42000
1084	ER_BLOBS_AND_NO_TERMINATED	S1009	42000
1090	ER_CANT_REMOVE_ALL_FIELDS	S1000	42000
1091	ER_CANT_DROP_FIELD_OR_KEY	S1000	42000
1101	ER_BLOB_CANT_HAVE_DEFAULT	S1000	42000
1102	ER_WRONG_DB_NAME	S1000	42000
1103	ER_WRONG_TABLE_NAME	S1000	42000
1104	ER_TOO_BIG_SELECT	S1000	42000
1106	ER_UNKNOWN_PROCEDURE	S1000	42000
1107	ER_WRONG_PARAMCOUNT_TO_PROCEDURE	S1000	42000
1109	ER_UNKNOWN_TABLE	S1000	42S02
1110	ER_FIELD_SPECIFIED_TWICE	S1000	42000
111	ER_UNS	S10	420

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
2	UPPORTED_EXTENSION	00	00
1113	ER_TABLE_MUST_HAVE_COLUMNS	S1000	42000
1115	ER_UNKNOWN_CHARACTER_SET	S1000	42000
1118	ER_TOO_BIG_ROWSIZE	S1000	42000
1120	ER_WRONG_OUTER_JOIN	S1000	42000
1121	ER_NULL_COLUMN_IN_INDEX	S1000	42000
1129	ER_HOST_IS_BLOCKED	08004	HY000
1130	ER_HOST_NOT_PRIVILEGED	08004	HY000
1131	ER_PASSWORD_ANONYMOUS_USER	S1000	42000
1132	ER_PASSWORD_NOT_ALLOWED	S1000	42000
1133	ER_PASSWORD_NO_MATCH	S1000	42000
1136	ER_WRONG_VALUE_COUNT_ON_ROW	S1000	21S01
1138	ER_INVAL-	S1000	42000

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
	ID_USE_OF_NULL		
1139	ER_REGEXP_ERROR	S1000	42000
1140	ER_MIX_OF_GROUP_FUNC_AND_FIELDS	S1000	42000
1141	ER_NONEXISTING_GRANT	S1000	42000
1142	ER_TABLEACCESS_DENIED_ERROR	S1000	42000
1143	ER_COLUMNACCESS_DENIED_ERROR	S1000	42000
1144	ER_ILLEGAL_GRANT_FOR_TABLE	S1000	42000
1145	ER_GRANT_WRONG_HOST_OR_USER	S1000	42000
1146	ER_NO_SUCH_TABLE	S1000	42S02
1147	ER_NONEXISTING_TABLE_GRANT	S1000	42000
1148	ER_NOT_ALLOWED_COMMAND	S1000	42000
1149	ER_SYNTAX_ERROR	S1000	42000
1152	ER_ABORTING_CO	S1000	08S01

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
	NNECTION		
1153	ER_NET_PACKET_TOO_LARGE	S1000	08S01
1154	ER_NET_READ_ERROR_FROM_PIPE	S1000	08S01
1155	ER_NET_FCNTL_ERROR	S1000	08S01
1156	ER_NET_PACKETS_OUT_OF_ORDER	S1000	08S01
1157	ER_NET_UNCOMPRESS_ERROR	S1000	08S01
1158	ER_NET_READ_ERROR	S1000	08S01
1159	ER_NET_READ_INTERRUPTED	S1000	08S01
1160	ER_NET_ERROR_ON_WRITE	S1000	08S01
1161	ER_NET_WRITE_INTERRUPTED	S1000	08S01
1162	ER_TOO_LONG_STRING	S1000	42000
1163	ER_TABLE_CANT_HANDLE_BLOB	S1000	42000
1164	ER_TABLE_CANT_HANDLE_AUTO_INCREMENT	S1000	42000
1166	ER_WRONG_C	S1000	42000

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
	OLUMN_NAME		
1167	ER_WRONG_KEY_COLUMN	S1000	42000
1169	ER_DUP_UNIQUE	S1000	23000
1170	ER_BLOB_KEY_WITHOUT_LENGTH	S1000	42000
1171	ER_PRIMARY_CANT_HAVE_NULL	S1000	42000
1172	ER_TOO_MANY_ROWS	S1000	42000
1173	ER_REQUIRES_PRIMARY_KEY	S1000	42000
1177	ER_CHECK_NO_SUCH_TABLE	S1000	42000
1178	ER_CHECK_NOT_IMPLEMENTED	S1000	42000
1179	ER_CANT_DO_THIS_DURING_AN_TRANSACTION	S1000	25000
1184	ER_NEW_ABORTING_CONNECTION	S1000	08S01
1189	ER_MASTER_NET_READ	S1000	08S01
1190	ER_MASTER_NET_WRITE	S1000	08S01
120	ER_TOO	S10	420

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
3	_MANY_USER_CONNECTIONS	00	00
1205	ER_LOCK_WAIT_TIMEOUT	41000	41000
1207	ER_READ_ONLY_TRANSACTION	S1000	25000
1211	ER_NO_PERMISSION_TO_CREATE_USER	S1000	42000
1213	ER_LOCK_DEADLOCK	41000	40001
1216	ER_NO_REFERENCED_ROW	S1000	23000
1217	ER_ROW_IS_REFERENCED	S1000	23000
1218	ER_CONNECT_TO_MASTER	S1000	08S01
1222	ER_WRONG_NUMBER_OF_COLUMNS_IN_SELECT	S1000	21000
1226	ER_USER_LIMIT_REACHED	S1000	42000
1230	ER_NO_DEFAULT	S1000	42000
1231	ER_WRONG_VALUE_FOR_VAR	S1000	42000

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
1232	ER_WRONG_TYPE_FOR_VAR	S1000	42000
1234	ER_CANT_USE_OPTION_HERE	S1000	42000
1235	ER_NOT_SUPPORTED_YET	S1000	42000
1239	ER_WRONG_FK_DEF	S1000	42000
1241	ER_OPERAND_COLUMNS	S1000	21000
1242	ER_SUBQUERY_NO_1_ROW	S1000	21000
1247	ER_ILLEGAL_REFERENCE	S1000	42S22
1248	ER_DERIVED_MUST_HAVE_ALIAS	S1000	42000
1249	ER_SELECT_REDUCED	S1000	01000
1250	ER_TABLENAME_NOT_ALLOWED_HERE	S1000	42000
1251	ER_NOT_SUPPORTED_AUTH_MODE	S1000	08004
1252	ER_SPATIAL_CANT_HAVE_NULL	S1000	42000
1253	ER_COLLATION_CHAR-	S1000	42000

MySQL Error Number	MySQL Error Name	Legacy (X/Open) SQLState	SQL Standard SQLState
	SET_MISMATCH		
1261	ER_WARN_TOO_FEW_RECORDS	S1000	01000
1262	ER_WARN_TOO_MANY_RECORDS	S1000	01000
1263	ER_WARN_NULL_TO_NOTNULL	S1000	01000
1264	ER_WARN_DATA_OUT_OF_RANGE	S1000	01000
1265	ER_WARN_DATA_TRUNCATED	S1000	01000
1280	ER_WRONG_NAME_FOR_INDEX	S1000	42000
1281	ER_WRONG_NAME_FOR_CATALOG	S1000	42000
1286	ER_UNKNOWN_STORAGE_ENGINE	S1000	42000

20.3.5. Connector/J Notes and Tips

20.3.5.1. Basic JDBC Concepts

This section provides some general JDBC background.

20.3.5.1.1. Connecting to MySQL Using the `DriverManager` Interface

When you are using JDBC outside of an application server, the `DriverManager` class manages the establishment of Connections.

The `DriverManager` needs to be told which JDBC drivers it should try to make Connections with. The easiest way to do this is to use `Class.forName()` on the class that implements the `java.sql.Driver` interface. With MySQL Connector/J, the name of this class is `com.mysql.jdbc.Driver`. With this method, you could use an external configuration file to supply the driver class name and driver parameters to use when connecting to a database.

The following section of Java code shows how you might register MySQL Connector/J from the `main()` method of your application. If testing this code please ensure you read the installation section first at Section 20.3.2, “Connector/J Installation”, to make sure you have connector installed correctly and the `CLASSPATH` set up. Also, ensure that MySQL is configured to accept external TCP/IP connections.

```
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.SQLException;

// Notice, do not import com.mysql.jdbc.*
// or you will have problems!

public class LoadDriver {
    public static void main(String[] args) {
        try {
            // The newInstance() call is a work around for some
            // broken Java implementations

            Class.forName("com.mysql.jdbc.Driver").newInstance();
        } catch (Exception ex) {
            // handle the error
        }
    }
}
```

After the driver has been registered with the `DriverManager`, you can obtain a `Connection` instance that is connected to a particular database by calling `DriverManager.getConnection()`:

Example 20.1. Connector/J: Obtaining a connection from the `DriverManager`

If you have not already done so, please review the section Section 20.3.5.1.1, “Connecting to MySQL Using the `DriverManager` Interface” before working with these examples.

This example shows how you can obtain a `Connection` instance from the `DriverManager`. There are a few different signatures for the `getConnection()` method. You should see the API documentation that comes with your JDK for more specific information on how to use them.

```
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.SQLException;

Connection conn = null;
...
try {
    conn =
       DriverManager.getConnection("jdbc:mysql://localhost/test?" +
                                   "user=monty&password=greatsqldb");

    // Do something with the Connection

   ...
} catch (SQLException ex) {
    // handle any errors
    System.out.println("SQLException: " + ex.getMessage());
    System.out.println("SQLState: " + ex.getSQLState());
    System.out.println("VendorError: " + ex.getErrorCode());
}
```

Once a `Connection` is established, it can be used to create `Statement` and `PreparedStatement` objects, as well as retrieve metadata about the database. This is explained in the following sections.

20.3.5.1.2. Using Statements to Execute SQL

`Statement` objects allow you to execute basic SQL queries and retrieve the results through the `ResultSet` class which is described later.

To create a `Statement` instance, you call the `createStatement()` method on the `Connection` object you have retrieved using one of the `DriverManager.getConnection()` or `DataSource.getConnection()` methods described earlier.

Once you have a `Statement` instance, you can execute a `SELECT` query by calling the `executeQuery(String)` method with the SQL you want to use.

To update data in the database, use the `executeUpdate(String SQL)` method. This method returns the number of rows matched by the update statement, not the number of rows that were modified.

If you do not know ahead of time whether the SQL statement will be a `SELECT` or an `UPDATE`/`INSERT`, then you can use the `ex-`

`ecute(String SQL)` method. This method will return true if the SQL query was a `SELECT`, or false if it was an `UPDATE`, `INSERT`, or `DELETE` statement. If the statement was a `SELECT` query, you can retrieve the results by calling the `getResultSet()` method. If the statement was an `UPDATE`, `INSERT`, or `DELETE` statement, you can retrieve the affected rows count by calling `getUpdateCount()` on the `Statement` instance.

Example 20.2. Connector/J: Using java.sql.Statement to execute a `SELECT` query

```
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.SQLException;
import java.sql.Statement;
import java.sql.ResultSet;

// assume that conn is an already created JDBC connection (see previous examples)

Statement stmt = null;
ResultSet rs = null;

try {
    stmt = conn.createStatement();
    rs = stmt.executeQuery("SELECT foo FROM bar");

    // or alternatively, if you don't know ahead of time that
    // the query will be a SELECT...

    if (stmt.execute("SELECT foo FROM bar")) {
        rs = stmt.getResultSet();
    }

    // Now do something with the ResultSet ....
}
catch (SQLException ex){
    // handle any errors
    System.out.println("SQLException: " + ex.getMessage());
    System.out.println("SQLState: " + ex.getSQLState());
    System.out.println("VendorError: " + ex.getErrorCode());
}
finally {
    // it is a good idea to release
    // resources in a finally{} block
    // in reverse-order of their creation
    // if they are no-longer needed

    if (rs != null) {
        try {
            rs.close();
        } catch (SQLException sqlEx) { } // ignore

        rs = null;
    }

    if (stmt != null) {
        try {
            stmt.close();
        } catch (SQLException sqlEx) { } // ignore

        stmt = null;
    }
}
```

20.3.5.1.3. Using `CallableStatements` to Execute Stored Procedures

Starting with MySQL server version 5.0 when used with Connector/J 3.1.1 or newer, the `java.sql.CallableStatement` interface is fully implemented with the exception of the `getParameterMetaData()` method.

For more information on MySQL stored procedures, please refer to http://dev.mysql.com/doc/mysql/en/stored-routines.html.

Connector/J exposes stored procedure functionality through JDBC's `CallableStatement` interface.

> **Note**
>
> Current versions of MySQL server do not return enough information for the JDBC driver to provide result set metadata for callable statements. This means that when using `CallableStatement`, `ResultSetMetaData` may return `NULL`.

The following example shows a stored procedure that returns the value of `inOutParam` incremented by 1, and the string passed in using `inputParam` as a `ResultSet`:

Example 20.3. Connector/J: Calling Stored Procedures

```
CREATE PROCEDURE demoSp(IN inputParam VARCHAR(255), \
                                        INOUT inOutParam INT)
BEGIN
    DECLARE z INT;
    SET z = inOutParam + 1;
    SET inOutParam = z;

    SELECT inputParam;

    SELECT CONCAT('zyxw', inputParam);
END
```

To use the `demoSp` procedure with Connector/J, follow these steps:

1. Prepare the callable statement by using `Connection.prepareCall()` .

   Notice that you have to use JDBC escape syntax, and that the parentheses surrounding the parameter placeholders are not optional:

   ### Example 20.4. Connector/J: Using `Connection.prepareCall()`

   ```
   import java.sql.CallableStatement;

   ...

       //
       // Prepare a call to the stored procedure 'demoSp'
       // with two parameters
       //
       // Notice the use of JDBC-escape syntax ({call ...})
       //

       CallableStatement cStmt = conn.prepareCall("{call demoSp(?, ?)}");


       cStmt.setString(1, "abcdefg");
   ```

   > **Note**
   >
   > `Connection.prepareCall()` is an expensive method, due to the metadata retrieval that the driver performs to support output parameters. For performance reasons, you should try to minimize unnecessary calls to `Connection.prepareCall()` by reusing `CallableStatement` instances in your code.

2. Register the output parameters (if any exist)

   To retrieve the values of output parameters (parameters specified as `OUT` or `INOUT` when you created the stored procedure), JDBC requires that they be specified before statement execution using the various `registerOutputParameter()` methods in the `CallableStatement` interface:

   ### Example 20.5. Connector/J: Registering output parameters

   ```
   import java.sql.Types;
   ...
   //
   // Connector/J supports both named and indexed
   // output parameters. You can register output
   // parameters using either method, as well
   // as retrieve output parameters using either
   // method, regardless of what method was
   // used to register them.
   //
   // The following examples show how to use
   // the various methods of registering
   // output parameters (you should of course
   // use only one registration per parameter).
   //

   //
   // Registers the second parameter as output, and
   // uses the type 'INTEGER' for values returned from
   // getObject()
   //

   cStmt.registerOutParameter(2, Types.INTEGER);

   //
   // Registers the named parameter 'inOutParam', and
   // uses the type 'INTEGER' for values returned from
   ```

```
// getObject()
//

cStmt.registerOutParameter("inOutParam", Types.INTEGER);
...
```

3. Set the input parameters (if any exist)

   Input and in/out parameters are set as for `PreparedStatement` objects. However, `CallableStatement` also supports setting parameters by name:

Example 20.6. Connector/J: Setting `CallableStatement` input parameters

```
...

    //
    // Set a parameter by index
    //

    cStmt.setString(1, "abcdefg");

    //
    // Alternatively, set a parameter using
    // the parameter name
    //

    cStmt.setString("inputParameter", "abcdefg");

    //
    // Set the 'in/out' parameter using an index
    //

    cStmt.setInt(2, 1);

    //
    // Alternatively, set the 'in/out' parameter
    // by name
    //

    cStmt.setInt("inOutParam", 1);

...
```

4. Execute the `CallableStatement`, and retrieve any result sets or output parameters.

   Although `CallableStatement` supports calling any of the `Statement` execute methods (`executeUpdate()`, `executeQuery()` or `execute()`), the most flexible method to call is `execute()`, as you do not need to know ahead of time if the stored procedure returns result sets:

Example 20.7. Connector/J: Retrieving results and output parameter values

```
...

    boolean hadResults = cStmt.execute();

    //
    // Process all returned result sets
    //

    while (hadResults) {
        ResultSet rs = cStmt.getResultSet();

        // process result set
        ...

        hadResults = cStmt.getMoreResults();
    }

    //
    // Retrieve output parameters
    //
    // Connector/J supports both index-based and
    // name-based retrieval
    //

    int outputValue = cStmt.getInt(2); // index-based

    outputValue = cStmt.getInt("inOutParam"); // name-based

...
```

20.3.5.1.4. Retrieving `AUTO_INCREMENT` Column Values

Before version 3.0 of the JDBC API, there was no standard way of retrieving key values from databases that supported auto increment or identity columns. With older JDBC drivers for MySQL, you could always use a MySQL-specific method on the `Statement` interface, or issue the query `SELECT LAST_INSERT_ID()` after issuing an `INSERT` to a table that had an `AUTO_INCREMENT` key. Using the MySQL-specific method call isn't portable, and issuing a `SELECT` to get the `AUTO_INCREMENT` key's value requires another round-trip to the database, which isn't as efficient as possible. The following code snippets demonstrate the three different ways to retrieve `AUTO_INCREMENT` values. First, we demonstrate the use of the new JDBC-3.0 method `getGeneratedKeys()` which is now the preferred method to use if you need to retrieve `AUTO_INCREMENT` keys and have access to JDBC-3.0. The second example shows how you can retrieve the same value using a standard `SELECT LAST_INSERT_ID()` query. The final example shows how updatable result sets can retrieve the `AUTO_INCREMENT` value when using the `insertRow()` method.

Example 20.8. Connector/J: Retrieving `AUTO_INCREMENT` column values using `Statement.getGeneratedKeys()`

```
   Statement stmt = null;
   ResultSet rs = null;

   try {

    //
    // Create a Statement instance that we can use for
    // 'normal' result sets assuming you have a
    // Connection 'conn' to a MySQL database already
    // available

    stmt = conn.createStatement(java.sql.ResultSet.TYPE_FORWARD_ONLY,
                                java.sql.ResultSet.CONCUR_UPDATABLE);

    //
    // Issue the DDL queries for the table for this example
    //

    stmt.executeUpdate("DROP TABLE IF EXISTS autoIncTutorial");
    stmt.executeUpdate(
            "CREATE TABLE autoIncTutorial ("
            + "priKey INT NOT NULL AUTO_INCREMENT, "
            + "dataField VARCHAR(64), PRIMARY KEY (priKey))");

    //
    // Insert one row that will generate an AUTO INCREMENT
    // key in the 'priKey' field
    //

    stmt.executeUpdate(
            "INSERT INTO autoIncTutorial (dataField) "
            + "values ('Can I Get the Auto Increment Field?')",
            Statement.RETURN_GENERATED_KEYS);

    //
    // Example of using Statement.getGeneratedKeys()
    // to retrieve the value of an auto-increment
    // value
    //

    int autoIncKeyFromApi = -1;

    rs = stmt.getGeneratedKeys();

    if (rs.next()) {
        autoIncKeyFromApi = rs.getInt(1);
    } else {

        // throw an exception from here
    }

    rs.close();

    rs = null;

    System.out.println("Key returned from getGeneratedKeys():"
        + autoIncKeyFromApi);
} finally {

    if (rs != null) {
        try {
            rs.close();
        } catch (SQLException ex) {
            // ignore
        }
    }

    if (stmt != null) {
        try {
            stmt.close();
        } catch (SQLException ex) {
            // ignore
        }
    }
}
```

Example 20.9. Connector/J: Retrieving `AUTO_INCREMENT` column values using `SELECT LAST_INSERT_ID()`

```
   Statement stmt = null;
   ResultSet rs = null;

   try {

    //
    // Create a Statement instance that we can use for
    // 'normal' result sets.

    stmt = conn.createStatement();

    //
    // Issue the DDL queries for the table for this example
    //

    stmt.executeUpdate("DROP TABLE IF EXISTS autoIncTutorial");
    stmt.executeUpdate(
            "CREATE TABLE autoIncTutorial ("
            + "priKey INT NOT NULL AUTO_INCREMENT, "
            + "dataField VARCHAR(64), PRIMARY KEY (priKey))");

    //
    // Insert one row that will generate an AUTO INCREMENT
    // key in the 'priKey' field
    //

    stmt.executeUpdate(
            "INSERT INTO autoIncTutorial (dataField) "
            + "values ('Can I Get the Auto Increment Field?')");

    //
    // Use the MySQL LAST_INSERT_ID()
    // function to do the same thing as getGeneratedKeys()
    //

    int autoIncKeyFromFunc = -1;
    rs = stmt.executeQuery("SELECT LAST_INSERT_ID()");

    if (rs.next()) {
        autoIncKeyFromFunc = rs.getInt(1);
    } else {
        // throw an exception from here
    }

    rs.close();

    System.out.println("Key returned from " +
                       "'SELECT LAST_INSERT_ID()': " +
                       autoIncKeyFromFunc);

} finally {

    if (rs != null) {
        try {
            rs.close();
        } catch (SQLException ex) {
            // ignore
        }
    }

    if (stmt != null) {
        try {
            stmt.close();
        } catch (SQLException ex) {
            // ignore
        }
    }
}
```

Example 20.10. Connector/J: Retrieving `AUTO_INCREMENT` column values in `Updatable ResultSets`

```
   Statement stmt = null;
   ResultSet rs = null;
   try {

    //
    // Create a Statement instance that we can use for
    // 'normal' result sets as well as an 'updatable'
    // one, assuming you have a Connection 'conn' to
    // a MySQL database already available
    //

    stmt = conn.createStatement(java.sql.ResultSet.TYPE_FORWARD_ONLY,
                                java.sql.ResultSet.CONCUR_UPDATABLE);

    //
    // Issue the DDL queries for the table for this example
    //

    stmt.executeUpdate("DROP TABLE IF EXISTS autoIncTutorial");
    stmt.executeUpdate(
            "CREATE TABLE autoIncTutorial ("
            + "priKey INT NOT NULL AUTO_INCREMENT, "
            + "dataField VARCHAR(64), PRIMARY KEY (priKey))");

    //
    // Example of retrieving an AUTO INCREMENT key
    // from an updatable result set
    //

    rs = stmt.executeQuery("SELECT priKey, dataField "
       + "FROM autoIncTutorial");

    rs.moveToInsertRow();

    rs.updateString("dataField", "AUTO INCREMENT here?");
    rs.insertRow();

    //
    // the driver adds rows at the end
    //

    rs.last();

    //
    // We should now be on the row we just inserted
    //

    int autoIncKeyFromRS = rs.getInt("priKey");

    rs.close();

    rs = null;

    System.out.println("Key returned for inserted row: "
        + autoIncKeyFromRS);

} finally {

    if (rs != null) {
        try {
            rs.close();
        } catch (SQLException ex) {
            // ignore
        }
    }

    if (stmt != null) {
        try {
            stmt.close();
        } catch (SQLException ex) {
            // ignore
        }
    }
}
```

When you run the preceding example code, you should get the following output: Key returned from `getGeneratedKeys()`: 1 Key returned from `SELECT LAST_INSERT_ID()`: 1 Key returned for inserted row: 2 You should be aware, that at times, it can be tricky to use the `SELECT LAST_INSERT_ID()` query, as that function's value is scoped to a connection. So, if some other query happens on the same connection, the value will be overwritten. On the other hand, the `getGeneratedKeys()` method is scoped by the `Statement` instance, so it can be used even if other queries happen on the same connection, but not on the same `Statement` instance.

20.3.5.2. Using Connector/J with J2EE and Other Java Frameworks

This section describes how to use Connector/J in several contexts.

20.3.5.2.1. General J2EE Concepts

This section provides general background on J2EE concepts that pertain to use of Connector/J.

20.3.5.2.1.1. Understanding Connection Pooling

Connection pooling is a technique of creating and managing a pool of connections that are ready for use by any thread that needs them.

This technique of pooling connections is based on the fact that most applications only need a thread to have access to a JDBC connection when they are actively processing a transaction, which usually take only milliseconds to complete. When not processing a transaction, the connection would otherwise sit idle. Instead, connection pooling enables the idle connection to be used by some other thread to do useful work.

In practice, when a thread needs to do work against a MySQL or other database with JDBC, it requests a connection from the pool. When the thread is finished using the connection, it returns it to the pool, so that it may be used by any other threads that want to use it.

When the connection is loaned out from the pool, it is used exclusively by the thread that requested it. From a programming point of view, it is the same as if your thread called `DriverManager.getConnection()` every time it needed a JDBC connection, however with connection pooling, your thread may end up using either a new, or already-existing connection.

Connection pooling can greatly increase the performance of your Java application, while reducing overall resource usage. The main benefits to connection pooling are:

- Reduced connection creation time

  Although this is not usually an issue with the quick connection setup that MySQL offers compared to other databases, creating new JDBC connections still incurs networking and JDBC driver overhead that will be avoided if connections are recycled.

- Simplified programming model

  When using connection pooling, each individual thread can act as though it has created its own JDBC connection, allowing you to use straight-forward JDBC programming techniques.

- Controlled resource usage

  If you do not use connection pooling, and instead create a new connection every time a thread needs one, your application's resource usage can be quite wasteful and lead to unpredictable behavior under load.

Remember that each connection to MySQL has overhead (memory, CPU, context switches, and so forth) on both the client and server side. Every connection limits how many resources there are available to your application as well as the MySQL server. Many of these resources will be used whether or not the connection is actually doing any useful work!

Connection pools can be tuned to maximize performance, while keeping resource utilization below the point where your application will start to fail rather than just run slower.

Luckily, Sun has standardized the concept of connection pooling in JDBC through the JDBC-2.0 Optional interfaces, and all major application servers have implementations of these APIs that work fine with MySQL Connector/J.

Generally, you configure a connection pool in your application server configuration files, and access it through the Java Naming and Directory Interface (JNDI). The following code shows how you might use a connection pool from an application deployed in a J2EE application server:

Example 20.11. Connector/J: Using a connection pool with a J2EE application server

```
import java.sql.Connection;
import java.sql.SQLException;
import java.sql.Statement;

import javax.naming.InitialContext;
import javax.sql.DataSource;


public class MyServletJspOrEjb {

    public void doSomething() throws Exception {
        /*
         * Create a JNDI Initial context to be able to
         *  lookup  the DataSource
         *
         * In production-level code, this should be cached as
         * an instance or static variable, as it can
         * be quite expensive to create a JNDI context.
         *
         * Note: This code only works when you are using servlets
         * or EJBs in a J2EE application server. If you are
         * using connection pooling in standalone Java code, you
         * will have to create/configure datasources using whatever
         * mechanisms your particular connection pooling library
         * provides.
         */

        InitialContext ctx = new InitialContext();

         /*
          * Lookup the DataSource, which will be backed by a pool
          * that the application server provides. DataSource instances
          * are also a good candidate for caching as an instance
          * variable, as JNDI lookups can be expensive as well.
          */

        DataSource ds =
          (DataSource)ctx.lookup("java:comp/env/jdbc/MySQLDB");

        /*
         * The following code is what would actually be in your
         * Servlet, JSP or EJB 'service' method...where you need
         * to work with a JDBC connection.
         */

        Connection conn = null;
        Statement stmt = null;

        try {
            conn = ds.getConnection();

            /*
             * Now, use normal JDBC programming to work with
             * MySQL, making sure to close each resource when you're
             * finished with it, which permits the connection pool
             * resources to be recovered as quickly as possible
             */

            stmt = conn.createStatement();
            stmt.execute("SOME SQL QUERY");

            stmt.close();
            stmt = null;

            conn.close();
            conn = null;
        } finally {
            /*
             * close any jdbc instances here that weren't
             * explicitly closed during normal code path, so
             * that we don't 'leak' resources...
             */

            if (stmt != null) {
                try {
                    stmt.close();
                } catch (sqlexception sqlex) {
                    // ignore -- as we can't do anything about it here
                }

                stmt = null;
            }

            if (conn != null) {
                try {
                    conn.close();
                } catch (sqlexception sqlex) {
                    // ignore -- as we can't do anything about it here
                }

                conn = null;
            }
        }
    }
}
```

As shown in the example above, after obtaining the JNDI InitialContext, and looking up the DataSource, the rest of the code should look familiar to anyone who has done JDBC programming in the past.

The most important thing to remember when using connection pooling is to make sure that no matter what happens in your code (exceptions, flow-of-control, and so forth), connections, and anything created by them (such as statements or result sets) are closed, so that they may be re-used, otherwise they will be stranded, which in the best case means that the MySQL server resources they represent (such as buffers, locks, or sockets) may be tied up for some time, or worst case, may be tied up forever.

What Is the Best Size for my Connection Pool?

As with all other configuration rules-of-thumb, the answer is: it depends. Although the optimal size depends on anticipated load and average database transaction time, the optimum connection pool size is smaller than you might expect. If you take Sun's Java Petstore blueprint application for example, a connection pool of 15-20 connections can serve a relatively moderate load (600 concurrent users) using MySQL and Tomcat with response times that are acceptable.

To correctly size a connection pool for your application, you should create load test scripts with tools such as Apache JMeter or The Grinder, and load test your application.

An easy way to determine a starting point is to configure your connection pool's maximum number of connections to be unbounded, run a load test, and measure the largest amount of concurrently used connections. You can then work backward from there to determine what values of minimum and maximum pooled connections give the best performance for your particular application.

Validating Connections

MySQL Connector/J has the ability to execute a lightweight ping against a server, in order to validate the connection. In the case of load-balanced connections, this is performed against all active pooled internal connections that are retained. This is beneficial to Java applications using connection pools, as the pool can use this feature to validate connections. Depending on your connection pool and configuration, this validation can be carried out at different times:

1. Before the pool returns a connection to the application.
2. When the application returns a connection to the pool.
3. During periodic checks of idle connections.

In order to use this feature you need to specify a validation query in your connection pool that starts with `/* ping */`. Note the syntax must be exactly as specified. This will cause the driver send a ping to the server and return a fake, light-weight, result set. When using a `ReplicationConnection` or `LoadBalancedConnection`, the ping will be sent across all active connections.

It is critical that the syntax be specified correctly. For example, consider the following snippets:

```
sql = "/* PING */ SELECT 1";
sql = "SELECT 1 /* ping*/";
sql = "/*ping*/ SELECT 1";
sql = " /* ping */ SELECT 1";
sql = "/*to ping or not to ping*/ SELECT 1";
```

None of the above statements will work. This is because the ping syntax is sensitive to whitespace, capitalization, and placement. The syntax needs to be exact for reasons of efficiency, as this test is done for every statement that is executed:

```
protected static final String PING_MARKER = "/* ping */";
...
if (sql.charAt(0) == '/') {
if (sql.startsWith(PING_MARKER)) {
doPingInstead();
...
```

All of the previous statements will issue a normal `SELECT` statement and will **not** be transformed into the lightweight ping. Further, for load-balanced connections the statement will be executed against one connection in the internal pool, rather than validating each underlying physical connection. This results in the non-active physical connections assuming a stale state, and they may die. If Connector/J then re-balances it may select a dead connection, resulting in an exception being passed to the application. To help prevent this you can use `loadBalanceValidateConnectionOnSwapServer` to validate the connection before use.

If your Connector/J deployment uses a connection pool that allows you to specify a validation query, this should be taken advantage of, but ensure that the query starts *exactly* with `/* ping */`. This is particularly important if you are using the load-balancing or replication-aware features of Connector/J, as it will help keep alive connections which otherwise will go stale and die, causing problems later.

20.3.5.2.1.2. Managing Load Balanced Connections

Connector/J has long provided an effective means to distribute read/write load across multiple MySQL server instances for Cluster or master-master replication deployments, but until version 5.1.13, managing such deployments frequently required a service outage to redeploy a new configuration. Given that the ease of scaling out by adding additional MySQL Cluster (server) instances is a key element in that product offering, which is also naturally targeted at deployments with very strict availability requirements, it was necessary to add support for online changes of this nature. This is also critical for online upgrades, as the alternative is to take a MySQL Cluster server instance down hard, which will lose any in-process transactions and will also generate application exceptions, if any application is trying to use that particular server instance. Connector/J now has the ability to dynamically configure load-balanced connections.

There are two connection string options associated with this functionality:

- `loadBalanceConnectionGroup` – This provides the ability to group connections from different sources. This allows you to manage these JDBC sources within a single class-loader in any combination you choose. If they use the same configuration, and you want to manage them as a logical single group, give them the same name. This is the key property for management, if you do not define a name (string) for `loadBalanceConnectionGroup`, you cannot manage the connections. All load-balanced connections sharing the same `loadBalanceConnectionGroup` value, regardless of how the application creates them, will be managed together.
- `loadBalanceEnableJMX` – The ability to manage the connections is exposed when you define a `loadBalanceConnectionGroup`, but if you want to manage this externally, it is necessary to enable JMX by setting this property to `true`. This enables a JMX implementation, which exposes the management and monitoring operations of a connection group. Further, you need to start your application with the `-Dcom.sun.management.jmxremote` JVM flag. You can then perform connect and perform operations using a JMX client such as `jconsole`.

Once a connection has been made using the correct connection string options, a number of monitoring properties are available:

- Current active host count
- Current active physical connection count
- Current active logical connection count
- Total logical connections created
- Total transaction count

The following management operations can also be performed:

- Add host
- Remove host

The JMX interface, `com.mysql.jdbc.jmx.LoadBalanceConnectionGroupManagerMBean`, has the following methods:

- int getActiveHostCount(String group);
- int getTotalHostCount(String group);
- long getTotalLogicalConnectionCount(String group);
- long getActiveLogicalConnectionCount(String group);
- long getActivePhysicalConnectionCount(String group);
- long getTotalPhysicalConnectionCount(String group);
- long getTotalTransactionCount(String group);
- void removeHost(String group, String host) throws SQLException;
- void stopNewConnectionsToHost(String group, String host) throws SQLException;
- void addHost(String group, String host, boolean forExisting);
- String getActiveHostsList(String group);
- String getRegisteredConnectionGroups();

The `getRegisteredConnectionGroups()` method will return the names of all connection groups defined in that class-loader.

You can test this setup with the following code:

```
public class Test {
    private static String URL = "jdbc:mysql:loadbalance://" +
        "localhost:3306,localhost:3310/test?" +
        "loadBalanceConnectionGroup=first&loadBalanceEnableJMX=true";

    public static void main(String[] args) throws Exception {
        new Thread(new Repeater()).start();
        new Thread(new Repeater()).start();
        new Thread(new Repeater()).start();
    }

    static Connection getNewConnection() throws SQLException, ClassNotFoundException {
        Class.forName("com.mysql.jdbc.Driver");
        return DriverManager.getConnection(URL, "root", "");
    }

    static void executeSimpleTransaction(Connection c, int conn, int trans){
        try {
            c.setAutoCommit(false);
            Statement s = c.createStatement();
            s.executeQuery("SELECT SLEEP(1) /* Connection: " + conn + ", transaction: " + trans + " */");
            c.commit();
        } catch (SQLException e) {
            e.printStackTrace();
        }
    }

    public static class Repeater implements Runnable {
        public void run() {
            for(int i=0; i < 100; i++){
                try {
                    Connection c = getNewConnection();
                    for(int j=0; j < 10; j++){
                        executeSimpleTransaction(c, i, j);
                        Thread.sleep(Math.round(100 * Math.random()));
                    }
                    c.close();
                    Thread.sleep(100);
                } catch (Exception e) {
                    e.printStackTrace();
                }
            }
        }
    }
}
```

After compiling, the application can be started with the `-Dcom.sun.management.jmxremote` flag, to enable remote management. `jconsole` can then be started. The Test main class will be listed by jconsole. Select this and click CONNECT. You can then navigate to the `com.mysql.jdbc.jmx.LoadBalanceConnectionGroupManager` bean. At this point you can click on various operations and examine the returned result.

If you now had an additional instance of MySQL running on port 3309, you could ensure that Connector/J starts using it by using the `addHost()`, which is exposed in `jconsole`. Note that these operations can be performed dynamically without having to stop the application running.

20.3.5.2.1.3. Load Balancing Failover Policies

Connector/J provides a useful load-balancing implementation for Cluster or multi-master deployments. As of Connector/J 5.1.12, this same implementation is used for balancing load between read-only slaves with `ReplicationDriver`. When trying to balance workload between multiple servers, the driver has to determine when it is safe to swap servers, doing so in the middle of a transaction, for example, could cause problems. It is important not to lose state information. For this reason, Connector/J will only try to pick a new server when one of the following happens:

1. At transaction boundaries (transactions are explicitly committed or rolled back).
2. A communication exception (SQL State starting with "08") is encountered.
3. When a `SQLException` matches conditions defined by user, using the extension points defined by the `loadBalanceSQLStateFailover`, `loadBalanceSQLExceptionSubclassFailover` or `loadBalanceExceptionChecker` properties.

The third condition revolves around three new properties introduced with Connector/J 5.1.13. It allows you to control which `SQLException`s trigger failover.

- `loadBalanceExceptionChecker` - The `loadBalanceExceptionChecker` property is really the key. This takes a fully-qualified class name which implements the new `com.mysql.jdbc.LoadBalanceExceptionChecker` interface. This interface is very simple, and you only need to implement the following method:

  ```
  public boolean shouldExceptionTriggerFailover(SQLException ex)
  ```

A `SQLException` is passed in, and a boolean returned. `True` triggers a failover, `false` does not.

You can use this to implement your own custom logic. An example where this might be useful is when dealing with transient errors when using MySQL Cluster, where certain buffers may become overloaded. The following code snippet illustrates this:

```
public class NdbLoadBalanceExceptionChecker
 extends StandardLoadBalanceExceptionChecker {

 public boolean shouldExceptionTriggerFailover(SQLException ex) {
  return super.shouldExceptionTriggerFailover(ex)
    ||  checkNdbException(ex);
 }

 private boolean checkNdbException(SQLException ex){
 // Have to parse the message since most NDB errors
 // are mapped to the same DEMC.
  return (ex.getMessage().startsWith("Lock wait timeout exceeded") ||
  (ex.getMessage().startsWith("Got temporary error")
  && ex.getMessage().endsWith("from NDB")));
 }
}
```

The code above extends `com.mysql.jdbc.StandardLoadBalanceExceptionChecker`, which is the default implementation. There are a few convenient shortcuts built into this, for those who want to have some level of control using properties, without writing Java code. This default implementation uses the two remaining properties: `loadBalanceSQLStateFailover` and `loadBalanceSQLExceptionSubclassFailover`.

- `loadBalanceSQLStateFailover` - allows you to define a comma-delimited list of `SQLState` code prefixes, against which a `SQLException` is compared. If the prefix matches, failover is triggered. So, for example, the following would trigger a failover if a given `SQLException` starts with "00", or is "12345":

  ```
  loadBalanceSQLStateFailover=00,12345
  ```

- `loadBalanceSQLExceptionSubclassFailover` - can be used in conjunction with `loadBalanceSQLStateFailover` or on its own. If you want certain subclasses of `SQLException` to trigger failover, simply provide a comma-delimited list of fully-qualified class or interface names to check against. For example, if you want all `SQLTransientConnectionExceptions` to trigger failover, you would specify:

  ```
  loadBalanceSQLExceptionSubclassFailover=java.sql.SQLTransientConnectionException
  ```

While the three fail-over conditions enumerated earlier suit most situations, if `auto-commit` is enabled, Connector/J never re-balances, and continues using the same physical connection. This can be problematic, particularly when load-balancing is being used to distribute read-only load across multiple slaves. However, Connector/J can be configured to re-balance after a certain number of statements are executed, when `auto-commit` is enabled. This functionality is dependent upon the following properties:

- `loadBalanceAutoCommitStatementThreshold` – defines the number of matching statements which will trigger the driver to potentially swap physical server connections. The default value, 0, retains the behavior that connections with `auto-commit` enabled are never balanced.

- `loadBalanceAutoCommitStatementRegex` – the regular expression against which statements must match. The default value, blank, matches all statements. So, for example, using the following properties will cause Connector/J to re-balance after every third statement that contains the string “test”:

  ```
  loadBalanceAutoCommitStatementThreshold=3
  loadBalanceAutoCommitStatementRegex=.*test.*
  ```

  `loadBalanceAutoCommitStatementRegex` can prove useful in a number of situations. Your application may use temporary tables, server-side session state variables, or connection state, where letting the driver arbitrarily swap physical connections before processing is complete could cause data loss or other problems. This allows you to identify a trigger statement that is only executed when it is safe to swap physical connections.

20.3.5.2.2. Using Connector/J with Tomcat

The following instructions are based on the instructions for Tomcat-5.x, available at http://tomcat.apache.org/tomcat-5.5-doc/jndi-datasource-examples-howto.html which is current at the time this document was written.

First, install the .jar file that comes with Connector/J in `$CATALINA_HOME/common/lib` so that it is available to all applications installed in the container.

Next, Configure the JNDI DataSource by adding a declaration resource to `$CATALINA_HOME/conf/server.xml` in the context that defines your web application:

```
<Context ....>

  ...

  <Resource name="jdbc/MySQLDB"
               auth="Container"
               type="javax.sql.DataSource"/>

  <!-- The name you used above, must match _exactly_ here!

       The connection pool will be bound into JNDI with the name
       "java:/comp/env/jdbc/MySQLDB"
  -->

  <ResourceParams name="jdbc/MySQLDB">
    <parameter>
      <name>factory</name>
      <value>org.apache.commons.dbcp.BasicDataSourceFactory</value>
    </parameter>

    <!-- Don't set this any higher than max_connections on your
         MySQL server, usually this should be a 10 or a few 10's
         of connections, not hundreds or thousands -->

    <parameter>
      <name>maxActive</name>
      <value>10</value>
    </parameter>

    <!-- You don't want to many idle connections hanging around
         if you can avoid it, only enough to soak up a spike in
         the load -->

    <parameter>
      <name>maxIdle</name>
      <value>5</value>
    </parameter>

    <!-- Don't use autoReconnect=true, it's going away eventually
         and it's a crutch for older connection pools that couldn't
         test connections. You need to decide whether your application
         is supposed to deal with SQLExceptions (hint, it should), and
         how much of a performance penalty you're willing to pay
         to ensure 'freshness' of the connection -->

    <parameter>
      <name>validationQuery</name>
      <value>SELECT 1</value> <-- See discussion below for update to this option -->
    </parameter>

   <!-- The most conservative approach is to test connections
        before they're given to your application. For most applications
        this is okay, the query used above is very small and takes
        no real server resources to process, other than the time used
        to traverse the network.

        If you have a high-load application you'll need to rely on
        something else. -->

    <parameter>
      <name>testOnBorrow</name>
      <value>true</value>
    </parameter>

   <!-- Otherwise, or in addition to testOnBorrow, you can test
        while connections are sitting idle -->

    <parameter>
      <name>testWhileIdle</name>
      <value>true</value>
    </parameter>

    <!-- You have to set this value, otherwise even though
         you've asked connections to be tested while idle,
         the idle evicter thread will never run -->

    <parameter>
      <name>timeBetweenEvictionRunsMillis</name>
      <value>10000</value>
    </parameter>

    <!-- Don't allow connections to hang out idle too long,
         never longer than what wait_timeout is set to on the
         server...A few minutes or even fraction of a minute
         is sometimes okay here, it depends on your application
         and how much spikey load it will see -->

    <parameter>
      <name>minEvictableIdleTimeMillis</name>
      <value>60000</value>
    </parameter>
    <!-- Username and password used when connecting to MySQL -->

    <parameter>
     <name>username</name>
     <value>someuser</value>
    </parameter>

    <parameter>
     <name>password</name>
     <value>somepass</value>
    </parameter>

    <!-- Class name for the Connector/J driver -->

    <parameter>
       <name>driverClassName</name>
       <value>com.mysql.jdbc.Driver</value>
    </parameter>

    <!-- The JDBC connection url for connecting to MySQL, notice
         that if you want to pass any other MySQL-specific parameters
         you should pass them here in the URL, setting them using the
         parameter tags above will have no effect, you will also
         need to use &amp; to separate parameter values as the
         ampersand is a reserved character in XML -->

    <parameter>
      <name>url</name>
      <value>jdbc:mysql://localhost:3306/test</value>
    </parameter>

  </ResourceParams>
</Context>
```

Note that Connector/J 5.1.3 introduced a facility whereby, rather than use a `validationQuery` value of `SELECT 1`, it is possible to use `validationQuery` with a value set to `/* ping */`. This sends a ping to the server which then returns a fake result set. This is a lighter weight solution. It also has the advantage that if using `ReplicationConnection` or `LoadBalancedConnection` type connections, the ping will be sent across all active connections. The following XML snippet illustrates how to select this option:

```
<parameter>
 <name>validationQuery</name>
 <value>/* ping */</value>
</parameter>
```

Note that `/* ping */` has to be specified exactly.

In general, you should follow the installation instructions that come with your version of Tomcat, as the way you configure datasources in Tomcat changes from time-to-time, and unfortunately if you use the wrong syntax in your XML file, you will most likely end up with an exception similar to the following:

```
Error: java.sql.SQLException: Cannot load JDBC driver class 'null ' SQL
state: null
```

20.3.5.2.3. Using Connector/J with JBoss

These instructions cover JBoss-4.x. To make the JDBC driver classes available to the application server, copy the .jar file that comes with Connector/J to the `lib` directory for your server configuration (which is usually called `default`). Then, in the same configuration directory, in the subdirectory named deploy, create a datasource configuration file that ends with "-ds.xml", which tells JBoss to deploy this file as a JDBC Datasource. The file should have the following contents:

```
<datasources>
    <local-tx-datasource>
        <!-- This connection pool will be bound into JNDI with the name
             "java:/MySQLDB" -->

        <jndi-name>MySQLDB</jndi-name>
        <connection-url>jdbc:mysql://localhost:3306/dbname</connection-url>
        <driver-class>com.mysql.jdbc.Driver</driver-class>
        <user-name>user</user-name>
        <password>pass</password>

        <min-pool-size>5</min-pool-size>

        <!-- Don't set this any higher than max_connections on your
         MySQL server, usually this should be a 10 or a few 10's
         of connections, not hundreds or thousands -->

        <max-pool-size>20</max-pool-size>

        <!-- Don't allow connections to hang out idle too long,
         never longer than what wait_timeout is set to on the
         server...A few minutes is usually okay here,
         it depends on your application
         and how much spikey load it will see -->

        <idle-timeout-minutes>5</idle-timeout-minutes>

        <!-- If you're using Connector/J 3.1.8 or newer, you can use
             our implementation of these to increase the robustness
             of the connection pool. -->

        <exception-sorter-class-name>
  com.mysql.jdbc.integration.jboss.ExtendedMysqlExceptionSorter
        </exception-sorter-class-name>
        <valid-connection-checker-class-name>
  com.mysql.jdbc.integration.jboss.MysqlValidConnectionChecker
        </valid-connection-checker-class-name>

    </local-tx-datasource>
</datasources>
```

20.3.5.2.4. Using Connector/J with Spring

The Spring Framework is a Java-based application framework designed for assisting in application design by providing a way to configure components. The technique used by Spring is a well known design pattern called Dependency Injection (see Inversion of Control Containers and the Dependency Injection pattern). This article will focus on Java-oriented access to MySQL databases with Spring 2.0. For those wondering, there is a .NET port of Spring appropriately named Spring.NET.

Spring is not only a system for configuring components, but also includes support for aspect oriented programming (AOP). This is one of the main benefits and the foundation for Spring's resource and transaction management. Spring also provides utilities for integrating resource management with JDBC and Hibernate.

For the examples in this section the MySQL world sample database will be used. The first task is to set up a MySQL data source through Spring. Components within Spring use the "bean" terminology. For example, to configure a connection to a MySQL server supporting the world sample database you might use:

```
<util:map id="dbProps">
    <entry key="db.driver" value="com.mysql.jdbc.Driver"/>
    <entry key="db.jdbcurl" value="jdbc:mysql://localhost/world"/>
    <entry key="db.username" value="myuser"/>
    <entry key="db.password" value="mypass"/>
</util:map>
```

In the above example we are assigning values to properties that will be used in the configuration. For the datasource configuration:

```
<bean id="dataSource"
       class="org.springframework.jdbc.datasource.DriverManagerDataSource">
    <property name="driverClassName" value="${db.driver}"/>
    <property name="url" value="${db.jdbcurl}"/>
    <property name="username" value="${db.username}"/>
    <property name="password" value="${db.password}"/>
</bean>
```

The placeholders are used to provide values for properties of this bean. This means that you can specify all the properties of the configuration in one place instead of entering the values for each property on each bean. We do, however, need one more bean to pull this all together. The last bean is responsible for actually replacing the placeholders with the property values.

```
<bean
 class="org.springframework.beans.factory.config.PropertyPlaceholderConfigurer">
    <property name="properties" ref="dbProps"/>
</bean>
```

Now that we have our MySQL data source configured and ready to go, we write some Java code to access it. The example below will retrieve three random cities and their corresponding country using the data source we configured with Spring.

```
// Create a new application context. this processes the Spring config
ApplicationContext ctx =
    new ClassPathXmlApplicationContext("ex1appContext.xml");
// Retrieve the data source from the application context
    DataSource ds = (DataSource) ctx.getBean("dataSource");
// Open a database connection using Spring's DataSourceUtils
Connection c = DataSourceUtils.getConnection(ds);
try {
    // retrieve a list of three random cities
    PreparedStatement ps = c.prepareStatement(
        "select City.Name as 'City', Country.Name as 'Country' " +
        "from City inner join Country on City.CountryCode = Country.Code " +
        "order by rand() limit 3");
    ResultSet rs = ps.executeQuery();
    while(rs.next()) {
        String city = rs.getString("City");
        String country = rs.getString("Country");
        System.out.printf("The city %s is in %s%n", city, country);
    }
} catch (SQLException ex) {
    // something has failed and we print a stack trace to analyse the error
    ex.printStackTrace();
    // ignore failure closing connection
    try { c.close(); } catch (SQLException e) { }
} finally {
    // properly release our connection
    DataSourceUtils.releaseConnection(c, ds);
}
```

This is very similar to normal JDBC access to MySQL with the main difference being that we are using DataSourceUtils instead of the DriverManager to create the connection.

While it may seem like a small difference, the implications are somewhat far reaching. Spring manages this resource in a way similar to a container managed data source in a J2EE application server. When a connection is opened, it can be subsequently accessed in other parts of the code if it is synchronized with a transaction. This makes it possible to treat different parts of your application as transactional instead of passing around a database connection.

20.3.5.2.4.1. Using `JdbcTemplate`

Spring makes extensive use of the Template method design pattern (see Template Method Pattern). Our immediate focus will be on the `JdbcTemplate` and related classes, specifically `NamedParameterJdbcTemplate`. The template classes handle obtaining and releasing a connection for data access when one is needed.

The next example shows how to use `NamedParameterJdbcTemplate` inside of a DAO (Data Access Object) class to retrieve a random city given a country code.

```
public class Ex2JdbcDao {
     /**
     * Data source reference which will be provided by Spring.
     */
     private DataSource dataSource;

     /**
     * Our query to find a random city given a country code. Notice
     * the ":country" parameter toward the end. This is called a
     * named parameter.
     */
     private String queryString = "select Name from City " +
        "where CountryCode = :country order by rand() limit 1";

     /**
     * Retrieve a random city using Spring JDBC access classes.
     */
     public String getRandomCityByCountryCode(String cntryCode) {
         // A template that permits using queries with named parameters
         NamedParameterJdbcTemplate template =
         new NamedParameterJdbcTemplate(dataSource);
         // A java.util.Map is used to provide values for the parameters
         Map params = new HashMap();
         params.put("country", cntryCode);
         // We query for an Object and specify what class we are expecting
         return (String)template.queryForObject(queryString, params, String.class);
     }

    /**
    * A JavaBean setter-style method to allow Spring to inject the data source.
    * @param dataSource
    */
    public void setDataSource(DataSource dataSource) {
        this.dataSource = dataSource;
    }
}
```

The focus in the above code is on the `getRandomCityByCountryCode()` method. We pass a country code and use the `NamedParameterJdbcTemplate` to query for a city. The country code is placed in a Map with the key "country", which is the parameter is named in the SQL query.

To access this code, you need to configure it with Spring by providing a reference to the data source.

```
<bean id="dao" class="code.Ex2JdbcDao">
    <property name="dataSource" ref="dataSource"/>
</bean>
```

At this point, we can just grab a reference to the DAO from Spring and call `getRandomCityByCountryCode()`.

```
// Create the application context
    ApplicationContext ctx =
    new ClassPathXmlApplicationContext("ex2appContext.xml");
    // Obtain a reference to our DAO
    Ex2JdbcDao dao = (Ex2JdbcDao) ctx.getBean("dao");

    String countryCode = "USA";

    // Find a few random cities in the US
    for(int i = 0; i < 4; ++i)
        System.out.printf("A random city in %s is %s%n", countryCode,
            dao.getRandomCityByCountryCode(countryCode));
```

This example shows how to use Spring's JDBC classes to completely abstract away the use of traditional JDBC classes including `Connection` and `PreparedStatement`.

20.3.5.2.4.2. Transactional JDBC Access

You might be wondering how we can add transactions into our code if we do not deal directly with the JDBC classes. Spring provides a transaction management package that not only replaces JDBC transaction management, but also enables declarative transaction management (configuration instead of code).

To use transactional database access, we will need to change the storage engine of the tables in the world database. The downloaded script explicitly creates MyISAM tables which do not support transactional semantics. The InnoDB storage engine does support transactions and this is what we will be using. We can change the storage engine with the following statements.

```
ALTER TABLE City ENGINE=InnoDB;
ALTER TABLE Country ENGINE=InnoDB;
ALTER TABLE CountryLanguage ENGINE=InnoDB;
```

A good programming practice emphasized by Spring is separating interfaces and implementations. What this means is that we can create a Java interface and only use the operations on this interface without any internal knowledge of what the actual implementation is. We will let Spring manage the implementation and with this it will manage the transactions for our implementation.

First you create a simple interface:

```
public interface Ex3Dao {
    Integer createCity(String name, String countryCode,
    String district, Integer population);
}
```

This interface contains one method that will create a new city record in the database and return the id of the new record. Next you need to create an implementation of this interface.

```
public class Ex3DaoImpl implements Ex3Dao {
    protected DataSource dataSource;
    protected SqlUpdate updateQuery;
    protected SqlFunction idQuery;

    public Integer createCity(String name, String countryCode,
        String district, Integer population) {
            updateQuery.update(new Object[] { name, countryCode,
                   district, population });
            return getLastId();
        }

    protected Integer getLastId() {
        return idQuery.run();
    }
}
```

You can see that we only operate on abstract query objects here and do not deal directly with the JDBC API. Also, this is the complete implementation. All of our transaction management will be dealt with in the configuration. To get the configuration started, we need to create the DAO.

```
<bean id="dao" class="code.Ex3DaoImpl">
    <property name="dataSource" ref="dataSource"/>
    <property name="updateQuery">...</property>
    <property name="idQuery">...</property>
</bean>
```

Now you need to set up the transaction configuration. The first thing you must do is create transaction manager to manage the data source and a specification of what transaction properties are required for the `dao` methods.

```
<bean id="transactionManager"
  class="org.springframework.jdbc.datasource.DataSourceTransactionManager">
    <property name="dataSource" ref="dataSource"/>
</bean>

<tx:advice id="txAdvice" transaction-manager="transactionManager">
    <tx:attributes>
        <tx:method name="*"/>
    </tx:attributes>
</tx:advice>
```

The preceding code creates a transaction manager that handles transactions for the data source provided to it. The `txAdvice` uses this transaction manager and the attributes specify to create a transaction for all methods. Finally you need to apply this advice with an AOP pointcut.

```
<aop:config>
    <aop:pointcut id="daoMethods"
        expression="execution(* code.Ex3Dao.*(..))"/>
     <aop:advisor advice-ref="txAdvice" pointcut-ref="daoMethods"/>
</aop:config>
```

This basically says that all methods called on the `Ex3Dao` interface will be wrapped in a transaction. To make use of this, you only have to retrieve the `dao` from the application context and call a method on the `dao` instance.

```
Ex3Dao dao = (Ex3Dao) ctx.getBean("dao");
Integer id = dao.createCity(name,  countryCode, district, pop);
```

We can verify from this that there is no transaction management happening in our Java code and it is all configured with Spring. This is a very powerful notion and regarded as one of the most beneficial features of Spring.

20.3.5.2.4.3. Connection Pooling

In many situations, such as web applications, there will be a large number of small database transactions. When this is the case, it usually makes sense to create a pool of database connections available for web requests as needed. Although MySQL does not spawn an extra process when a connection is made, there is still a small amount of overhead to create and set up the connection. Pooling of connections also alleviates problems such as collecting large amounts of sockets in the `TIME_WAIT` state.

Setting up pooling of MySQL connections with Spring is as simple as changing the data source configuration in the application context. There are a number of configurations that we can use. The first example is based on the Jakarta Commons DBCP library. The example below replaces the source configuration that was based on `DriverManagerDataSource` with DBCP's BasicDataSource.

```
<bean id="dataSource" destroy-method="close"
  class="org.apache.commons.dbcp.BasicDataSource">
    <property name="driverClassName" value="${db.driver}"/>
    <property name="url" value="${db.jdbcurl}"/>
    <property name="username" value="${db.username}"/>
    <property name="password" value="${db.password}"/>
    <property name="initialSize" value="3"/>
</bean>
```

The configuration of the two solutions is very similar. The difference is that DBCP will pool connections to the database instead of creating a new connection every time one is requested. We have also set a parameter here called `initialSize`. This tells DBCP that we want three connections in the pool when it is created.

Another way to configure connection pooling is to configure a data source in our J2EE application server. Using JBoss as an example, you can set up the MySQL connection pool by creating a file called `mysql-local-ds.xml` and placing it in the server/default/deploy directory in JBoss. Once we have this setup, we can use JNDI to look it up. With Spring, this lookup is very simple. The data source configuration looks like this.

```
<jee:jndi-lookup id="dataSource" jndi-name="java:MySQL_DS"/>
```

20.3.5.2.5. Using Connector/J with GlassFish

This section explains how to use MySQL Connector/J with Glassfish ™ Server Open Source Edition 3.0.1. Glassfish can be downloaded from the Glassfish website.

Once Glassfish is installed you will need to make sure it can access MySQL Connector/J. To do this copy the MySQL Connector/J JAR file to the directory *`GLASSFISH_INSTALL`*`/glassfish/lib`. For example, copy `mysql-connector-java-5.1.12-bin.jar` to `C:\glassfishv3\glassfish\lib`. Restart the Glassfish Application Server.

You are now ready to create JDBC Connection Pools and JDBC Resources.

Creating a Connection Pool

1. In the Glassfish Administration Console, using the navigation tree navigate to **RESOURCES**, **JDBC**, **CONNECTION POOLS**.
2. In the **JDBC CONNECTION POOLS** frame click NEW. You will enter a two step wizard.

3. In the **NAME** field under **GENERAL SETTINGS** enter the name for the connection pool, for example enter **`MySQLConnPool`**.
4. In the **RESOURCE TYPE** field, select `javax.sql.DataSource` from the drop-down listbox.
5. In the **DATABASE VENDOR** field, select `MySQL` from the drop-down listbox. Click NEXT to go to the next page of the wizard.
6. You can accept the default settings for General Settings, Pool Settings and Transactions for this example. Scroll down to Additional Properties.
7. In Additional Properties you will need to ensure the following properties are set:
   - **ServerName** - The server you wish to connect to. For local testing this will be `localhost`.
   - **User** - The user name with which to connect to MySQL.
   - **Password** - The corresponding password for the user.
   - **DatabaseName** - The database you wish to connect to, for example the sample MySQL database `World`.
8. Click FINISH to exit the wizard. You will be taken to the **JDBC CONNECTION POOLS** page where all current connection pools, including the one you just created, will be displayed.
9. In the **JDBC CONNECTION POOLS** frame click on the connection pool you just created. Here you can review and edit information about the connection pool.
10. To test your connection pool click the PING button at the top of the frame. A message will be displayed confirming correct operation or otherwise. If an error message is received recheck the previous steps, and ensure that MySQL Connector/J has been correctly copied into the previously specified location.

Now that you have created a connection pool you will also need to create a JDBC Resource (data source) for use by your application.

Creating a JDBC Resource

Your Java application will usually reference a data source object to establish a connection with the database. This needs to be created first using the following procedure.

- Using the navigation tree in the Glassfish Administration Console, navigate to **RESOURCES**, **JDBC**, **JDBC RESOURCES**. A list of resources will be displayed in the **JDBC RESOURCES** frame.
- Click NEW. The **NEW JDBC RESOURCE** frame will be displayed.
- In the **JNDI NAME** field, enter the JNDI name that will be used to access this resource, for example enter **`jdbc/MySQLDataSource`**.
- In the **POOL NAME** field, select a connection pool you want this resource to use from the drop-down listbox.
- Optionally, you can enter a description into the **DESCRIPTION** field.
- Additional properties can be added if required.
- Click OK to create the new JDBC resource. The **JDBC RESOURCES** frame will list all available JDBC Resources.

20.3.5.2.5.1. A Simple JSP Application with Glassfish, Connector/J and MySQL

This section shows how to deploy a simple JSP application on Glassfish, that connects to a MySQL database.

This example assumes you have already set up a suitable Connection Pool and JDBC Resource, as explained in the preceding sections. It is also assumed you have a sample database installed, such as `world`.

The main application code, `index.jsp` is presented here:

```
<%@ page import="java.sql.*, javax.sql.*, java.io.*, javax.naming.*" %>
<html>
<head><title>Hello world from JSP</title></head>
<body>
<%
  InitialContext ctx;
  DataSource ds;
  Connection conn;
  Statement stmt;
  ResultSet rs;

  try {
    ctx = new InitialContext();
    ds = (DataSource) ctx.lookup("java:comp/env/jdbc/MySQLDataSource");
    //ds = (DataSource) ctx.lookup("jdbc/MySQLDataSource");
    conn = ds.getConnection();
    stmt = conn.createStatement();
    rs = stmt.executeQuery("SELECT * FROM Country");

    while(rs.next()) {
%>
    <h3>Name: <%= rs.getString("Name") %></h3>
    <h3>Population: <%= rs.getString("Population") %></h3>
<%
    }
  }
  catch (SQLException se) {
%>
    <%= se.getMessage() %>
<%
  }
  catch (NamingException ne) {
%>
    <%= ne.getMessage() %>
<%
  }
%>
</body>
</html>
```

In addition two XML files are required: `web.xml`, and `sun-web.xml`. There may be other files present, such as classes and images. These files are organized into the directory structure as follows:

```
index.jsp
WEB-INF
   |
   - web.xml
   - sun-web.xml
```

The code for `web.xml` is:

```
<?xml version="1.0" encoding="UTF-8"?>
<web-app version="2.4" xmlns="http://java.sun.com/xml/ns/j2ee" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xs
  <display-name>HelloWebApp</display-name>
  <distributable/>
  <resource-ref>
    <res-ref-name>jdbc/MySQLDataSource</res-ref-name>
    <res-type>javax.sql.DataSource</res-type>
    <res-auth>Container</res-auth>
    <res-sharing-scope>Shareable</res-sharing-scope>
  </resource-ref>
</web-app>
```

The code for `sun-web.xml` is:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE sun-web-app PUBLIC "-//Sun Microsystems, Inc.//DTD Application Server 8.1 Servlet 2.4//EN" "http://www.sun.co
<sun-web-app>
  <context-root>HelloWebApp</context-root>
  <resource-ref>
    <res-ref-name>jdbc/MySQLDataSource</res-ref-name>
    <jndi-name>jdbc/MySQLDataSource</jndi-name>
  </resource-ref>
</sun-web-app>
```

These XML files illustrate a very important aspect of running JDBC applications on Glassfish. On Glassfish it is important to map the string specified for a JDBC resource to its JNDI name, as set up in the Glassfish administration console. In this example, the JNDI name for the JDBC resource, as specified in the Glassfish Administration console when creating the JDBC Resource, was `jdbc/MySQLDataSource`. This must be mapped to the name given in the application. In this example the name specified in the application, `jdbc/MySQLDataSource`, and the JNDI name, happen to be the same, but this does not necessarily have to be the case. Note that the XML element <res-ref-name> is used to specify the name as used in the application source code, and this is mapped to the JNDI name specified using the <jndi-name> element, in the file `sun-web.xml`. The resource also has to be created in the `web.xml` file, although the mapping of the resource to a JNDI name takes place in the `sun-web.xml` file.

If you do not have this mapping set up correctly in the XML files you will not be able to lookup the data source using a JNDI lookup string such as:

```
ds = (DataSource) ctx.lookup("java:comp/env/jdbc/MySQLDataSource");
```

You will still be able to access the data source directly using:

```
ds = (DataSource) ctx.lookup("jdbc/MySQLDataSource");
```

With the source files in place, in the correct directory structure, you are ready to deploy the application:

1. In the navigation tree, navigate to **APPLICATIONS** - the **APPLICATIONS** frame will be displayed. Click DEPLOY.
2. You can now deploy an application packaged into a single WAR file from a remote client, or you can choose a packaged file or directory that is locally accessible to the server. If you are simply testing an application locally you can simply point Glassfish at the directory that contains your application, without needing to package the application into a WAR file.
3. Now select the application type from the **TYPE** drop-down listbox, which in this example is `Web application`.
4. Click OK.

Now, when you navigate to the **APPLICATIONS** frame, you will have the option to **LAUNCH**, **REDEPLOY**, or **RESTART** your application. You can test your application by clicking **LAUNCH**. The application will connection to the MySQL database and display the Name and Population of countries in the `Country` table.

20.3.5.2.5.2. A Simple Servlet with Glassfish, Connector/J and MySQL

This section describes a simple servlet that can be used in the Glassfish environment to access a MySQL database. As with the previous section, this example assumes the sample database `world` is installed.

The project is set up with the following directory structure:

```
index.html
WEB-INF
   |
   - web.xml
   - sun-web.xml
   - classes
        |
        - HelloWebServlet.java
        - HelloWebServlet.class
```

The code for the servlet, located in `HelloWebServlet.java`, is as follows:

```
import javax.servlet.http.*;
import javax.servlet.*;
import java.io.*;
import java.sql.*;
import javax.sql.*;
import javax.naming.*;

public class HelloWebServlet extends HttpServlet {

  InitialContext ctx = null;
  DataSource ds = null;
  Connection conn = null;
  PreparedStatement ps = null;
  ResultSet rs = null;

  String sql = "SELECT Name, Population FROM Country WHERE Name=?";

  public void init () throws ServletException {
    try {
      ctx = new InitialContext();
      ds = (DataSource) ctx.lookup("java:comp/env/jdbc/MySQLDataSource");
      conn = ds.getConnection();
      ps = conn.prepareStatement(sql);
    }
    catch (SQLException se) {
      System.out.println("SQLException: "+se.getMessage());
    }
    catch (NamingException ne) {
      System.out.println("NamingException: "+ne.getMessage());
    }
  }

  public void destroy () {
    try {
      if (rs != null)
        rs.close();
      if (ps != null)
        ps.close();
      if (conn != null)
```

```
        conn.close();
      if (ctx != null)
        ctx.close();
    }
    catch (SQLException se) {
      System.out.println("SQLException: "+se.getMessage());
    }
    catch (NamingException ne) {
      System.out.println("NamingException: "+ne.getMessage());
    }
  }

  public void doPost(HttpServletRequest req, HttpServletResponse resp){
    try {
      String country_name = req.getParameter("country_name");
      resp.setContentType("text/html");
      PrintWriter writer = resp.getWriter();
      writer.println("<html><body>");
      writer.println("<p>Country: "+country_name+"</p>");
      ps.setString(1, country_name);
      rs = ps.executeQuery();
      if (!rs.next()){
        writer.println("<p>Country does not exist!</p>");
      }
      else {
        rs.beforeFirst();
        while(rs.next()) {
          writer.println("<p>Name: "+rs.getString("Name")+"</p>");
          writer.println("<p>Population: "+rs.getString("Population")+"</p>");
        }
      }
      writer.println("</body></html>");
      writer.close();
    }
    catch (Exception e) {
      e.printStackTrace();
    }
  }

  public void doGet(HttpServletRequest req, HttpServletResponse resp){
    try {
      resp.setContentType("text/html");
      PrintWriter writer = resp.getWriter();
      writer.println("<html><body>");
      writer.println("<p>Hello from servlet doGet()</p>");
      writer.println("</body></html>");
      writer.close();
    }
    catch (Exception e) {
      e.printStackTrace();
    }
  }
}
```

In the preceding code a basic `doGet()` method is implemented, but is not used in the example. The code to establish the connection with the database is as shown in the previous example, Section 20.3.5.2.5.1, “A Simple JSP Application with Glassfish, Connector/J and MySQL”, and is most conveniently located in the servlet `init()` method. The corresponding freeing of resources is located in the destroy method. The main functionality of the servlet is located in the `doPost()` method. If the user enters nto the input form a country name that can be located in the database, the population of the country is returned. The code is invoked using a POST action associated with the input form. The form is defined in the file `index.html`:

```
<html>
  <head><title>HelloWebServlet</title></head>

  <body>
    <h1>HelloWebServlet</h1>

    <p>Please enter country name:</p>

    <form action="HelloWebServlet" method="POST">
      <input type="text" name="country_name" length="50" />
      <input type="submit" value="Submit" />
    </form>

  </body>
</html>
```

The XML files `web.xml` and `sun-web.xml` are as for the example in the preceding section, Section 20.3.5.2.5.1, “A Simple JSP Application with Glassfish, Connector/J and MySQL”, no additional changes are required.

Whe compiling the Java source code, you will need to specify the path to the file `javaee.jar`. On Windows, this can be done as follows:

```
shell> javac -classpath c:\glassfishv3\glassfish\lib\javaee.jar HelloWebServlet.java
```

Once the code is correctly located within its directory structure, and compiled, the application can be deployed in Glassfish. This is done in exactly the same way as described in the preceding section, Section 20.3.5.2.5.1, “A Simple JSP Application with Glassfish, Connector/J and MySQL”.

Once deployed the application can be launched from within the Glassfish Administration Console. Enter a country name such as “England”, and the application will return “Country does not exist!”. Enter “France”, and the application will return a population of 59225700.

20.3.5.3. Connector/J: Common Problems and Solutions

There are a few issues that seem to be commonly encountered often by users of MySQL Connector/J. This section deals with their symptoms, and their resolutions.

Questions

- 21.3.5.3.1: When I try to connect to the database with MySQL Connector/J, I get the following exception:

  ```
  SQLException: Server configuration denies access to data source
  SQLState: 08001
  VendorError: 0
  ```

  What is going on? I can connect just fine with the MySQL command-line client.

- 21.3.5.3.2: My application throws an SQLException 'No Suitable Driver'. Why is this happening?

- 21.3.5.3.3: I'm trying to use MySQL Connector/J in an applet or application and I get an exception similar to:

  ```
  SQLException: Cannot connect to MySQL server on host:3306.
  Is there a MySQL server running on the machine/port you
  are trying to connect to?

  (java.security.AccessControlException)
  SQLState: 08S01
  VendorError: 0
  ```

- 21.3.5.3.4: I have a servlet/application that works fine for a day, and then stops working overnight

- 21.3.5.3.5: I'm trying to use JDBC-2.0 updatable result sets, and I get an exception saying my result set is not updatable.

- 21.3.5.3.6: I cannot connect to the MySQL server using Connector/J, and I'm sure the connection paramters are correct.

- 21.3.5.3.7: I am trying to connect to my MySQL server within my application, but I get the following error and stack trace:

  ```
  java.net.SocketException
  MESSAGE: Software caused connection abort: recv failed

  STACKTRACE:

  java.net.SocketException: Software caused connection abort: recv failed
  at java.net.SocketInputStream.socketRead0(Native Method)
  at java.net.SocketInputStream.read(Unknown Source)
  at com.mysql.jdbc.MysqlIO.readFully(MysqlIO.java:1392)
  at com.mysql.jdbc.MysqlIO.readPacket(MysqlIO.java:1414)
  at com.mysql.jdbc.MysqlIO.doHandshake(MysqlIO.java:625)
  at com.mysql.jdbc.Connection.createNewIO(Connection.java:1926)
  at com.mysql.jdbc.Connection.<init>(Connection.java:452)
  at com.mysql.jdbc.NonRegisteringDriver.connect(NonRegisteringDriver.java:411)
  ```

- 21.3.5.3.8: My application is deployed through JBoss and I am using transactions to handle the statements on the MySQL database. Under heavy loads I am getting a error and stack trace, but these only occur after a fixed period of heavy activity.

- 21.3.5.3.9: When using `gcj` an `java.io.CharConversionException` is raised when working with certain character sequences.

- 21.3.5.3.10: Updating a table that contains a primary key that is either `FLOAT` or compound primary key that uses `FLOAT` fails to update the table and raises an exception.

- 21.3.5.3.11: You get an `ER_NET_PACKET_TOO_LARGE` exception, even though the binary blob size you want to insert using JDBC is safely below the `max_allowed_packet` size.

- 21.3.5.3.12: What should you do if you receive error messages similar to the following: “Communications link failure – Last packet sent to the server was X ms ago”?

- 21.3.5.3.13: Why does Connector/J not reconnect to MySQL and re-issue the statement after a communication failure, instead of throwing an Exception, even though I use the `autoReconnect` connection string option?

- 21.3.5.3.14: How can I use 3-byte UTF8 with Connector/J?
- 21.3.5.3.15: How can I use 4-byte UTF8, `utf8mb4` with Connector/J?
- 21.3.5.3.16: Using `useServerPrepStmts=false` and certain character encodings can lead to corruption when inserting BLOBs. How can this be avoided?

Questions and Answers

21.3.5.3.1: When I try to connect to the database with MySQL Connector/J, I get the following exception:

```
SQLException: Server configuration denies access to data source
SQLState: 08001
VendorError: 0
```

What is going on? I can connect just fine with the MySQL command-line client.

MySQL Connector/J must use TCP/IP sockets to connect to MySQL, as Java does not support Unix Domain Sockets. Therefore, when MySQL Connector/J connects to MySQL, the security manager in MySQL server will use its grant tables to determine whether the connection should be permitted.

You must add the necessary security credentials to the MySQL server for this to happen, using the `GRANT` statement to your MySQL Server. See Section 12.4.1.3, "`GRANT` Syntax", for more information.

> **Note**
>
> Testing your connectivity with the `mysql` command-line client will not work unless you add the `--host` flag, and use something other than `localhost` for the host. The `mysql` command-line client will use Unix domain sockets if you use the special host name `localhost`. If you are testing connectivity to `localhost`, use `127.0.0.1` as the host name instead.

> **Warning**
>
> Changing privileges and permissions improperly in MySQL can potentially cause your server installation to not have optimal security properties.

21.3.5.3.2: My application throws an SQLException 'No Suitable Driver'. Why is this happening?

There are three possible causes for this error:

- The Connector/J driver is not in your `CLASSPATH`, see Section 20.3.2, "Connector/J Installation".
- The format of your connection URL is incorrect, or you are referencing the wrong JDBC driver.
- When using DriverManager, the `jdbc.drivers` system property has not been populated with the location of the Connector/J driver.

21.3.5.3.3: I'm trying to use MySQL Connector/J in an applet or application and I get an exception similar to:

```
SQLException: Cannot connect to MySQL server on host:3306.
Is there a MySQL server running on the machine/port you
are trying to connect to?

(java.security.AccessControlException)
SQLState: 08S01
VendorError: 0
```

Either you're running an Applet, your MySQL server has been installed with the "--skip-networking" option set, or your MySQL server has a firewall sitting in front of it.

Applets can only make network connections back to the machine that runs the web server that served the .class files for the applet. This means that MySQL must run on the same machine (or you must have some sort of port re-direction) for this to work. This also means that you will not be able to test applets from your local file system, you must always deploy them to a web server.

MySQL Connector/J can only communicate with MySQL using TCP/IP, as Java does not support Unix domain sockets. TCP/IP communication with MySQL might be affected if MySQL was started with the "--skip-networking" flag, or if it is firewalled.

If MySQL has been started with the "--skip-networking" option set (the Debian Linux package of MySQL server does this for example), you need to comment it out in the file /etc/mysql/my.cnf or /etc/my.cnf. Of course your my.cnf file might also exist in the `data` directory of your MySQL server, or anywhere else (depending on how MySQL was compiled for your system). Binaries created by us always look in /etc/my.cnf and [datadir]/my.cnf. If your MySQL server has been firewalled, you will need to have the firewall configured to allow TCP/IP connections from the host where your Java code is running to the MySQL server on the port that MySQL is listening to (by default, 3306).

21.3.5.3.4: I have a servlet/application that works fine for a day, and then stops working overnight

MySQL closes connections after 8 hours of inactivity. You either need to use a connection pool that handles stale connections or use the "autoReconnect" parameter (see Section 20.3.4.1, "Driver/Datasource Class Names, URL Syntax and Configuration Properties for Connector/J").

Also, you should be catching SQLExceptions in your application and dealing with them, rather than propagating them all the way until your application exits, this is just good programming practice. MySQL Connector/J will set the SQLState (see `java.sql.SQLException.getSQLState()` in your APIDOCS) to "08S01" when it encounters network-connectivity issues during the processing of a query. Your application code should then attempt to re-connect to MySQL at this point.

The following (simplistic) example shows what code that can handle these exceptions might look like:

Example 20.12. Connector/J: Example of transaction with retry logic

```
public void doBusinessOp() throws SQLException {
    Connection conn = null;
    Statement stmt = null;
    ResultSet rs = null;

    //
    // How many times do you want to retry the transaction
    // (or at least _getting_ a connection)?
    //
    int retryCount = 5;

    boolean transactionCompleted = false;

    do {
        try {
            conn = getConnection(); // assume getting this from a
                                    // javax.sql.DataSource, or the
                                    // java.sql.DriverManager

            conn.setAutoCommit(false);

            //
            // Okay, at this point, the 'retry-ability' of the
            // transaction really depends on your application logic,
            // whether or not you're using autocommit (in this case
            // not), and whether you're using transactional storage
            // engines
            //
            // For this example, we'll assume that it's _not_ safe
            // to retry the entire transaction, so we set retry
            // count to 0 at this point
            //
            // If you were using exclusively transaction-safe tables,
            // or your application could recover from a connection going
            // bad in the middle of an operation, then you would not
            // touch 'retryCount' here, and just let the loop repeat
            // until retryCount == 0.
            //
            retryCount = 0;

            stmt = conn.createStatement();

            String query = "SELECT foo FROM bar ORDER BY baz";

            rs = stmt.executeQuery(query);

            while (rs.next()) {
            }

            rs.close();
            rs = null;

            stmt.close();
            stmt = null;

            conn.commit();
            conn.close();
            conn = null;

            transactionCompleted = true;
        } catch (SQLException sqlEx) {

            //
            // The two SQL states that are 'retry-able' are 08S01
            // for a communications error, and 40001 for deadlock.
            //
            // Only retry if the error was due to a stale connection,
            // communications problem or deadlock
            //
            String sqlState = sqlEx.getSQLState();

            if ("08S01".equals(sqlState) || "40001".equals(sqlState)) {
                retryCount--;
            } else {
                retryCount = 0;
            }
        } finally {
            if (rs != null) {
                try {
                    rs.close();
                } catch (SQLException sqlEx) {
                    // You'd probably want to log this . . .
                }
            }

            if (stmt != null) {
                try {
                    stmt.close();
                } catch (SQLException sqlEx) {
                    // You'd probably want to log this as well . . .
                }
            }

            if (conn != null) {
                try {
                    //
                    // If we got here, and conn is not null, the
                    // transaction should be rolled back, as not
                    // all work has been done

                    try {
                        conn.rollback();
                    } finally {
                        conn.close();
                    }
                } catch (SQLException sqlEx) {
                    //
                    // If we got an exception here, something
                    // pretty serious is going on, so we better
                    // pass it up the stack, rather than just
                    // logging it. . .

                    throw sqlEx;
                }
            }
        }
    } while (!transactionCompleted && (retryCount > 0));
}
```

Note

Use of the `autoReconnect` option is not recommended because there is no safe method of reconnecting to the MySQL server without risking some corruption of the connection state or database state information. Instead, you should use a connection pool which will enable your application to connect to the MySQL server using an available connection from the pool. The `autoReconnect` facility is deprecated, and may be removed in a future release.

21.3.5.3.5: I'm trying to use JDBC-2.0 updatable result sets, and I get an exception saying my result set is not updatable.

Because MySQL does not have row identifiers, MySQL Connector/J can only update result sets that have come from queries on tables that have at least one primary key, the query must select every primary key and the query can only span one table (that is, no joins). This is outlined in the JDBC specification.

Note that this issue only occurs when using updatable result sets, and is caused because Connector/J is unable to guarantee that it can identify the correct rows within the result set to be updated without having a unique reference to each row. There is no requirement to have a unique field on a table if you are using `UPDATE` or `DELETE` statements on a table where you can individually specify the criteria to be matched using a `WHERE` clause.

21.3.5.3.6: I cannot connect to the MySQL server using Connector/J, and I'm sure the connection paramters are correct.

Make sure that the `skip-networking` option has not been enabled on your server. Connector/J must be able to communicate with your server over TCP/IP, named sockets are not supported. Also ensure that you are not filtering connections through a Firewall or other network security system. For more information, see Section C.5.2.2, “`Can't connect to [local] MySQL server`”.

21.3.5.3.7: I am trying to connect to my MySQL server within my application, but I get the following error and stack trace:

```
java.net.SocketException
MESSAGE: Software caused connection abort: recv failed

STACKTRACE:

java.net.SocketException: Software caused connection abort: recv failed
```

```
at java.net.SocketInputStream.socketRead0(Native Method)
at java.net.SocketInputStream.read(Unknown Source)
at com.mysql.jdbc.MysqlIO.readFully(MysqlIO.java:1392)
at com.mysql.jdbc.MysqlIO.readPacket(MysqlIO.java:1414)
at com.mysql.jdbc.MysqlIO.doHandshake(MysqlIO.java:625)
at com.mysql.jdbc.Connection.createNewIO(Connection.java:1926)
at com.mysql.jdbc.Connection.<init>(Connection.java:452)
at com.mysql.jdbc.NonRegisteringDriver.connect(NonRegisteringDriver.java:411)
```

The error probably indicates that you are using a older version of the Connector/J JDBC driver (2.0.14 or 3.0.x) and you are trying to connect to a MySQL server with version 4.1x or newer. The older drivers are not compatible with 4.1 or newer of MySQL as they do not support the newer authentication mechanisms.

It is likely that the older version of the Connector/J driver exists within your application directory or your `CLASSPATH` includes the older Connector/J package.

21.3.5.3.8: My application is deployed through JBoss and I am using transactions to handle the statements on the MySQL database. Under heavy loads I am getting a error and stack trace, but these only occur after a fixed period of heavy activity.

This is a JBoss, not Connector/J, issue and is connected to the use of transactions. Under heavy loads the time taken for transactions to complete can increase, and the error is caused because you have exceeded the predefined timeout.

You can increase the timeout value by setting the `TransactionTimeout` attribute to the `TransactionManagerService` within the `/conf/jboss-service.xml` file (pre-4.0.3) or `/deploy/jta-service.xml` for JBoss 4.0.3 or later. See TransactionTimeoute within the JBoss wiki for more information.

21.3.5.3.9: When using `gcj` an `java.io.CharConversionException` is raised when working with certain character sequences.

This is a known issue with `gcj` which raises an exception when it reaches an unknown character or one it cannot convert. You should add `useJvmCharsetConverters=true` to your connection string to force character conversion outside of the `gcj` libraries, or try a different JDK.

21.3.5.3.10: Updating a table that contains a primary key that is either `FLOAT` or compound primary key that uses `FLOAT` fails to update the table and raises an exception.

Connector/J adds conditions to the `WHERE` clause during an `UPDATE` to check the old values of the primary key. If there is no match then Connector/J considers this a failure condition and raises an exception.

The problem is that rounding differences between supplied values and the values stored in the database may mean that the values never match, and hence the update fails. The issue will affect all queries, not just those from Connector/J.

To prevent this issue, use a primary key that does not use `FLOAT`. If you have to use a floating point column in your primary key use `DOUBLE` or `DECIMAL` types in place of `FLOAT`.

21.3.5.3.11: You get an `ER_NET_PACKET_TOO_LARGE` exception, even though the binary blob size you want to insert using JDBC is safely below the `max_allowed_packet` size.

This is because the `hexEscapeBlock()` method in `com.mysql.jdbc.PreparedStatement.streamToBytes()` may almost double the size of your data.

21.3.5.3.12: What should you do if you receive error messages similar to the following: “Communications link failure – Last packet sent to the server was X ms ago”?

Generally speaking, this error suggests that the network connection has been closed. There can be several root causes:

- Firewalls or routers may clamp down on idle connections (the MySQL client/server protocol does not ping).
- The MySQL Server may be closing idle connections which exceed the `wait_timeout` or `interactive_timeout` threshold.

To help troubleshoot these issues, the following tips can be used. If a recent (5.1.13+) version of Connector/J is used, you will see an improved level of information compared to earlier versions. Older versions simply display the last time a packet was sent to the server, which is frequently 0 ms ago. This is of limited use, as it may be that a packet was just sent, while a packet from the server has not been received for several hours. Knowing the period of time since Connector/J last received a packet from the server is useful information, so if this is not displayed in your exception message, it is recommended that you update Connector/J.

Further, if the time a packet was last sent/received exceeds the `wait_timeout` or `interactive_timeout` threshold, this is noted in the exception message.

Although network connections can be volatile, the following can be helpful in avoiding problems:

- Ensure connections are valid when used from the connection pool. Use a query that starts with `/* ping */` to execute a lightweight ping instead of full query. Note, the syntax of the ping needs to be exactly as specified here.
- Minimize the duration a connection object is left idle while other application logic is executed.
- Explicitly validate the connection before using it if the connection has been left idle for an extended period of time.
- Ensure that `wait_timeout` and `interactive_timeout` are set sufficiently high.
- Ensure that `tcpKeepalive` is enabled.
- Ensure that any configurable firewall or router timeout settings allow for the maximum expected connection idle time.

> **Note**
>
> Do not expect to be able to reuse a connection without problems, if it has being lying idle for a period. If a connection is to be reused after being idle for any length of time, ensure that you explicitly test it before reusing it.

21.3.5.3.13: Why does Connector/J not reconnect to MySQL and re-issue the statement after a communication failure, instead of throwing an Exception, even though I use the `autoReconnect` connection string option?

There are several reasons for this. The first is transactional integrity. The MySQL Reference Manual states that “there is no safe method of reconnecting to the MySQL server without risking some corruption of the connection state or database state information”. Consider the following series of statements for example:

```
conn.createStatement().execute(
  "UPDATE checking_account SET balance = balance - 1000.00 WHERE customer='Smith'");
conn.createStatement().execute(
  "UPDATE savings_account SET balance = balance + 1000.00 WHERE customer='Smith'");
conn.commit();
```

Consider the case where the connection to the server fails after the `UPDATE` to `checking_account`. If no exception is thrown, and the application never learns about the problem, it will continue executing. However, the server did not commit the first transaction in this case, so that will get rolled back. But execution continues with the next transaction, and increases the `savings_account` balance by 1000. The application did not receive an exception, so it continued regardless, eventually committing the second transaction, as the commit only applies to the changes made in the new connection. Rather than a transfer taking place, a deposit was made in this example.

Note that running with `auto-commit` enabled does not solve this problem. When Connector/J encounters a communication problem, there is no means to determine whether the server processed the currently executing statement or not. The following theoretical states are equally possible:

- The server never received the statement, and therefore no related processing occurred on the server.
- The server received the statement, executed it in full, but the response was not received by the client.

If you are running with `auto-commit` enabled, it is not possible to guarantee the state of data on the server when a communication exception is encountered. The statement may have reached the server, or it may not. All you know is that communication failed at some point, before the client received confirmation (or data) from the server. This does not only affect `auto-commit` statements though. If the communication problem occurred during `Connection.commit()`, the question arises of whether the transaction was committed on the server before the communication failed, or whether the server received the commit request at all.

The second reason for the generation of exceptions is that transaction-scoped contextual data may be vulnerable, for example:

- Temporary tables
- User-defined variables
- Server-side prepared statements

These items are lost when a connection fails, and if the connection silently reconnects without generating an exception, this could be detrimental to the correct execution of your application.

In summary, communication errors generate conditions that may well be unsafe for Connector/J to simply ignore by silently reconnecting. It is necessary for the application to be notified. It is then for the application developer to decide how to proceed in the event of connection errors and failures.

21.3.5.3.14: How can I use 3-byte UTF8 with Connector/J?

To use 3-byte UTF8 with Connector/J set `characterEncoding=utf8` and set `useUnicode=true` in the connection string.

21.3.5.3.15: How can I use 4-byte UTF8, `utf8mb4` with Connector/J?

To use 4-byte UTF8 with Connector/J configure the MySQL server with `character_set_server=utf8mb4`. Connector/J will then use that setting as long as `characterEncoding` has not been set in the connection string. This is equivalent to autodetection of the character set.

21.3.5.3.16: Using `useServerPrepStmts=false` and certain character encodings can lead to corruption when inserting BLOBs. How can this be avoided?

When using certain character encodings, such as SJIS, CP932, and BIG5, it is possible that BLOB data contains characters that can be interpreted as control characters, for example, backslash, '\'. This can lead to corrupted data when inserting BLOBs into the database. There are two things that need to be done to avoid this:

1. Set the connection string option `useServerPrepStmts` to `true`.
2. Set `SQL_MODE` to `NO_BACKSLASH_ESCAPES`.

20.3.6. Connector/J Support

20.3.6.1. Connector/J Community Support

Oracle provides assistance to the user community by means of its mailing lists. For Connector/J related issues, you can get help from experienced users by using the MySQL and Java mailing list. Archives and subscription information is available online at http://lists.mysql.com/java.

For information about subscribing to MySQL mailing lists or to browse list archives, visit http://lists.mysql.com/. See Section 1.6.1, “MySQL Mailing Lists”.

Community support from experienced users is also available through the JDBC Forum. You may also find help from other users in the other MySQL Forums, located at http://forums.mysql.com. See Section 1.6.2, “MySQL Community Support at the MySQL Forums”.

20.3.6.2. How to Report Connector/J Bugs or Problems

The normal place to report bugs is http://bugs.mysql.com/, which is the address for our bugs database. This database is public, and can be browsed and searched by anyone. If you log in to the system, you will also be able to enter new reports.

If you have found a sensitive security bug in MySQL, you can send email to `<security@mysql.com>`.

Writing a good bug report takes patience, but doing it right the first time saves time both for us and for yourself. A good bug report, containing a full test case for the bug, makes it very likely that we will fix the bug in the next release.

This section will help you write your report correctly so that you do not waste your time doing things that may not help us much or at all.

If you have a repeatable bug report, please report it to the bugs database at http://bugs.mysql.com/. Any bug that we are able to repeat has a high chance of being fixed in the next MySQL release.

To report other problems, you can use one of the MySQL mailing lists.

Remember that it is possible for us to respond to a message containing too much information, but not to one containing too little. People often omit facts because they think they know the cause of a problem and assume that some details do not matter.

A good principle is this: If you are in doubt about stating something, state it. It is faster and less troublesome to write a couple more lines in your report than to wait longer for the answer if we must ask you to provide information that was missing from the initial report.

The most common errors made in bug reports are (a) not including the version number of Connector/J or MySQL used, and (b) not fully describing the platform on which Connector/J is installed (including the JVM version, and the platform type and version number that MySQL itself is installed on).

This is highly relevant information, and in 99 cases out of 100, the bug report is useless without it. Very often we get questions like, “Why doesn't this work for me?” Then we find that the feature requested wasn't implemented in that MySQL version, or that a bug described in a report has already been fixed in newer MySQL versions.

Sometimes the error is platform-dependent; in such cases, it is next to impossible for us to fix anything without knowing the operating system and the version number of the platform.

If at all possible, you should create a repeatable, standalone testcase that doesn't involve any third-party classes.

To streamline this process, we ship a base class for testcases with Connector/J, named '`com.mysql.jdbc.util.BaseBugReport`'. To create a testcase for Connector/J using this class, create your own class that inherits from `com.mysql.jdbc.util.BaseBugReport` and override the methods `setUp()`, `tearDown()` and `runTest()`.

In the `setUp()` method, create code that creates your tables, and populates them with any data needed to demonstrate the bug.

In the `runTest()` method, create code that demonstrates the bug using the tables and data you created in the `setUp` method.

In the `tearDown()` method, drop any tables you created in the `setUp()` method.

In any of the above three methods, you should use one of the variants of the `getConnection()` method to create a JDBC connection to MySQL:

- `getConnection()` - Provides a connection to the JDBC URL specified in `getUrl()`. If a connection already exists, that connection is returned, otherwise a new connection is created.
- `getNewConnection()` - Use this if you need to get a new connection for your bug report (that is, there is more than one connection involved).
- `getConnection(String url)` - Returns a connection using the given URL.
- `getConnection(String url, Properties props)` - Returns a connection using the given URL and properties.

If you need to use a JDBC URL that is different from 'jdbc:mysql:///test', override the method `getUrl()` as well.

Use the `assertTrue(boolean expression)` and `assertTrue(String failureMessage, boolean expression)` methods to create conditions that must be met in your testcase demonstrating the behavior you are expecting (vs. the behavior you are observing, which is why you are most likely filing a bug report).

Finally, create a `main()` method that creates a new instance of your testcase, and calls the `run` method:

```
public static void main(String[] args) throws Exception {
      new MyBugReport().run();
 }
```

Once you have finished your testcase, and have verified that it demonstrates the bug you are reporting, upload it with your bug report to http://bugs.mysql.com/.

20.3.6.3. Connector/J Change History

The Connector/J Change History (Changelog) is located with the main Changelog for MySQL. See Section D.5, “MySQL Connector/J Change History”.

20.4. MySQL Connector/MXJ

MySQL Connector/MXJ is a Java Utility package for deploying and managing a MySQL database. Deploying and using MySQL can be as easy as adding another parameter to the JDBC connection url, which will result in the database being started when the first connection is made. This makes it easy for Java developers to deploy applications which require a database by reducing installation barriers for their end-users.

MySQL Connector/MXJ makes the MySQL database appear to be a java-based component. It does this by determining what platform the system is running on, selecting the appropriate binary, and launching the executable. It will also optionally deploy an initial database, with any specified parameters.

Included are instructions for use with a JDBC driver and deploying as a JMX MBean to JBoss.

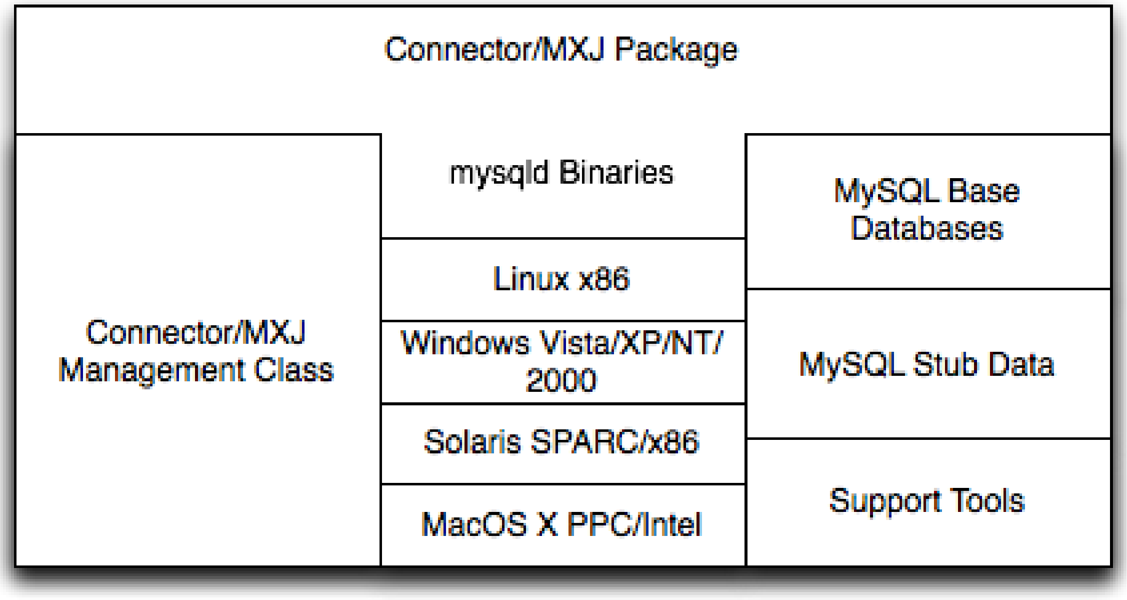
You can download sources and binaries from: http://dev.mysql.com/downloads/connector/mxj/

This a beta release and feedback is welcome and encouraged.

Please send questions or comments to the MySQL and Java mailing list.

20.4.1. Connector/MXJ Overview

Connector/MXJ consists of a Java class, a copy of the `mysqld` binary for a specific list of platforms, and associated files and support utilities. The Java class controls the initialization of an instance of the embedded `mysqld` binary, and the ongoing management of the `mysqld` process. The entire sequence and management can be controlled entirely from within Java using the Connector/MXJ Java classes. You can see an overview of the contents of the Connector/MXJ package in the figure below.



It is important to note that Connector/MXJ is not an embedded version of MySQL, or a version of MySQL written as part of a Java class. Connector/MXJ works through the use of an embedded, compiled binary of `mysqld` as would normally be used when deploying a standard MySQL installation.

It is the Connector/MXJ wrapper, support classes and tools, that enable Connector/MXJ to appear as a MySQL instance.

When Connector/MXJ is initialized, the corresponding `mysqld` binary for the current platform is extracted, along with a pre-configured data directed. Both are contained within the Connector/MXJ JAR file. The `mysqld` instance is then started, with any additional options as specified during the initialization, and the MySQL database becomes accessible.

Because Connector/MXJ works in combination with Connector/J, you can access and integrate with the MySQL instance through a JDBC connection. When you have finished with the server, the instance is terminated, and, by default, any data created during the session is retained within the temporary directory created when the instance was started.

Connector/MXJ and the embedded `mysqld` instance can be deployed in a number of environments where relying on an existing database, or installing a MySQL instance would be impossible, including CD-ROM embedded database applications and temporary database requirements within a Java-based application environment.

20.4.2. Connector/MXJ Versions

Connector/MXJ 5.x, currently in beta status, includes `mysqld` version 5.x and includes binaries for Linux x86, Mac OS X PPC, Windows XP/NT/2000 x86 and Solaris SPARC. Connector/MXJ 5.x requires the Connector/J 5.x package.

A summary of the different MySQL versions supplied with each Connector/MXJ release are shown in the table.

Connector/MXJ Version	**MySQL Version(s)**
5.0.11	5.1.40
5.0.9	5.0.51a (CS), 5.0.54 (ES)
5.0.8	5.0.45 (CS), 5.0.46 (ES)
5.0.7	5.0.41 (CS), 5.0.42 (ES)
5.0.6	5.0.37 (CS), 5.0.40 (ES)
5.0.5	5.0.37 (CS), 5.0.36 (ES)

Connector/MXJ Version	MySQL Version(s)
5.0.4	5.0.27 (CS), 5.0.32 (ES)
5.0.3	5.0.22
5.0.2	5.0.19

This guide provides information on the Connector/MXJ 5.x release. For information on using the older releases, please see the documentation included with the appropriate distribution.

20.4.3. Connector/MXJ Installation

Connector/MXJ does not have a installation application or process, but there are some steps you can follow to make the installation and deployment of Connector/MXJ easier.

Before you start, there are some baseline requirements for

- Java Runtime Environment (v1.4.0 or newer) if you are only going to deploy the package.
- Java Development Kit (v1.4.0 or newer) if you want to build Connector/MXJ from source.
- Connector/J 5.0 or newer.

Depending on your target installation/deployment environment you may also require:

- JBoss - 4.0rc1 or newer
- Apache Tomcat - 5.0 or newer
- Sun's JMX reference implementation version 1.2.1 (from http://java.sun.com/products/JavaManagement/)

20.4.3.1. Supported Platforms

Connector/MXJ is compatible with any platform supporting Java and MySQL. By default, Connector/MXJ incorporates the `mysqld` binary for a select number of platforms which differs by version. The following platforms have been tested and working as deployment platforms. Support for all the platforms listed below is not included by default.

- Linux (i386)
- FreeBSD (i386)
- Windows NT (x86), Windows 2000 (x86), Windows XP (x86), Windows Vista (x86)
- Solaris 8, SPARC 32-bit (compatible with Solaris 8, Solaris 9 and Solaris 10 on SPARC 32-bit and 64-bit platforms)
- Mac OS X (PowerPC and Intel)

The Connector/MXJ 5.0.8 release includes `mysqld` binaries for the following platforms:

- Linux (i386)
- Windows (x86), compatible with Windows NT, Windows 2000, Windows XP , Windows Vista
- Solaris 8, SPARC 32-bit (compatible with Solaris 8, Solaris 9 and Solaris 10 on SPARC 32-bit and 64-bit platforms)
- Mac OS X (PowerPC and Intel)

For more information on packaging your own Connector/MXJ with the platforms you require, see Section 20.4.6.1, “Creating your own Connector/MXJ Package”

20.4.3.2. Connector/MXJ Base Installation

Because there is no formal installation process, the method, installation directory, and access methods you use for Connector/MXJ are entirely up to your individual requirements.

To perform a basic installation, choose a target directory for the files included in the Connector/MXJ package. On Unix/Linux systems you may opt to use a directory such as `/usr/local/connector-mxj`; On Windows, you may want to install the files in the base directory, `C:\Connector-MXJ`, or within the `Program Files` directory.

To install the files, for a Connector/MXJ 5.0.4 installation:

1. Download the Connector/MXJ package, either in Tar/Gzip format (ideal for Unix/Linux systems) or Zip format (Windows).
2. Extract the files from the package. This will create a directory `mysql-connector-mxj-gpl-[ver]`. Copy and optionally rename this directory to your desired location.
3. For best results, you should update your global `CLASSPATH` variable with the location of the required `jar` files.

   Within Unix/Linux you can do this globally by editing the global shell profile, or on a user by user basis by editing their individual shell profile.

   On Windows 2000, Windows NT and Windows XP, you can edit the global `CLASSPATH` by editing the `Environment Variables` configured through the `System` control panel.

For Connector/MXJ 5.0.6 and later you need the following JAR files in your `CLASSPATH`:

- `mysql-connector-mxj-gpl-[ver].jar`: contains the main Connector/MXJ classes.
- `mysql-connector-mxj-gpl-[ver]-db-files.jar`: contains the embedded `mysqld` and database files.
- `aspectjrt.jar`: the AspectJ runtime library, located in `lib/aspectjrt.jar` in the Connector/MXJ package.
- `mysql-connector-java-[ver]-bin.jar`: Connector/J, see Section 20.3, “MySQL Connector/J”.

For Connector/MXJ 5.0.4 and later you need the following JAR files in your `CLASSPATH`:

- `connector-mxj.jar`: contains the main Connector/MXJ classes.
- `connector-mxj-db-files.jar`: contains the embedded `mysqld` and database files.
- `aspectjrt.jar`: the AspectJ runtime library, located in `lib/aspectjrt.jar` in the Connector/MXJ package.
- `mysql-connector-mxj-gpl-[ver].jar`: Connector/J, see Section 20.3, “MySQL Connector/J”.

For Connector/MXJ 5.0.3 and earlier, you need the following JAR files:

- `connector-mxj.jar`
- `aspectjrt.jar`: the AspectJ runtime library, located in `lib/aspectjrt.jar` in the Connector/MXJ package.
- `mysql-connector-mxj-gpl-[ver].jar`: Connector/J, see Section 20.3, “MySQL Connector/J”.

20.4.3.3. Connector/MXJ Quick Start Guide

Once you have extracted the Connector/MXJ and Connector/J components you can run one of the sample applications that initiates a MySQL instance. You can test the installation by running the `ConnectorMXJUrlTestExample`:

```
shell> java ConnectorMXJUrlTestExample
jdbc:mysql:mxj://localhost:3336/our_test_app?server.basedir»
    =/var/tmp/test-mxj&createDatabaseIfNotExist=true&server.initialize-user=true
[/var/tmp/test-mxj/bin/mysqld][--no-defaults][--port=3336][--socket=mysql.sock]»
    [--basedir=/var/tmp/test-mxj][--datadir=/var/tmp/test-mxj/data]»
    [--pid-file=/var/tmp/test-mxj/data/MysqldResource.pid]
[MysqldResource] launching mysqld (driver_launched_mysqld_1)
InnoDB: The first specified data file ./ibdata1 did not exist:
InnoDB: a new database to be created!
080220  9:40:20  InnoDB: Setting file ./ibdata1 size to 10 MB
InnoDB: Database physically writes the file full: wait...
080220  9:40:20  InnoDB: Log file ./ib_logfile0 did not exist: new to be created
```

```
InnoDB: Setting log file ./ib_logfile0 size to 5 MB
InnoDB: Database physically writes the file full: wait...
080220  9:40:20  InnoDB: Log file ./ib_logfile1 did not exist: new to be created
InnoDB: Setting log file ./ib_logfile1 size to 5 MB
InnoDB: Database physically writes the file full: wait...
InnoDB: Doublewrite buffer not found: creating new
InnoDB: Doublewrite buffer created
InnoDB: Creating foreign key constraint system tables
InnoDB: Foreign key constraint system tables created
080220  9:40:21  InnoDB: Started; log sequence number 0 0
080220  9:40:21 [Note] /var/tmp/test-mxj/bin/mysqld: ready for connections.
Version: '5.0.51a'  socket: 'mysql.sock'  port: 3336  MySQL Community Server (GPL)
[MysqldResource] mysqld running as process: 2238
------------------------
SELECT VERSION()
------------------------
5.0.51a
------------------------
[MysqldResource] stopping mysqld (process: 2238)
080220  9:40:27 [Note] /var/tmp/test-mxj/bin/mysqld: Normal shutdown

080220  9:40:27  InnoDB: Starting shutdown...
080220  9:40:29  InnoDB: Shutdown completed; log sequence number 0 43655
080220  9:40:29 [Note] /var/tmp/test-mxj/bin/mysqld: Shutdown complete

[MysqldResource] shutdown complete
```

The above output shows an instance of MySQL starting, the necessary files being created (log files, InnoDB data files) and the MySQL database entering the running state. The instance is then shutdown by Connector/MXJ before the example terminates.

> **Warning**
>
> You should avoid running your Connector/MXJ application as the `root` user, because this will cause the `mysqld` to also be executed with root privileges. For more information, see Section 5.3.6, “How to Run MySQL as a Normal User”.

20.4.3.4. Deploying Connector/MXJ using Driver Launch

Connector/MXJ and Connector/J work together to enable you to launch an instance of the `mysqld` server through the use of a keyword in the JDBC connection string. Deploying Connector/MXJ within a Java application can be automated through this method, making the deployment of Connector/MXJ a simple process:

1. Download and unzip Connector/MXJ, add `mysql-connector-mxj-gpl-[ver].jar` to the `CLASSPATH`.

   If you are using Connector/MXJ v5.0.4 or later you will also need to add the `mysql-connector-mxj-gpl-[ver]-db-files.jar` file to your `CLASSPATH`.

2. To the JDBC connection string, embed the `mxj` keyword, for example: `jdbc:mysql:mxj://localhost:`*`PORT/DBNAME`*.

For more details, see Section 20.4.4, “Connector/MXJ Configuration”.

20.4.3.5. Deploying Connector/MXJ within JBoss

For deployment of Connector/MXJ within a JBoss environment, you must configure the JBoss environment to use the Connector/MXJ component within the JDBC parameters:

1. Download Connector/MXJ and copy the `mysql-connector-mxj-gpl-[ver].jar` file to the `$JBOSS_HOME/server/default/lib` directory.

   If you are using Connector/MXJ v5.0.4 or later you will also need to copy the `mysql-connector-mxj-gpl-[ver]-db-files.jar` file to `$JBOSS_HOME/server/default/lib`.

2. Download Connector/J and copy the `mysql-connector-java-`*`5.1.5`*`-bin.jar` file to the `$JBOSS_HOME/server/default/lib` directory.

3. Create an MBean service xml file in the `$JBOSS_HOME/server/default/deploy` directory with any attributes set, for instance the `datadir` and `autostart`.

4. Set the JDBC parameters of your web application to use:

   ```
   String driver = "com.mysql.jdbc.Driver";
   String url = "jdbc:mysql:///test?propertiesTransform="+
                "com.mysql.management.jmx.ConnectorMXJPropertiesTransform";
   String user = "root";
   ```

```
String password = "";
Class.forName(driver);
Connection conn = DriverManager.getConnection(url, user, password);
```

You may wish to create a separate users and database table spaces for each application, rather than using "root and test".

We highly suggest having a routine backup procedure for backing up the database files in the `datadir`.

20.4.3.6. Verifying Installation using JUnit

The best way to ensure that your platform is supported is to run the JUnit tests. These will test the Connector/MXJ classes and the associated components.

20.4.3.6.1. JUnit Test Requirements

The first thing to do is make sure that the components will work on the platform. The `MysqldResource` class is really a wrapper for a native version of MySQL, so not all platforms are supported. At the time of this writing, Linux on the i386 architecture has been tested and seems to work quite well, as does OS X v10.3. There has been limited testing on Windows and Solaris.

Requirements:

1. JDK-1.4 or newer (or the JRE if you aren't going to be compiling the source or JSPs).
2. MySQL Connector/J version 5.0 or newer (from http://dev.mysql.com/downloads/connector/j/) installed and available using your CLASSPATH.
3. The `javax.management` classes for JMX version 1.2.1, these are present in the following application servers:
    - JBoss - 4.0rc1 or newer.
    - Apache Tomcat - 5.0 or newer.
    - Sun's JMX reference implementation version 1.2.1 (from http://java.sun.com/products/JavaManagement/).
4. JUnit 3.8.1 (from http://www.junit.org/).

If building from source, All of the requirements from above, plus:

1. Ant version 1.5 or newer (download from http://ant.apache.org/).

20.4.3.6.2. Running the JUnit Tests

1. The tests attempt to launch MySQL on the port 3336. If you have a MySQL running, it may conflict, but this isn't very likely because the default port for MySQL is 3306. However, You may set the "c-mxj_test_port" Java property to a port of your choosing. Alternatively, you may wish to start by shutting down any instances of MySQL you have running on the target machine.

   The tests suppress output to the console by default. For verbose output, you may set the "c-mxj_test_silent" Java property to "false".

2. To run the JUnit test suite, the $CLASSPATH must include the following:
    - JUnit
    - JMX
    - Connector/J
    - MySQL Connector/MXJ
3. If `connector-mxj.jar` is not present in your download, unzip MySQL Connector/MXJ source archive.

```
cd mysqldjmx
ant dist
```

Then add `$TEMP/cmxj/stage/connector-mxj/connector-mxj.jar` to the CLASSPATH.

4. If you have `junit`, execute the unit tests. From the command line, type:

   ```
   java com.mysql.management.AllTestsSuite
   ```

   The output should look something like this:

   ```
   .........................................
   .........................................
   ..........
   Time: 259.438

   OK (101 tests)
   ```

   Note that the tests are a bit slow near the end, so please be patient.

20.4.4. Connector/MXJ Configuration

20.4.4.1. Running as part of the JDBC Driver

A feature of the MySQL Connector/J JDBC driver is the ability to specify a connection to an embedded Connector/MXJ instance through the use of the mxj keyword in the JDBC connection string.

In the following example, we have a program which creates a connection, executes a query, and prints the result to the System.out. The MySQL database will be deployed and started as part of the connection process, and shutdown as part of the finally block.

You can find this file in the Connector/MXJ package as `src/ConnectorMXJUrlTestExample.java`.

```
import java.io.File;
import java.sql.Connection;
import java.sql.DriverManager;

import com.mysql.management.driverlaunched.ServerLauncherSocketFactory;
import com.mysql.management.util.QueryUtil;

public class ConnectorMXJUrlTestExample {
  public static String DRIVER = "com.mysql.jdbc.Driver";

  public static String JAVA_IO_TMPDIR = "java.io.tmpdir";

  public static void main(String[] args) throws Exception {
    File ourAppDir = new File(System.getProperty(JAVA_IO_TMPDIR));
    File databaseDir = new File(ourAppDir, "test-mxj");
    int port = Integer.parseInt(System.getProperty("c-mxj_test_port", "3336"));
    String dbName = "our_test_app";

    String url = "jdbc:mysql:mxj://localhost:" + port + "/" + dbName //
      + "?" + "server.basedir=" + databaseDir //
      + "&" + "createDatabaseIfNotExist=true"//
      + "&" + "server.initialize-user=true" //
    ;

    System.out.println(url);

    String userName = "alice";
    String password = "q93uti0opwhkd";

    Class.forName(DRIVER);
    Connection conn = null;
    try {
      conn = DriverManager.getConnection(url, userName, password);
      String sql = "SELECT VERSION()";
      String queryForString = new QueryUtil(conn).queryForString(sql);

      System.out.println("------------------------");
      System.out.println(sql);
      System.out.println("------------------------");
      System.out.println(queryForString);
      System.out.println("------------------------");
      System.out.flush();
      Thread.sleep(100); // wait for System.out to finish flush
    } finally {
      try {
        if (conn != null)
           conn.close();
      } catch (Exception e) {
        e.printStackTrace();
      }

      ServerLauncherSocketFactory.shutdown(databaseDir, null);
```

```
    }
  }
}
```

To run the above program, be sure to have connector-mxj.jar and Connector/J in the CLASSPATH. Then type:

```
java ConnectorMXJUrlTestExample
```

20.4.4.2. Running within a Java Object

If you have a java application and wish to “embed” a MySQL database, make use of the `com.mysql.management.MysqldResource` class directly. This class may be instantiated with the default (no argument) constructor, or by passing in a java.io.File object representing the directory you wish the server to be "unzipped" into. It may also be instantiated with printstreams for "stdout" and "stderr" for logging.

Once instantiated, a `java.util.Map`, the object will be able to provide a `java.util.Map` of server options appropriate for the platform and version of MySQL which you will be using.

The `MysqldResource` enables you to "start" MySQL with a `java.util.Map` of server options which you provide, as well as "shutdown" the database. The following example shows a simplistic way to embed MySQL in an application using plain java objects.

You can find this file in the Connector/MXJ package as `src/ConnectorMXJObjectTestExample.java`.

```
import java.io.File;
import java.sql.Connection;
import java.sql.DriverManager;
import java.util.HashMap;
import java.util.Map;

import com.mysql.management.MysqldResource;
import com.mysql.management.MysqldResourceI;
import com.mysql.management.util.QueryUtil;

public class ConnectorMXJObjectTestExample {
    public static final String DRIVER = "com.mysql.jdbc.Driver";

    public static final String JAVA_IO_TMPDIR = "java.io.tmpdir";

    public static void main(String[] args) throws Exception {
        File ourAppDir = new File(System.getProperty(JAVA_IO_TMPDIR));
        File databaseDir = new File(ourAppDir, "mysql-mxj");
        int port = Integer.parseInt(System.getProperty("c-mxj_test_port",
                "3336"));
        String userName = "alice";
        String password = "q93uti0opwhkd";

        MysqldResource mysqldResource = startDatabase(databaseDir, port,
                userName, password);

        Class.forName(DRIVER);
        Connection conn = null;
        try {
            String dbName = "our_test_app";
            String url = "jdbc:mysql://localhost:" + port + "/" + dbName //
                    + "?" + "createDatabaseIfNotExist=true"//
            ;
            conn = DriverManager.getConnection(url, userName, password);
            String sql = "SELECT VERSION()";
            String queryForString = new QueryUtil(conn).queryForString(sql);

            System.out.println("------------------------");
            System.out.println(sql);
            System.out.println("------------------------");
            System.out.println(queryForString);
            System.out.println("------------------------");
            System.out.flush();
            Thread.sleep(100); // wait for System.out to finish flush
        } finally {
            try {
                if (conn != null) {
                    conn.close();
                }
            } catch (Exception e) {
                e.printStackTrace();
            }
            try {
                mysqldResource.shutdown();
            } catch (Exception e) {
                e.printStackTrace();
            }
        }
    }

    public static MysqldResource startDatabase(File databaseDir, int port,
            String userName, String password) {
```

```
        MysqldResource mysqldResource = new MysqldResource(databaseDir);

        Map database_options = new HashMap();
        database_options.put(MysqldResourceI.PORT, Integer.toString(port));
        database_options.put(MysqldResourceI.INITIALIZE_USER, "true");
        database_options.put(MysqldResourceI.INITIALIZE_USER_NAME, userName);
        database_options.put(MysqldResourceI.INITIALIZE_PASSWORD, password);

        mysqldResource.start("test-mysqld-thread", database_options);

        if (!mysqldResource.isRunning()) {
            throw new RuntimeException("MySQL did not start.");
        }

        System.out.println("MySQL is running.");

        return mysqldResource;
    }
}
```

20.4.4.3. Setting server options

Of course there are many options we may wish to set for a MySQL database. These options may be specified as part of the JDBC connection string simply by prefixing each server option with `server.`. In the following example we set two driver parameters and two server parameters:

```
        String url = "jdbc:mysql://" + hostColonPort + "/"
                + "?"
                + "cacheServerConfiguration=true"
                + "&"
                + "useLocalSessionState=true"
                + "&"
                + "server.basedir=/opt/myapp/db"
                + "&"
                + "server.datadir=/mnt/bigdisk/myapp/data";
```

Starting with Connector/MXJ 5.0.6 you can use the `initialize-user` property to a connection string. If set to true, the default anonymous and root users will be removed and the user/password combination from the connection URL will be used to create a new user. For example:

```
        String url = "jdbc:mysql:mxj://localhost:" + port
        + "/alice_db"
        + "?server.datadir=" + dataDir.getPath()
        + "&server.initialize-user=true"
        + "&createDatabaseIfNotExist=true"
        ;
```

20.4.5. Connector/MXJ Reference

The following sections include detailed information on the different API interfaces to Connector/MXJ.

20.4.5.1. MysqldResource Constructors

The `MysqldResource` class supports three different constructor forms:

- `public MysqldResource(File baseDir, File dataDir, String mysqlVersionString, PrintStream out, PrintStream err)`

  Enables you to set the base directory, data directory, select a server by its version string, standard out and standard error.

- `public MysqldResource(File baseDir, File dataDir, String mysqlVersionString)`

  Enables you to set the base directory, data directory and select a server by its version string. Output for standard out and standard err are directed to System.out and System.err.

- `public MysqldResource(File baseDir, File dataDir)`

  Enables you to set the base directory and data directory. The default MySQL version is selected, and output for standard out and standard err are directed to System.out and System.err.

- `public MysqldResource(File baseDir);`

  Enables the setting of the "basedir" to deploy the MySQL files to. Output for standard out and standard err are directed to System.out and System.err.

- `public MysqldResource();`

  The basedir is defaulted to a subdirectory of the java.io.tempdir. Output for standard out and standard err are directed to System.out and System.err;

20.4.5.2. MysqldResource Methods

MysqldResource API includes the following methods:

- `void start(String threadName, Map mysqldArgs);`

  Deploys and starts MySQL. The "threadName" string is used to name the thread which actually performs the execution of the MySQL command line. The map is the set of arguments and their values to be passed to the command line.

- `void shutdown();`

  Shuts down the MySQL instance managed by the MysqldResource object.

- `Map getServerOptions();`

  Returns a map of all the options and their current (or default, if not running) options available for the MySQL database.

- `boolean isRunning();`

  Returns true if the MySQL database is running.

- `boolean isReadyForConnections();`

  Returns true once the database reports that is ready for connections.

- `void setKillDelay(int millis);`

  The default “Kill Delay” is 30 seconds. This represents the amount of time to wait between the initial request to shutdown and issuing a “force kill” if the database has not shutdown by itself.

- `void addCompletionListenser(Runnable listener);`

  Enables applications to be notified when the server process completes. Each “listener” will be fired off in its own thread.

- `String getVersion();`

  Returns the version of MySQL.

- `void setVersion(int MajorVersion, int minorVersion, int patchLevel);`

  The standard distribution comes with only one version of MySQL packaged. However, it is possible to package multiple versions, and specify which version to use.

20.4.6. Connector/MXJ Notes and Tips

This section contains notes and tips on using the Connector/MXJ component within your applications.

20.4.6.1. Creating your own Connector/MXJ Package

If you want to create a custom Connector/MXJ package that includes a specific `mysqld` version or platform then you must extract and rebuild the `mysql-connector-mxj.jar` (Connector/MXJ v5.0.3 or earlier) or `mysql-connector-mxj-gpl-[ver]-db-files.jar` (Connector/MXJ v5.0.4 or later) file.

First, you should create a new directory into which you can extract the current `connector-mxj.jar`:

```
shell> mkdir custom-mxj
shell> cd custom-mxj
shell> jar -xf connector-mxj.jar
shell> ls
5-0-22/
ConnectorMXJObjectTestExample.class
ConnectorMXJUrlTestExample.class
META-INF/
TestDb.class
com/
kill.exe
```

If you are using Connector/MXJ v5.0.4 or later, you should unpack the `connector-mxj-db-files.jar`:

```
shell> mkdir custom-mxj
shell> cd custom-mxj
shell> jar -xf connector-mxj-db-files.jar
shell> ls
5-0-51a/
META-INF/
connector-mxj.properties
```

The MySQL version directory, `5-0-22` or `5-0-51a` in the preceding examples, contains all of the files used to create an instance of MySQL when Connector/MXJ is executed. All of the files in this directory are required for each version of MySQL that you want to embed. Note as well the format of the version number, which uses hyphens instead of periods to separate the version number components.

Within the version specific directory are the platform specific directories, and archives of the `data` and `share` directory required by MySQL for the various platforms. For example, here is the listing for the default Connector/MXJ package:

```
shell>> ls
Linux-i386/
META-INF/
Mac_OS_X-ppc/
SunOS-sparc/
Win-x86/
com/
data_dir.jar
share_dir.jar
win_share_dir.jar
```

Platform specific directories are listed by their OS and platform - for example the `mysqld` for Mac OS X PowerPC is located within the `Mac_OS_X-ppc` directory. You can delete directories from this location that you do not require, and add new directories for additional platforms that you want to support.

To add a platform specific `mysqld`, create a new directory with the corresponding name for your operating system/platform. For example, you could add a directory for Mac OS X/Intel using the directory `Mac_OS_X-i386`.

On Unix systems, you can determine the platform using `uname`:

```
shell> uname -p
i386
```

In Connector/MXJ v5.0.9 and later, an additional `platform-map.properties` file is used to associate a specific platform and operating system combination with the directory in which the `mysqld` for that combination is located. The determined operating system and platform are on the left, and the directory name where the appropriate mysqld is located is on the right. You can see a sample of the file below:

```
Linux-i386=Linux-i386
Linux-x86=Linux-i386
Linux-i686=Linux-i386
Linux-x86_64=Linux-i386
Linux-ia64=Linux-i386

#Linux-ppc=Linux-ppc
#Linux-ppc64=Linux-ppc

Mac_OS_X-i386=Mac_OS_X-i386
Mac_OS_X-ppc=Mac_OS_X-ppc
Rhapsody-PowerPC=Mac_OS_X-ppc
#Mac_OS-PowerPC=
#macos-PowerPC=
#MacOS-PowerPC=

SunOS-sparc=SunOS-sparc
Solaris-sparc=SunOS-sparc
SunOS-x86=SunOS-x86
Solaris-x86=SunOS-x86

FreeBSD-x86=FreeBSD-x86

Windows_Vista-x86=Win-x86
Windows_2003-x86=Win-x86
Windows_XP-x86=Win-x86
Windows_2000-x86=Win-x86
Windows_NT-x86=Win-x86
Windows_NT_(unknown)-x86=Win-x86
```

Now you need to download or compile `mysqld` for the MySQL version and platform you want to include in your custom `connector-mxj.jar` package into the new directory.

Create a file called `version.txt` in the OS/platform directory you have just created that contains the version string/path of the mysqld binary. For example:

```
mysql-5.0.22-osx10.3-i386/bin/mysqld
```

You can now recreate the `connector-mxj.jar` file with the added `mysqld`:

```
shell> cd custom-mxj
shell> jar -cf ../connector-mxj.jar *
```

For Connector/MXJ v5.0.4 and later, you should repackage to the `connector-mxj-db-files.jar`:

```
shell> cd custom-mxj
shell> jar -cf ../mysql-connector-mxj-gpl-[ver]-db-files.jar *
```

You should test this package using the steps outlined in Section 20.4.3.3, “Connector/MXJ Quick Start Guide”.

> **Note**
>
> Because the `mysql-connector-mxj-gpl-[ver]-db-files.jar` file is separate from the main Connector/MXJ classes you can distribute different `mysql-connector-mxj-gpl-[ver]-db-files.jar` files to different hosts or for different projects without having to create a completely new main `mysql-connector-mxj-gpl-[ver].jar` file for each one.

20.4.6.2. Deploying Connector/MXJ with a pre-configured database

To include a pre-configured/populated database within your Connector/MXJ JAR file you must create a custom `data_dir.jar` file, as included within the main `connector-mxj.jar` (Connector/MXJ 5.0.3 or earlier) or `mysql-connector-mxj-gpl-[ver]-db-files.jar` (Connector/MXJ 5.0.4 or later) file:

1. First extract the `connector-mxj.jar` or `mysql-connector-gpl-[ver]-db-files.jar` file, as outlined in the previous section (see Section 20.4.6.1, “Creating your own Connector/MXJ Package”).

2. First, create your database and populate the database with the information you require in an existing instance of MySQL - including Connector/MXJ instances. Data file formats are compatible across platforms.

3. Shutdown the instance of MySQL.

4. Create a JAR file of the data directory and databases that you want to include your Connector/MXJ package. You should include the `mysql` database, which includes user authentication information, in addition to the specific databases you want to include. For example, to create a JAR of the `mysql` and `mxjtest` databases:

   ```
   shell> jar -cf ../data_dir.jar mysql mxjtest
   ```

5. For Connector/MXJ 5.0.3 or earlier, copy the `data_dir.jar` file into the extracted `connector-mxj.jar` directory, and then create an archive for `connector-mxj.jar`.

   For Connector/MXJ 5.0.4 or later, copy the `data_dir.jar` file into the extracted `mysql-connector-mxj-gpl-[ver]-db-files.jar` directory, and then create an archive for `mysql-connector-mxj-db-gpl-[ver]--files.jar`.

Note that if you are create databases using the InnoDB engine, you must include the `ibdata.*` and `ib_logfile*` files within the `data_dir.jar` archive.

20.4.6.3. Running within a JMX Agent (custom)

As a JMX MBean, MySQL Connector/MXJ requires a JMX v1.2 compliant MBean container, such as JBoss version 4. The MBean will uses the standard JMX management APIs to present (and allow the setting of) parameters which are appropriate for that platform.

If you are not using the SUN Reference implementation of the JMX libraries, you should skip this section. Or, if you are deploying to JBoss, you also may wish to skip to the next section.

We want to see the MysqldDynamicMBean in action inside of a JMX agent. In the `com.mysql.management.jmx.sunri` package is a custom JMX agent with two MBeans:

1. The MysqldDynamicMBean, and

2. A com.sun.jdmk.comm.HtmlAdaptorServer, which provides a web interface for manipulating the beans inside of a JMX agent.

When this very simple agent is started, it will allow a MySQL database to be started and stopped with a web browser.

1. Complete the testing of the platform as above.
    - Current JDK, JUnit, Connector/J, MySQL Connector/MXJ
    - This section *requires* the SUN reference implementation of JMX
    - `PATH`, `JAVA_HOME`, `ANT_HOME`, `CLASSPATH`
2. If not building from source, skip to next step

    Rebuild with the "sunri.present"

    ```
    ant -Dsunri.present=true dist
    re-run tests:
    java junit.textui.TestRunner com.mysql.management.AllTestsSuite
    ```
3. Launch the test agent from the command line:

    ```
    java com.mysql.management.jmx.sunri.MysqldTestAgentSunHtmlAdaptor &
    ```
4. From a browser:

    ```
    http://localhost:9092/
    ```
5. Under MysqldAgent,

    ```
    select "name=mysqld"
    ```
6. Observe the MBean View
7. Scroll to the bottom of the screen press the STARTMYSQLD button
8. Click `Back to MBean View`
9. Scroll to the bottom of the screen press STOPMYSQLD button
10. Kill the java process running the Test Agent (jmx server)

20.4.6.4. Deployment in a standard JMX Agent environment (JBoss)

Once there is confidence that the MBean will function on the platform, deploying the MBean inside of a standard JMX Agent is the next step. Included are instructions for deploying to JBoss.

1. Ensure a current version of java development kit (v1.4.x), see above.
    - Ensure `JAVA_HOME` is set (JBoss requires `JAVA_HOME`)
    - Ensure `JAVA_HOME/bin` is in the `PATH` (You will NOT need to set your CLASSPATH, nor will you need any of the jars used in the previous tests).
2. Ensure a current version of JBoss (v4.0RC1 or better)

    ```
    http://www.jboss.org/index.html
    select "Downloads"
    select "jboss-4.0.zip"
    pick a mirror
    unzip ~/dload/jboss-4.0.zip
    create a JBOSS_HOME environment variable set to the unzipped directory
    unix only:
    cd $JBOSS_HOME/bin
    chmod +x *.sh
    ```

3. Deploy (copy) the `connector-mxj.jar` to `$JBOSS_HOME/server/default/lib`.
4. Deploy (copy) `mysql-connector-java-3.1.4-beta-bin.jar` to `$JBOSS_HOME/server/default/lib`.
5. Create a `mxjtest.war` directory in `$JBOSS_HOME/server/default/deploy`.
6. Deploy (copy) `index.jsp` to `$JBOSS_HOME/server/default/deploy/mxjtest.war`.
7. Create a `mysqld-service.xml` file in `$JBOSS_HOME/server/default/deploy`.

```
<?xml version="1.0" encoding="UTF-8"?>
 <server>
  <mbean code="com.mysql.management.jmx.jboss.JBossMysqldDynamicMBean"
     name="mysql:type=service,name=mysqld">
  <attribute name="datadir">/tmp/xxx_data_xxx</attribute>
  <attribute name="autostart">true</attribute>
  </mbean>
 </server>
```

8. Start jboss:

   - On unix: `$JBOSS_HOME/bin/run.sh`
   - On windows: `%JBOSS_HOME%\bin\run.bat`

   Be ready: JBoss sends a lot of output to the screen.

9. When JBoss seems to have stopped sending output to the screen, open a web browser to: `http://localhost:8080/jmx-console`
10. Scroll down to the bottom of the page in the `mysql` section, select the bulleted `mysqld` link.
11. Observe the JMX MBean View page. MySQL should already be running.
12. (If "autostart=true" was set, you may skip this step.) Scroll to the bottom of the screen. You may press the INVOKE button to stop (or start) MySQL observe `Operation completed successfully without a return value.` Click `Back to MBean View`
13. To confirm MySQL is running, open a web browser to `http://localhost:8080/mxjtest/` and you should see that

    ```
    SELECT 1
    ```

    returned with a result of

    ```
    1
    ```

14. Guided by the `$JBOSS_HOME/server/default/deploy/mxjtest.war/index.jsp` you will be able to use MySQL in your Web Application. There is a `test` database and a `root` user (no password) ready to experiment with. Try creating a table, inserting some rows, and doing some selects.
15. Shut down MySQL. MySQL will be stopped automatically when JBoss is stopped, or: from the browser, scroll down to the bottom of the MBean View press the stop service INVOKE button to halt the service. Observe `Operation completed successfully without a return value.` Using `ps` or `task manager` see that MySQL is no longer running

As of 1.0.6-beta version is the ability to have the MBean start the MySQL database upon start up. Also, we've taken advantage of the JBoss life-cycle extension methods so that the database will gracefully shut down when JBoss is shutdown.

20.4.7. Connector/MXJ Samples

This section contains some sample applications using Connector/MXJ.

20.4.7.1. Using Connector/MXJ with JSP

The following web application was provided by Pavan Venkatesh as an example of a JSP based application using Connector/MXJ to provide contact data. The example consists of two components, `insertdata.jsp` and `response.jsp`. The `insertdata.jsp` provides a form into which you can enter information to be stored within the MySQL database provided by Connector/MXJ. The `response.jsp` file is called when you submit the form and then provides a table of the data.

Because the data is stored through Connector/MXJ the instantiation of the MySQL database is handled dynamically on the fly, making the script lightweight and self-contained.

Example 20.13. `insertdata.jsp`

```
<%@page contentType="text/html" pageEncoding="UTF-8"%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
   "http://www.w3.org/TR/html4/loose.dtd">
<%@ page import="java.sql.*"%>
<%@ page import="java.io.*"%>
<%@ page import="java.io.*"%>
<%@ page import="java.sql.*"%>

<HTML>
<HEAD>
<TITLE>insert data</TITLE>
<script language="Javascript">

function validFields(){

if (document.form2.ID.value == "" || document.form2.ID.value == null){
alert ( "Please enter ID / Field cannot be left blank" );
return false;
}

if (document.form2.names.value == "" || document.form2.names.value == null){
alert ( "Please enter Name / Field cannot be left blank" );
return false;
}
if (document.form2.place.value == ""|| document.form2.place.value == null){
alert ( "Please enter Place / Field cannot be left blank" );
return false;
}
if (document.form2.phone.value == ""|| document.form2.phone.value == null){
alert ( "Please enter Phone number / Field cannot be left blank" );
return false;
}
return true;
}
</script>
</HEAD>

<BODY bgcolor="#ffffcc">

<H1>Welcome to MySQL world</H1>


<H2>MySQL with MXJ Connection</H2>

<P>Insert data in existing "contactdetails2009" table under
"Directory" database</P>

<FORM action="response.jsp" method="get" name="form2">

<TABLE style="background-color: #ECE5B6;" WIDTH="30%">

        <TR>
                <TH width="50%">
                <center>ID</center>
                </TH>
                <TD width="50%"><INPUT TYPE="text" NAME="ID"></TD>
        </TR>

        <TR>
                <TH width="50%">
                <center>Name</center>
                </TH>
                <TD width="50%"><INPUT TYPE="text" NAME="names"></TD>
        </TR>

        <TR>
                <TH width="50%">
                <center>City</center>
                </TH>
                <TD width="50%"><INPUT TYPE="text" NAME="place"></TD>
        </TR>

        <TR>
                <TH width="50%">
                <center>Phone</center>
                </TH>
                <TD width="50%"><INPUT TYPE="text" NAME="phone"></TD>
        </TR>

        <TR>
                <TH></TH>
                <TD width="50%"><INPUT TYPE="submit" VALUE="Insert"
                        OnClick="return validFields();"></TD>
        </TR>

</TABLE>
</FORM>

</BODY>
```

Example 20.14. `response.jsp`

```
<%@ page import="java.sql.*"%>
<%@ page import="java.sql.*"%>
<%@ page import="java.io.*"%>
<%@ page import="java.io.*"%>
<%@ page import="java.sql.*"%>
<%@ page import="java.sql.Connection"%>
<%@ page import="java.sql.DriverManager"%>
<%@ page language="java"%>
<%@ page import=" com.mysql.management.util.QueryUtil"%>

<%@page contentType="text/html" pageEncoding="UTF-8"%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
   "http://www.w3.org/TR/html4/loose.dtd">

<HTML>
<HEAD>
<META http-equiv="Content-Type" content="text/html; charset=UTF-8">
<TITLE>JSP Page</TITLE>
</HEAD>

<BODY bgcolor="#ffffcc">

<P><INPUT type=button value="Back" onCLick="history.back()"></P>

<H1>Welcome to Directory Database</H1>
<%
        String ID = request.getParameter("ID");
        String name = request.getParameter("names");
        String city = request.getParameter("place");
        String phone = request.getParameter("phone");

        File ourAppDir1 = new File("/tmp/src");
        File databaseDir1 = new File(ourAppDir1,"database");
        int port = 4336;
        String dbName = "Directory";

      try
                {
        String url = "jdbc:mysql:mxj://localhost:" + port + "/" + dbName //
                + "?" + "server.basedir=" + databaseDir1 //
                + "&" + "createDatabaseIfNotExist=true"//
                + "&" + "server.initialize-user=true" //
                ;

    Connection connection = null;
    int updateQuery=0;

 Class.forName("com.mysql.jdbc.Driver").newInstance();

       String userName = "alice";
        String password = "q93uti0opwhkd";
            connection = DriverManager.getConnection(url, userName, password);
              PreparedStatement pstatement = null;

             String sql = "SELECT VERSION()";
            String queryForString = new QueryUtil(connection).queryForString(sql);

            String command = "INSERT INTO contactdetails2009 (ID, name,city,phone) VALUES (?,?,?,?)";

             pstatement = connection.prepareStatement(command);
             pstatement.setString(1, ID);
             pstatement.setString(2, name);
                         pstatement.setString(3, city);
                         pstatement.setString(4, phone);
                        updateQuery =  pstatement.executeUpdate();

            ResultSet resultset = pstatement.executeQuery("select * from contactdetails2009");


              if (updateQuery != 0) { %>

<P>MySQL Version------------&gt; <%         out.println(queryForString);          %>
</P>

<TABLE style="background-color: #ECE5B6;" WIDTH="50%">

        <TR>
                <TH style="text-align: center;">Data successfully inserted into
                MySQL database using MXJ connection</TH>
        </TR>
        <TR>
                <th style="text-align: center;">Storage Engine used is MyISAM</th>
        </TR>
        <TR>
                <TD>
                <H2>ContactDetails2009 Table</H2>
                <TABLE cellpadding="10" border="1" style="background-color: #ffffcc;">
                        <TR>
                                <TH>ID</TH>
                                <TH>name</TH>
                                <TH>city</TH>
                                <TH>phone</TH>
                        </TR>

                        <%
            while(resultset.next()){
        %>

                        <TR>
                                <TD><%= resultset.getString(1) %></TD>

                                <TD><%= resultset.getString(2) %></TD>

                                <TD><%= resultset.getString(3) %></TD>

                                <TD><%= resultset.getString(4) %></TD>
                        </TR>

                        <%
           } %>

                        <%

                resultset.close();
               pstatement.close();
               connection.close();
               }
            }

       catch (Exception e) {

    %>


                        <TR>
                                <TD>ERROR------------&gt; <%
                out.println("ID or Row already exist");
            }
        %>
                                </TD>
                        </TR>
                </TABLE>
                </TD>
        </TR>
</TABLE>

</BODY>

</HTML>
```

20.4.8. Connector/MXJ Support

There are a wide variety of options available for obtaining support for using Connector/MXJ. You should contact the Connector/MXJ community for help before reporting a potential bug or problem. See Section 20.4.8.1, “Connector/MXJ Community Support”.

20.4.8.1. Connector/MXJ Community Support

Oracle provides assistance to the user community by means of a number of mailing lists and web based forums.

You can find help and support through the MySQL and Java mailing list.

For information about subscribing to MySQL mailing lists or to browse list archives, visit http://lists.mysql.com/. See Section 1.6.1, “MySQL Mailing Lists”.

Community support from experienced users is also available through the MyODBC Forum. You may also find help from other users in the other MySQL Forums, located at http://forums.mysql.com. See Section 1.6.2, “MySQL Community Support at the MySQL Forums”.

20.4.8.2. How to Report Connector/MXJ Problems

If you encounter difficulties or problems with Connector/MXJ, contact the Connector/MXJ community Section 20.4.8.1, “Connector/MXJ Community Support”.

If reporting a problem, you should ideally include the following information with the email:

- Operating system and version
- Connector/MXJ version
- MySQL server version
- Copies of error messages or other unexpected output
- Simple reproducible sample

Remember that the more information you can supply to us, the more likely it is that we can fix the problem.

If you believe the problem to be a bug, then you must report the bug through http://bugs.mysql.com/.

20.4.8.3. Connector/MXJ Change History

The Connector/MXJ Change History (Changelog) is located with the main Changelog for MySQL. See Section D.6, "MySQL Connector/MXJ Change History".

20.5. MySQL Connector/C++

MySQL Connector/C++ is a MySQL database connector for C++.

The MySQL Connector/C++ is licensed under the terms of the GPL, like most MySQL Connectors. There are special exceptions to the terms and conditions of the GPL as it is applied to this software, see FLOSS License Exception. If you need a non-GPL license for commercial distribution please contact us.

The MySQL Connector/C++ is compatible with the JDBC 4.0 API. However, MySQL Connector/C++ does not implement all of the JDBC 4.0 API. The MySQL Connector/C++ current version features the following classes:

- `Connection`
- `DatabaseMetaData`
- `Driver`
- `PreparedStatement`
- `ResultSet`
- `ResultSetMetaData`
- `Savepoint`
- `Statement`

The JDBC 4.0 API defines approximately 450 methods for the above mentioned classes. MySQL Connector/C++ implements around 80% of these and makes them available in the current release.

The release has been successfully compiled and tested on the following platforms:

AIX

- 5.2 (PPC32, PPC64)
- 5.3 (PPC32, PPC64)

FreeBSD

- 6.0 (x86, x86_64)

HPUX

- 11.11 (PA-RISC 32bit, PA-RISC 64bit)

Linux

- Debian 3.1 (PPC32, x86)
- FC4 (x86)
- RHEL 3 (ia64, x86, x86_64)
- RHEL 4 (ia64, x86, x86_64)
- RHEL 5 (ia64, x86, x86_64)
- SLES 9 (ia64, x86, x86_64)
- SLES 10 (ia64, x86_64)
- SuSE 10.3, (x86_64)
- Ubuntu 8.04 (x86)
- Ubuntu 8.10 (x86_64)

Mac

- MacOSX 10.3 (PPC32, PPC64)
- MacOSX 10.4 (PPC32, PPC64, x86)
- MacOSX 10.5 (PPC32, PPC64, x86, x86_64)

SunOS

- Solaris 8 (SPARC32, SPARC64, x86)
- Solaris 9 (SPARC32, SPARC64, x86)
- Solaris 10 (SPARC32, SPARC64, x86, x86_64)

Windows

- XP Professional (32bit)
- 2003 (64bit)

Future versions will run on all platforms supported by the MySQL Server.

> **Note**
>
> MySQL Connector/C++ supports MySQL 5.1 and later.

> **Note**
>
> MySQL Connector/C++ supports only Microsoft Visual Studio 2003 and above on Windows.

MySQL Connector/C++ Download

You can download the source code for the MySQL Connector/C++ current release at the MySQL Connector/C++ downloads.

MySQL Connector/C++ Source repository

The latest development version is also available through Launchpad.

Bazaar is used for the MySQL Connector/C++ code repository. You can check out the latest source code using the `bzr` command line tool:

```
shell> bzr branch lp:~mysql/mysql-connector-cpp/trunk .
```

Binary distributions

Starting with 1.0.4 Beta, binary distributions were made available in addition to source code releases. The releases available are shown below.

Microsoft Windows platform:

- Without installer, a Zip file
- MSI installer package

Other platforms:

- Compressed GNU TAR archive (tar.gz)

> **Note**
>
> Note that source packages are available for all platforms in the Compressed GNU TAR archive (tar.gz) format.

Binary and source packages can be obtained from MySQL Connector/C++ downloads.

MySQL Connector/C++ Advantages

Using MySQL Connector/C++ instead of the MySQL C API (MySQL Client Library) offers the following advantages for C++ users:

- Convenience of pure C++, no C function calls required
- Supports an industry standard API, JDBC 4.0
- Supports the object-oriented programming paradigm
- Reduces development time
- MySQL Connector/C++ is licensed under the GPL with the FLOSS License Exception
- MySQL Connector/C++ is available under a commercial license upon request

MySQL Connector/C++ Status

MySQL Connector/C++ is available as a GA version. We kindly ask users and developers to try it out and provide us with feedback.

Note that MySQL Workbench is successfully using MySQL Connector/C++.

If you have any queries please contact us.

20.5.1. MySQL Connector/C++ Binary Installation

> **Caution**
>
> One problem that can occur is when the tools you use to build your application are not compatible with the tools used to build the binary versions of MySQL Connector/C++. Ideally you need to build your application with the same tools that were used to build the MySQL Connector/C++ binaries. To help with this the following resources are provided.
>
> All distributions contain a `README` file, which contains platform-specific notes. At the end of the `README` file contained in the binary distribution you will find the settings used to build the binaries. If you experience build-related issues on a platform, it may help to check the settings used on the platform to build the binary.
>
> Developers using Microsoft Windows need to ensure they meet the following requirements:

1. Use a supported version of Visual Studio, either Visual Studio 2005 or Visual Studio 2008.
2. Ensure that your application uses the same run time library as that used to build MySQL Connector/C++. Visual Studio 2005 builds use Microsoft.VC80.CRT (8.0.50727.762), and Visual Studio 2008 builds use Microsoft.VC90.CRT (9.0.21022.8).
3. Your application should use the same linker configuration as MySQL Connector/C++, for example use one of /MD, /MDd, /MT, /MTd.

If you wish to use a variation of the requirements previously listed, such as a different compiler version, release configuration, or run time library, you must compile MySQL Connector/C++ from source using your desired settings, and then ensure that your application is built with these same settings. The three variables of compiler version, run time library, and run time linker configuration settings should always be the same for both application and MySQL Connector/C++ itself, in order to avoid issues.

For your convenience the same information, but more frequently updated, can be found on the MySQL Forge site.

A better solution is to build your MySQL Connector/C++ libraries from the source code, using the same tools that you use for building your application. This ensures compatibility.

Downloading MySQL Connector/C++

Binary and source packages can be obtained from MySQL Connector/C++ downloads.

Archive Package

Unpack the archive into an appropriate directory. If you plan to use a dynamically linked version of MySQL Connector/C++, make sure that your system can reference the MySQL Client Library. Consult your operating system documentation on how do modify and expand the search path for libraries. In case you cannot modify the library search path it may help to copy your application, the MySQL Connector/C++ library and the MySQL Client Library into the same directory. Most systems search for libraries in the current directory.

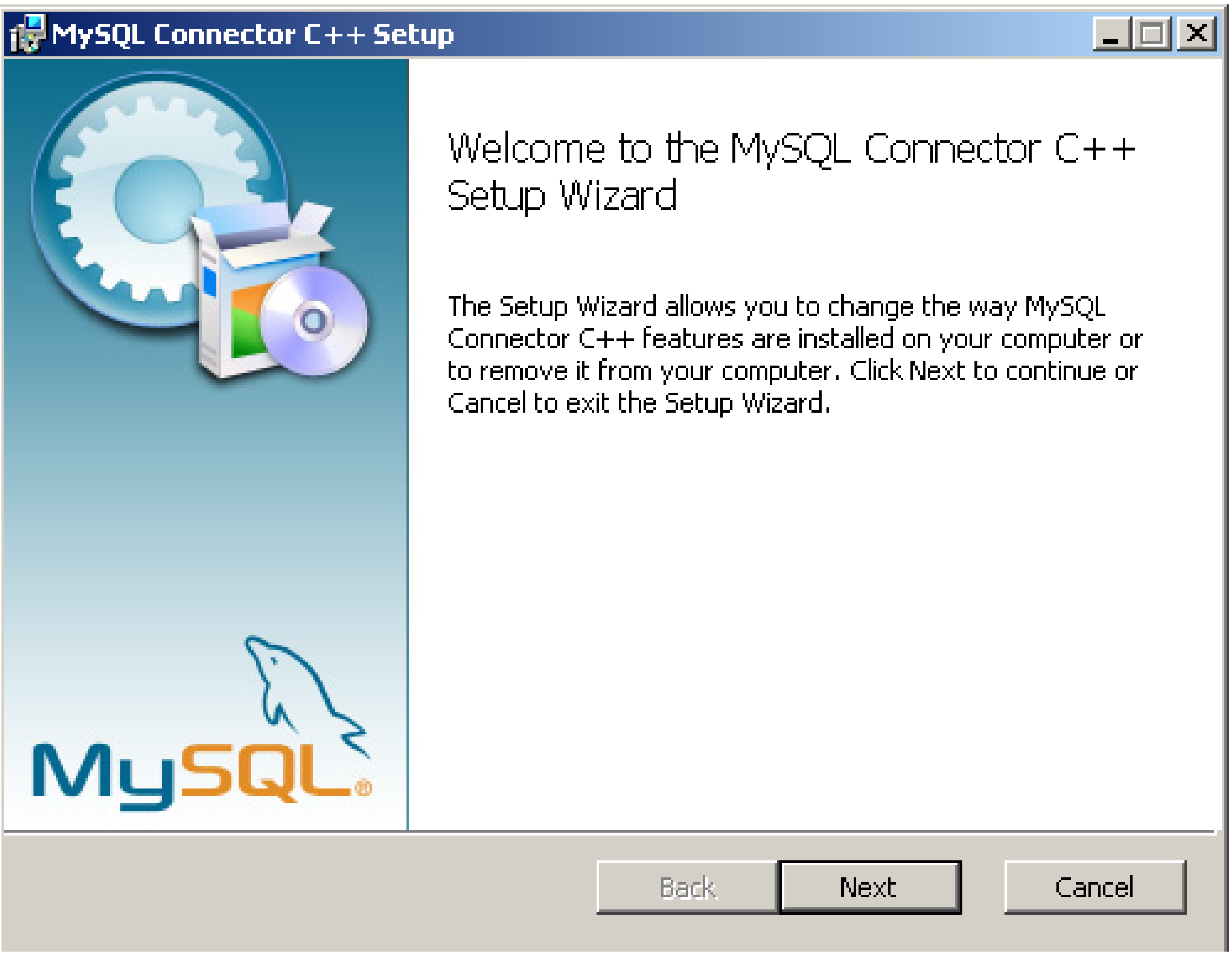
Windows MSI Installer

Windows users can choose between two binary packages:

1. Without installer (unzip in C:\)
2. Windows MSI Installer (x86)

Using the MSI Installer may be the easiest solution. Running the MSI Installer does not require any administrative permissions as it simply copies files.

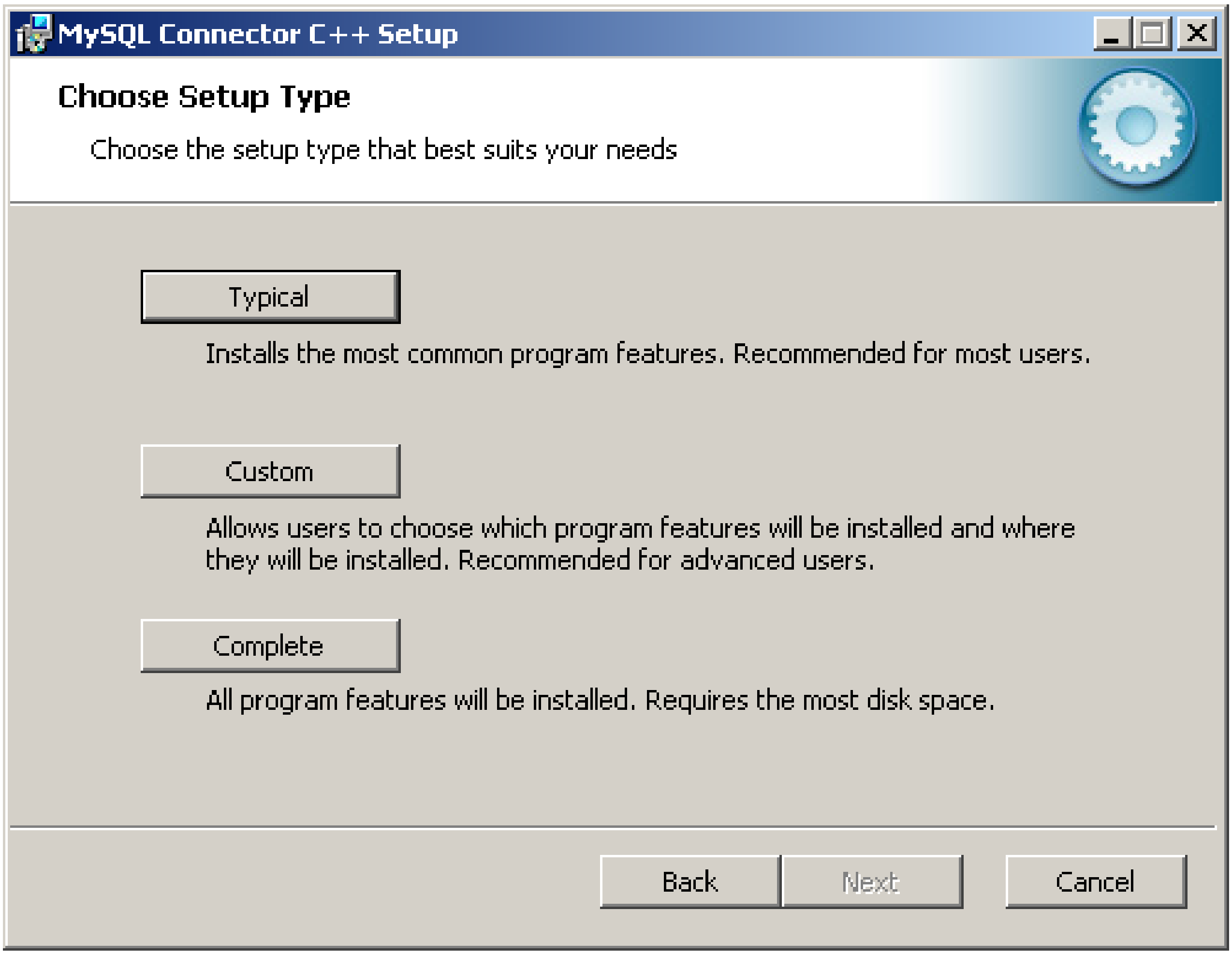
Figure 20.59. Windows Installer Welcome Screen


MySQL Connector C++ Setup
MySQL
Back
Next
Cancel

Welcome to the MySQL Connector C++ Setup Wizard

The Setup Wizard allows you to change the way MySQL Connector C++ features are installed on your computer or to remove it from your computer. Click Next to continue or Cancel to exit the Setup Wizard.

Figure 20.60. Windows Installer Overview Screen



Choose Setup Type

Choose the setup type that best suits your needs

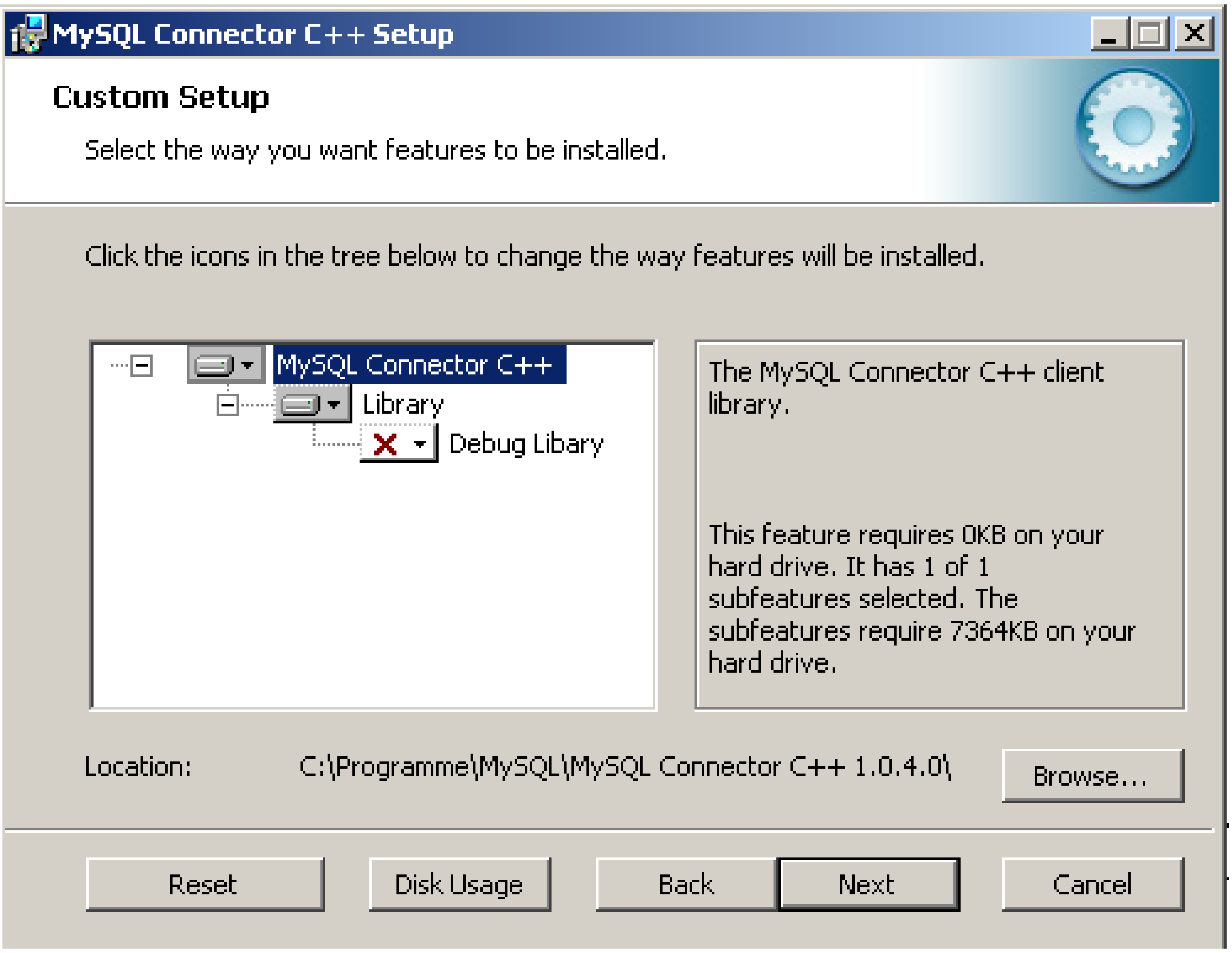
Installs the most common program features. Recommended for most users.

Allows users to choose which program features will be installed and where they will be installed. Recommended for advanced users.

All program features will be installed. Requires the most disk space.

The “Typical” installation consists of all required header files and the Release libraries. The only available “Custom” installation option enables you to install additional Debug versions of the connector libraries.

Figure 20.61. Windows Installer Custom Setup Screen



MySQL Connector C++ Setup

Custom Setup

Select the way you want features to be installed.

Click the icons in the tree below to change the way features will be installed.

The MySQL Connector C++ client library.

This feature requires 0KB on your hard drive. It has 1 of 1 subfeatures selected. The subfeatures require 7364KB on your hard drive.

Location: C:\Programme\MySQL\MySQL Connector C++ 1.0.4.0\

20.5.2. MySQL Connector/C++ Source Installation

The MySQL Connector/C++ is based on the MySQL Client Library (MySQL C API). MySQL Connector/C++ is linked against the MySQL Client Library. You need to have the MySQL Client Library installed to compile MySQL Connector/C++.

You also need to have the cross-platform build tool `CMake` 2.4, or newer, and GLib 2.2.3 or newer installed. Check the `README` file included with the distribution for platform specific notes on building for Windows and SunOS.

Typically the MySQL Client Library is installed when the MySQL Server is installed. However, check your operating system documentation for other installation options.

As of MySQL Connector/C++ version 1.1.0 it is necessary to have the Boost C++ libraries 1.34.0 or newer installed. Boost is only required to build the connector, it is not required to use the connector. You can obtain Boost from the official site and installation instructions can be obtained from the same site. Once Boost has been installed you will need to tell the make system where the Boost files are. This is done by setting the define `-DBOOST_ROOT:STRING=`. This can be done when initially invoking `CMake`, for example:

```
shell> CMake . -DBOOST_ROOT:STRING=/usr/local/boost_1_40_0
```

You may need to change */usr/local/boost_1_40_0/* to match your installation. See the Section 20.5.2.1, "Building source on Unix, Solaris and Mac OS X" and Section 20.5.2.2, "Building source on Windows" for further details.

20.5.2.1. Building source on Unix, Solaris and Mac OS X

1. Run `CMake` to build a `Makefile`:

```
shell> me@host:/path/to/mysql-connector-cpp> cmake .
-- Check for working C compiler: /usr/local/bin/gcc
-- Check for working C compiler: /usr/local/bin/gcc -- works
[...]
-- Generating done
-- Build files have been written to: /path/to/mysql-connector-cpp/
```

On non-Windows systems, `CMake` first checks to see if the `CMake` variable `MYSQL_CONFIG_EXECUTABLE` is set. If it is not found `CMake` tries to locate `mysql_config` in the default locations.

If you have any problems with the configure process please check the troubleshooting instructions below.

2. Use make to build the libraries. First make sure you have a clean build:

```
shell> me@host:/path/to/mysql-connector-cpp> make clean
```

Then build the connector:

```
me@host:/path/to/mysql-connector-cpp> make
[  1%] Building CXX object »
driver/CMakeFiles/mysqlcppconn.dir/mysql_connection.o
[  3%] Building CXX object »
driver/CMakeFiles/mysqlcppconn.dir/mysql_constructed_resultset.o
[...]
[100%] Building CXX object examples/CMakeFiles/statement.dir/statement.o
Linking CXX executable statement
```

If all goes well, you will find the MySQL Connector/C++ library in `/path/to/cppconn/libmysqlcppconn.so`.

3. Finally make sure the header and library files are installed to their correct locations:

```
make install
```

Unless you have changed this in the configuration step, the header files will be copied to the directory `/usr/local/include`. The header files copied are `mysql_connection.h` and `mysql_driver.h`.

Again, unless you have specified otherwise, the library files will be copied to `/usr/local/lib`. The files copied are `libmysqlcppcon.so`, the dynamic library, and `libmysqlcppconn-static.a`, the static library.

If you encounter any errors, please first carry out the checks shown below:

1. `CMake` options: MySQL installation path, debug version and more

In case of configuration or compilation problems, check the list of `CMake` options:

```
shell> me@host:/path/to/mysql-connector-cpp> cmake -L
[...]
CMAKE_BACKWARDS_COMPATIBILITY:STRING=2.4
CMAKE_BUILD_TYPE:STRING=
CMAKE_INSTALL_PREFIX:PATH=/usr/local
EXECUTABLE_OUTPUT_PATH:PATH=
LIBRARY_OUTPUT_PATH:PATH=
MYSQLCPPCONN_GCOV_ENABLE:BOOL=0
MYSQLCPPCONN_TRACE_ENABLE:BOOL=0
MYSQL_CONFIG_EXECUTABLE:FILEPATH=/usr/bin/mysql_config
```

For example, if your MySQL Server installation path is not `/usr/local/mysql` and you want to build a debug version of the MySQL Connector/C++ use:

```
shell> me@host:/path/to/mysql-connector-cpp> cmake »
-D CMAKE_BUILD_TYPE:STRING=Debug »
-D MYSQL_CONFIG_EXECUTABLE=/path/to/my/mysql/server/bin/mysql_config .
```

2. Verify your settings with `cmake -L`:

```
shell> me@host:/path/to/mysql-connector-cpp> cmake -L
[...]
CMAKE_BACKWARDS_COMPATIBILITY:STRING=2.4
CMAKE_BUILD_TYPE:STRING=
CMAKE_INSTALL_PREFIX:PATH=/usr/local
EXECUTABLE_OUTPUT_PATH:PATH=
LIBRARY_OUTPUT_PATH:PATH=
MYSQLCPPCONN_GCOV_ENABLE:BOOL=0
MYSQLCPPCONN_TRACE_ENABLE:BOOL=0
MYSQL_CONFIG_EXECUTABLE=/path/to/my/mysql/server/bin/mysql_config
```

Proceed by carrying out a `make clean` command followed by a `make` command, as described above.

Once you have installed MySQL Connector/C++ you can carry out a quick test to check the installation. To do this you can compile and run one of the example programs, such as `examples/standalone_example.cpp`. This example is discussed in more detail later, but for now you can use it to test the connector has been correctly installed. This procedure assumes you have a working MySQL Server that you can connect to.

1. First compile the example. To do this change to the `examples` directory and type:

   ```
   shell> g++ -o test_install -I/usr/local/include -I/usr/local/include/cppconn -Wl,-Bdynamic -lmysqlcppconn standalo
   ```

2. You need to make sure the dynamic library which is used in this case can be found at run time. To do this enter:

   ```
   shell> export LD_LIBRARY_PATH=/usr/local/lib
   ```

3. Now run the program to test your installation, exchanging the host, user, password and database to be accessed given below to match your system:

   ```
   ./test_install localhost root password database
   ```

   You will see something similar to the following:

   ```
   Connector/C++ standalone program example...

   ... running 'SELECT 'Welcome to Connector/C++' AS _message'
   ... MySQL replies: Welcome to Connector/C++
   ... say it again, MySQL
   ....MySQL replies: Welcome to Connector/C++

   ... find more at http://www.mysql.com
   ```

   If you see any errors take note of them and go through the troubleshooting procedures discussed earlier.

20.5.2.2. Building source on Windows

Note

Please note the only compiler formally supported for Windows is Microsoft Visual Studio 2003 and above.

The basic steps for building the connector on Windows are the same as for Unix. It is important to use `CMake` 2.6.2 or newer to generate build files for your compiler and to invoke the compiler.

Note

On Windows, `mysql_config` is not present, so `CMake` will attempt to retrieve the location of MySQL from the environment variable `$ENV{MYSQL_DIR}`. If `MYSQL_DIR` is not set, `CMake` will then proceed to check for MySQL in the following locations: `$ENV{ProgramFiles}/MySQL/*/include`, and `$ENV{SystemDrive}/MySQL/*/include`.

`CMake` makes it easy for you to try other compilers. However, you may experience compile warnings, compile errors or linking issues not detected by Visual Studio. Patches are gratefully accepted to fix issues with other compilers.

Consult the `CMake` manual or check `cmake --help` to find out which build systems are supported by your `CMake` version:

```
C:\>cmake --help
cmake version 2.6-patch 2
Usage
[...]
Generators

The following generators are available on this platform:
  Borland Makefiles           = Generates Borland makefiles.
  MSYS Makefiles              = Generates MSYS makefiles.
  MinGW Makefiles             = Generates a make file for use with
                                mingw32-make.
  NMake Makefiles             = Generates NMake makefiles.
  Unix Makefiles              = Generates standard UNIX makefiles.
  Visual Studio 6             = Generates Visual Studio 6 project files.
  Visual Studio 7             = Generates Visual Studio .NET 2002 project
                                files.
  Visual Studio 7 .NET 2003   = Generates Visual Studio .NET 2003 project
                                files.
  Visual Studio 8 2005        = Generates Visual Studio .NET 2005 project
                                files.
  Visual Studio 8 2005 Win64  = Generates Visual Studio .NET 2005 Win64
                                project files.
  Visual Studio 9 2008        = Generates Visual Studio 9 2008 project fil
```

```
  Visual Studio 9 2008 Win64  = Generates Visual Studio 9 2008 Win64 proje
                                files.
[...]
```

It is likely that your `CMake` binary will support more compilers, known by `CMake` as *generators*, than supported by MySQL Connector/C++. We have built the connector using the following generators:

- Microsoft Visual Studio 8 (Visual Studio 2005)
- Microsoft Visual Studio 9 (Visual Studio 2008, Visual Studio 2008 Express)
- NMake

Please see the building instructions for Unix, Solaris and Mac OS X for troubleshooting and configuration hints.

The steps to build the connector are given below:

1. Run `CMake` to generate build files for your *generator*:

   Visual Studio

   ```
    C:\path_to_mysql_cpp>cmake -G "Visual Studio 9 2008"
   -- Check for working C compiler: cl
   -- Check for working C compiler: cl -- works
   -- Detecting C compiler ABI info
   -- Detecting C compiler ABI info - done
   -- Check for working CXX compiler: cl
   -- Check for working CXX compiler: cl -- works
   -- Detecting CXX compiler ABI info
   -- Detecting CXX compiler ABI info - done
   -- ENV{MYSQL_DIR} =
   -- MySQL Include dir: C:/Programme/MySQL/MySQL Server 5.1/include
   -- MySQL Library    : C:/Progams/MySQL/MySQL Server 5.1/lib/opt/mysqlclient.lib
   -- MySQL Library dir: C:/Progams/MySQL/MySQL Server 5.1/lib/opt
   -- MySQL CFLAGS:
   -- MySQL Link flags:
   -- MySQL Include dir: C:/Progams/MySQL/MySQL Server 5.1/include
   -- MySQL Library dir: C:/Progams/MySQL/MySQL Server 5.1/lib/opt
   -- MySQL CFLAGS:
   -- MySQL Link flags:
   -- Configuring cppconn
   -- Configuring test cases
   -- Looking for isinf
   -- Looking for isinf - not found
   -- Looking for isinf
   -- Looking for isinf - not found.
   -- Looking for finite
   -- Looking for finite - not found.
   -- Configuring C/J junit tests port
   -- Configuring examples
   -- Configuring done
   -- Generating done
   -- Build files have been written to: C:\path_to_mysql_cpp
   C:\path_to_mysql_cpp>dir *.sln *.vcproj
   [...]
   19.11.2008  12:16            23.332 MYSQLCPPCONN.sln
   [...]
   19.11.2008  12:16            27.564 ALL_BUILD.vcproj
   19.11.2008  12:16            27.869 INSTALL.vcproj
   19.11.2008  12:16            28.073 PACKAGE.vcproj
   19.11.2008  12:16            27.495 ZERO_CHECK.vcproj
   ```

   NMake

   ```
    C:\path_to_mysql_cpp>cmake -G "NMake Makefiles"
   -- The C compiler identification is MSVC
   -- The CXX compiler identification is MSVC
   [...]
   -- Build files have been written to: C:\path_to_mysql_cpp
   ```

2. Use your compiler to build MySQL Connector/C++

   Visual Studio - GUI

   Open the newly generated project files in the Visual Studio GUI or use a Visual Studio command line to build the driver. The project files contain a variety of different configurations. Among them debug and nondebug versions.

   Visual Studio - NMake

```
C:\path_to_mysql_cpp>nmake

Microsoft (R) Program Maintenance Utility Version 9.00.30729.01
Copyright (C) Microsoft Corporation.  All rights reserved.

Scanning dependencies of target mysqlcppconn
[  2%] Building CXX object driver/CMakeFiles/mysqlcppconn.dir/mysql_connection.obj
mysql_connection.cpp
[...]
Linking CXX executable statement.exe
[100%] Built target statement
```

20.5.2.3. Dynamically Linking MySQL Connector/C++ against the MySQL Client Library

> **Note**
>
> Note this section refers to dynamic linking of the MySQL Connector/C++ with the client library, not the dynamic linking of the application to MySQL Connector/C++.

An application that uses MySQL Connector/C++ can be either statically or dynamically linked to the MySQL Connector/C++ libraries. MySQL Connector/C++ is usually statically linked to the underlying MySQL Client Library (or Connector/C). Note, that unless otherwise stated, reference to the MySQL Client Library is also taken to include Connector/C, which is a separately packaged, stand alone version of the MySQL Client Library. From MySQL Connector/C++ version 1.1.0 it is possible to also dynamically link to the underlying MySQL Client Library. The ability of MySQL Connector/C++ to dynamically link to MySQL Client Library is not enabled by default, and enabling this feature is done through a compile time option, when compiling the MySQL Connector/C++ source code.

To use the ability to dynamically link the client library to MySQL Connector/C++ the `MYSQLCLIENT_STATIC_BINDING:BOOL` needs to be defined when building the MySQL Connector/C++ source code:

```
rm CMakeCache.txt
cmake -DMYSQLCLIENT_STATIC_BINDING:BOOL=1 .
make clean
make
make install
```

Note that precompiled binaries of MySQL Connector/C++ use static binding with the client library by default.

Now, in your application, when creating a connection, MySQL Connector/C++ will select and load a client library at runtime. It will choose the client library by searching defined locations and environment variables depending on the host operating system. It also possible when creating a connection in an application to define an absolute path to the client library to be loaded at runtime. This can be convenient if you have defined a standard location from which you want the client library to be loaded. This is sometimes done to circumvent possible conflicts with other versions of the client library that may be located on the system.

20.5.3. MySQL Connector/C++ Building Windows applications with Microsoft Visual Studio

MySQL Connector/C++ is available as a static or dynamic library to use with your application. This section looks at how to link the library to your application.

> **Note**
>
> To avoid potential crashes the build configuration of MySQL Connector/C++ should match the build configuration of the application using it. For example, do not use the release build of MySQL Connector/C++ with a debug build of the client application.

Static library

The MySQL Connector/C++ static library file is `mysqlcppconn-static.lib`. This needs to be statically linked with your application. You also need to link against the files `libmysql.dll` and `libmysql.lib`. Once linking has been successfully completed, the application will require access to `libmysql.dll` at run time.

Dynamic library

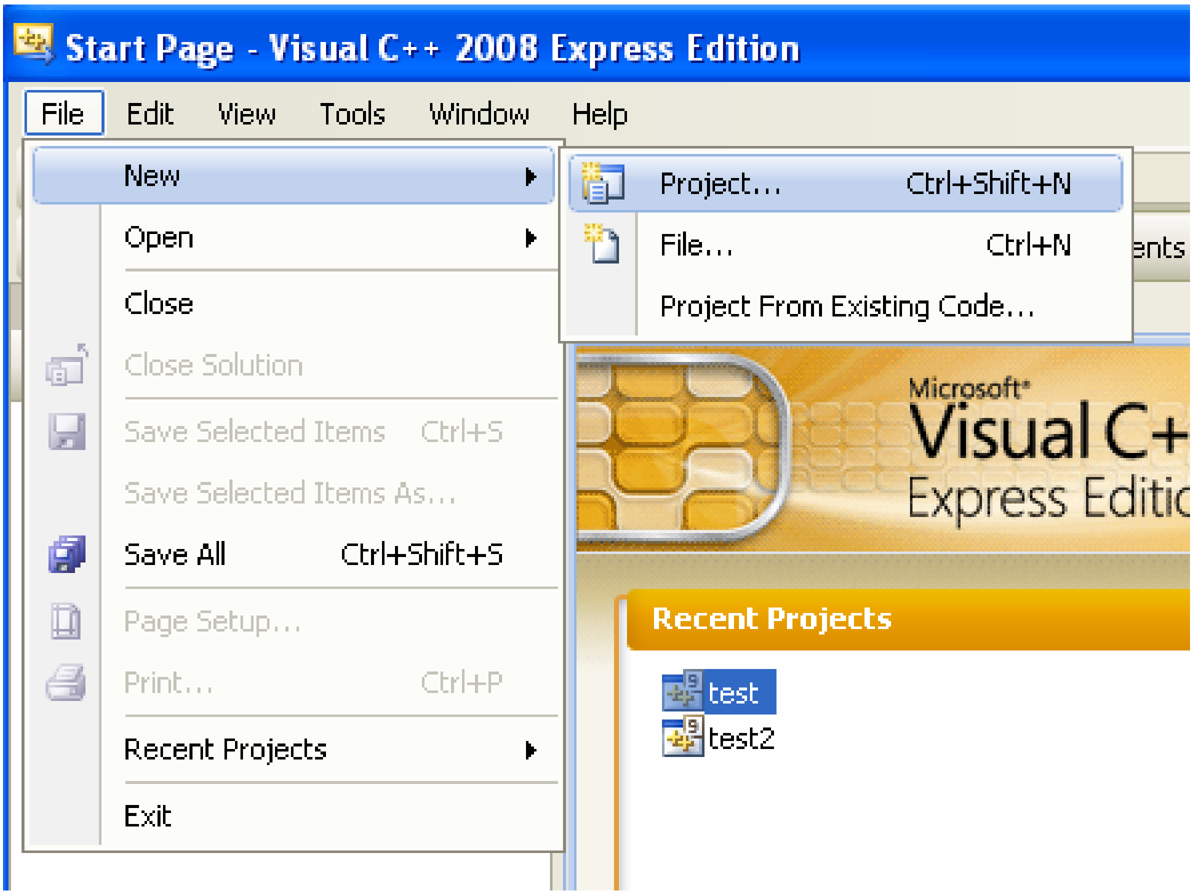
The MySQL Connector/C++ dynamic library file is `mysqlcppconn.dll`. To build your client application, you must link it with the file `mysqlcppconn.lib`. At run time, the application will require access to the files `mysqlcppconn.dll` and `libmysql.dll`.

Building a MySQL Connector/C++ application with Microsoft Visual Studio

Initially, the procedure for building an application to use either the static or dynamic library is the same. You then carry out some additional steps depending on whether you want to build your application to use the static or dynamic library.

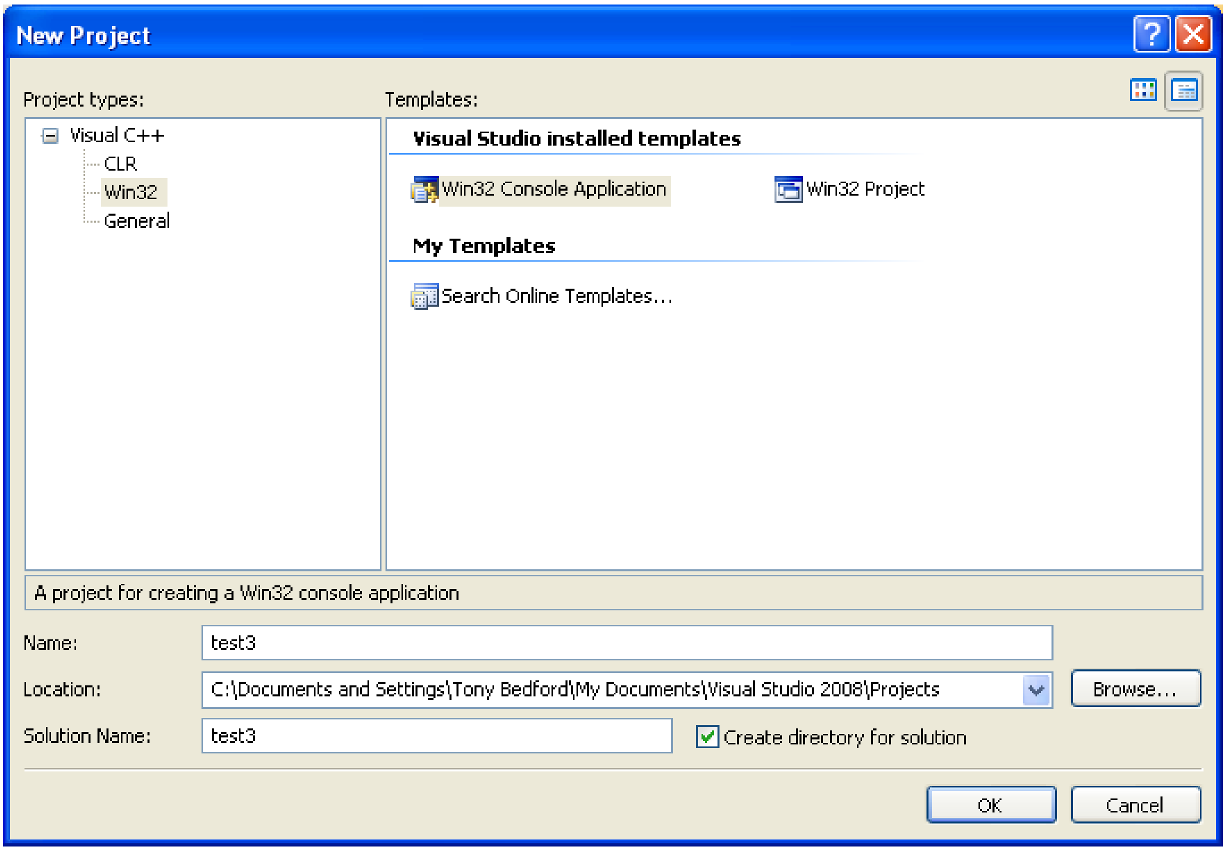
1. Select FILE, NEW, PROJECT from the main menu.

Figure 20.62. Creating a New Project


Start Page - Visual C++ 2008 Express Edition
File
Edit
View
Tools
Window
Help
New
Open
Close
Close Solution
Save Selected Items Ctrl+S
Save Selected Items As...
Save All Ctrl+Shift+S
Page Setup...
Print... Ctrl+P
Recent Projects
Exit
Project... Ctrl+Shift+N
File... Ctrl+N
Project From Existing Code...
Microsoft Visual C+
Express Editic
Recent Projects
test
test2

2. In the wizard select **VISUAL C++**, **WIN32**. From **VISUAL STUDIO INSTALLED TEMPLATES** select the application type **WIN32 CONSOLE APPLICATION**. Enter a name for the application, and then click OK, to move to the Win32 Application Wizard.

Figure 20.63. The New Project Dialog Box



New Project
Project types:
Templates:
Visual C++
CLR
Win32
General
Visual Studio installed templates
Win32 Console Application
Win32 Project
My Templates
Search Online Templates...
Browse...
OK
Cancel

A project for creating a Win32 console application

Name: test3

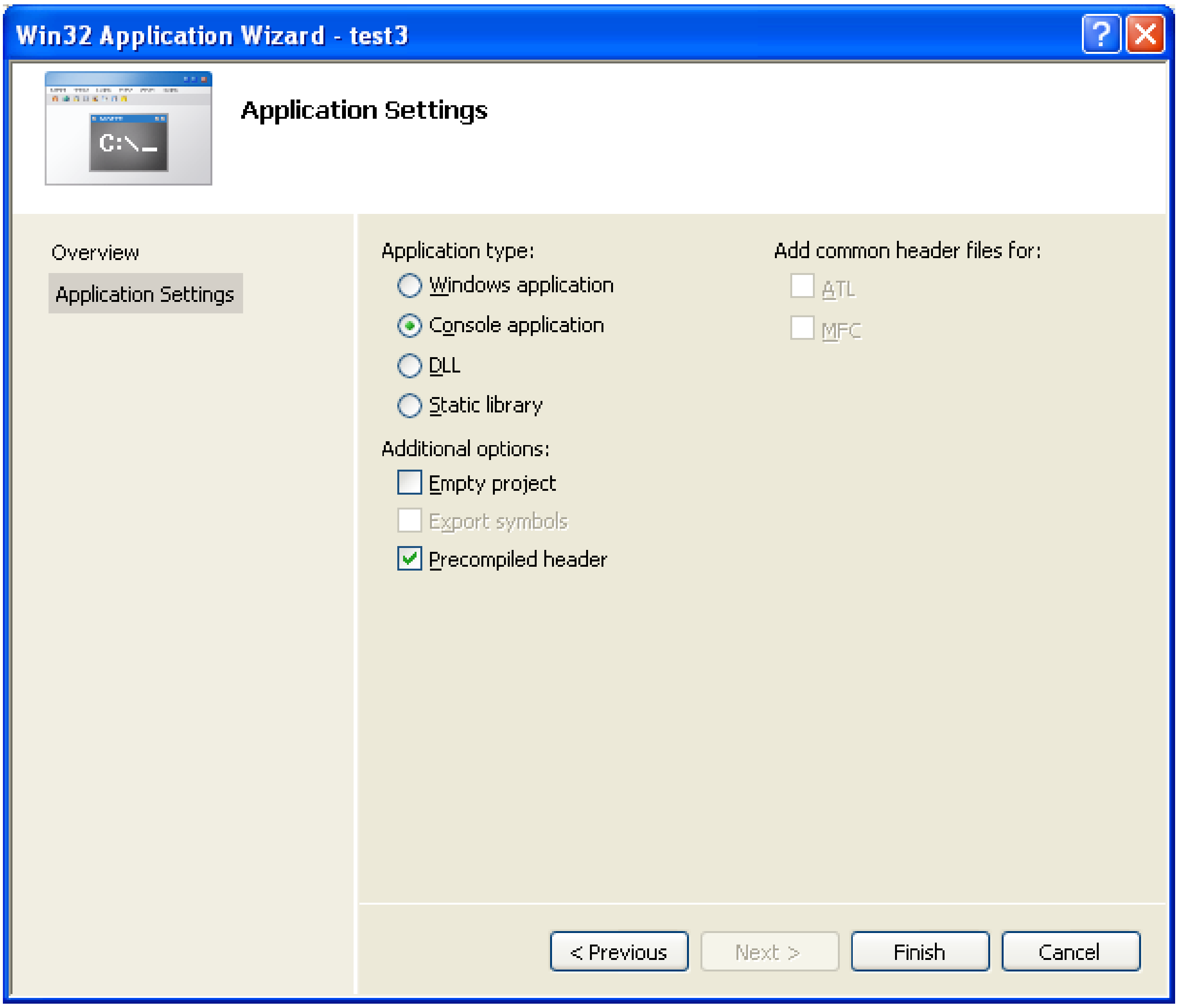
Location: C:\Documents and Settings\Tony Bedford\My Documents\Visual Studio 2008\Projects

Solution Name: test3

☑ Create directory for solution

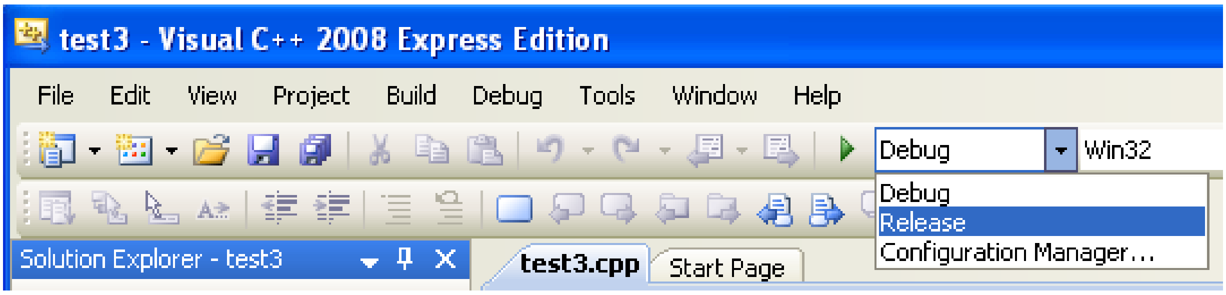
3. In the Win32 Application Wizard, click **APPLICATION SETTINGS** and ensure the defaults are selected. The radio button **CONSOLE APPLICATION**, and the check box **PRECOMPILED HEADERS** will be selected. Click FINISH to close the wizard.

Figure 20.64. The Win32 Application Wizard


Win32 Application Wizard - test3
Application Settings
Overview
Application Settings
Application type:
○ Windows application
● Console application
○ DLL
○ Static library
Additional options:
☐ Empty project
☐ Export symbols
☑ Precompiled header
Add common header files for:
☐ ATL
☐ MFC
< Previous
Next >
Finish
Cancel

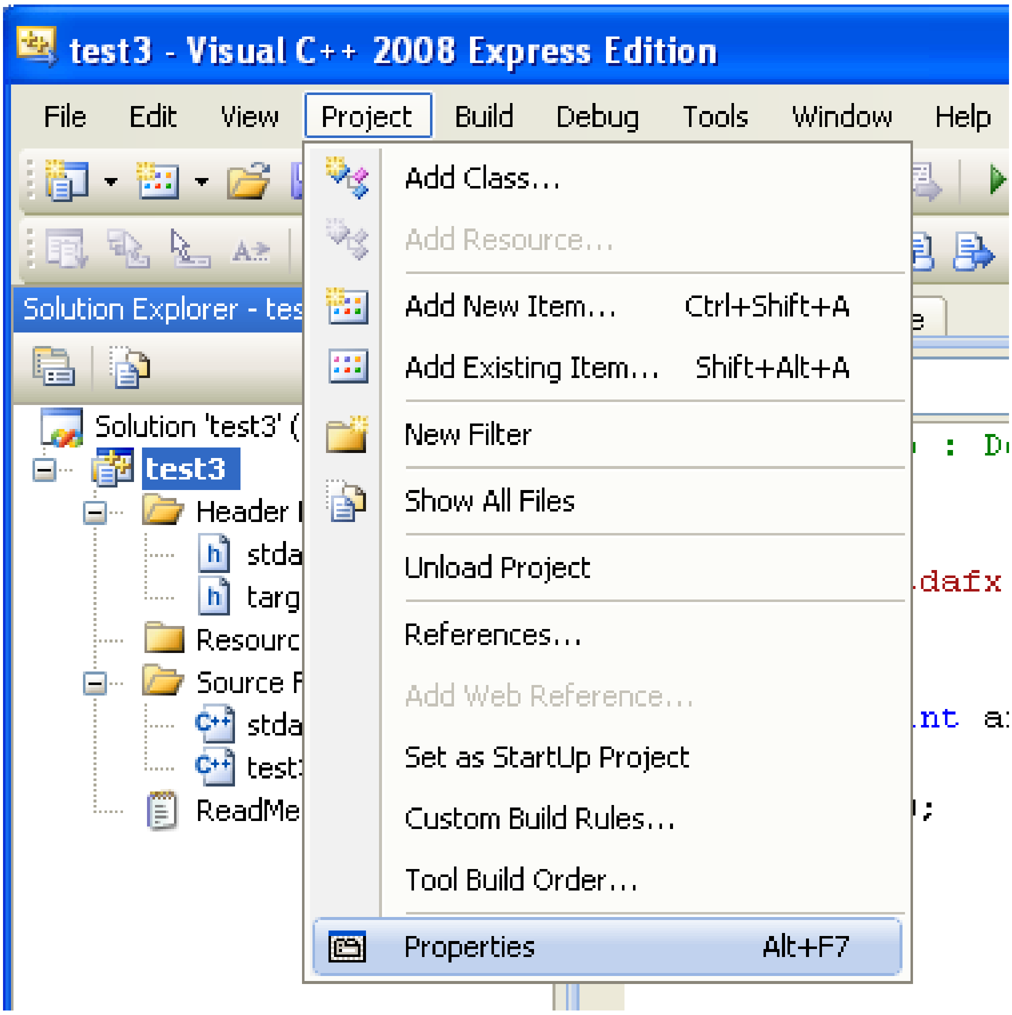
4. From the drop down list box on the toolbar, change from the default **DEBUG** build to the **RELEASE** build.

Figure 20.65. Selecting the Release Build


test3 - Visual C++ 2008 Express Edition
File
Edit
View
Project
Build
Debug
Tools
Window
Help
Debug
Win32
Debug
Release
Configuration Manager...
Solution Explorer - test3
test3.cpp
Start Page

5. From the main menu select PROJECT, PROPERTIES. This can also be accessed using the hot key ALT + F7.

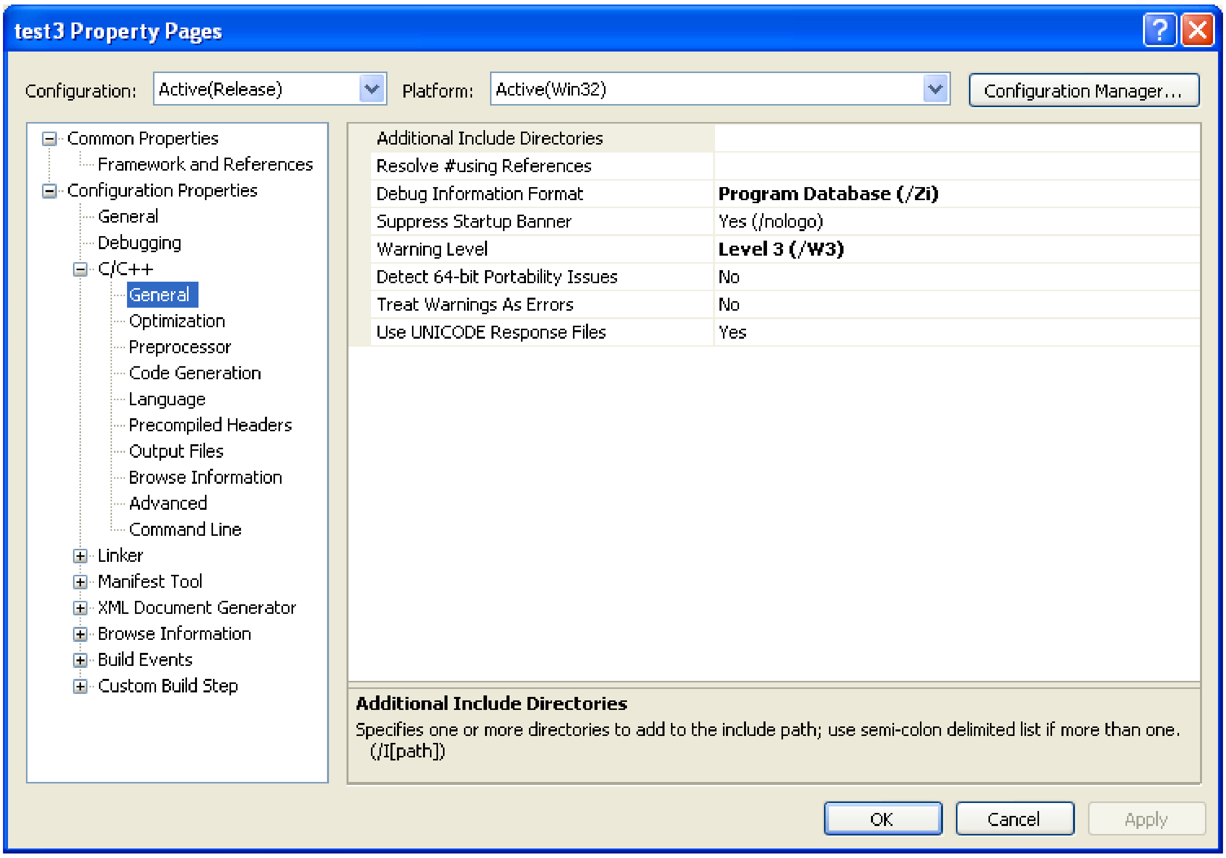
Figure 20.66. Selecting Project Properties from the Main Menu


test3 - Visual C++ 2008 Express Edition
File
Edit
View
Project
Build
Debug
Tools
Window
Help
Solution Explorer - tes
Solution 'test3' (
test3
Header I
stda
targ
Resourc
Source F
stda
test
ReadMe
Add Class...
Add Resource...
Add New Item... Ctrl+Shift+A
Add Existing Item... Shift+Alt+A
New Filter
Show All Files
Unload Project
References...
Add Web Reference...
Set as StartUp Project
Custom Build Rules...
Tool Build Order...
Properties Alt+F7

6. Under **CONFIGURATION PROPERTIES**, open the tree view.

7. Select C++, **GENERAL** in the tree view.

Figure 20.67. Setting Properties


test3 Property Pages
Common Properties
Framework and References
Configuration Properties
General
Debugging
C/C++
General
Optimization
Preprocessor
Code Generation
Language
Precompiled Headers
Output Files
Browse Information
Advanced
Command Line
Linker
Manifest Tool
XML Document Generator
Browse Information
Build Events
Custom Build Step
Configuration Manager...
OK
Cancel
Apply

Configuration: Active(Release)

Platform: Active(Win32)

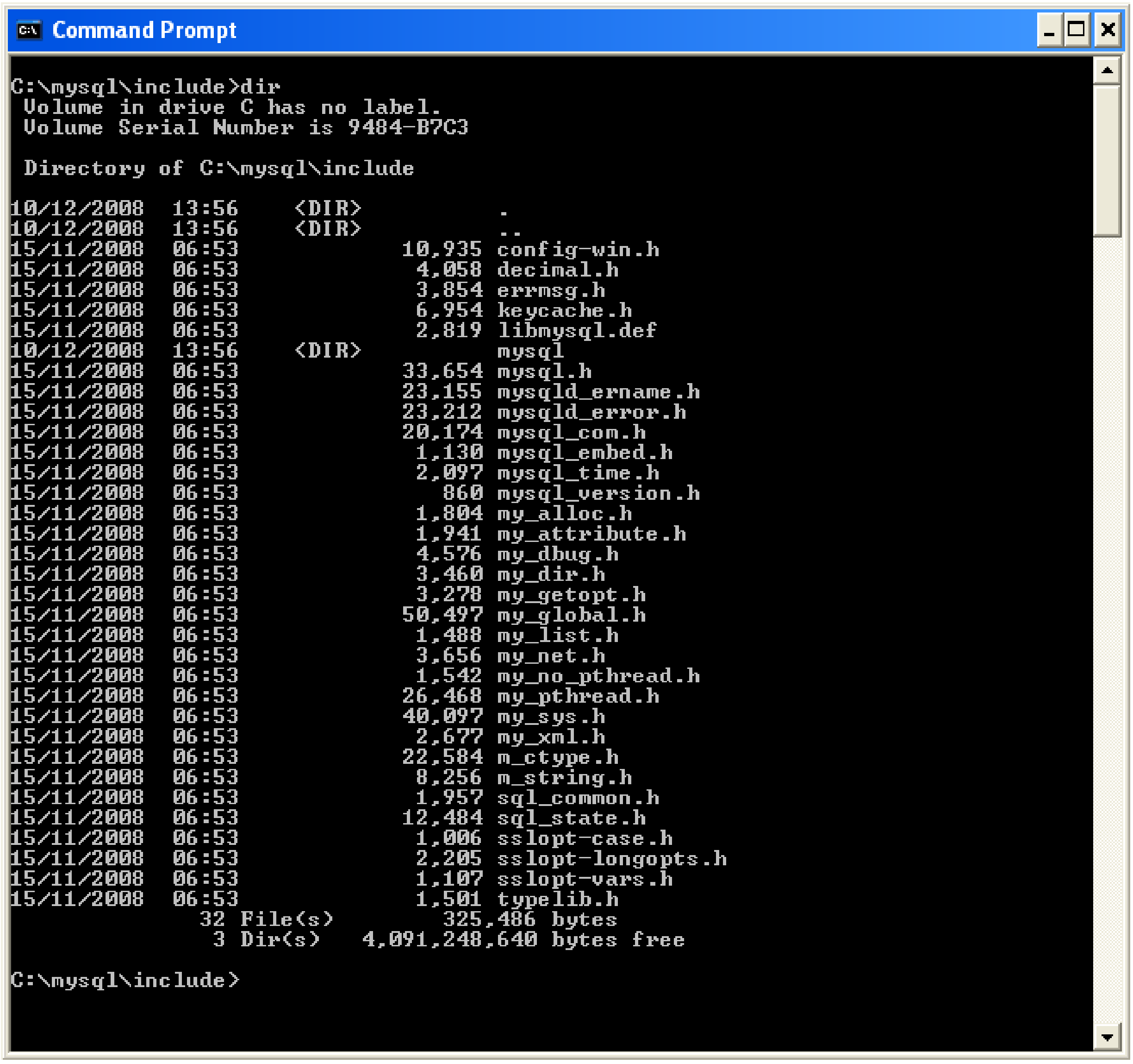
Additional Include Directories	
Resolve #using References	
Debug Information Format	**Program Database (/Zi)**
Suppress Startup Banner	Yes (/nologo)
Warning Level	**Level 3 (/W3)**
Detect 64-bit Portability Issues	No
Treat Warnings As Errors	No
Use UNICODE Response Files	Yes

Additional Include Directories

Specifies one or more directories to add to the include path; use semi-colon delimited list if more than one. (/I[path])

8. You now need to ensure that Visual Studio can find the MySQL include directory. This directory includes header files that can optionally be installed when installing MySQL Server.

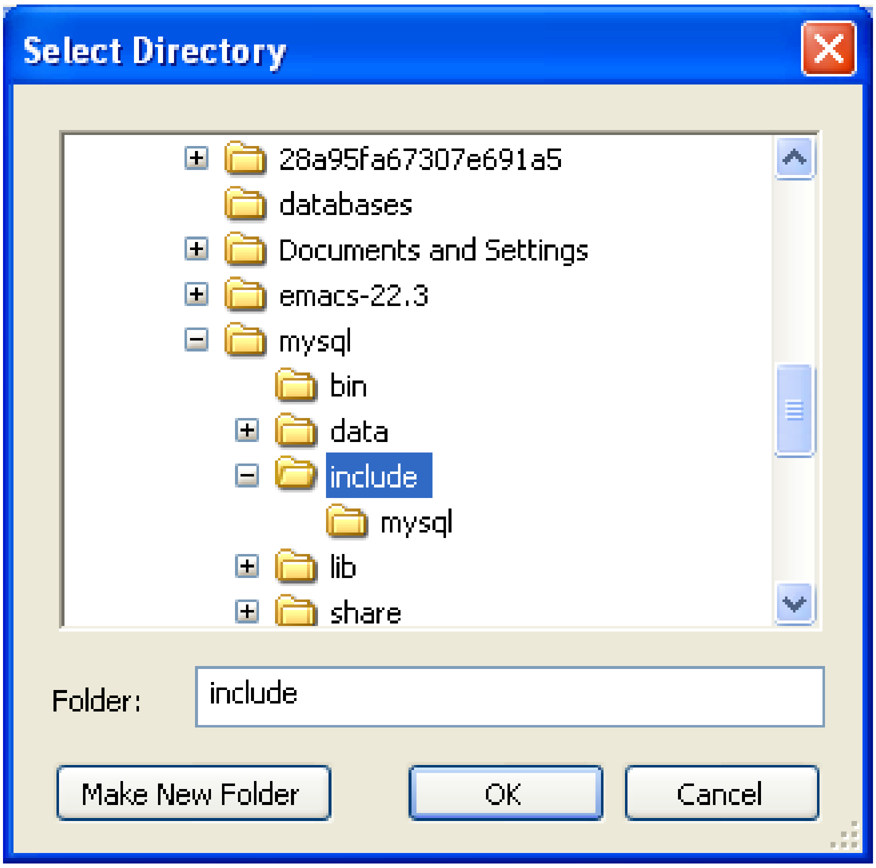
Figure 20.68. MySQL Include Directory



```
C:\mysql\include>dir
 Volume in drive C has no label.
 Volume Serial Number is 9484-B7C3

 Directory of C:\mysql\include

10/12/2008  13:56    <DIR>          .
10/12/2008  13:56    <DIR>          ..
15/11/2008  06:53            10,935 config-win.h
15/11/2008  06:53             4,058 decimal.h
15/11/2008  06:53             3,854 errmsg.h
15/11/2008  06:53             6,954 keycache.h
15/11/2008  06:53             2,819 libmysql.def
10/12/2008  13:56    <DIR>          mysql
15/11/2008  06:53            33,654 mysql.h
15/11/2008  06:53            23,155 mysqld_ername.h
15/11/2008  06:53            23,212 mysqld_error.h
15/11/2008  06:53            20,174 mysql_com.h
15/11/2008  06:53             1,130 mysql_embed.h
15/11/2008  06:53             2,097 mysql_time.h
15/11/2008  06:53               860 mysql_version.h
15/11/2008  06:53             1,804 my_alloc.h
15/11/2008  06:53             1,941 my_attribute.h
15/11/2008  06:53             4,576 my_dbug.h
15/11/2008  06:53             3,460 my_dir.h
15/11/2008  06:53             3,278 my_getopt.h
15/11/2008  06:53            50,497 my_global.h
15/11/2008  06:53             1,488 my_list.h
15/11/2008  06:53             3,656 my_net.h
15/11/2008  06:53             1,542 my_no_pthread.h
15/11/2008  06:53            26,468 my_pthread.h
15/11/2008  06:53            40,097 my_sys.h
15/11/2008  06:53             2,677 my_xml.h
15/11/2008  06:53            22,584 m_ctype.h
15/11/2008  06:53             8,256 m_string.h
15/11/2008  06:53             1,957 sql_common.h
15/11/2008  06:53            12,484 sql_state.h
15/11/2008  06:53             1,006 sslopt-case.h
15/11/2008  06:53             2,205 sslopt-longopts.h
15/11/2008  06:53             1,107 sslopt-vars.h
15/11/2008  06:53             1,501 typelib.h
              32 File(s)        325,486 bytes
               3 Dir(s)   4,091,248,640 bytes free

C:\mysql\include>
```

9. Then in the **ADDITIONAL INCLUDE DIRECTORIES** text field, add the MySQL `include/` directory.

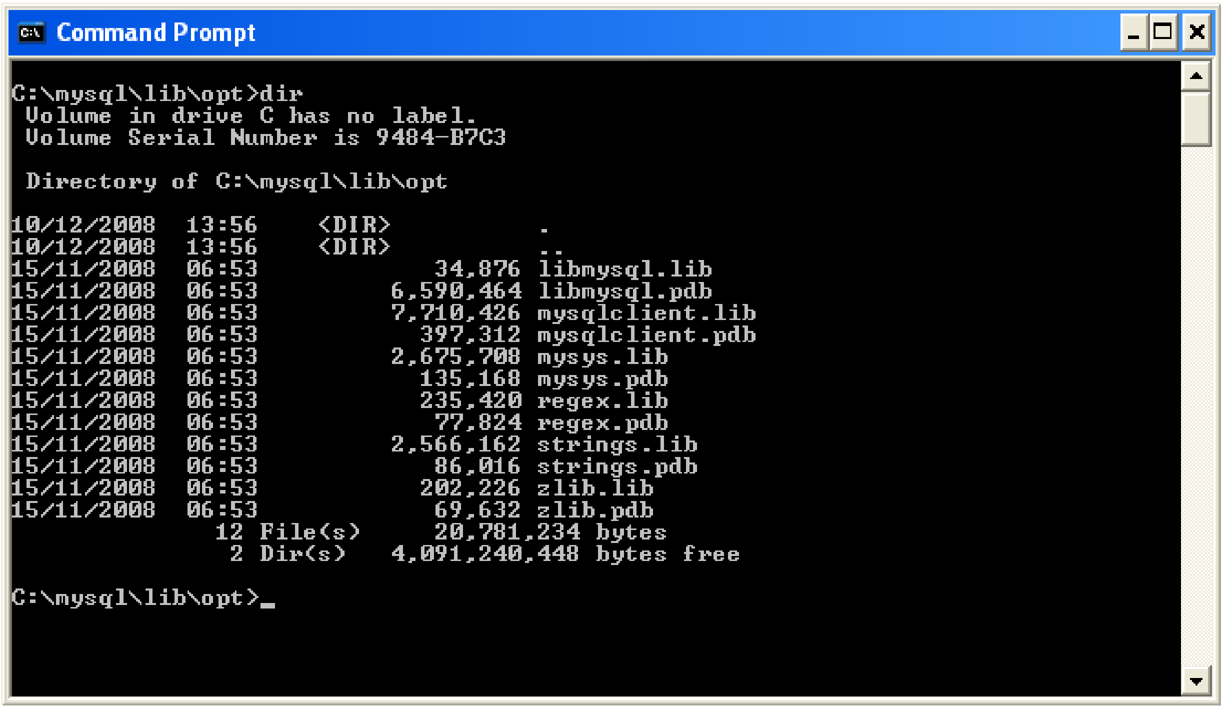
Figure 20.69. Select Directory Dialog


Select Directory
28a95fa67307e691a5
databases
Documents and Settings
emacs-22.3
mysql
bin
data
include
mysql
lib
share
Make New Folder
OK
Cancel

Folder: include

10. You will also need to set the location of additional libraries that Visual Studio will need to build the application. These are located in the MySQL `lib/opt` directory, a sub-directory of the MySQL Server installation directory.

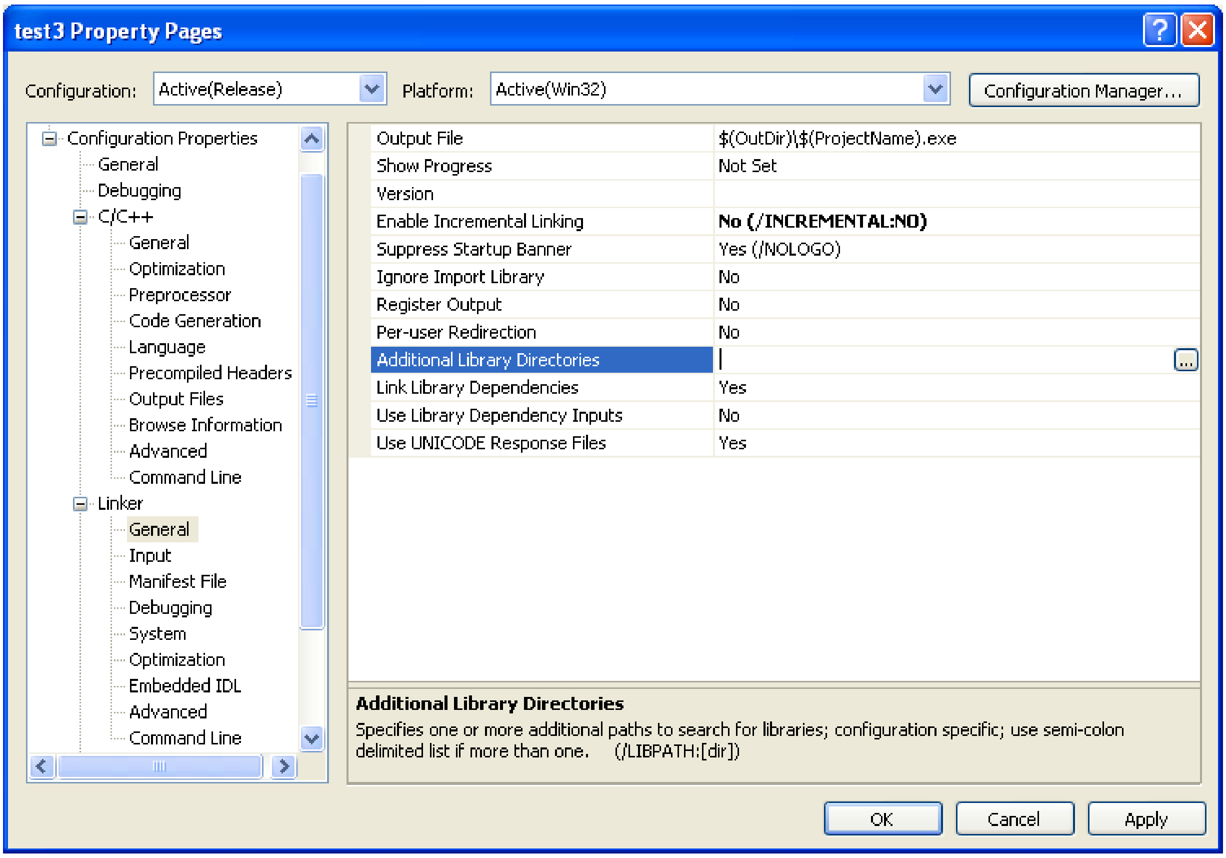
Figure 20.70. Typical Contents of MySQL lib/opt Directory


Command Prompt

```
C:\mysql\lib\opt>dir
 Volume in drive C has no label.
 Volume Serial Number is 9484-B7C3

 Directory of C:\mysql\lib\opt

10/12/2008  13:56    <DIR>          .
10/12/2008  13:56    <DIR>          ..
15/11/2008  06:53            34,876 libmysql.lib
15/11/2008  06:53         6,590,464 libmysql.pdb
15/11/2008  06:53         7,710,426 mysqlclient.lib
15/11/2008  06:53           397,312 mysqlclient.pdb
15/11/2008  06:53         2,675,708 mysys.lib
15/11/2008  06:53           135,168 mysys.pdb
15/11/2008  06:53           235,420 regex.lib
15/11/2008  06:53            77,824 regex.pdb
15/11/2008  06:53         2,566,162 strings.lib
15/11/2008  06:53            86,016 strings.pdb
15/11/2008  06:53           202,226 zlib.lib
15/11/2008  06:53            69,632 zlib.pdb
              12 File(s)     20,781,234 bytes
               2 Dir(s)   4,091,240,448 bytes free

C:\mysql\lib\opt>_
```

11. In the tree view open LINKER, GENERAL, ADDITIONAL LIBRARY DIRECTORIES.

Figure 20.71. Additional Library Directories


test3 Property Pages
Configuration Manager...
Configuration Properties
General
Debugging
C/C++
General
Optimization
Preprocessor
Code Generation
Language
Precompiled Headers
Output Files
Browse Information
Advanced
Command Line
Linker
General
Input
Manifest File
Debugging
System
Optimization
Embedded IDL
Advanced
Command Line
OK
Cancel
Apply

Configuration: Active(Release)

Platform: Active(Win32)

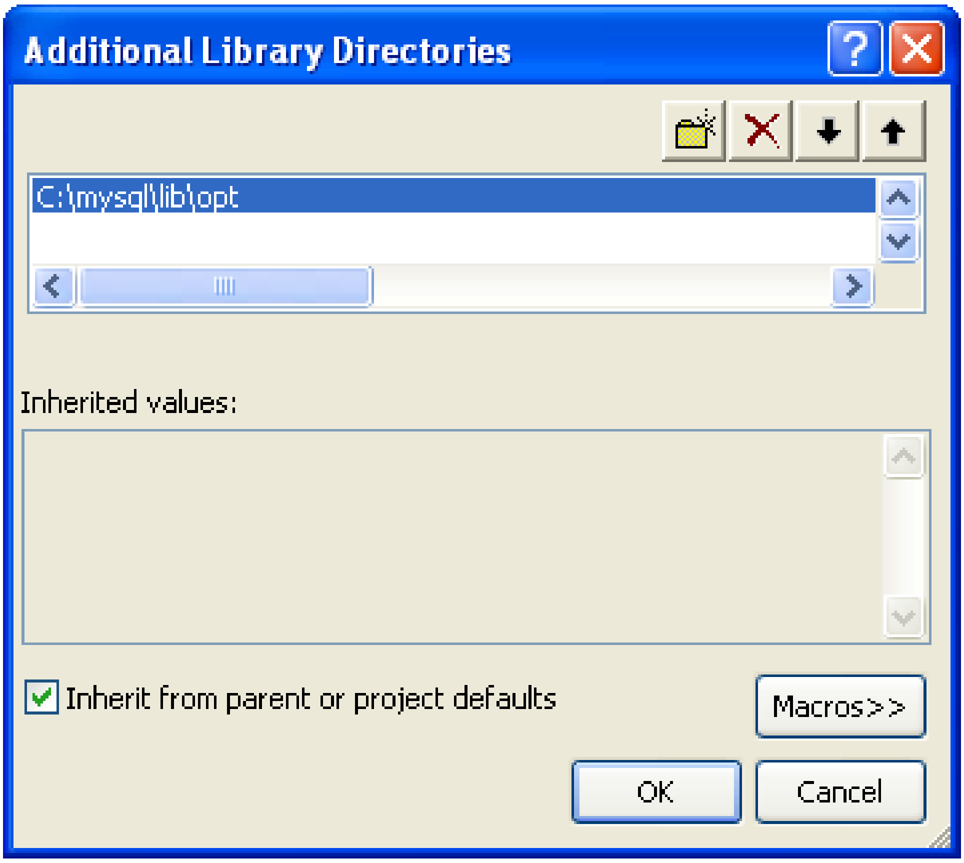
Output File	$(OutDir)\$(ProjectName).exe
Show Progress	Not Set
Version	
Enable Incremental Linking	**No (/INCREMENTAL:NO)**
Suppress Startup Banner	Yes (/NOLOGO)
Ignore Import Library	No
Register Output	No
Per-user Redirection	No
Additional Library Directories	
Link Library Dependencies	Yes
Use Library Dependency Inputs	No
Use UNICODE Response Files	Yes

Additional Library Directories

Specifies one or more additional paths to search for libraries; configuration specific; use semi-colon delimited list if more than one. (/LIBPATH:[dir])

12. Add the `lib/opt` directory into the **ADDITIONAL LIBRARY DIRECTORIES** text field. This enables the library file `libmysql.lib` to be found.

Figure 20.72. Additional Library Directories Dialog


Additional Library Directories
Inherited values:
Macros>>
OK
Cancel

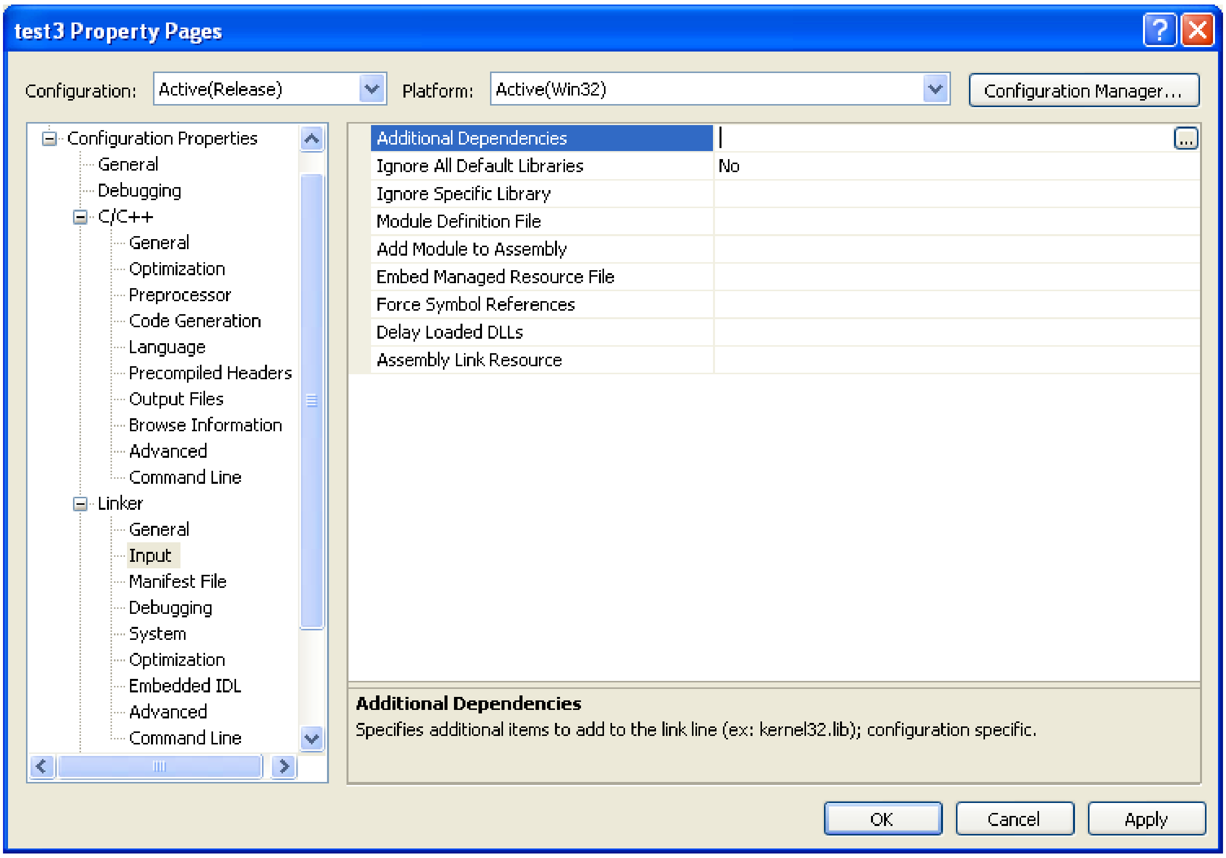
C:\mysql\lib\opt

☑ Inherit from parent or project defaults

The remaining steps depend on whether you are building an application to use the MySQL Connector/C++ static or dynamic library. If you are building your application to use the dynamic library go here. If you are building your application to use the static library, carry out the following steps:

1. Then open **Linker**, **Input**, **Additional Dependencies**.

   Figure 20.73.



test3 Property Pages

Configuration: Active(Release)

Platform: Active(Win32)

Additional Dependencies	
Ignore All Default Libraries	No
Ignore Specific Library	
Module Definition File	
Add Module to Assembly	
Embed Managed Resource File	
Force Symbol References	
Delay Loaded DLLs	
Assembly Link Resource	

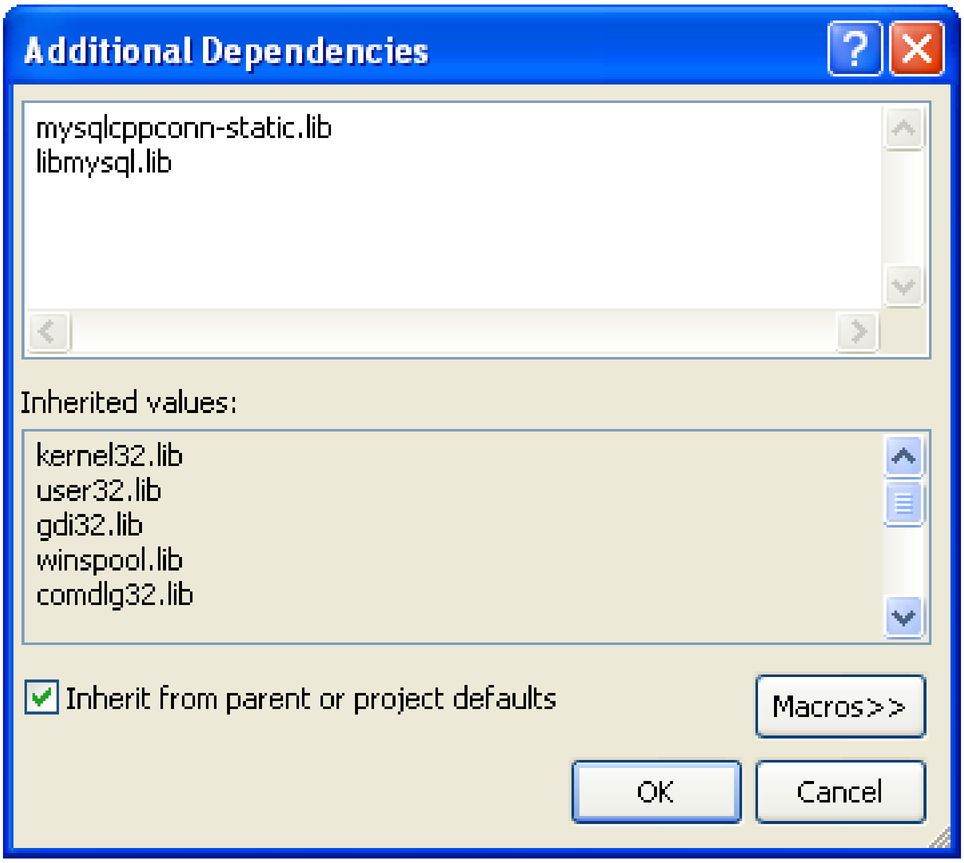
Additional Dependencies

Specifies additional items to add to the link line (ex: kernel32.lib); configuration specific.

Configuration Manager...
Configuration Properties
General
Debugging
C/C++
General
Optimization
Preprocessor
Code Generation
Language
Precompiled Headers
Output Files
Browse Information
Advanced
Command Line
Linker
General
Input
Manifest File
Debugging
System
Optimization
Embedded IDL
Advanced
Command Line
OK
Cancel
Apply

2. Enter `mysqlcppconn-static.lib` and `libmysql.lib`.

Figure 20.74. Adding Additional Dependencies



mysqlcppconn-static.lib
libmysql.lib

Inherited values:

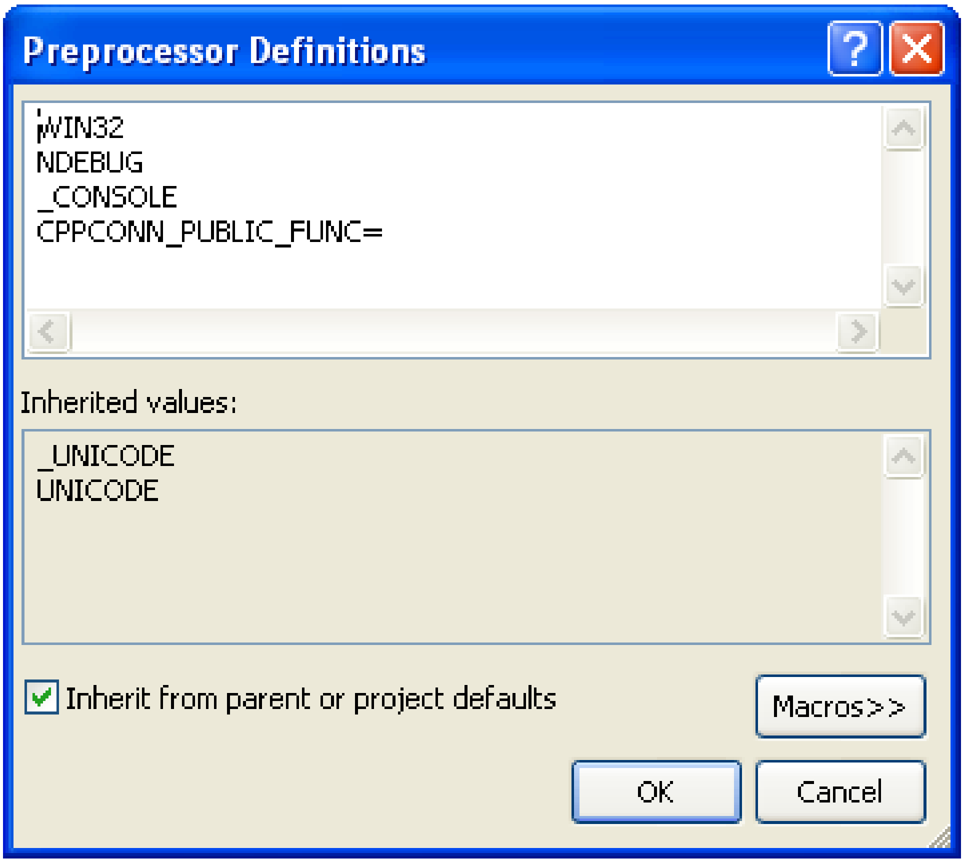
kernel32.lib
user32.lib
gdi32.lib
winspool.lib
comdlg32.lib

☑ Inherit from parent or project defaults

3. By default `CPPCONN_PUBLIC_FUNC` is defined to declare functions to be compatible with an application that calls a DLL. If building an application to call the static library, you must ensure that function prototypes are compatible with this. In this case `CPPCONN_PUBLIC_FUNC` needs to be defined to be an empty string, so that functions are declared with the correct prototype.

   In the **Project**, **Properties** tree view, under **C++**, **Preprocessor**, enter `CPPCONN_PUBLIC_FUNC=` into the Preprocessor Definitions text field.

   Figure 20.75. Setting the CPPCONN_PUBLIC_FUNC Define



WIN32
NDEBUG
_CONSOLE
CPPCONN_PUBLIC_FUNC=

Inherited values:

_UNICODE
UNICODE

☑ Inherit from parent or project defaults

Note

Make sure you enter `CPPCONN_PUBLIC_FUNC=` and not `CPPCONN_PUBLIC_FUNC`, as it needs to be defined as an empty string.

If building an application to use the MySQL Connector/C++ dynamically linked library carry out these steps:

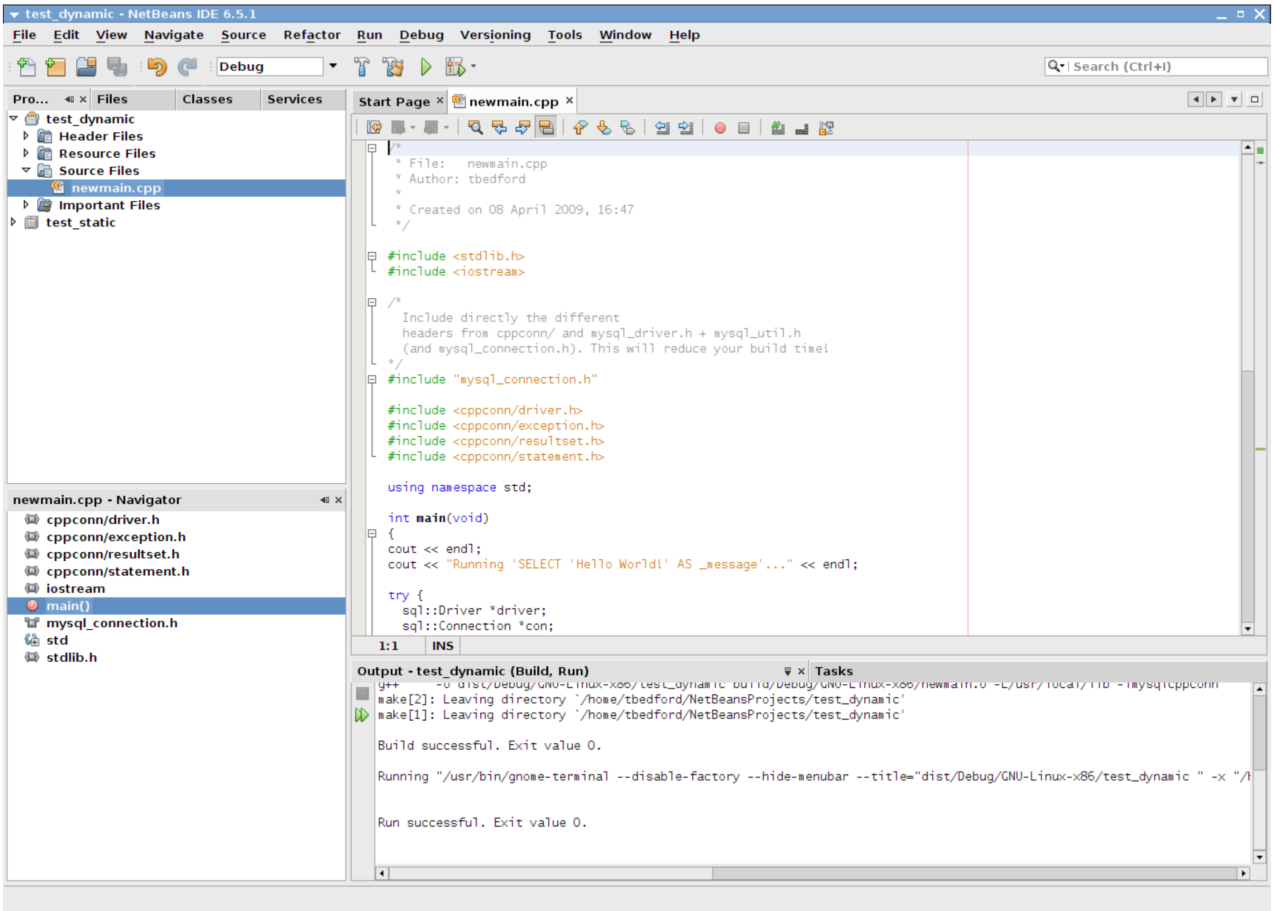
1. Under **Linker**, **Input**, add `mysqlcppconn.lib` into the **Additional Dependencies** text field.
2. The application will need to access the MySQL Connector/C++ Dynamic Linked Library at run time. Therefore, `mysqlcppconn.dll` needs to be in the same directory as the application executable, or somewhere on the system's path.

   Copy `mysqlcppconn.dll` to the same directory as the application. Alternatively, extend the `PATH` environment variable using `SET PATH=%PATH%;C:\path\to\cpp`. Alternatively, you can copy `mysqlcppconn.dll` to the Windows installation Directory, typically `c:\windows`.

20.5.4. MySQL Connector/C++ Building Linux applications with NetBeans

This section describes how you can build MySQL Connector/C++ applications for Linux using the NetBeans IDE.

Figure 20.76. The NetBeans IDE


test_dynamic - NetBeans IDE 6.5.1
File Edit View Navigate Source Refactor Run Debug Versioning Tools Window Help
Debug
Search (Ctrl+I)
Pro... Files Classes Services
test_dynamic
Header Files
Resource Files
Source Files
newmain.cpp
Important Files
test_static
newmain.cpp - Navigator
cppconn/driver.h
cppconn/exception.h
cppconn/resultset.h
cppconn/statement.h
iostream
main()
mysql_connection.h
std
stdlib.h
Start Page
newmain.cpp
1:1
INS
Output - test_dynamic (Build, Run)
Tasks

```
/*
 * File:   newmain.cpp
 * Author: tbedford
 *
 * Created on 08 April 2009, 16:47
 */

#include <stdlib.h>
#include <iostream>

/*
  Include directly the different
  headers from cppconn/ and mysql_driver.h + mysql_util.h
  (and mysql_connection.h). This will reduce your build time!
*/
#include "mysql_connection.h"

#include <cppconn/driver.h>
#include <cppconn/exception.h>
#include <cppconn/resultset.h>
#include <cppconn/statement.h>

using namespace std;

int main(void)
{
cout << endl;
cout << "Running 'SELECT 'Hello World!' AS _message'..." << endl;

try {
  sql::Driver *driver;
  sql::Connection *con;
```

```
g++     -o dist/Debug/GNU-Linux-x86/test_dynamic build/Debug/GNU-Linux-x86/newmain.o -L/usr/local/lib -lmysqlcppconn
make[2]: Leaving directory `/home/tbedford/NetBeansProjects/test_dynamic'
make[1]: Leaving directory `/home/tbedford/NetBeansProjects/test_dynamic'

Build successful. Exit value 0.

Running "/usr/bin/gnome-terminal --disable-factory --hide-menubar --title="dist/Debug/GNU-Linux-x86/test_dynamic " -x "/


Run successful. Exit value 0.
```

> ### Note
>
> To avoid potential crashes the build configuration of MySQL Connector/C++ should match the build configuration of the application using it. For example, do not use the release build of MySQL Connector/C++ with a debug build of the client application.

1. The first step of building your application is to create a new project. Select FILE, NEW PROJECT. Choose a **C/C++ APPLICATION** and click NEXT.

2. Give the project a name and click FINISH. A new project is created.

3. In the **PROJECTS** tab, right-click **SOURCE FILES** and select NEW, then MAIN C++ FILE....

4. Change the filename, or simply select the defaults and click FINISH to add the new file to the project.

5. You now need to add some working code to you main source file. Explore your MySQL Connector/C++ installation and navigate to the `examples` directory.

6. Select a suitable example such as `standalone_example_docs1.cpp`. Copy all the code in this file, and use it to replace the code in your existing main source file. Amend the code to reflect the connection properties required for your test database. You now have a working example that will access a MySQL database using MySQL Connector/C++.

7. You will notice that at this point NetBeans is showing some errors in the source code. This is because you need to direct NetBeans to the necessary header files that need to be included. Select FILE, PROJECT PROPERTIES from the main menu.

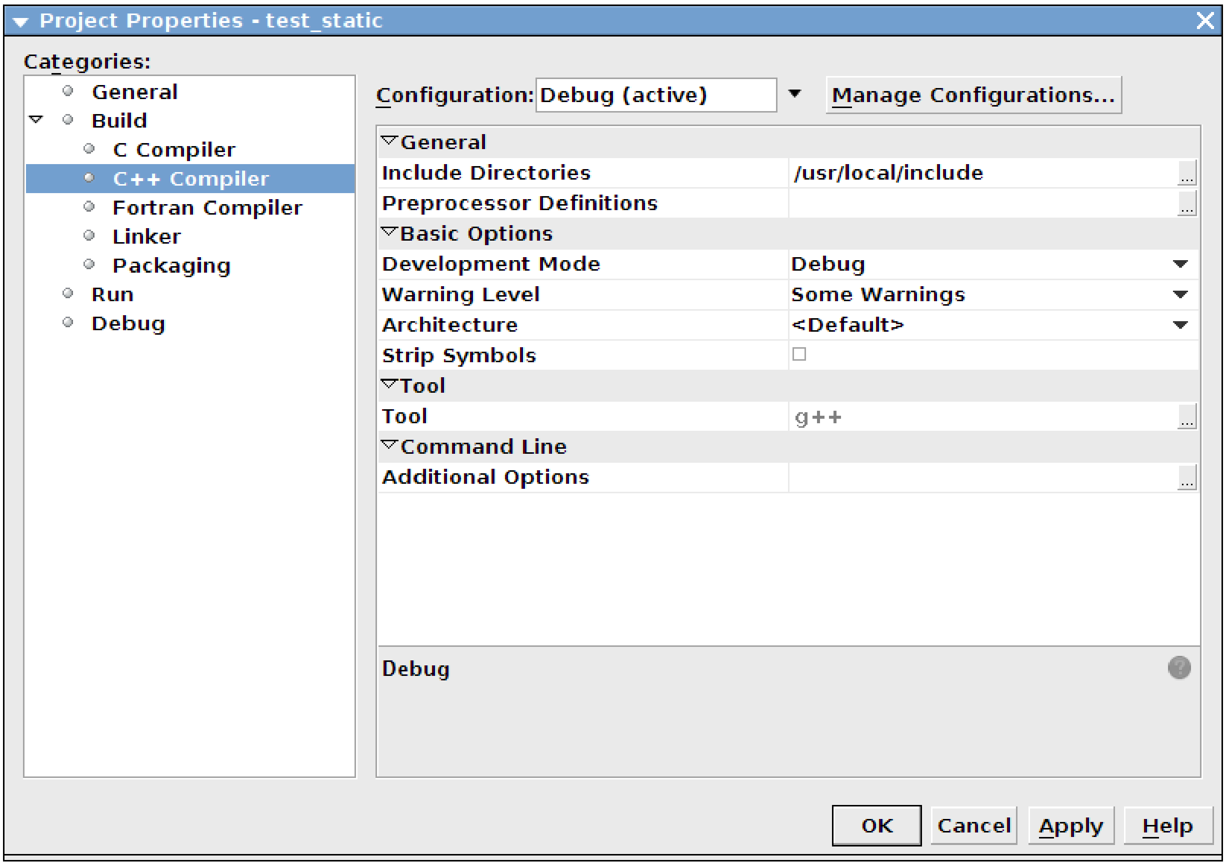
8. In the **CATEGORIES:** tree view panel, navigate to **BUILD**, **C++ COMPILER**.

9. In the **GENERAL** panel, select **INCLUDE DIRECTORIES**.

10. Click the ... button.

11. Click ADD and then navigate to the directory where the MySQL Connector/C++ header files are located. This will be `/usr/local/include` unless you have installed the files to a different location. Click SELECT. Click OK.

Figure 20.77. Setting the Header Include Directory


Project Properties - test_static
Categories:
General
Build
C Compiler
C++ Compiler
Fortran Compiler
Linker
Packaging
Run
Debug
Manage Configurations...
General
Basic Options
Tool
Command Line
Preprocessor Definitions
Additional Options
OK
Cancel
Apply
Help

Configuration: Debug (active)

Include Directories: /usr/local/include

Development Mode: Debug

Warning Level: Some Warnings

Architecture: <Default>

Strip Symbols: ☐

Tool: g++

Debug

12. Click OK again to close the **Project Properties** dialog.

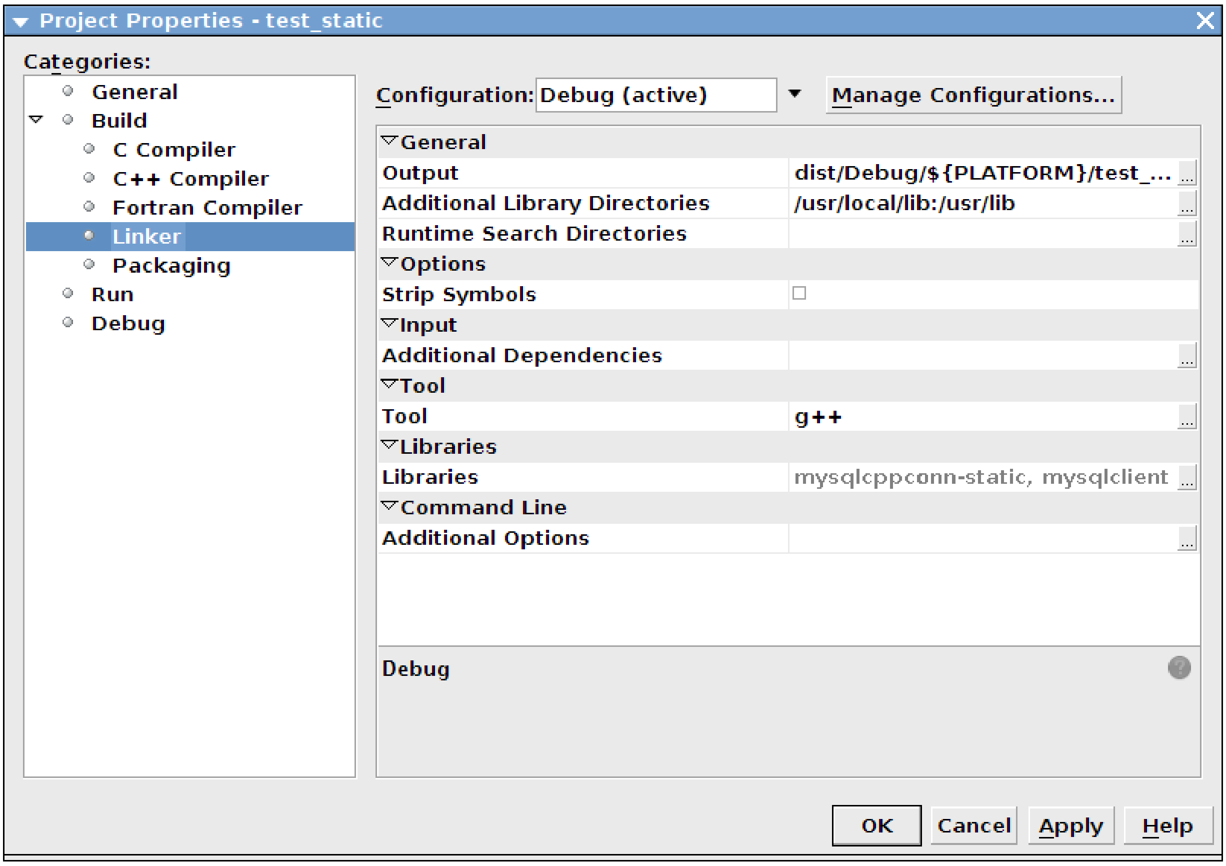
At this point you have created a NetBeans project, containing a single C++ source file. You have also ensured that the necessary include files are accessible. Before continuing, you need to decide whether your project is to use the MySQL Connector/C++ static or dynamic library. The project settings are slightly different in each case, as you need to link against a different library.

Using the static library

If you intend to use the static library you will need to link against two library files, `libmysqlcppconn-static.a` and `libmysqlclient.a`. The locations of the files will depend on your setup, but typically the former will be found in `/usr/local/lib` and the latter in `/usr/lib`. Note the file `libmysqlclient.a` is not part of MySQL Connector/C++, but is the MySQL Client Library file distributed with MySQL Server. Remember, the MySQL Client Library is an optional component as part of the MySQL Server installation process. Note the MySQL Client Library is also available as part of the new MySQL Connector/C distribution.

1. The first step is to set the project to link the necessary library files. Select File, Project Properties from the main menu.
2. In the **Categories:** tree view navigate to **Linker**.
3. In the **General** panel select **Additional Library Directories**. Click the ... button.
4. Select and add the `/usr/lib` and `/usr/local/lib` directories.
5. In the same panel add the two library files required for static linking as discussed earlier. The properties panel should then look similar to the following screenshot:

Figure 20.78. Setting the Static Library Directories and File Names


Project Properties - test_static
Categories:
General
Build
C Compiler
C++ Compiler
Fortran Compiler
Linker
Packaging
Run
Debug
Manage Configurations...
General
Options
Input
Tool
Libraries
Command Line
Debug
OK
Cancel
Apply
Help

Configuration: Debug (active)

Output	dist/Debug/${PLATFORM}/test_...
Additional Library Directories	/usr/local/lib:/usr/lib
Runtime Search Directories	
Strip Symbols	☐
Additional Dependencies	
Tool	g++
Libraries	mysqlcppconn-static, mysqlclient
Additional Options	

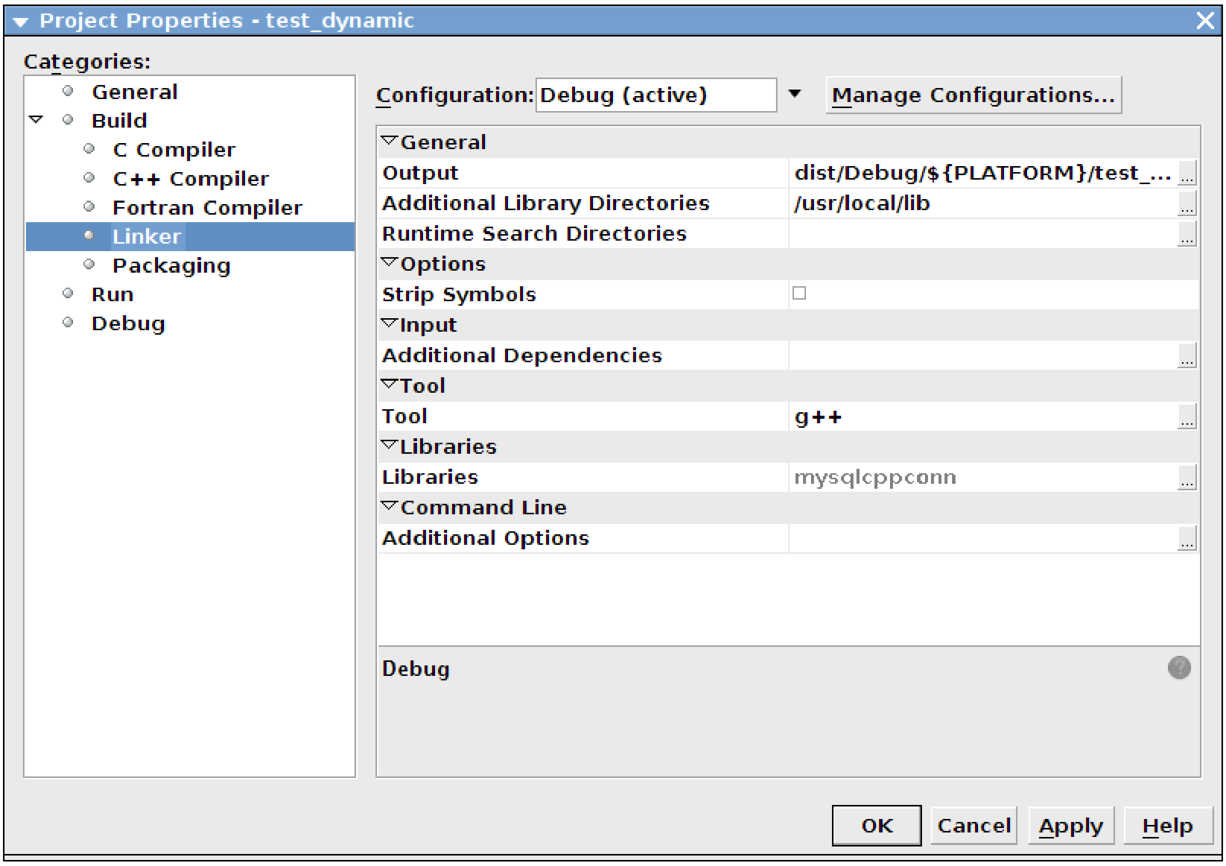
6. Click OK to close the **PROJECT PROPERTIES** dialog.

Using the dynamic library

If you require your application to use the MySQL Connector/C++ dynamic library, you simply need to link your project with a single library file, `libmysqlcppconn.so`. The location of this file will depend on how you configured your installation of MySQL Connector/C++, but will typically be `/usr/local/lib`.

1. The first step is to set the project to link the necessary library file. Select FILE, PROJECT PROPERTIES from the main menu.
2. In the **CATEGORIES:** tree view navigate to **LINKER**.
3. In the **GENERAL** panel select **ADDITIONAL LIBRARY DIRECTORIES**. Click the ... button.
4. Select and add the `/usr/local/lib` directories.
5. In the same panel add the library file required for static linking as discussed earlier. The properties panel should then look similar to the following screenshot:

Figure 20.79. Setting the Dynamic Library Directory and File Name


Project Properties - test_dynamic
Categories:
General
Build
C Compiler
C++ Compiler
Fortran Compiler
Linker
Packaging
Run
Debug
Manage Configurations...
OK
Cancel
Apply
Help

Configuration: Debug (active)

General	
Output	dist/Debug/${PLATFORM}/test_...
Additional Library Directories	/usr/local/lib
Runtime Search Directories	
Options	
Strip Symbols	☐
Input	
Additional Dependencies	
Tool	
Tool	g++
Libraries	
Libraries	mysqlcppconn
Command Line	
Additional Options	

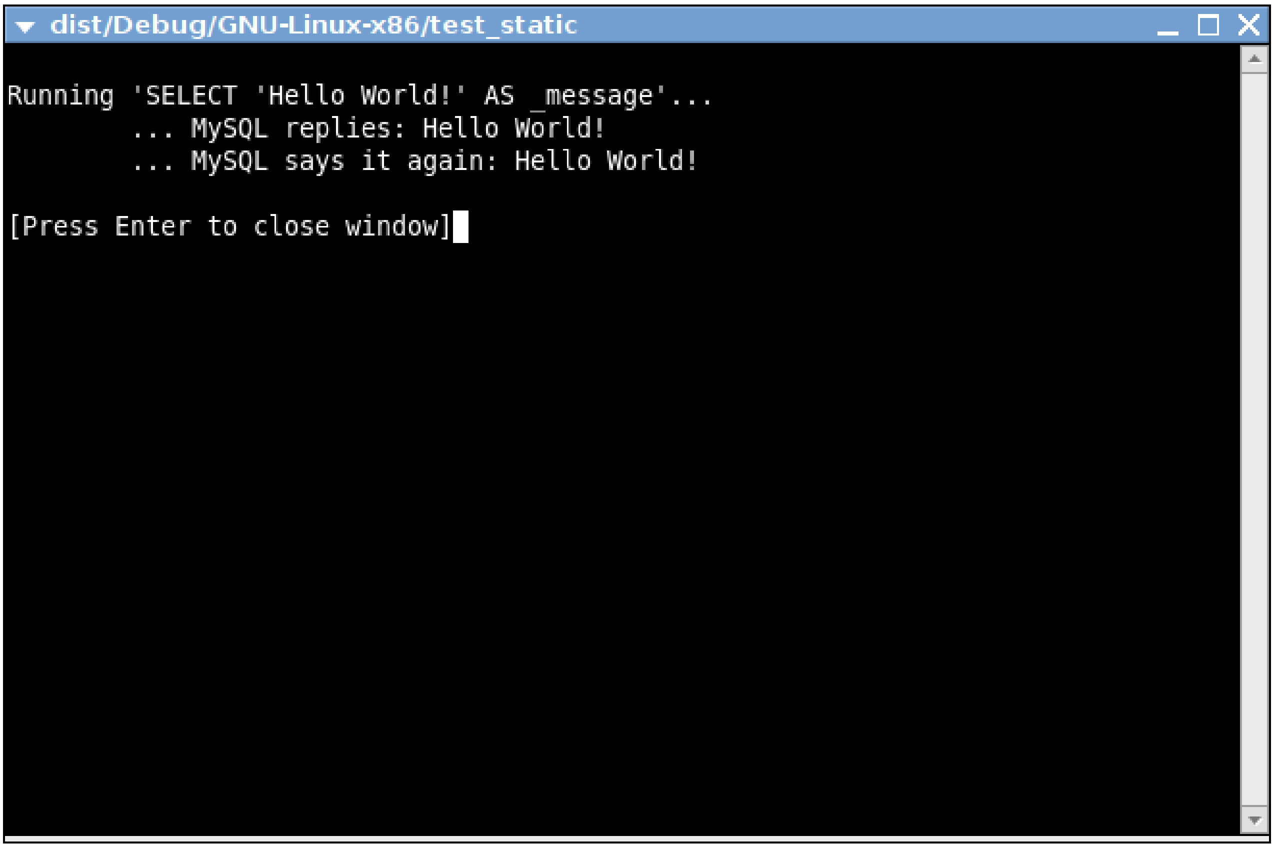
Debug

6. Click OK to close the Project Properties dialog.

Having configured your project you can build it by selecting Run, Build Main Project from the main menu. You can then run the project using Run, Run Main Project.

On running the application you should see a screen similar to the following (this is actually the static version of the application shown):

Figure 20.80. The Example Application Running



```
Running 'SELECT 'Hello World!' AS _message'...
        ... MySQL replies: Hello World!
        ... MySQL says it again: Hello World!

[Press Enter to close window]
```

Note

Note the above settings and procedures were carried out for the default `Debug` configuration. If you want to create a `Release` configuration you will need to select that configuration before setting the Project Properties.

20.5.5. MySQL Connector/C++ Getting Started: Usage Examples

The download package contains usage examples in the directory `examples/`. The examples explain the basic usage of the following classes:

- `Connection`
- `Driver`
- `PreparedStatement`
- `ResultSet`
- `ResultSetMetaData`
- `Statement`

The examples cover:

- Using the `Driver` class to connect to MySQL
- Creating tables, inserting rows, fetching rows using (simple) statements
- Creating tables, inserting rows, fetching rows using prepared statements
- Hints for working around prepared statement limitations
- Accessing result set metadata

The examples in this document are only code snippets. The code snippets provide a brief overview on the API. They are not complete programs. Please check the `examples/` directory of your MySQL Connector/C++ installation for complete programs. Please also read the `README` file in the `examples/` directory. Note to test the example code you will first need to edit the `examples.h` file in the `examples/` directory, to add your connection information. Then simply rebuild the code by issuing a `make` command.

The examples in the `examples/` directory include:

- `examples/connect.cpp`:

  How to create a connection, insert data into MySQL and handle exceptions.

- `examples/connection_meta_schemaobj.cpp`:

  How to obtain metadata associated with a connection object, for example, a list of tables, databases, MySQL version, connector version.

- `examples/debug_output.cpp`:

  How to activate and deactivate the MySQL Connector/C++ debug protocol.

- `examples/exceptions.cpp`:

  A closer look at the exceptions thrown by the connector and how to fetch error information.

- `examples/prepared_statements.cpp`:

  How to run Prepared Statements including an example how to handle SQL commands that cannot be prepared by the MySQL Server.

- `examples/resultset.cpp`:

  How to fetch data and iterate over the result set (cursor).

- `examples/resultset_meta.cpp`:

  How to obtain metadata associated with a result set, for example, number of columns and column types.

- `examples/resultset_types.cpp`:

  Result sets returned from metadata methods - this is more a test than much of an example.

- `examples/standalone_example.cpp`:

  Simple standalone program not integrated into regular `CMake` builds.

- `examples/statements.cpp`:

  How to run SQL commands without using Prepared Statements.

- `examples/cpp_trace_analyzer.cpp`:

  This example shows how to filter the output of the debug trace. Please see the inline comments for further documentation. This script is unsupported.

20.5.5.1. MySQL Connector/C++ Connecting to MySQL

A connection to MySQL is established by retrieving an instance of `sql::Connection` from a `sql::mysql::MySQL_Driver` object. A `sql::mysql::MySQL_Driver` object is returned by `sql::mysql::MySQL_Driver::get_mysql_driver_instance()`.

```
sql::mysql::MySQL_Driver *driver;
sql::Connection *con;

driver = sql::mysql::MySQL_Driver::get_mysql_driver_instance();
con = driver->connect("tcp://127.0.0.1:3306", "user", "password");

delete con;
```

Make sure that you free the `sql::Connection` object as soon as you do not need it any more. But do not explicitly free the connector object!

20.5.5.2. MySQL Connector/C++ Running a simple query

For running simple queries you can use the methods `sql::Statement::execute()`, `sql::Statement::executeQuery()` and `sql::Statement::executeUpdate()`. The method `sql::Statement::execute()` should be used if your query does not return a result set or if your query returns more than one result set. See the `examples/` directory for more on this.

```
sql::mysql::MySQL_Driver *driver;
sql::Connection *con;
sql::Statement *stmt

driver = sql::mysql::get_mysql_driver_instance();
con = driver->connect("tcp://127.0.0.1:3306", "user", "password");

stmt = con->createStatement();
stmt->execute("USE " EXAMPLE_DB);
stmt->execute("DROP TABLE IF EXISTS test");
stmt->execute("CREATE TABLE test(id INT, label CHAR(1))");
stmt->execute("INSERT INTO test(id, label) VALUES (1, 'a')");

delete stmt;
delete con;
```

Note that you have to free `sql::Statement` and `sql::Connection` objects explicitly using delete.

20.5.5.3. MySQL Connector/C++ Fetching results

The API for fetching result sets is identical for (simple) statements and prepared statements. If your query returns one result set you should use `sql::Statement::executeQuery()` or `sql::PreparedStatement::executeQuery()` to run your query. Both methods return `sql::ResultSet` objects. The preview version does buffer all result sets on the client to support cursors.

```
// ...
sql::Connection *con;
sql::Statement *stmt
sql::ResultSet  *res;
// ...
stmt = con->createStatement();
// ...

res = stmt->executeQuery("SELECT id, label FROM test ORDER BY id ASC");
while (res->next()) {
  // You can use either numeric offsets...
  cout << "id = " << res->getInt(1); // getInt(1) returns the first column
  // ... or column names for accessing results.
  // The latter is recommended.
  cout << ", label = '" << res->getString("label") << "'" << endl;
}

delete res;
delete stmt;
delete con;
```

Note

Note in the preceding code snippet that column indexing starts from 1.

Note that you have to free `sql::Statement`, `sql::Connection` and `sql::ResultSet` objects explicitly using delete.

The usage of cursors is demonstrated in the examples contained in the download package.

20.5.5.4. MySQL Connector/C++ Using Prepared Statements

If you are not familiar with Prepared Statements on MySQL have an extra look at the source code comments and explanations in the file `examples/prepared_statement.cpp`.

`sql::PreparedStatement` is created by passing an SQL query to `sql::Connection::prepareStatement()`. As `sql::PreparedStatement` is derived from `sql::Statement`, you will feel familiar with the API once you have learned how to use (simple) statements (`sql::Statement`). For example, the syntax for fetching results is identical.

```
// ...
sql::Connection *con;
sql::PreparedStatement *prep_stmt
// ...

prep_stmt = con->prepareStatement("INSERT INTO test(id, label) VALUES (?, ?)");

prep_stmt->setInt(1, 1);
prep_stmt->setString(2, "a");
```

```
prep_stmt->execute();

prep_stmt->setInt(1, 2);
prep_stmt->setString(2, "b");
prep_stmt->execute();

delete prep_stmt;
delete con;
```

As usual, you have to free `sql::PreparedStatement` and `sql::Connection` objects explicitly.

20.5.5.5. MySQL Connector/C++ Complete Example 1

The following code shows a complete example of how to use MySQL Connector/C++:

```
/* Copyright 2008, 2010, Oracle and/or its affiliates. All rights reserved.

This program is free software; you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation; version 2 of the License.

There are special exceptions to the terms and conditions of the GPL
as it is applied to this software. View the full text of the
exception in file EXCEPTIONS-CONNECTOR-C++ in the directory of this
software distribution.

This program is distributed in the hope that it will be useful,
but WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
GNU General Public License for more details.

You should have received a copy of the GNU General Public License
along with this program; if not, write to the Free Software
Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA
*/

/* Standard C++ includes */
#include <stdlib.h>
#include <iostream>

/*
  Include directly the different
  headers from cppconn/ and mysql_driver.h + mysql_util.h
  (and mysql_connection.h). This will reduce your build time!
*/
#include "mysql_connection.h"

#include <cppconn/driver.h>
#include <cppconn/exception.h>
#include <cppconn/resultset.h>
#include <cppconn/statement.h>

using namespace std;

int main(void)
{
cout << endl;
cout << "Running 'SELECT 'Hello World!' »
   AS _message'..." << endl;

try {
  sql::Driver *driver;
  sql::Connection *con;
  sql::Statement *stmt;
  sql::ResultSet *res;

  /* Create a connection */
  driver = get_driver_instance();
  con = driver->connect("tcp://127.0.0.1:3306", "root", "root");
  /* Connect to the MySQL test database */
  con->setSchema("test");

  stmt = con->createStatement();
  res = stmt->executeQuery("SELECT 'Hello World!' AS _message");
  while (res->next()) {
    cout << "\t... MySQL replies: ";
    /* Access column data by alias or column name */
    cout << res->getString("_message") << endl;
    cout << "\t... MySQL says it again: ";
    /* Access column fata by numeric offset, 1 is the first column */
    cout << res->getString(1) << endl;
  }
  delete res;
  delete stmt;
  delete con;

} catch (sql::SQLException &e) {
  cout << "# ERR: SQLException in " << __FILE__;
  cout << "(" << __FUNCTION__ << ") on line " »
     << __LINE__ << endl;
  cout << "# ERR: " << e.what();
  cout << " (MySQL error code: " << e.getErrorCode();
  cout << ", SQLState: " << e.getSQLState() << " )" << endl;
}

cout << endl;

return EXIT_SUCCESS;
}
```

20.5.5.6. MySQL Connector/C++ Complete Example 2

The following code shows a complete example of how to use MySQL Connector/C++:

```
/* Copyright 2008, 2010, Oracle and/or its affiliates. All rights reserved.

This program is free software; you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation; version 2 of the License.

There are special exceptions to the terms and conditions of the GPL
as it is applied to this software. View the full text of the
exception in file EXCEPTIONS-CONNECTOR-C++ in the directory of this
software distribution.

This program is distributed in the hope that it will be useful,
but WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
GNU General Public License for more details.

You should have received a copy of the GNU General Public License
along with this program; if not, write to the Free Software
Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA
*/

/* Standard C++ includes */
#include <stdlib.h>
#include <iostream>

/*
  Include directly the different
  headers from cppconn/ and mysql_driver.h + mysql_util.h
  (and mysql_connection.h). This will reduce your build time!
*/
#include "mysql_connection.h"

#include <cppconn/driver.h>
#include <cppconn/exception.h>
#include <cppconn/resultset.h>
#include <cppconn/statement.h>
#include <cppconn/prepared_statement.h>

using namespace std;

int main(void)
{
cout << endl;
cout << "Let's have MySQL count from 10 to 1..." << endl;

try {
  sql::Driver *driver;
  sql::Connection *con;
  sql::Statement *stmt;
  sql::ResultSet *res;
  sql::PreparedStatement *pstmt;

  /* Create a connection */
  driver = get_driver_instance();
  con = driver->connect("tcp://127.0.0.1:3306", "root", "root");
  /* Connect to the MySQL test database */
  con->setSchema("test");

  stmt = con->createStatement();
  stmt->execute("DROP TABLE IF EXISTS test");
  stmt->execute("CREATE TABLE test(id INT)");
  delete stmt;

  /* '?' is the supported placeholder syntax */
  pstmt = con->prepareStatement("INSERT INTO test(id) VALUES (?)");
  for (int i = 1; i <= 10; i++) {
    pstmt->setInt(1, i);
    pstmt->executeUpdate();
  }
  delete pstmt;

  /* Select in ascending order */
  pstmt = con->prepareStatement("SELECT id FROM test ORDER BY id ASC");
  res = pstmt->executeQuery();

  /* Fetch in reverse = descending order! */
  res->afterLast();
  while (res->previous())
    cout << "\t... MySQL counts: " << res->getInt("id") << endl;
  delete res;

  delete pstmt;
  delete con;

} catch (sql::SQLException &e) {
  cout << "# ERR: SQLException in " << __FILE__;
  cout << "(" << __FUNCTION__ << ") on line " »
     << __LINE__ << endl;
  cout << "# ERR: " << e.what();
  cout << " (MySQL error code: " << e.getErrorCode();
  cout << ", SQLState: " << e.getSQLState() << »
     " )" << endl;
}

cout << endl;

return EXIT_SUCCESS;
}
```

20.5.6. MySQL Connector/C++ Tutorials

Here are some tutorials on using MySQL Connector/C++. You should also have a look at the examples which can be found in the following section Section 20.5.5, “MySQL Connector/C++ Getting Started: Usage Examples”.

Setting up the World database for use in the tutorials

These tutorials primarily use the `World` database, so you need to have that installed. You can download the `World` database, and documentation on how to install it, from the MySQL Documentation page - look for the section called “Example Databases”.

Tutorial framework code

Rather than repeating the same code, a framework is given here. You can reuse this framework with all the tutorials unless otherwise stated. This boiler plate code can then simply be reused for each tutorial.

The framework code is given here:

```
#include <stdlib.h>
#include <iostream>
#include <sstream>
#include <stdexcept>

#include "mysql_connection.h"

#include <cppconn/driver.h>
#include <cppconn/exception.h>
#include <cppconn/resultset.h>
#include <cppconn/statement.h>
#include <cppconn/prepared_statement.h>

#define EXAMPLE_HOST "localhost"
#define EXAMPLE_USER "root"
#define EXAMPLE_PASS ""
#define EXAMPLE_DB "world"

using namespace std;

int main(int argc, const char **argv)
{

    string url(argc >= 2 ? argv[1] : EXAMPLE_HOST);
    const string user(argc >= 3 ? argv[2] : EXAMPLE_USER);
    const string pass(argc >= 4 ? argv[3] : EXAMPLE_PASS);
    const string database(argc >= 5 ? argv[4] : EXAMPLE_DB);

    cout << "Connector/C++ tutorial framework..." << endl;
    cout << endl;


    try {

        /* INSERT TUTORIAL CODE HERE! */

    } catch (sql::SQLException &e) {
        /*
          The MySQL Connector/C++ throws three different exceptions:

          - sql::MethodNotImplementedException (derived from sql::SQLException)
          - sql::InvalidArgumentException (derived from sql::SQLException)
          - sql::SQLException (derived from std::runtime_error)
        */
        cout << "# ERR: SQLException in " << __FILE__;
        cout << "(" << __FUNCTION__ << ") on line " << __LINE__ << endl;
        /* Use what() (derived from std::runtime_error) to fetch the error message */
        cout << "# ERR: " << e.what();
        cout << " (MySQL error code: " << e.getErrorCode();
        cout << ", SQLState: " << e.getSQLState() << " )" << endl;

        return EXIT_FAILURE;
    }
    cout << "Done." << endl;
    return EXIT_SUCCESS;
}
```

To compile and run the framework

First, copy and paste the framework code to a file such as `frmwk.cpp`. Edit the `#define` statements to reflect your connection details (server, user, password, database).

To compile the framework, for example on Mac OS X, type:

```
shell> g++ -o frmwk -I/usr/local/include -I/usr/local/include/cppconn -lmysqlcppconn frmwk.cpp
```

To run the framework, enter the following:

```
shell> ./frmwk
```

You will see a simple message. You are now ready to continue to the tutorials.

20.5.6.1. Tutorial: Calling Stored Procedures with Statements in MySQL Connector/C++

Stored Procedures can be called using both Statements and Prepared Statements. This tutorial looks at calling Stored Procedures using Statements. The following tutorial Section 20.5.6.2, “Tutorial: Calling Stored Procedures with Prepared Statements in MySQL Connector/C++” will cover the use of Prepared Statements.

When considering calling Stored Procedures there are several scenarios that can occur:

1. A Stored Procedure that does not return a result set.
2. A Stored Procedure that returns an output parameter.
3. A Stored Procedure that returns a result set.

Stored Procedures are given below that illustrate each of the above scenarios.

The following routine enables you to add a country into the World database, but does not return a result. This corresponds to Scenario 1 above.

```
CREATE PROCEDURE add_country (IN country_code CHAR(3), IN country_name CHAR(52), IN continent_name CHAR(30))
BEGIN
   INSERT INTO Country(Code, Name, Continent) VALUES (country_code, country_name, continent_name);
END
```

The next routine returns the population of a specified country, and corresponds to Scenario 2 above:

```
CREATE PROCEDURE get_pop (IN country_name CHAR(52), OUT country_pop INT(11))
BEGIN
   SELECT Population INTO country_pop FROM Country WHERE Name = country_name;
END
```

The next routine is an example of a procedure returning a result set containing multiple records. This routine corresponds to Scenario 3 above.

```
CREATE PROCEDURE get_data ()
BEGIN
        SELECT Code, Name, Population, Continent FROM Country WHERE Continent = "Oceania" AND Population < 10000;
        SELECT Code, Name, Population, Continent FROM Country WHERE Continent = "Europe" AND Population < 10000;
        SELECT Code, Name, Population, Continent FROM Country WHERE Continent = "North America" AND Population < 10000
END
```

Enter and test the Stored Procedures to ensure no errors have been introduced. You are now ready to start writing routines to test out the use of Stored Procedures using Connector/C++.

Scenario 1 - Stored Procedure does not return a result set

In the first case you will examine Scenario 1, you call a Stored procedure that does not return a result set.

1. Make a copy of the tutorial framework code.
2. Insert the following code into the framework at the correct location (denoted by an INSERT HERE comment in the framework).

```
sql::Driver* driver = get_driver_instance();
std::auto_ptr<sql::Connection> con(driver->connect(url, user, pass));
con->setSchema(database);
std::auto_ptr<sql::Statement> stmt(con->createStatement());

// We don't need to check the return value explicitly, if it indicates
// an error Connector/C++ will generate an exception.
stmt->execute("CALL add_country(\"ATL\", \"Atlantis\", \"North America\")");
```

3. Compile the program using the following command:

```
shell> g++ -o sp_scenario1 -I/usr/local/include/cppconn/ -lmysqlcppconn sp_scenario1.cpp
```

4. Run the program by typing:

```
shell> ./sp_scenario1
```

5. Using the MySQL Command Line Client, or other suitable tool, check the World database to determine that it has been updated correctly. You can use a query such as:

```
SELECT Code, Name, Continent FROM Country WHERE Code="ATL";
```

The code in this case simply creates a statement and then invokes the execute method on it, passing the call to the Stored Procedure as a parameter. The Stored Procedure itself does not return a value, although it is important to note there will always be a return value from the call - this is simply the call status. MySQL Connector/C++ handles this status for you, so you do not need code to handle it explicitly. If the call should fail for some reason an exception will be raised, and this will be handled by the `catch` statement in the code.

Scenario 2 - Stored Procedure returns an output parameter

You will now see how to handle a Stored Procedure that returns an output parameter.

1. Enter the following code into the tutorial framework code:

```
sql::Driver* driver = get_driver_instance();
std::auto_ptr<sql::Connection> con(driver->connect(url, user, pass));
con->setSchema(database);
std::auto_ptr<sql::Statement> stmt(con->createStatement());

stmt->execute("CALL get_pop(\"Uganda\", @pop)");

std::auto_ptr<sql::ResultSet> res(stmt->executeQuery("SELECT @pop AS _reply"));
while (res->next())
   cout << "Population of Uganda: " << res->getString("_reply") << endl;

stmt->execute("CALL get_pop_continent(\"Asia\", @pop)");

res.reset(stmt->executeQuery("SELECT @pop AS _reply"));
while (res->next())
    cout << "Population of Asia: " << res->getString("_reply") << endl;

stmt->execute("CALL get_world_pop(@pop)");

res.reset(stmt->executeQuery("SELECT @pop AS _reply"));
while (res->next())
    cout << "Population of World: " << res->getString("_reply") << endl;
```

2. Compile the program using the following command:

```
shell> g++ -o sp_scenario2 -I/usr/local/include/cppconn/ -lmysqlcppconn sp_scenario2.cpp
```

3. Run the program by typing:

```
shell> ./sp_scenario2
```

   Note the output generated by the program.

In this scenario the Stored Procedure sets an output parameter. This is not returned as such, but needs to be obtained using a query. If running the SQL statements directly this might be similar to the following:

```
CALL get_world_pop(@pop);
SELECT @pop;
```

In the C++ code a similar sequence is carried out. First, the `CALL` is executed as seen earlier. To obtain the output parameter an additional query must be executed. This query results in a `ResultSet` that can then be processed in a `while` loop. The simplest way to retrieve the data in this case is to use a getString method on the ResultSet, passing the name of the variable to access. In this example `_reply` is used as a placeholder for the variable and therefore is used as the key to access the correct element of the result dictionary.

Scenario 3 - Stored Procedure returns a Result Set

You will now see how to handle a Stored Procedure that returns a result set.

1. Enter the following code into the tutorial framework code:

   ```
   sql::Driver* driver = get_driver_instance();
   std::auto_ptr<sql::Connection> con(driver->connect(url, user, pass));
   con->setSchema(database);
   std::auto_ptr<sql::Statement> stmt(con->createStatement());

   stmt->execute("CALL get_stats()");
   std::auto_ptr< sql::ResultSet > res;
   do {
      res.reset(stmt->getResultSet());
      while (res->next()) {
         cout << "Result: " << res->getString(1) << endl;
      }
   } while (stmt->getMoreResults());
   ```

2. Compile the program using the following command:

   ```
   shell> g++ -o sp_scenario3 -I/usr/local/include/cppconn/ -lmysqlcppconn sp_scenario3.cpp
   ```

3. Run the program by typing:

   ```
   shell> ./sp_scenario3
   ```

   Note the output generated by the program.

The code is similar to the examples you have previously seen. The code of particular interest in this case is:

```
do {
   res.reset(stmt->getResultSet());
   while (res->next()) {
      cout << "Name: " << res->getString("Name")
           << " Population: " << res->getInt("Population")
           << endl;
   }
} while (stmt->getMoreResults());
```

The `CALL` is executed as before, with the results being returned into multiple `ResultSet`s. This is because the Stored Procedure in this case uses multiple `SELECT` statements. In this example the output shows that three Result Sets are processed, because there are three `SELECT` statements in the Stored Procedure. All of the Result Sets have more than one row.

Studying the code it should be noted that the results are processed using the pattern:

```
do {
   Get Result Set
   while (Get Result) {
      Process Result
   }
} while (Get More Result Sets);
```

> **Note**
>
> Note this pattern would be used even if the Stored Procedure carried out a single `SELECT` and you knew there was

only one result set. This is a requirement of the underlying protocol.

20.5.6.2. Tutorial: Calling Stored Procedures with Prepared Statements in MySQL Connector/C++

Before working through this tutorial it is recommended you first work through the previous tutorial Section 20.5.6.1, “Tutorial: Calling Stored Procedures with Statements in MySQL Connector/C++”.

Scenario 1 - Using a Prepared Statement to prepare a Stored Procedure that does not return a result set

1. Add the following code to the `try` block of the tutorial framework:

   ```
   vector<string> code_vector;
   code_vector.push_back("SLD");
   code_vector.push_back("DSN");
   code_vector.push_back("ATL");

   vector<string> name_vector;
   name_vector.push_back("Sealand");
   name_vector.push_back("Disneyland");
   name_vector.push_back("Atlantis");

   vector<string> cont_vector;
   cont_vector.push_back("Europe");
   cont_vector.push_back("North America");
   cont_vector.push_back("Oceania");

   sql::Driver * driver = get_driver_instance();

   std::auto_ptr< sql::Connection > con(driver->connect(url, user, pass));
   con->setSchema(database);

   std::auto_ptr< sql::PreparedStatement >  pstmt;

   pstmt.reset(con->prepareStatement("CALL add_country(?,?,?)"));
   for (int i=0; i<3; i++)
   {
      pstmt->setString(1,code_vector[i]);
      pstmt->setString(2,name_vector[i]);
      pstmt->setString(3,cont_vector[i]);

      pstmt->execute();
   }
   ```

   You will also need to add `#include <vector>` to the top of your code as vectors are used to store sample data.

2. Compile the code using the following command:

   ```
   g++ -o ps_scenario1 -I/usr/local/include/cppconn/ -lmysqlcppconn ps_scenario1.cpp
   ```

3. Run the code using the command:

   ```
   ./ps_scenario1
   ```

4. You can test the database has been updated correctly by using a query such as:

   ```
   SELECT Code, Name, Continent FROM Country WHERE Code = "DSN" OR Code="ATL" OR Code="SLD";
   ```

The code is relatively simple, as no processing is required to handle Result Sets. The procedure call, `CALL add_country(?,?,?)`, is made using placeholders for input parameters denoted by '?'. These placeholders are replaced by values using the Prepared Statement's `setString` method in this case. The `for` loop is set up to iterate 3 times, as there are three data sets in this example. The same Prepared Statement is executed three times, each time with different input parameters.

Scenario 2 - Using a Prepared Statement to prepare a Stored Procedure that uses an output parameter

In this scenario a different Stored Procedure is going to be used compared to the one used in the tutorial Section 20.5.6.1, “Tutorial: Calling Stored Procedures with Statements in MySQL Connector/C++”. This is to illustrate passing an input parameter as well as fetching an output parameter. The stored routine is as follows:

```
CREATE PROCEDURE get_pop_continent (IN continent_name CHAR(30), OUT continent_pop INT(11))
BEGIN
        SELECT SUM(Population) INTO continent_pop FROM Country WHERE Continent = continent_name;
END
```

1. Copy the following code into the try block of the tutorial framework code:

   ```
   vector<string> cont_vector;
   cont_vector.push_back("Europe");
   cont_vector.push_back("North America");
   cont_vector.push_back("Oceania");

   sql::Driver * driver = get_driver_instance();

   std::auto_ptr< sql::Connection > con(driver->connect(url, user, pass));
   con->setSchema(database);

   std::auto_ptr< sql::Statement > stmt(con->createStatement());
   std::auto_ptr< sql::PreparedStatement >  pstmt;
   std::auto_ptr< sql::ResultSet > res;

   pstmt.reset(con->prepareStatement("CALL get_pop_continent(?,@pop)"));

   for (int i=0; i<3; i++)
   {
      pstmt->setString(1,cont_vector[i]);
      pstmt->execute();
      res.reset(stmt->executeQuery("SELECT @pop AS _population"));
      while (res->next())
         cout << "Population of " << cont_vector[i] << " is " << res->getString("_population") << endl;
   }
   ```

   You will also need to add the line `#include <vector>` to the top of the code, as vectors are used in this example.

2. Compile the code using:

   ```
   shell> g++ -o ps_scenario2 -I/usr/local/include/cppconn/ -lmysqlcppconn ps_scenario2.cpp
   ```

3. Run the code using:

   ```
   shell> ./ps_scenario2
   ```

4. Make a note of the output.

In this scenario a Prepared Statement is created that calls the Stored Procedure `get_pop_continent`. This procedure takes an input parameter, and also returns an output parameter. The approach used is to create another statement that can be used to fetch the output parameter using a `SELECT` query. Note that when the Prepared Statement is created, the input parameter to the Stored Procedure is denoted by '?'. Prior to execution of Prepared Statement it is necessary to replace this placeholder by an actual value. This is done using methods such as `setString` and `setInt`, for example:

```
pstmt->setString(1,cont_vector[i]);
```

Although for the query used to obtain the output parameter a single result set is expected, it is important to use the `while` loop to catch more than one result, to avoid the possibility of the connection becoming unstable.

Scenario 3 - Using a Prepared Statement to prepare a Stored Procedure that returns multiple Result Sets

> **Note**
>
> Note this scenario is not supported on versions of MySQL prior to 5.5.3. This is due to a limitation in the client/server protocol.

1. Enter the following code into the `try` block of the tutorial framework:

   ```
   sql::Driver * driver = get_driver_instance();

   std::auto_ptr< sql::Connection > con(driver->connect(url, user, pass));
   con->setSchema(database);

   std::auto_ptr< sql::PreparedStatement >  pstmt;
   std::auto_ptr< sql::ResultSet > res;

   pstmt.reset(con->prepareStatement("CALL get_data()"));
   res.reset(pstmt->executeQuery());

   do {
      res.reset(pstmt->getResultSet());
      while (res->next()) {
         cout << "Name: " << res->getString("Name")
              << " Population: " << res->getInt("Population")
              << endl;
   ```

```
   }
} while (pstmt->getMoreResults());
```

2. Compile the code using the following command:

   ```
   shell> g++ -o ps_scenario3 -I/usr/local/include/cppconn/ -lmysqlcppconn ps_scenario3.cpp
   ```

3. Run the program using the command:

   ```
   shell> ./ps_scenario3
   ```

4. Make a note of the output generated.

The code executes the Stored Procedure using a Prepared Statement. The standard do-while construct is used to ensure that all Result Sets are fetched. In this case the returned values are fetched from the Result Sets using the `getInt` and `getString` methods.

20.5.7. MySQL Connector/C++ Debug Tracing

Although a debugger can be used to debug your application, you may find it beneficial to turn on the debug traces of the connector. Some problems happen randomly which makes them difficult to debug using a debugger. In such cases debug traces and protocol files are more useful because they allow you to trace the activities of all instances of your program.

DTrace is a very powerful technology to trace any application without having to develop an extra trace module for your application. Unfortunately, DTrace is currently only available on Solaris, MacOS 10.5, and FreeBSD.

The MySQL Connector/C++ can write two trace files:

1. Trace file generated by the MySQL Client Library
2. Trace file generated internally by MySQL Connector/C++

The first trace file can be generated by the underlying MySQL Client Library (libmysql). To enable this trace the connector will call the C-API function `mysql_debug()` internally. Only debug versions of the MySQL Client Library are capable of writing a trace file. Therefore you need to compile MySQL Connector/C++ against a debug version of the library, if you want utilize this trace. The trace shows the internal function calls and the addresses of internal objects as you can see below:

```
>mysql_stmt_init
| >_mymalloc
| | enter: Size: 816
| | exit: ptr: 0x68e7b8
| <_mymalloc | >init_alloc_root
| | enter: root: 0x68e7b8
| | >_mymalloc
| | | enter: Size: 2064
| | | exit: ptr: 0x68eb28
[...]
```

The second trace is the MySQL Connector/C++ internal trace. It is available with debug and nondebug builds of the connector as long as you have enabled the tracing module at compile time using `cmake -DMYSQLCPPCONN_TRACE_ENABLE:BOOL=1`. By default, the tracing functionality is not available and calls to trace functions are removed by the preprocessor.

Compiling the connector with tracing functionality enabled will cause two additional tracing function calls per each connector function call. You will need to run your own benchmark to find out how much this will impact the performance of your application.

A simple test using a loop running 30,000 INSERT SQL statements showed no significant real-time impact. The two variants of this application using a trace enabled and trace disabled version of the connector performed equally well. The run time measured in real-time was not significantly impacted as long as writing a debug trace was not enabled. However, there will be a difference in the time spent in the application. When writing a debug trace the IO subsystem may become a bottleneck.

In summary, use connector builds with tracing enabled carefully. Trace enabled versions may cause higher CPU usage even if the overall run time of your application is not impacted significantly.

```
|  INF: Tracing enabled
<MySQL_Connection::setClientOption
>MySQL_Prepared_Statement::setInt
|  INF: this=0x69a2e0
|  >MySQL_Prepared_Statement::checkClosed
|  <MySQL_Prepared_Statement::checkClosed
| <MySQL_Prepared_Statement::setInt
```

```
[...]
```

The example from `examples/debug_output.cpp` demonstrates how to activate the debug traces in your program. Currently they can only be activated through API calls. The traces are controlled on a per-connection basis. You can use the `setClientOptions()` method of a connection object to activate and deactivate the generation of a trace. The MySQL Client Library trace is always written into a file, whereas the connector's protocol messages are printed to standard out.

```
sql::Driver *driver;
int on_off = 1;

/* Using the Driver to create a connection */
driver = get_driver_instance();
std::auto_ptr< sql::Connection > con(driver->connect(host, user, pass));

/*
Activate debug trace of the MySQL Client Library (C-API)
Only available with a debug build of the MySQL Client Library!
*/
con->setClientOption("libmysql_debug", "d:t:O,client.trace");

/*
Tracing is available if you have compiled the driver using
cmake -DMYSQLCPPCONN_TRACE_ENABLE:BOOL=1
*/
con->setClientOption("client_trace", &on_off);
```

20.5.8. MySQL Connector/C++ Usage Notes

See the JDBC overview for information on JDBC 4.0. Please also check the `examples/` directory of the download package.

Notes on using the MySQL Connector/C++ API

- `DatabaseMetaData::supportsBatchUpdates()` returns `true` because MySQL supports batch updates in general. However, no API calls for batch updates are provided by the MySQL Connector/C++ API.
- Two non-JDBC methods have been introduced for fetching and setting unsigned integers: `getUInt64()` and `getUInt()`. These are available for `ResultSet` and `Prepared_Statement`:
  - `ResultSet::getUInt64()`
  - `ResultSet::getUInt()`
  - `Prepared_Statement::setUInt64()`
  - `Prepared_Statement::setUInt()`

  The corresponding `getLong()` and `setLong()` methods have been removed.
- The method `DatabaseMetaData::getColumns()` has 23 columns in its result set, rather than the 22 columns defined by JDBC. The first 22 columns are as described in the JDBC documentation, but column 23 is new:

  23. `IS_AUTOINCREMENT`: String which is “YES” if the column is an auto-increment column. Otherwise the string contains “NO”.
- MySQL Connector/C++ may return different metadata for the same column.

  When you have any column that accepts a charset and a collation in its specification and you specify a binary collation, such as:

  ```
  CHAR(250) CHARACTER SET 'latin1' COLLATE 'latin1_bin'
  ```

  The server sets the `BINARY` flag in the result set metadata of this column. The method `ResultSetMetadata::getColumnTypeName()` uses the metadata and will report, due to the `BINARY` flag, that the column type name is `BINARY`. This is illustrated below:

  ```
  mysql> create table varbin(a varchar(20) character set utf8 collate utf8_bin);
  Query OK, 0 rows affected (0.00 sec)

  mysql> select * from varbin;
  Field   1:  `a`
  Catalog:    `def`
  Database:   `test`
  Table:      `varbin`
  Org_table:  `varbin`
  Type:       VAR_STRING
  Collation:  latin1_swedish_ci (8)
  Length:     20
  ```

```
Max_length: 0
Decimals:   0
Flags:      BINARY


0 rows in set (0.00 sec)

mysql> select * from information_schema.columns where table_name='varbin'\G
*************************** 1. row ***************************
           TABLE_CATALOG: NULL
            TABLE_SCHEMA: test
              TABLE_NAME: varbin
             COLUMN_NAME: a
        ORDINAL_POSITION: 1
          COLUMN_DEFAULT: NULL
             IS_NULLABLE: YES
               DATA_TYPE: varchar
CHARACTER_MAXIMUM_LENGTH: 20
  CHARACTER_OCTET_LENGTH: 60
       NUMERIC_PRECISION: NULL
           NUMERIC_SCALE: NULL
      CHARACTER_SET_NAME: utf8
          COLLATION_NAME: utf8_bin
             COLUMN_TYPE: varchar(20)
              COLUMN_KEY:
                   EXTRA:
              PRIVILEGES: select,insert,update,references
          COLUMN_COMMENT:
1 row in set (0.01 sec)
```

However, `INFORMATION_SCHEMA` gives no hint in its `COLUMNS` table that metadata will contain the `BINARY` flag. `DatabaseMetaData::getColumns()` uses `INFORMATION_SCHEMA`. It will report the type name `CHAR` for the same column. Note, a different type code is also returned.

- The MySQL Connector/C++ class `sql::DataType` defines the following JDBC standard data types: `UNKNOWN`, `BIT`, `TINYINT`, `SMALLINT`, `MEDIUMINT`, `INTEGER`, `BIGINT`, `REAL`, `DOUBLE`, `DECIMAL`, `NUMERIC`, `CHAR`, `BINARY`, `VARCHAR`, `VARBINARY`, `LONGVARCHAR`, `LONGVARBINARY`, `TIMESTAMP`, `DATE`, `TIME`, `GEOMETRY`, `ENUM`, `SET`, `SQLNULL`.

  However, the following JDBC standard data types are *not* supported by MySQL Connector/C++: `ARRAY`, `BLOB`, `CLOB`, `DISTINCT`, `FLOAT`, `OTHER`, `REF`, `STRUCT`.

- When inserting or updating `BLOB` or `TEXT` columns, MySQL Connector/C++ developers are advised not to use `setString()`. Instead it is recommended that the dedicated API function `setBlob()` be used instead.

  The use of `setString()` can cause a Packet too large error message. The error will occur if the length of the string passed to the connector using `setString()` exceeds `max_allowed_packet` (minus a few bytes reserved in the protocol for control purposes). This situation is not handled in MySQL Connector/C++, as this could lead to security issues, such as extremely large memory allocation requests due to malevolently long strings.

  However, if `setBlob()` is used, this problem does not arise. This is because `setBlob()` takes a streaming approach based on `std::istream`. When sending the data from the stream to MySQL Server, MySQL Connector/C++ will split the stream into chunks appropriate for MySQL Server and observe the `max_allowed_packet` setting currently being used.

  > **Caution**
  >
  > When using `setString()` it is not possible to set `max_allowed_packet` to a value large enough for the string, prior to passing it to MySQL Connector/C++. The MySQL 5.1 documentation for `max_allowed_packet` states: “As of MySQL 5.1.31, the session value of this variable is read only. Before 5.1.31, setting the session value is permitted but has no effect.”

  This difference with the JDBC specification ensures that MySQL Connector/C++ is not vulnerable to memory flooding attacks.

- In general MySQL Connector/C++ works with MySQL 5.0, but it is not completely supported. Some methods may not be available when connecting to MySQL 5.0. This is because the Information Schema is used to obtain the requested information. There are no plans to improve the support for 5.0 because the current GA version of MySQL Server is 5.1. As a new product, MySQL Connector/C++ is primarily targeted at the MySQL Server GA version that was available on its release.

  The following methods will throw a `sql::MethodNotImplemented` exception when you connect to MySQL earlier than 5.1.0:

  - `DatabaseMetadata::getCrossReference()`
  - `DatabaseMetadata::getExportedKeys()`

- MySQL Connector/C++ includes a method `Connection::getClientOption()` which is not included in the JDBC API specification. The prototype is:

```
void getClientOption(const std::string & optionName, void * optionValue)
```

The method can be used to check the value of connection properties set when establishing a database connection. The values are returned through the `optionValue` argument passed to the method with the type `void *`.

Currently, `getClientOption()` supports fetching the `optionValue` of the following options:

- `metadataUseInfoSchema`
- `defaultStatementResultType`
- `defaultPreparedStatementResultType`

The connection option `metadataUseInfoSchema` controls whether to use the `Information_Schemata` for returning the meta data of `SHOW` commands. In the case of `metadataUseInfoSchema` the `optionValue` argument should be interpreted as a boolean upon return.

In the case of both `defaultStatementResultType` and `defaultPreparedStatementResultType`, the `optionValue` argument should be interpreted as an integer upon return.

The connection property can be either set when establishing the connection through the connection property map or using `void Connection::setClientOption(const std::string & optionName, const void * optionValue)` where `optionName` is assigned the value `metadataUseInfoSchema`.

Some examples are given below:

```
int defaultStmtResType;
int defaultPStmtResType;
conn->getClientOption("defaultStatementResultType", (void *) &defaultStmtResType);
conn->getClientOption("defaultPreparedStatementResultType", (void *) &defaultPStmtResType);

bool isInfoSchemaUsed;
conn->getClientOption("metadataUseInfoSchema", (void *) &isInfoSchemaUsed);
```

- MySQL Connector/C++ also supports the following methods not found in the JDBC API standard:

  ```
  std::string MySQL_Connection::getSessionVariable(const std::string & varname)
  ```

  ```
  void MySQL_Connection::setSessionVariable(const std::string & varname, const std::string & value)
  ```

  Note that both methods are members of the `MySQL_Connection` class. The methods get and set MySQL session variables.

  `setSessionVariable()` is equivalent to executing:

  ```
  SET SESSION <varname> = <value>
  ```

  `getSessionVariable()` is equivalent to executing the following and fetching the first return value:

  ```
  SHOW SESSION VARIABLES LIKE "<varname>"
  ```

  You can use “%” and other placeholders in <varname>, if the underlying MySQL server supports this.

- Fetching the value of a column can sometimes return different values depending on whether the call is made from a Statement or Prepared Statement. This is because the protocol used to communicate with the server differs depending on whether a Statement or Prepared Statement is used.

  To illustrate this, consider the case where a column has been defined as of type `BIGINT`. The most negative `BIGINT` value is then inserted into the column. If a Statement and Prepared Statement are created that perform a `GetUInt64()` call, then the results will be found to be different in each case. The Statement returns the maximum positive value for `BIGINT`. The Prepared Statement returns 0.

  The reason for the different results is due to the fact that Statements use a text protocol, and Prepared Statements use a binary protocol. With the binary protocol in this case, a binary value is returned from the server that can be interpreted as an `int64`. In the above scenario a very large negative value was fetched with `GetUInt64()`, which fetches unsigned integers. As the large negative value cannot be sensibly converted to an unsigned value 0 is returned.

  In the case of the Statement, which uses the text protocol, values are returned from the server as strings, and then converted as required. When a string value is returned from the server in the above scenario the large negative value will need to be converted by the runtime library function `strtoul()`, which `GetUInt64()` calls. The behavior of `strtoul()` is dependent upon the specific runtime and host operating system, so the results can be variable. In the case given a large positive value was actually returned.

Although it is very rare, there are some cases where Statements and Prepared Statements can return different values unexpectedly, but this usually only happens in extreme cases such as the one mentioned.

- The JDBC documentation lists many fields for the `DatabaseMetaData` class. JDBC also appears to define certain values for those fields. However, MySQL Connector/C++ does not define certain values for those fields. Internally enumerations are used and the compiler determines the values to assign to a field.

  To compare a value with the field, code such as the following should be used, rather than making assumptions about specific values for the attribute:

  ```
  // dbmeta is an instance of DatabaseMetaData
  if (myvalue == dbmeta->attributeNoNulls) {
      ...
  }
  ```

  Usually *`myvalue`* will be a column from a result set holding metadata information. MySQL Connector/C++ does not guarantee that `attributeNoNulls` is 0. It can be any value.

- When programming Stored Procedures JDBC has available an extra class, an extra abstraction layer for callable statements, the `CallableStatement` class. This is not present in MySQL Connector/C++. You therefore need to use the methods from the `Statement` and `Prepared Statement` classes to run a Stored Procedure using `CALL`.

20.5.9. MySQL Connector/C++ Known Bugs and Issues

> **Note**
>
> Please report bugs through MySQL Bug System .

Known bugs:

None.

Known issues:

- When linking against a static library for 1.0.3 on Windows you need to define `CPPDBC_PUBLIC_FUNC` either in the compiler options (preferable) or with `/D "CPPCONN_PUBLIC_FUNC="`. You can also explicitly define it in your code by placing `#define CPPCONN_PUBLIC_FUNC` before the header inclusions.

- Generally speaking C++ library binaries are less portable than C library binaries. Issues can be caused by name mangling, different Standard Template Library (STL) versions and using different compilers and linkers for linking against the libraries than were used for building the library itself.

  Even a small change in the compiler version can, but does not have to, cause problems. If you obtain error messages, that you suspect are related to binary incompatibilities, build MySQL Connector/C++ from source, using the same compiler and linker that you will use to build and link your application.

  Due to the variations between Linux distributions, compiler and linker versions and STL versions, it is not possible to provide binaries for each and every possible configuration. However, the MySQL Connector/C++ binary distributions contain a `README` file that describes the environment and settings used to build the binary versions of the libraries.

- To avoid potential crashes the build configuration of MySQL Connector/C++ should match the build configuration of the application using it. For example, do not use the release build of MySQL Connector/C++ with a debug build of the client application.

See also the MySQL Connector/C++ Changelogs which can be found here Section D.7, “MySQL Connector/C++ Change History”.

20.5.10. MySQL Connector/C++ Feature requests

You can suggest new features in the first instance by joining the mailing list or forum and talking with the developers directly. See Section 20.5.11, “MySQL Connector/C++ Support”

The following feature requests are currently being worked on:

- C++ references for `Statements`, `ResultSets`, and exceptions, are being considered, instead of pointers to heap memory.

This reduces the exception handling burden for the programmer.

- Adopt STL (suggestions are welcome).
- JDBC compliance: data type interfaces and support through `ResultSet:getType()` and `PreparedStatement:bind()`. Introduce `sql::Blob`, `sql::Clob`, `sql::Date`, `sql::Time`, `sql::Timestamp`, `sql::URL`. Support `get|setBlob()`, `get|setClob()`, `get|setDate()`, `get|setTime()`, `get|setTimestamp()`, `get|setURL()`
- Add support for all C-API connection options. Improved support for `mysql_options`.
- Add connect method which supports passing options using HashMaps.
- Create Windows installer.

20.5.11. MySQL Connector/C++ Support

For general discussion of the MySQL Connector/C++ please use the C/C++ community forum or join the MySQL Connector/C++ mailing list.

Bugs can be reported at the MySQL bug Web site.

For Licensing questions, and to purchase MySQL Products and Services, please http://www.mysql.com/buy-mysql/

The MySQL Connector/C++ Changelogs can be found here Section D.7, “MySQL Connector/C++ Change History”

20.5.12. MySQL Connector/C++ FAQ

Questions

- 21.5.12.1: What is MySQL Connector/C++?
- 21.5.12.2: Are any MySQL products using MySQL Connector/C++?
- 21.5.12.3: Does MySQL Connector/C++ implement the client/server protocol?
- 21.5.12.4: Which MySQL Server version(s) is MySQL Connector/C++ compatible with?

Questions and Answers

21.5.12.1: What is MySQL Connector/C++?

MySQL Connector/C++ is a MySQL database connector for C++. It allows you develop applications in C++ that connect to the MySQL Server. MySQL Connector/C++ is compatible with the JDBC 4.0 API.

21.5.12.2: Are any MySQL products using MySQL Connector/C++?

Yes, MySQL Workbench and MySQL Connector/OpenOffice.org.

21.5.12.3: Does MySQL Connector/C++ implement the client/server protocol?

No. MySQL Connector/C++ uses the MySQL Client Library for the client/server communication.

21.5.12.4: Which MySQL Server version(s) is MySQL Connector/C++ compatible with?

MySQL Connector/C++ fully supports MySQL Server 5.1 and later.

20.6. MySQL Connector/C

What is MySQL Connector/C?

MySQL Connector/C is a C client library for client/server communication. It is a standalone replacement for the MySQL Client Library shipped with the MySQL Server.

Why have a replacement for MySQL Client Library?

There is no need to compile or install the MySQL Server package if you only need the client library.

MySQL Connector/C does not rely on the MySQL Server release cycle, so bug fixes and new features are released more often.

MySQL Connector/C API documentation is available here Section 20.9.3, “C API Function Descriptions”.

Supported platforms include:

- Windows
- Windows x64
- Linux
- Solaris
- FreeBSD
- Mac OS X
- HP-UX
- IBM AIX
- IBM i5/OS

20.6.1. Building MySQL Connector/C from the Source Code

Obtaining the Source Code

A TAR file containing the source code can be downloaded from the MySQL Developers site. You will need to select the source code package from the drop down list.

The source code for development releases of the connector can be found at Launchpad. The project home page can be found here.

The source code for the 1.0 branch can be found here.

To obtain the code you will need to have Bazaar installed and use the command `bzr branch lp:libmysql`.

- **Building on Unix**

  Examples of supported Unix or Unix-like operating systems include:

  - Solaris
  - Linux
  - HP-UX
  - AIX
  - OS X

  Compiler Tools

  Ideally, the native compiler tool set for the target platform is used for compilation. This would be SunStudio for Solaris and aCC for HP-UX for example. However, the GNU tool-chain can be used across all platforms.

  You also need `CMake` 2.6 or newer, which is available online.

  To Build

  If using GNU AutoTools change to the MySQL Connector/C source directory and follow the procedure below.

  1. To generate the makefile enter:

     ```
     shell> cmake -G "Unix Makefiles"
     ```

     or for a Debug build enter:

     ```
     shell> cmake -G "Unix Makefiles" -DCMAKE_BUILD_TYPE=Debug
     ```

2. Then build the project using:

   ```
   shell> make
   ```

To Install

By default make install will install the MySQL Connector/C files in the `/usr/local` directory. You can change this behavior by specifying another directory when generating the `makefile`:

```
shell> cmake -G "Unix Makefiles" -DCMAKE_INSTALL_PREFIX=/mypath
```

Now, in the root shell, enter the following to install the MySQL Connector/C libraries and tools:

```
root-shell> make install
```

At this point all of the MySQL Connector/C files will be in place.

- **Building on Microsoft Windows**

  Older versions of Microsoft Windows are not supported. Supported versions are Windows 2000, Windows XP, Windows Vista, Windows Server 2003, or Windows Server 2008.

  Compiler Tools

  Microsoft Visual Studio 8 and 9 are recommended. The Express Edition of Visual Studio and other compilers may work, but are untested.

  You also need `CMake` 2.6 or newer, available at http://www.cmake.org

  To Build

  You need to have the environment variables set for the Visual Studio toolchain. Visual Studio includes a batch file to set these for you, and installs a shortcut into the **START** menu to open a command prompt with these variables set.

  Build MySQL Connector/C using the `CMake` command-line tool by entering the following from the source root directory in a command prompt window:

  ```
  shell> cmake -G "Visual Studio 9 2008"
  ```

  This produces a project file that you can open with Visual Studio or build from the command line with either of:

  ```
  shell> devenv.com libmysql.sln /build Release
  ```

  ```
  shell> devenv.com libmysql.sln /build RelWithDebInfo
  ```

  For other versions of Visual Studio or `nmake` based build, run the following command:

  ```
  shell> cmake --help
  ```

  to check the supported generators.

  To compile the Debug build, you must run set the `CMake` build type so the correct version of external libraries are used:

  ```
  shell> cmake -G "Visual Studio 8 2005" -DCMAKE_BUILD_TYPE=Debug
  ```

  Followed by:

  ```
  shell> devenv.com libmysql.sln /build Debug
  ```

  To Install

  To create a install package you can choose between two variants:

  1. Creating a Zip package
  2. Creating an MSI install package

- **Zip package**

  To create a Zip package, run the `cpack` command from the root of your MySQL Connector/C source directory.

- **MSI Install package**

  The required tools include Windows XML Installer toolset (WIX), which is available online.

  To create the MSI install package change to the subdirectory `win` and generate the `makefile`:

  ```
  shell> cmake -G "NMake Makefiles"
  ```

  Create the MSI install package by calling `nmake`:

  ```
  shell> nmake
  ```

Build Options

The following options can be used when building the MySQL Connector/C source code:

Build Option	Description
-DWITH_OPENSSL=1	Enables dynamic linking to the system OpenSSL library.
-DWITH_EXTERNAL_ZLIB=1	Enables dynamic linking to the system Zlib library.

20.6.2. Testing MySQL Connector/C

For testing MySQL Connector/C you will need a running MySQL server instance. Before you run the test suite you need to specify the following environment variables:

- `MYSQL_TEST_HOST` (default localhost)
- `MYSQL_TEST_USER`
- `MYSQL_TEST_PASSWD`
- `MYSQL_TEST_PORT`
- `MYSQL_TEST_SOCKET`
- `MYSQL_TEST_DB` (default test)

To run the test suite, execute `ctest` from the command line:

```
shell> ctest
```

20.6.3. MySQL Connector/C FAQ

Questions

- 21.6.3.1: What is the “MySQL Native C API”? What are its typical benefits and use cases?
- 21.6.3.2: What is “libmysql”?
- 21.6.3.3: What is “libmysqld”?
- 21.6.3.4: What is “MySQL Connector/C”?
- 21.6.3.5: What is the difference between “Native C API”, “libmysql”, “libmysqld” and “MySQL Connector/C”?
- 21.6.3.6: Does MySQL Connector/C replace any of “Native C API”, “libmysql” and “libmysqld”?

Questions and Answers

21.6.3.1: What is the “MySQL Native C API”? What are its typical benefits and use cases?

MySQL Connector/C, also known as `libmysql`, or MySQL Native C API, is a standalone, C-based API and library that you can use in C applications to connect with the MySQL Server. It implements the same MySQL client API that has been in use for a decade.

It is also used as the foundation for drivers for standard database APIs such as ODBC, Perl's DBI, and Python's DB API.

21.6.3.2: What is “libmysql”?

`libmysql` is the name of the library that MySQL Connector/C provides.

21.6.3.3: What is “libmysqld”?

`libmysqld` is an embedded database server with the same API as MySQL Connector/C. It is included with the MySQL Server distribution.

21.6.3.4: What is “MySQL Connector/C”?

MySQL Connector/C is a standalone distribution of the `libmysql` library, which was previously only available as part of the MySQL Server distribution. The version of `libmysql` included with MySQL Connector/C and the version bundled with the server are functionally equivalent, but the cross-platform build system for MySQL Connector/C uses `CMake`.

21.6.3.5: What is the difference between “Native C API”, “libmysql”, “libmysqld” and “MySQL Connector/C”?

MySQL Connector/C and `libmysql` are the “native C API for MySQL”, and all three terms can be used interchangeably. “libmysqld” is the embedded version of the MySQL Server, and is included in the server distribution.

21.6.3.6: Does MySQL Connector/C replace any of “Native C API”, “libmysql” and “libmysqld”?

MySQL Connector/C contains `libmysql`, and implements a native C API. It does not include `libmysqld`, which can be found with the MySQL server distribution.

20.7. MySQL Connector/OpenOffice.org

MySQL Connector/OpenOffice.org is a native MySQL database connector for OpenOffice.org. Currently, it is in preview status and supports OpenOffice.org 3.1 and above. It can be used to connect OpenOffice.org applications to a MySQL server.

Before MySQL Connector/OpenOffice.org became available you would have to use MySQL Connector/J (JDBC) or MySQL Connector/ODBC to connect to a MySQL server.

Connector/OpenOffice.org is a community project. The source code for Connector/OpenOffice.org is available under GPL with the FLOSS License Exception.

Advantages

Using MySQL Connector/OpenOffice.org has the following advantages:

- Easy installation through the OpenOffice.org Extension Manager.
- Seamless integration into OpenOffice.org.
- No need to go through an additional Connector installation routine (ODBC/JDBC)
- No need to configure or register an additional Connector (ODBC)
- No need to install or configure a driver manager (ODBC)

Status

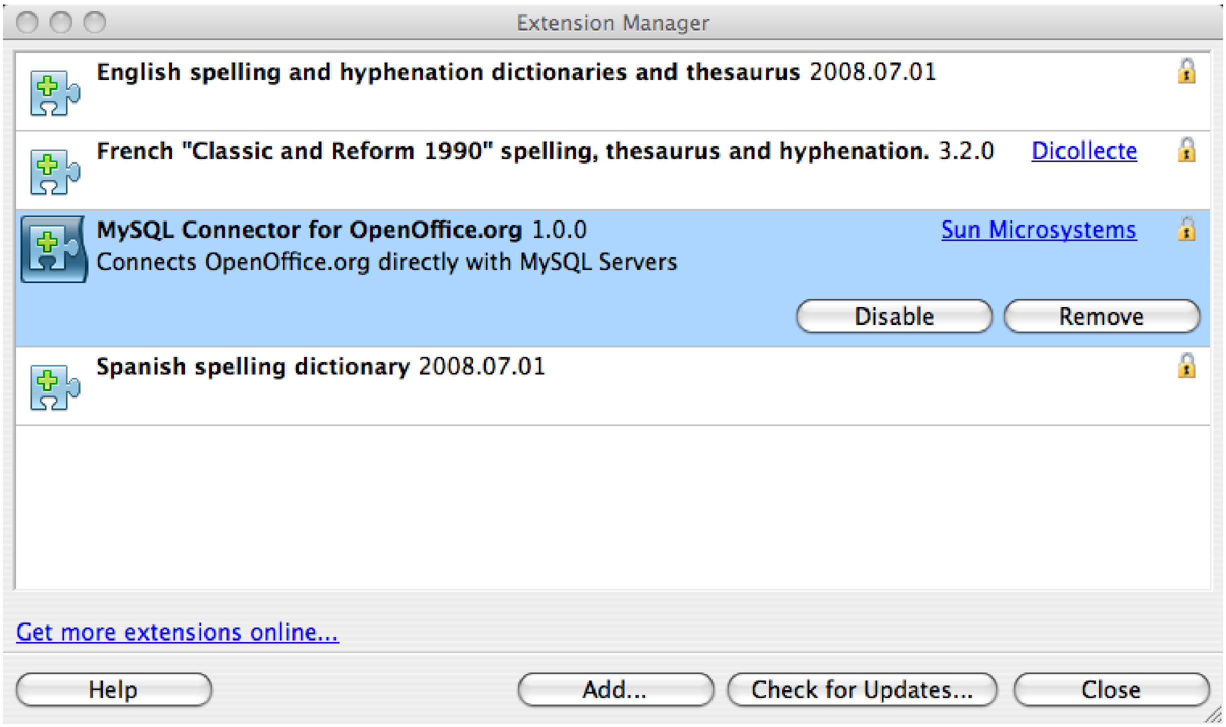
MySQL Connector/OpenOffice.org is currently at version 1.0 GA.

If you have any queries please contact us through our mailing list at `<users@dba.openoffice.org>`

20.7.1. Installation

1. Install or upgrade to OpenOffice.org 3.1.
2. Download MySQL Connector/OpenOffice.org from The OpenOffice.org extension download site. Save the file corresponding to your platform. Currently supported platforms are Windows, Linux, Linux x86-64, Mac OS X, Solaris x86 and Solaris SPARC.
3. Add the `.oxt` extension through the Extension Manager of OpenOffice.org. In OpenOffice.org, select Tools, Extension Manager... and specify the `.oxt` file as a new extension. When done, MySQL Connector/OpenOffice.org will show up as a new extension in the Extension Manager.

Figure 20.81. Adding an Extension



English spelling and hyphenation dictionaries and thesaurus 2008.07.01

French "Classic and Reform 1990" spelling, thesaurus and hyphenation. 3.2.0 Dicollecte

MySQL Connector for OpenOffice.org 1.0.0 Sun Microsystems
Connects OpenOffice.org directly with MySQL Servers

Spanish spelling dictionary 2008.07.01

4. Restart OpenOffice.org.

20.7.2. Getting Started: Connecting to MySQL

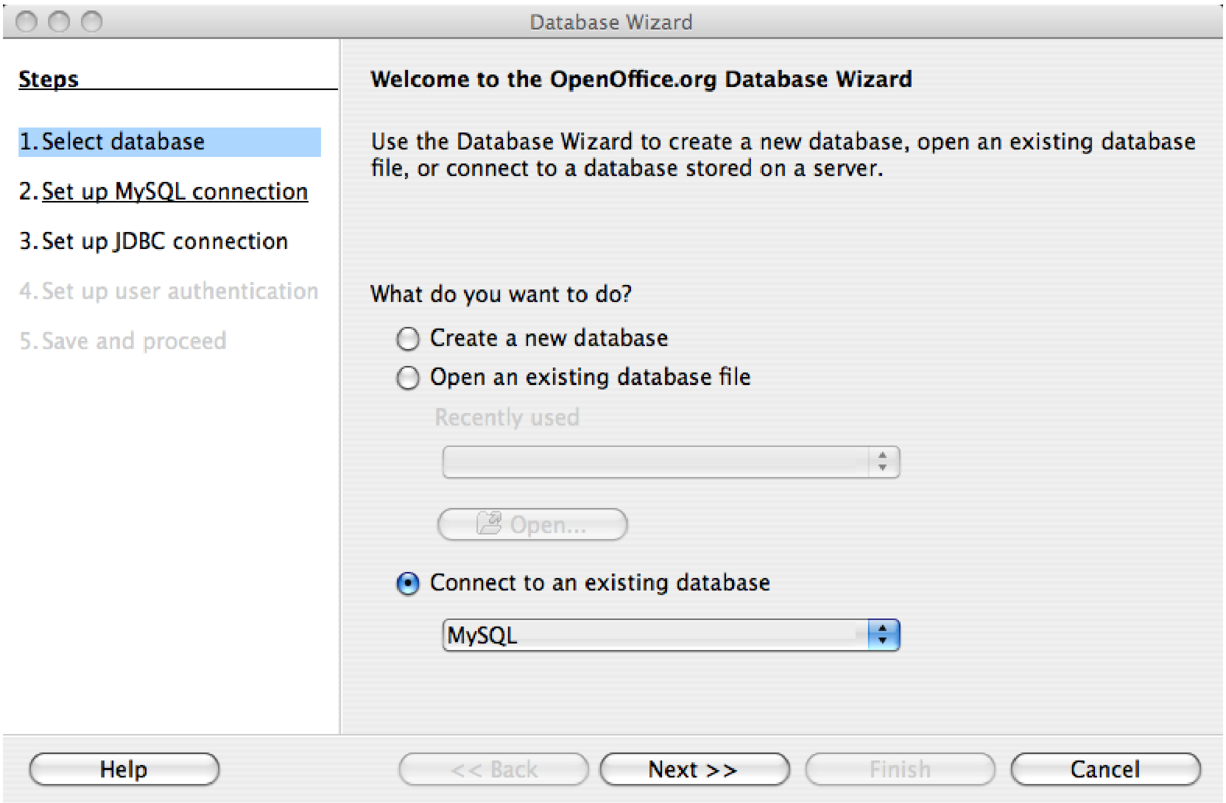
MySQL Connector/OpenOffice.org enables you to access the MySQL Server and its schemata from the OpenOffice.org suite.

The following example demonstrates the creation of a new OpenOffice.org Base database which uses a local MySQL Server for storage and the new connector for connecting.

1. **Select the database**

   Create a new database by selecting File, New, Database. This starts a wizard that enables you to create a new database, open an existing database, or connect to an existing database. Select the **Connect to existing database** radio button. From the listbox select MySQL. Click Next >>.

Figure 20.82. Selecting the Database



Welcome to the OpenOffice.org Database Wizard

Use the Database Wizard to create a new database, open an existing database file, or connect to a database stored on a server.

What do you want to do?

○ Create a new database

○ Open an existing database file

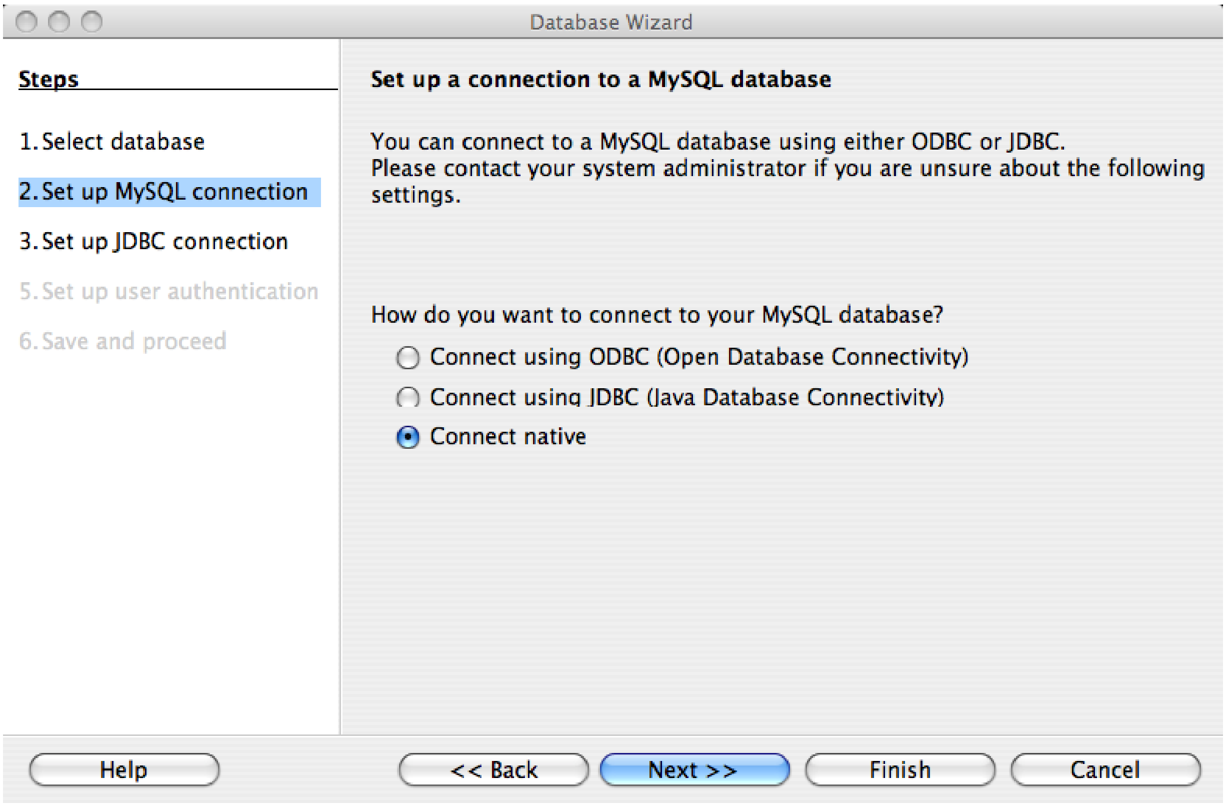
● Connect to an existing database

MySQL

Database Wizard
Steps
1. Select database
2. Set up MySQL connection
3. Set up JDBC connection
4. Set up user authentication
5. Save and proceed
Recently used
Open...
Help
<< Back
Next >>
Finish
Cancel

2. You will be asked how you would like to connect to the database. Select the **Connect native** radio button.

Figure 20.83. Selecting the connection type



Set up a connection to a MySQL database

You can connect to a MySQL database using either ODBC or JDBC.
Please contact your system administrator if you are unsure about the following settings.

How do you want to connect to your MySQL database?

○ Connect using ODBC (Open Database Connectivity)

○ Connect using JDBC (Java Database Connectivity)

● Connect native

Database Wizard
Steps
1. Select database
2. Set up MySQL connection
3. Set up JDBC connection
5. Set up user authentication
6. Save and proceed
Help
<< Back
Next >>
Finish
Cancel

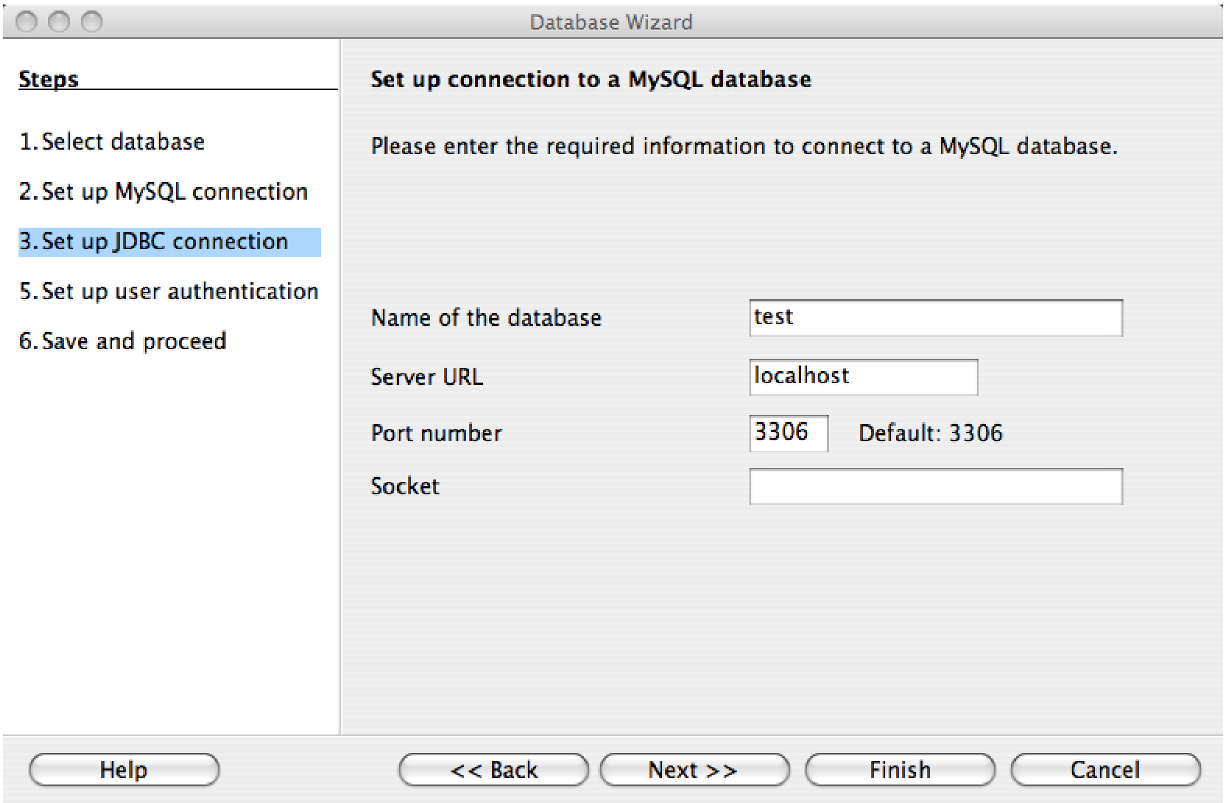
Click NEXT >>.

3. **Fill in the connection settings**

   Enter the name of the database, server URL, and optionally the socket to connect on (if not using the default).

   Note that if you do not specify a database all databases will be available for selection.

Figure 20.84. Entering Connection Settings


Database Wizard
Steps
1. Select database
2. Set up MySQL connection
3. Set up JDBC connection
5. Set up user authentication
6. Save and proceed
Help
<< Back
Next >>
Finish
Cancel

Set up connection to a MySQL database

Please enter the required information to connect to a MySQL database.

Name of the database: test

Server URL: localhost

Port number: 3306 Default: 3306

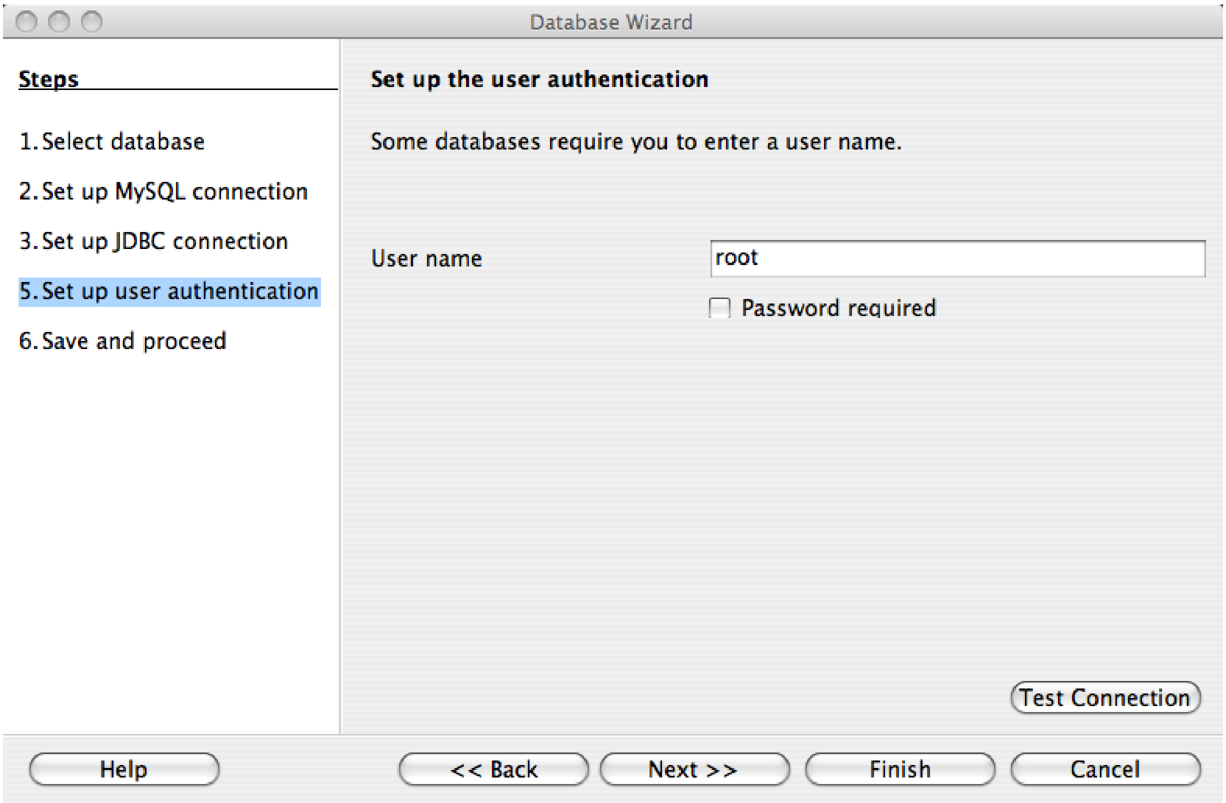
Socket:

Click NEXT >>.

4. **Set up user authentication**

   If you are using MySQL server's anonymous account without a password, you do not have to fill in anything in this step. Otherwise, fill in your MySQL user name and check the password check box. Note, for security reasons, you should not normally use the anonymous account without a password.

Figure 20.85. Setting Up User Authentication


Database Wizard
Steps
1. Select database
2. Set up MySQL connection
3. Set up JDBC connection
5. Set up user authentication
6. Save and proceed
Set up the user authentication
Some databases require you to enter a user name.
Test Connection
Help
<< Back
Next >>
Finish
Cancel

User name: root

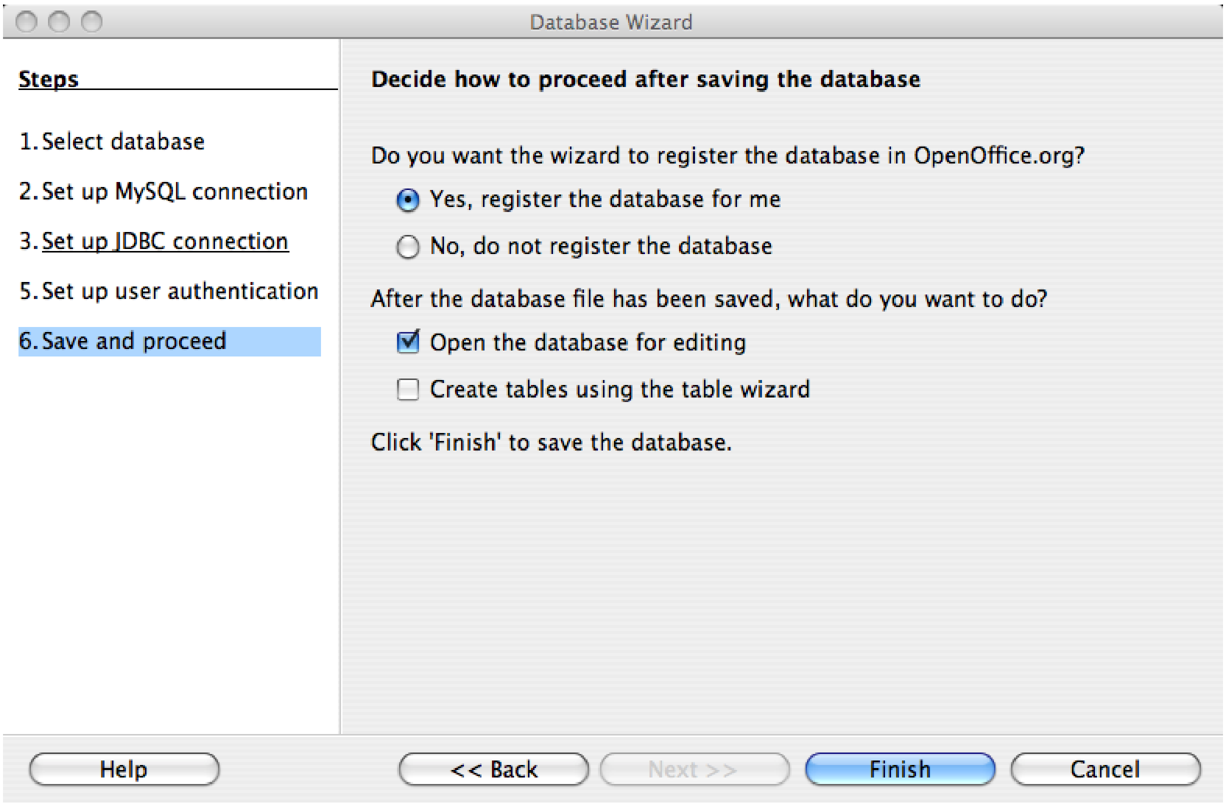
☐ Password required

You can now test your connection to the MySQL database server by clicking the TEST CONNECTION button. Check the check box if you do not want OpenOffice.org to ask you for your password again in the current session. Testing the connection is optional, although recommended.

Click NEXT >>.

5. **Decide how to proceed after connecting to the database**

Figure 20.86. After Connecting to the Database



Database Wizard

Steps

1. Select database
2. Set up MySQL connection
3. Set up JDBC connection
5. Set up user authentication
6. Save and proceed

Decide how to proceed after saving the database

Do you want the wizard to register the database in OpenOffice.org?

● Yes, register the database for me

○ No, do not register the database

After the database file has been saved, what do you want to do?

☑ Open the database for editing

☐ Create tables using the table wizard

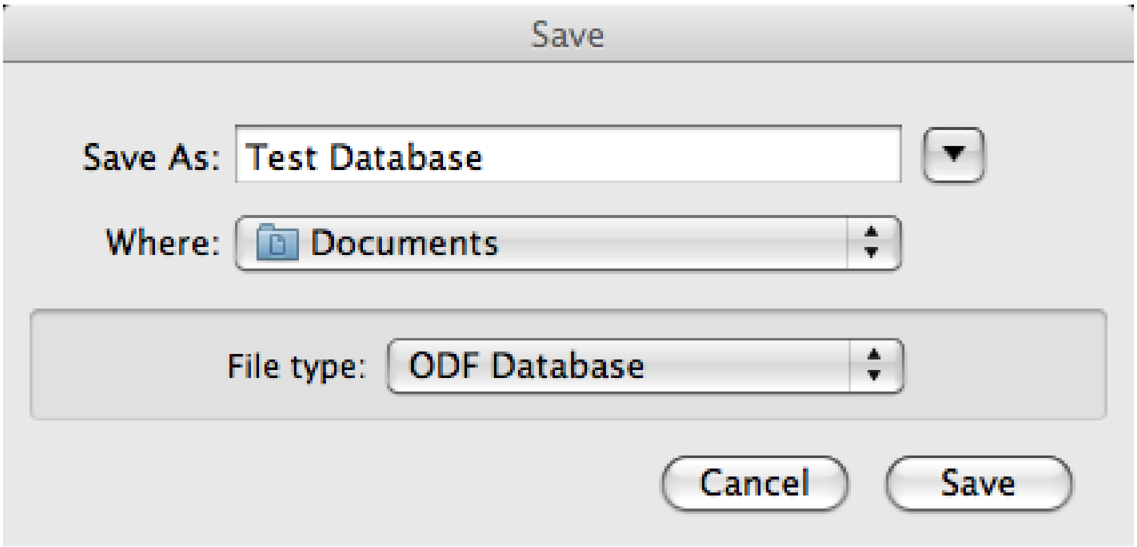
Click 'Finish' to save the database.

Keep the default settings.

Click FINISH.

6. You will then be prompted to save you database as a database file. Enter the name of the database and the location in which to save the file.

Figure 20.87. Entering the Database File Name



Save

Save As: Test Database

Where: Documents

File type: ODF Database

Click SAVE.

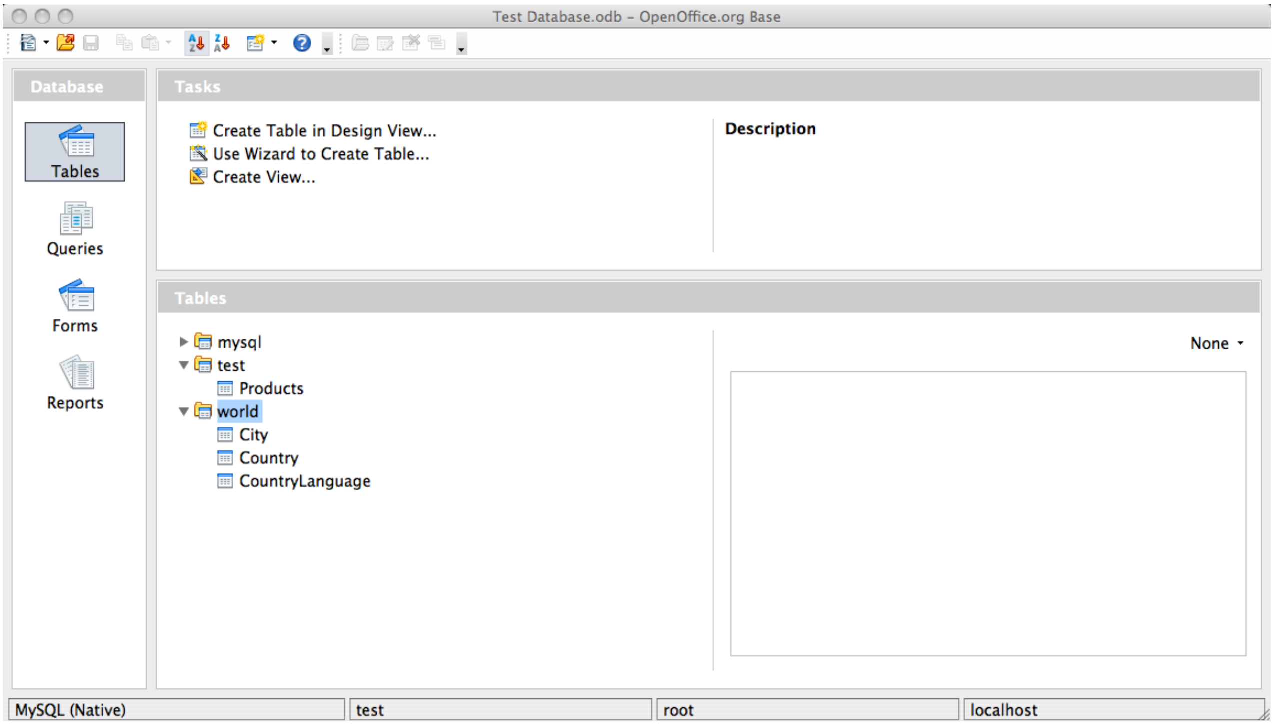
You will be located in the Base application with your database tables displayed.

20.7.3. Getting Started: Usage Examples

Listing Tables

In the **DATABASE** area of the **BASE** main window, select **TABLES**. If this is the first time you are accessing the database you will be prompted for your credentials (user name and password); you can store these settings for your current Base session.

Figure 20.88. Listing Tables


Test Database.odb – OpenOffice.org Base
Database
Tables
Queries
Forms
Reports
Tasks
Create Table in Design View...
Use Wizard to Create Table...
Create View...
Description
Tables
mysql
test
Products
world
City
Country
CountryLanguage
None
MySQL (Native)
test
root
localhost

Depending on your connection settings you will now see all databases with all their tables, or just the database you have specified in the connection settings.

20.7.4. References

See the OpenOffice.org Web site for documentation of the office suite and its Extension Manager.

20.7.5. Known Bugs

If you discover a bug in Connector/OpenOffice.org please add it to this list and send an email to `<users@dba.openoffice.org>`. You need to be logged in with an OpenOffice.org account for both; see the project mailing list for details.

20.7.6. Contact

To discuss the new MySQL Connector/OpenOffice.org, please subscribe to the mailing list `<users@dba.openoffice.org>`. It is a low-volume list with less than 10 mails per day.

20.8. libmysqld, the Embedded MySQL Server Library

The embedded MySQL server library makes it possible to run a full-featured MySQL server inside a client application. The main benefits are increased speed and more simple management for embedded applications.

The embedded server library is based on the client/server version of MySQL, which is written in C/C++. Consequently, the embedded server also is written in C/C++. There is no embedded server available in other languages.

The API is identical for the embedded MySQL version and the client/server version. To change an old threaded application to use the embedded library, you normally only have to add calls to the following functions.

Function	When to Call
`mysql_library_init()`	Should be called before any other MySQL function is called, preferably early in the `main()` function.
`mysql_library_end()`	Should be called before your program exits.
`mysql_thread_init()`	Should be called in each thread you create that accesses MySQL.
`mysql_thread_end()`	Should be called before calling `pthread_exit()`

Then you must link your code with `libmysqld.a` instead of `libmysqlclient.a`. To ensure binary compatibility between your application and the server library, be sure to compile your application against headers for the same series of MySQL that was used to compile the server library. For example, if `libmysqld` was compiled against MySQL 4.1 headers, do not compile your application against MySQL 5.1 headers, or vice versa.

The `mysql_library_xxx()` functions are also included in `libmysqlclient.a` to enable you to change between the embedded and the client/server version by just linking your application with the right library. See Section 20.9.3.40, “`mysql_library_init()`”.

One difference between the embedded server and the standalone server is that for the embedded server, authentication for connections is disabled by default. To use authentication for the embedded server, define the `HAVE_EMBEDDED_PRIVILEGE_CONTROL` compiler flag when you invoke `CMake` to configure your MySQL distribution. See Section 2.9.4, “MySQL Source-Configuration Options”.

20.8.1. Compiling Programs with `libmysqld`

In precompiled binary MySQL distributions that include `libmysqld`, the embedded server library, MySQL builds the library using the appropriate vendor compiler if there is one.

To get a `libmysqld` library if you build MySQL from source yourself, you should configure MySQL with the `-DWITH_EMBEDDED_SERVER=1` option. See Section 2.9.4, “MySQL Source-Configuration Options”.

When you link your program with `libmysqld`, you must also include the system-specific `pthread` libraries and some libraries that the MySQL server uses. You can get the full list of libraries by executing `mysql_config --libmysqld-libs`.

The correct flags for compiling and linking a threaded program must be used, even if you do not directly call any thread functions in your code.

To compile a C program to include the necessary files to embed the MySQL server library into an executable version of a program, the compiler will need to know where to find various files and need instructions on how to compile the program. The following example shows how a program could be compiled from the command line, assuming that you are using `gcc`, use the GNU C compiler:

```
gcc mysql_test.c -o mysql_test -lz \
`/usr/local/mysql/bin/mysql_config --include --libmysqld-libs`
```

Immediately following the `gcc` command is the name of the C program source file. After it, the `-o` option is given to indicate that the file name that follows is the name that the compiler is to give to the output file, the compiled program. The next line of code tells the compiler to obtain the location of the include files and libraries and other settings for the system on which it is compiled. Because of a problem with `mysql_config`, the option `-lz` (for compression) is added here. The `mysql_config` command is contained in backticks, not single quotation marks.

On some non-`gcc` platforms, the embedded library depends on C++ runtime libraries and linking against the embedded library might result in missing-symbol errors. To solve this, link using a C++ compiler or explicitly list the required libraries on the link command line.

20.8.2. Restrictions When Using the Embedded MySQL Server

The embedded server has the following limitations:

- No user-defined functions (UDFs).
- No stack trace on core dump.
- You cannot set this up as a master or a slave (no replication).
- Very large result sets may be unusable on low memory systems.

- You cannot connect to an embedded server from an outside process with sockets or TCP/IP. However, you can connect to an intermediate application, which in turn can connect to an embedded server on the behalf of a remote client or outside process.
- `InnoDB` is not reentrant in the embedded server and cannot be used for multiple connections, either successively or simultaneously.
- The Event Scheduler is not available. Because of this, the `event_scheduler` system variable is disabled.

Some of these limitations can be changed by editing the `mysql_embed.h` include file and recompiling MySQL.

20.8.3. Options with the Embedded Server

Any options that may be given with the `mysqld` server daemon, may be used with an embedded server library. Server options may be given in an array as an argument to the `mysql_library_init()`, which initializes the server. They also may be given in an option file like `my.cnf`. To specify an option file for a C program, use the `--defaults-file` option as one of the elements of the second argument of the `mysql_library_init()` function. See Section 20.9.3.40, “`mysql_library_init()`”, for more information on the `mysql_library_init()` function.

Using option files can make it easier to switch between a client/server application and one where MySQL is embedded. Put common options under the `[server]` group. These are read by both MySQL versions. Client/server-specific options should go under the `[mysqld]` section. Put options specific to the embedded MySQL server library in the `[embedded]` section. Options specific to applications go under section labeled `[ApplicationName_SERVER]`. See Section 4.2.3.3, “Using Option Files”.

20.8.4. Embedded Server Examples

These two example programs should work without any changes on a Linux or FreeBSD system. For other operating systems, minor changes are needed, mostly with file paths. These examples are designed to give enough details for you to understand the problem, without the clutter that is a necessary part of a real application. The first example is very straightforward. The second example is a little more advanced with some error checking. The first is followed by a command-line entry for compiling the program. The second is followed by a GNUmake file that may be used for compiling instead.

Example 1

`test1_libmysqld.c`

```
#include <stdio.h>
#include <stdlib.h>
#include <stdarg.h>
#include "mysql.h"

MYSQL *mysql;
MYSQL_RES *results;
MYSQL_ROW record;

static char *server_options[] = \
       { "mysql_test", "--defaults-file=my.cnf", NULL };
int num_elements = (sizeof(server_options) / sizeof(char *)) - 1;

static char *server_groups[] = { "libmysqld_server",
                                 "libmysqld_client", NULL };

int main(void)
{
   mysql_library_init(num_elements, server_options, server_groups);
   mysql = mysql_init(NULL);
   mysql_options(mysql, MYSQL_READ_DEFAULT_GROUP, "libmysqld_client");
   mysql_options(mysql, MYSQL_OPT_USE_EMBEDDED_CONNECTION, NULL);

   mysql_real_connect(mysql, NULL,NULL,NULL, "database1", 0,NULL,0);

   mysql_query(mysql, "SELECT column1, column2 FROM table1");

   results = mysql_store_result(mysql);

   while((record = mysql_fetch_row(results))) {
      printf("%s - %s \n", record[0], record[1]);
   }

   mysql_free_result(results);
   mysql_close(mysql);
   mysql_library_end();

   return 0;
}
```

Here is the command line for compiling the above program:

```
gcc test1_libmysqld.c -o test1_libmysqld -lz \
 `/usr/local/mysql/bin/mysql_config --include --libmysqld-libs`
```

Example 2

To try the example, create an `test2_libmysqld` directory at the same level as the MySQL source directory. Save the `test2_libmysqld.c` source and the `GNUmakefile` in the directory, and run GNU `make` from inside the `test2_libmysqld` directory.

`test2_libmysqld.c`

```
/*
 * A simple example client, using the embedded MySQL server library
*/

#include <mysql.h>
#include <stdarg.h>
#include <stdio.h>
#include <stdlib.h>

MYSQL *db_connect(const char *dbname);
void db_disconnect(MYSQL *db);
void db_do_query(MYSQL *db, const char *query);

const char *server_groups[] = {
  "test2_libmysqld_SERVER", "embedded", "server", NULL
};

int
main(int argc, char **argv)
{
  MYSQL *one, *two;

  /* mysql_library_init() must be called before any other mysql
   * functions.
   *
   * You can use mysql_library_init(0, NULL, NULL), and it
   * initializes the server using groups = {
   *   "server", "embedded", NULL
   *  }.
   *
   * In your $HOME/.my.cnf file, you probably want to put:

[test2_libmysqld_SERVER]
language = /path/to/source/of/mysql/sql/share/english

   * You could, of course, modify argc and argv before passing
   * them to this function.  Or you could create new ones in any
   * way you like.  But all of the arguments in argv (except for
   * argv[0], which is the program name) should be valid options
   * for the MySQL server.
   *
   * If you link this client against the normal mysqlclient
   * library, this function is just a stub that does nothing.
   */
  mysql_library_init(argc, argv, (char **)server_groups);

  one = db_connect("test");
  two = db_connect(NULL);

  db_do_query(one, "SHOW TABLE STATUS");
  db_do_query(two, "SHOW DATABASES");

  mysql_close(two);
  mysql_close(one);

  /* This must be called after all other mysql functions */
  mysql_library_end();

  exit(EXIT_SUCCESS);
}

static void
die(MYSQL *db, char *fmt, ...)
{
  va_list ap;
  va_start(ap, fmt);
  vfprintf(stderr, fmt, ap);
  va_end(ap);
  (void)putc('\n', stderr);
  if (db)
    db_disconnect(db);
  exit(EXIT_FAILURE);
}

MYSQL *
db_connect(const char *dbname)
{
  MYSQL *db = mysql_init(NULL);
  if (!db)
    die(db, "mysql_init failed: no memory");
  /*
   * Notice that the client and server use separate group names.
   * This is critical, because the server does not accept the
   * client's options, and vice versa.
   */
  mysql_options(db, MYSQL_READ_DEFAULT_GROUP, "test2_libmysqld_CLIENT");
  if (!mysql_real_connect(db, NULL, NULL, NULL, dbname, 0, NULL, 0))
    die(db, "mysql_real_connect failed: %s", mysql_error(db));

  return db;
}

void
db_disconnect(MYSQL *db)
{
  mysql_close(db);
}

void
db_do_query(MYSQL *db, const char *query)
{
  if (mysql_query(db, query) != 0)
    goto err;

  if (mysql_field_count(db) > 0)
  {
    MYSQL_RES   *res;
    MYSQL_ROW    row, end_row;
    int num_fields;

    if (!(res = mysql_store_result(db)))
      goto err;
    num_fields = mysql_num_fields(res);
    while ((row = mysql_fetch_row(res)))
    {
      (void)fputs(">> ", stdout);
      for (end_row = row + num_fields; row < end_row; ++row)
        (void)printf("%s\t", row ? (char*)*row : "NULL");
      (void)fputc('\n', stdout);
    }
    (void)fputc('\n', stdout);
    mysql_free_result(res);
  }
  else
    (void)printf("Affected rows: %lld\n", mysql_affected_rows(db));

  return;

err:
  die(db, "db_do_query failed: %s [%s]", mysql_error(db), query);
}
```

`GNUmakefile`

```
# This assumes the MySQL software is installed in /usr/local/mysql
inc      := /usr/local/mysql/include/mysql
lib      := /usr/local/mysql/lib

# If you have not installed the MySQL software yet, try this instead
#inc      := $(HOME)/mysql-5.5/include
#lib      := $(HOME)/mysql-5.5/libmysqld

CC       := gcc
CPPFLAGS := -I$(inc) -D_THREAD_SAFE -D_REENTRANT
CFLAGS   := -g -W -Wall
LDFLAGS  := -static
# You can change -lmysqld to -lmysqlclient to use the
# client/server library
LDLIBS    = -L$(lib) -lmysqld -lz -lm -ldl -lcrypt

ifneq (,$(shell grep FreeBSD /COPYRIGHT 2>/dev/null))
# FreeBSD
LDFLAGS += -pthread
else
# Assume Linux
LDLIBS += -lpthread
endif

# This works for simple one-file test programs
sources := $(wildcard *.c)
objects := $(patsubst %c,%o,$(sources))
targets := $(basename $(sources))

all: $(targets)

clean:
	rm -f $(targets) $(objects) *.core
```

20.8.5. Licensing the Embedded Server

We encourage everyone to promote free software by releasing code under the GPL or a compatible license. For those who are not able to do this, another option is to purchase a commercial license for the MySQL code from Oracle Corporation. For details, please see http://www.mysql.com/company/legal/licensing/.

20.9. MySQL C API

The C API code is distributed with MySQL. It is included in the `mysqlclient` library and enables C programs to access a database.

Many of the clients in the MySQL source distribution are written in C. If you are looking for examples that demonstrate how to use the C API, take a look at these clients. You can find these in the `client` directory in the MySQL source distribution.

Most of the other client APIs (all except Connector/J and Connector/Net) use the `mysqlclient` library to communicate with the MySQL server. This means that, for example, you can take advantage of many of the same environment variables that are used by other client programs, because they are referenced from the library. See Chapter 4, *MySQL Programs*, for a list of these variables.

The client has a maximum communication buffer size. The size of the buffer that is allocated initially (16KB) is automatically increased up to the maximum size (the maximum is 16MB). Because buffer sizes are increased only as demand warrants, simply increasing the default maximum limit does not in itself cause more resources to be used. This size check is mostly a check for erroneous statements and communication packets.

The communication buffer must be large enough to contain a single SQL statement (for client-to-server traffic) and one row of returned data (for server-to-client traffic). Each thread's communication buffer is dynamically enlarged to handle any query or row up to the maximum limit. For example, if you have `BLOB` values that contain up to 16MB of data, you must have a communication buffer limit of at least 16MB (in both server and client). The client's default maximum is 16MB, but the default maximum in the server is 1MB. You can increase this by changing the value of the `max_allowed_packet` parameter when the server is started. See Section 7.11.2, “Tuning Server Parameters”.

The MySQL server shrinks each communication buffer to `net_buffer_length` bytes after each query. For clients, the size of the buffer associated with a connection is not decreased until the connection is closed, at which time client memory is reclaimed.

For programming with threads, see Section 20.9.17.2, “How to Write a Threaded Client”. For creating a standalone application which includes the "server" and "client" in the same program (and does not communicate with an external MySQL server), see Section 20.8, “libmysqld, the Embedded MySQL Server Library”.

> **Note**
>
> If, after an upgrade, you experience problems with compiled client programs, such as `Commands out of sync` or unexpected core dumps, you probably have used old header or library files when compiling your programs. In this case, you should check the date for your `mysql.h` file and `libmysqlclient.a` library to verify that they are from the new MySQL distribution. If not, recompile your programs with the new headers and libraries. Recompilation might also be necessary for programs compiled against the shared client library if the library major version number has changed (for example from `libmysqlclient.so.15` to `libmysqlclient.so.16`.

20.9.1. C API Data Structures

This section describes C API data structures other than those used for prepared statements. For information about the latter, see Section 20.9.5, “C API Prepared Statement Data Structures”.

- `MYSQL`

  This structure represents a handle to one database connection. It is used for almost all MySQL functions. You should not try to make a copy of a `MYSQL` structure. There is no guarantee that such a copy will be usable.

- `MYSQL_RES`

  This structure represents the result of a query that returns rows (`SELECT`, `SHOW`, `DESCRIBE`, `EXPLAIN`). The information returned from a query is called the *result set* in the remainder of this section.

- `MYSQL_ROW`

  This is a type-safe representation of one row of data. It is currently implemented as an array of counted byte strings. (You cannot treat these as null-terminated strings if field values may contain binary data, because such values may contain null bytes internally.) Rows are obtained by calling `mysql_fetch_row()`.

- `MYSQL_FIELD`

  This structure contains information about a field, such as the field's name, type, and size. Its members are described in more detail later in this section. You may obtain the `MYSQL_FIELD` structures for each field by calling `mysql_fetch_field()` repeatedly. Field values are not part of this structure; they are contained in a `MYSQL_ROW` structure.

- `MYSQL_FIELD_OFFSET`

This is a type-safe representation of an offset into a MySQL field list. (Used by `mysql_field_seek()`.) Offsets are field numbers within a row, beginning at zero.

- `my_ulonglong`

  The type used for the number of rows and for `mysql_affected_rows()`, `mysql_num_rows()`, and `mysql_insert_id()`. This type provides a range of `0` to `1.84e19`.

  On some systems, attempting to print a value of type `my_ulonglong` does not work. To print such a value, convert it to `unsigned long` and use a `%lu` print format. Example:

  ```
  printf ("Number of rows: %lu\n",
          (unsigned long) mysql_num_rows(result));
  ```

- `my_bool`

  A boolean type, for values that are true (nonzero) or false (zero).

The `MYSQL_FIELD` structure contains the members described in the following list. The definitions apply primarily for columns of result sets such as those produced by `SELECT` statements. As of MySQL 5.5.3, `MYSQL_FIELD` structures are also used to provide metadata for `OUT` and `INOUT` parameters returned from stored procedures executed using prepared `CALL` statements. For such parameters, some of the structure members have a meaning different from the meaning for column values.

- `char * name`

  The name of the field, as a null-terminated string. If the field was given an alias with an `AS` clause, the value of `name` is the alias. For a procedure parameter, the parameter name.

- `char * org_name`

  The name of the field, as a null-terminated string. Aliases are ignored. For a procedure parameter, the parameter name.

- `char * table`

  The name of the table containing this field, if it isn't a calculated field. For calculated fields, the `table` value is an empty string. If the column is selected from a view, `table` names the view. If the table or view was given an alias with an `AS` clause, the value of `table` is the alias. For a `UNION`, the value is the empty string. For a procedure parameter, the procedure name.

- `char * org_table`

  The name of the table, as a null-terminated string. Aliases are ignored. If the column is selected from a view, `org_table` names the underlying table. For a `UNION`, the value is the empty string. For a procedure parameter, the procedure name.

- `char * db`

  The name of the database that the field comes from, as a null-terminated string. If the field is a calculated field, `db` is an empty string. For a `UNION`, the value is the empty string. For a procedure parameter, the name of the database containing the procedure.

- `char * catalog`

  The catalog name. This value is always `"def"`.

- `char * def`

  The default value of this field, as a null-terminated string. This is set only if you use `mysql_list_fields()`.

- `unsigned long length`

  The width of the field. This corresponds to the display length, in bytes.

  The server determines the `length` value before it generates the result set, so this is the minimum length required for a data type capable of holding the largest possible value from the result column, without knowing in advance the actual values that will be produced by the query for the result set.

- `unsigned long max_length`

  The maximum width of the field for the result set (the length in bytes of the longest field value for the rows actually in the result set). If you use `mysql_store_result()` or `mysql_list_fields()`, this contains the maximum length for the field. If you use `mysql_use_result()`, the value of this variable is zero.

The value of `max_length` is the length of the string representation of the values in the result set. For example, if you retrieve a `FLOAT` column and the “widest” value is `-12.345`, `max_length` is 7 (the length of `'-12.345'`).

If you are using prepared statements, `max_length` is not set by default because for the binary protocol the lengths of the values depend on the types of the values in the result set. (See Section 20.9.5, “C API Prepared Statement Data Structures”.) If you want the `max_length` values anyway, enable the `STMT_ATTR_UPDATE_MAX_LENGTH` option with `mysql_stmt_attr_set()` and the lengths will be set when you call `mysql_stmt_store_result()`. (See Section 20.9.7.3, “`mysql_stmt_attr_set()`”, and Section 20.9.7.28, “`mysql_stmt_store_result()`”.)

- `unsigned int name_length`

  The length of `name`.

- `unsigned int org_name_length`

  The length of `org_name`.

- `unsigned int table_length`

  The length of `table`.

- `unsigned int org_table_length`

  The length of `org_table`.

- `unsigned int db_length`

  The length of `db`.

- `unsigned int catalog_length`

  The length of `catalog`.

- `unsigned int def_length`

  The length of `def`.

- `unsigned int flags`

  Bit-flags that describe the field. The `flags` value may have zero or more of the bits set that are shown in the following table.

Flag Value	Flag Description
`NOT_NULL_FLAG`	Field can't be `NULL`
`PRI_KEY_FLAG`	Field is part of a primary key
`UNIQUE_KEY_FLAG`	Field is part of a unique key
`MULTIPLE_KEY_FLAG`	Field is part of a nonunique key
`UNSIGNED_FLAG`	Field has the `UNSIGNED` attribute
`ZEROFILL_FLAG`	Field has the `ZEROFILL` attribute
`BINARY_FLAG`	Field has the `BINARY` attribute
`AUTO_INCREMENT_FLAG`	Field has the `AUTO_INCREMENT` attribute
`NUM_FLAG`	Field is numeric
`ENUM_FLAG`	Field is an `ENUM` (deprecated)
`SET_FLAG`	Field is a `SET` (deprecated)
`BLOB_FLAG`	Field is a `BLOB` or `TEXT` (deprecated)
`TIMESTAMP_FLAG`	Field is a `TIMESTAMP` (deprecated)
`NO_DEFAULT_VALUE_FLAG`	Field has no default value; see additional notes following table

Some of these flags indicate data type information and are superseded by or used in conjunction with the `MYSQL_TYPE_xxx` value in the `field->type` member described later:

- To check for `BLOB` or `TIMESTAMP` values, check whether `type` is `MYSQL_TYPE_BLOB` or `MYSQL_TYPE_TIMESTAMP`. (The `BLOB_FLAG` and `TIMESTAMP_FLAG` flags are unneeded.)
- `ENUM` and `SET` values are returned as strings. For these, check that the `type` value is `MYSQL_TYPE_STRING` and that the `ENUM_FLAG` or `SET_FLAG` flag is set in the `flags` value.

`NUM_FLAG` indicates that a column is numeric. This includes columns with a type of `MYSQL_TYPE_DECIMAL`, `MYSQL_TYPE_NEWDECIMAL`, `MYSQL_TYPE_TINY`, `MYSQL_TYPE_SHORT`, `MYSQL_TYPE_LONG`, `MYSQL_TYPE_FLOAT`, `MYSQL_TYPE_DOUBLE`, `MYSQL_TYPE_NULL`, `MYSQL_TYPE_LONGLONG`, `MYSQL_TYPE_INT24`, and `MYSQL_TYPE_YEAR`.

`NO_DEFAULT_VALUE_FLAG` indicates that a column has no `DEFAULT` clause in its definition. This does not apply to `NULL` columns (because such columns have a default of `NULL`), or to `AUTO_INCREMENT` columns (which have an implied default value).

The following example illustrates a typical use of the `flags` value:

```
if (field->flags & NOT_NULL_FLAG)
    printf("Field can't be null\n");
```

You may use the convenience macros shown in the following table to determine the boolean status of the `flags` value.

Flag Status	Description
`IS_NOT_NULL(flags)`	True if this field is defined as `NOT NULL`
`IS_PRI_KEY(flags)`	True if this field is a primary key
`IS_BLOB(flags)`	True if this field is a `BLOB` or `TEXT` (deprecated; test `field->type` instead)

- `unsigned int decimals`

  The number of decimals for numeric fields.

- `unsigned int charsetnr`

  An ID number that indicates the character set/collation pair for the field.

  To distinguish between binary and nonbinary data for string data types, check whether the `charsetnr` value is 63. If so, the character set is `binary`, which indicates binary rather than nonbinary data. This enables you to distinguish `BINARY` from `CHAR`, `VARBINARY` from `VARCHAR`, and the `BLOB` types from the `TEXT` types.

  `charsetnr` values are the same as those displayed in the `Id` column of the `SHOW COLLATION` statement or the `ID` column of the `INFORMATION_SCHEMA` `COLLATIONS` table. You can use those information sources to see which character set and collation specific `charsetnr` values indicate:

```
mysql> SHOW COLLATION WHERE Id = 63;
+-----------+---------+----+---------+----------+---------+
| Collation | Charset | Id | Default | Compiled | Sortlen |
+-----------+---------+----+---------+----------+---------+
| binary    | binary  | 63 | Yes     | Yes      |       1 |
+-----------+---------+----+---------+----------+---------+

mysql> SELECT COLLATION_NAME, CHARACTER_SET_NAME
    -> FROM INFORMATION_SCHEMA.COLLATIONS WHERE ID = 33;
+-----------------+--------------------+
| COLLATION_NAME  | CHARACTER_SET_NAME |
+-----------------+--------------------+
| utf8_general_ci | utf8               |
+-----------------+--------------------+
```

- `enum enum_field_types type`

  The type of the field. The `type` value may be one of the `MYSQL_TYPE_` symbols shown in the following table.

Type Value	Type Description
`MYSQL_TYPE_TINY`	`TINYINT` field
`MYSQL_TYPE_SHORT`	`SMALLINT` field
`MYSQL_TYPE_LONG`	`INTEGER` field
`MYSQL_TYPE_INT24`	`MEDIUMINT` field

Type Value	Type Description
`MYSQL_TYPE_LONGLONG`	`BIGINT` field
`MYSQL_TYPE_DECIMAL`	`DECIMAL` or `NUMERIC` field
`MYSQL_TYPE_NEWDECIMAL`	Precision math `DECIMAL` or `NUMERIC`
`MYSQL_TYPE_FLOAT`	`FLOAT` field
`MYSQL_TYPE_DOUBLE`	`DOUBLE` or `REAL` field
`MYSQL_TYPE_BIT`	`BIT` field
`MYSQL_TYPE_TIMESTAMP`	`TIMESTAMP` field
`MYSQL_TYPE_DATE`	`DATE` field
`MYSQL_TYPE_TIME`	`TIME` field
`MYSQL_TYPE_DATETIME`	`DATETIME` field
`MYSQL_TYPE_YEAR`	`YEAR` field
`MYSQL_TYPE_STRING`	`CHAR` or `BINARY` field
`MYSQL_TYPE_VAR_STRING`	`VARCHAR` or `VARBINARY` field
`MYSQL_TYPE_BLOB`	`BLOB` or `TEXT` field (use `max_length` to determine the maximum length)
`MYSQL_TYPE_SET`	`SET` field
`MYSQL_TYPE_ENUM`	`ENUM` field
`MYSQL_TYPE_GEOMETRY`	Spatial field
`MYSQL_TYPE_NULL`	`NULL`-type field

You can use the `IS_NUM()` macro to test whether a field has a numeric type. Pass the `type` value to `IS_NUM()` and it evaluates to TRUE if the field is numeric:

```
if (IS_NUM(field->type))
    printf("Field is numeric\n");
```

`ENUM` and `SET` values are returned as strings. For these, check that the `type` value is `MYSQL_TYPE_STRING` and that the `ENUM_FLAG` or `SET_FLAG` flag is set in the `flags` value.

20.9.2. C API Function Overview

The functions available in the C API are summarized here and described in greater detail in a later section. See Section 20.9.3, “C API Function Descriptions”.

Table 20.4. C API Function Names and Descriptions

Function	Description
`my_init()`	Initialize global variables, and thread handler in thread-safe programs
`mysql_affected_rows()`	Returns the number of rows changed/deleted/inserted by the last `UPDATE`, `DELETE`, or `INSERT` query
`mysql_autocommit()`	Toggles autocommit mode on/off
`mysql_change_user()`	Changes user and database on an open connection
`mysql_character_set_name()`	Return default character set name for current connection
`mysql_client_find_plugin()`	Return pointer to plugin
`mysql_client_register_plugin()`	Register a plugin
`mysql_close()`	Closes a server connection
`mysql_commit()`	Commits the transaction
`mysql_connect()`	Connects to a MySQL server (this function is deprecated; use `mysql_real_connect()` instead)
`mysql_create_db()`	Creates a database (this function is deprecated; use the SQL statement `CREATE DATABASE` instead)

Function	Description
`mysql_data_seek()`	Seeks to an arbitrary row number in a query result set
`mysql_debug()`	Does a `DBUG_PUSH` with the given string
`mysql_drop_db()`	Drops a database (this function is deprecated; use the SQL statement `DROP DATABASE` instead)
`mysql_dump_debug_info()`	Makes the server write debug information to the log
`mysql_eof()`	Determines whether the last row of a result set has been read (this function is deprecated; `mysql_errno()` or `mysql_error()` may be used instead)
`mysql_errno()`	Returns the error number for the most recently invoked MySQL function
`mysql_error()`	Returns the error message for the most recently invoked MySQL function
`mysql_escape_string()`	Escapes special characters in a string for use in an SQL statement
`mysql_fetch_field()`	Returns the type of the next table field
`mysql_fetch_field_direct()`	Returns the type of a table field, given a field number
`mysql_fetch_fields()`	Returns an array of all field structures
`mysql_fetch_lengths()`	Returns the lengths of all columns in the current row
`mysql_fetch_row()`	Fetches the next row from the result set
`mysql_field_count()`	Returns the number of result columns for the most recent statement
`mysql_field_seek()`	Puts the column cursor on a specified column
`mysql_field_tell()`	Returns the position of the field cursor used for the last `mysql_fetch_field()`
`mysql_free_result()`	Frees memory used by a result set
`mysql_get_character_set_info()`	Return information about default character set
`mysql_get_client_info()`	Returns client version information as a string
`mysql_get_client_version()`	Returns client version information as an integer
`mysql_get_host_info()`	Returns a string describing the connection
`mysql_get_proto_info()`	Returns the protocol version used by the connection
`mysql_get_server_info()`	Returns the server version number
`mysql_get_server_version()`	Returns version number of server as an integer
`mysql_get_ssl_cipher()`	Return current SSL cipher
`mysql_hex_string()`	Encode string in hexadecimal format
`mysql_info()`	Returns information about the most recently executed query
`mysql_init()`	Gets or initializes a `MYSQL` structure
`mysql_insert_id()`	Returns the ID generated for an `AUTO_INCREMENT` column by the previous query
`mysql_kill()`	Kills a given thread
`mysql_library_end()`	Finalize the MySQL C API library
`mysql_library_init()`	Initialize the MySQL C API library
`mysql_list_dbs()`	Returns database names matching a simple regular expression
`mysql_list_fields()`	Returns field names matching a simple regular expression
`mysql_list_processes()`	Returns a list of the current server threads
`mysql_list_tables()`	Returns table names matching a simple regular expression
`mysql_load_plugin()`	Load a plugin
`mysql_load_plugin_v()`	Load a plugin
`mysql_more_results()`	Checks whether any more results exist
`mysql_next_result()`	Returns/initiates the next result in multiple-result executions
`mysql_num_fields()`	Returns the number of columns in a result set
`mysql_num_rows()`	Returns the number of rows in a result set
`mysql_options()`	Sets connect options for `mysql_real_connect()`
`mysql_ping()`	Checks whether the connection to the server is working, reconnecting as necessary
`mysql_plugin_options()`	Set a plugin option
`mysql_query()`	Executes an SQL query specified as a null-terminated string

Function	Description
`mysql_real_connect()`	Connects to a MySQL server
`mysql_real_escape_string()`	Escapes special characters in a string for use in an SQL statement, taking into account the current character set of the connection
`mysql_real_query()`	Executes an SQL query specified as a counted string
`mysql_refresh()`	Flush or reset tables and caches
`mysql_reload()`	Tells the server to reload the grant tables
`mysql_rollback()`	Rolls back the transaction
`mysql_row_seek()`	Seeks to a row offset in a result set, using value returned from `mysql_row_tell()`
`mysql_row_tell()`	Returns the row cursor position
`mysql_select_db()`	Selects a database
`mysql_server_end()`	Finalize the MySQL C API library
`mysql_server_init()`	Initialize the MySQL C API library
`mysql_set_character_set()`	Set default character set for current connection
`mysql_set_local_infile_default()`	Set the `LOAD DATA LOCAL INFILE` handler callbacks to their default values
`mysql_set_local_infile_handler()`	Install application-specific `LOAD DATA LOCAL INFILE` handler callbacks
`mysql_set_server_option()`	Sets an option for the connection (like `multi-statements`)
`mysql_sqlstate()`	Returns the SQLSTATE error code for the last error
`mysql_shutdown()`	Shuts down the database server
`mysql_ssl_set()`	Prepare to establish SSL connection to server
`mysql_stat()`	Returns the server status as a string
`mysql_store_result()`	Retrieves a complete result set to the client
`mysql_thread_end()`	Finalize thread handler
`mysql_thread_id()`	Returns the current thread ID
`mysql_thread_init()`	Initialize thread handler
`mysql_thread_safe()`	Returns 1 if the clients are compiled as thread-safe
`mysql_use_result()`	Initiates a row-by-row result set retrieval
`mysql_warning_count()`	Returns the warning count for the previous SQL statement

Application programs should use this general outline for interacting with MySQL:

1. Initialize the MySQL library by calling `mysql_library_init()`. This function exists in both the `mysqlclient` C client library and the `mysqld` embedded server library, so it is used whether you build a regular client program by linking with the `-libmysqlclient` flag, or an embedded server application by linking with the `-libmysqld` flag.

2. Initialize a connection handler by calling `mysql_init()` and connect to the server by calling `mysql_real_connect()`.

3. Issue SQL statements and process their results. (The following discussion provides more information about how to do this.)

4. Close the connection to the MySQL server by calling `mysql_close()`.

5. End use of the MySQL library by calling `mysql_library_end()`.

The purpose of calling `mysql_library_init()` and `mysql_library_end()` is to provide proper initialization and finalization of the MySQL library. For applications that are linked with the client library, they provide improved memory management. If you don't call `mysql_library_end()`, a block of memory remains allocated. (This does not increase the amount of memory used by the application, but some memory leak detectors will complain about it.) For applications that are linked with the embedded server, these calls start and stop the server.

In a nonmulti-threaded environment, the call to `mysql_library_init()` may be omitted, because `mysql_init()` will invoke it automatically as necessary. However, `mysql_library_init()` is not thread-safe in a multi-threaded environment, and thus neither is `mysql_init()`, which calls `mysql_library_init()`. You must either call `mysql_library_init()` prior to spawning any threads, or else use a mutex to protect the call, whether you invoke `mysql_library_init()` or indirectly through `mysql_init()`. This should be done prior to any other client library call.

To connect to the server, call `mysql_init()` to initialize a connection handler, then call `mysql_real_connect()` with that handler (along with other information such as the host name, user name, and password). Upon connection, `mysql_real_connect()` sets the `reconnect` flag (part of the `MYSQL` structure) to a value of `1` in versions of the API older than 5.0.3, or `0` in newer versions. A value of `1` for this flag indicates that if a statement cannot be performed because of a lost connection, to try reconnecting to the server before giving up. You can use the `MYSQL_OPT_RECONNECT` option to `mysql_options()` to control reconnection behavior. When you are done with the connection, call `mysql_close()` to terminate it.

While a connection is active, the client may send SQL statements to the server using `mysql_query()` or `mysql_real_query()`. The difference between the two is that `mysql_query()` expects the query to be specified as a null-terminated string whereas `mysql_real_query()` expects a counted string. If the string contains binary data (which may include null bytes), you must use `mysql_real_query()`.

For each non-`SELECT` query (for example, `INSERT`, `UPDATE`, `DELETE`), you can find out how many rows were changed (affected) by calling `mysql_affected_rows()`.

For `SELECT` queries, you retrieve the selected rows as a result set. (Note that some statements are `SELECT`-like in that they return rows. These include `SHOW`, `DESCRIBE`, and `EXPLAIN`. They should be treated the same way as `SELECT` statements.)

There are two ways for a client to process result sets. One way is to retrieve the entire result set all at once by calling `mysql_store_result()`. This function acquires from the server all the rows returned by the query and stores them in the client. The second way is for the client to initiate a row-by-row result set retrieval by calling `mysql_use_result()`. This function initializes the retrieval, but does not actually get any rows from the server.

In both cases, you access rows by calling `mysql_fetch_row()`. With `mysql_store_result()`, `mysql_fetch_row()` accesses rows that have previously been fetched from the server. With `mysql_use_result()`, `mysql_fetch_row()` actually retrieves the row from the server. Information about the size of the data in each row is available by calling `mysql_fetch_lengths()`.

After you are done with a result set, call `mysql_free_result()` to free the memory used for it.

The two retrieval mechanisms are complementary. Client programs should choose the approach that is most appropriate for their requirements. In practice, clients tend to use `mysql_store_result()` more commonly.

An advantage of `mysql_store_result()` is that because the rows have all been fetched to the client, you not only can access rows sequentially, you can move back and forth in the result set using `mysql_data_seek()` or `mysql_row_seek()` to change the current row position within the result set. You can also find out how many rows there are by calling `mysql_num_rows()`. On the other hand, the memory requirements for `mysql_store_result()` may be very high for large result sets and you are more likely to encounter out-of-memory conditions.

An advantage of `mysql_use_result()` is that the client requires less memory for the result set because it maintains only one row at a time (and because there is less allocation overhead, `mysql_use_result()` can be faster). Disadvantages are that you must process each row quickly to avoid tying up the server, you don't have random access to rows within the result set (you can only access rows sequentially), and you don't know how many rows are in the result set until you have retrieved them all. Furthermore, you *must* retrieve all the rows even if you determine in mid-retrieval that you've found the information you were looking for.

The API makes it possible for clients to respond appropriately to statements (retrieving rows only as necessary) without knowing whether the statement is a `SELECT`. You can do this by calling `mysql_store_result()` after each `mysql_query()` (or `mysql_real_query()`). If the result set call succeeds, the statement was a `SELECT` and you can read the rows. If the result set call fails, call `mysql_field_count()` to determine whether a result was actually to be expected. If `mysql_field_count()` returns zero, the statement returned no data (indicating that it was an `INSERT`, `UPDATE`, `DELETE`, and so forth), and was not expected to return rows. If `mysql_field_count()` is nonzero, the statement should have returned rows, but didn't. This indicates that the statement was a `SELECT` that failed. See the description for `mysql_field_count()` for an example of how this can be done.

Both `mysql_store_result()` and `mysql_use_result()` enable you to obtain information about the fields that make up the result set (the number of fields, their names and types, and so forth). You can access field information sequentially within the row by calling `mysql_fetch_field()` repeatedly, or by field number within the row by calling `mysql_fetch_field_direct()`. The current field cursor position may be changed by calling `mysql_field_seek()`. Setting the field cursor affects subsequent calls to `mysql_fetch_field()`. You can also get information for fields all at once by calling `mysql_fetch_fields()`.

For detecting and reporting errors, MySQL provides access to error information by means of the `mysql_errno()` and `mysql_error()` functions. These return the error code or error message for the most recently invoked function that can succeed or fail, enabling you to determine when an error occurred and what it was.

20.9.3. C API Function Descriptions

In the descriptions here, a parameter or return value of `NULL` means `NULL` in the sense of the C programming language, not a MySQL `NULL` value.

Functions that return a value generally return a pointer or an integer. Unless specified otherwise, functions returning a pointer return a non-`NULL` value to indicate success or a `NULL` value to indicate an error, and functions returning an integer return zero to indicate success or nonzero to indicate an error. Note that "nonzero" means just that. Unless the function description says otherwise, do not test against a value other than zero:

```
if (result)                   /* correct */
    ... error ...

if (result < 0)               /* incorrect */
    ... error ...

if (result == -1)             /* incorrect */
    ... error ...
```

When a function returns an error, the **Errors** subsection of the function description lists the possible types of errors. You can find out which of these occurred by calling `mysql_errno()`. A string representation of the error may be obtained by calling `mysql_error()`.

20.9.3.1. `mysql_affected_rows()`

`my_ulonglong mysql_affected_rows(MYSQL *mysql)`

Description

`mysql_affected_rows()` may be called immediately after executing a statement with `mysql_query()` or `mysql_real_query()`. It returns the number of rows changed, deleted, or inserted by the last statement if it was an `UPDATE`, `DELETE`, or `INSERT`. For `SELECT` statements, `mysql_affected_rows()` works like `mysql_num_rows()`.

For `UPDATE` statements, the affected-rows value by default is the number of rows actually changed. If you specify the `CLIENT_FOUND_ROWS` flag to `mysql_real_connect()` when connecting to `mysqld`, the affected-rows value is the number of rows "found"; that is, matched by the `WHERE` clause.

For `REPLACE` statements, the affected-rows value is 2 if the new row replaced an old row, because in this case, one row was inserted after the duplicate was deleted.

For `INSERT ... ON DUPLICATE KEY UPDATE` statements, the affected-rows value is 1 if the row is inserted as a new row and 2 if an existing row is updated.

Following a `CALL` statement for a stored procedure, `mysql_affected_rows()` returns the value that it would return for the last statement executed within the procedure, or `0` if that statement would return `-1`. Within the procedure, you can use `ROW_COUNT()` at the SQL level to obtain the affected-rows value for individual statements.

As of MySQL 5.5.5, `mysql_affected_rows()` returns a meaningful value for a wider range of statements. For details, see the description for `ROW_COUNT()` in Section 11.14, "Information Functions".

Return Values

An integer greater than zero indicates the number of rows affected or retrieved. Zero indicates that no records were updated for an `UPDATE` statement, no rows matched the `WHERE` clause in the query or that no query has yet been executed. -1 indicates that the query returned an error or that, for a `SELECT` query, `mysql_affected_rows()` was called prior to calling `mysql_store_result()`.

Because `mysql_affected_rows()` returns an unsigned value, you can check for -1 by comparing the return value to `(my_ulonglong)-1` (or to `(my_ulonglong)~0`, which is equivalent).

Errors

None.

Example

```
char *stmt = "UPDATE products SET cost=cost*1.25
              WHERE group=10";
mysql_query(&mysql,stmt);
printf("%ld products updated",
       (long) mysql_affected_rows(&mysql));
```

20.9.3.2. `mysql_autocommit()`

`my_bool mysql_autocommit(MYSQL *mysql, my_bool mode)`

Description

Sets autocommit mode on if `mode` is 1, off if `mode` is 0.

Return Values

Zero if successful. Nonzero if an error occurred.

Errors

None.

20.9.3.3. `mysql_change_user()`

```
my_bool mysql_change_user(MYSQL *mysql, const char *user, const char *password, const
char *db)
```

Description

Changes the user and causes the database specified by `db` to become the default (current) database on the connection specified by `mysql`. In subsequent queries, this database is the default for table references that do not include an explicit database specifier.

`mysql_change_user()` fails if the connected user cannot be authenticated or doesn't have permission to use the database. In this case, the user and database are not changed.

The `db` parameter may be set to `NULL` if you don't want to have a default database.

This command resets the state as if one had done a new connect. (See Section 20.9.12, “Controlling Automatic Reconnection Behavior”.) It always performs a `ROLLBACK` of any active transactions, closes and drops all temporary tables, and unlocks all locked tables. Session system variables are reset to the values of the corresponding global system variables. Prepared statements are released and `HANDLER` variables are closed. Locks acquired with `GET_LOCK()` are released. These effects occur even if the user didn't change.

Return Values

Zero for success. Nonzero if an error occurred.

Errors

The same that you can get from `mysql_real_connect()`.

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

- `ER_UNKNOWN_COM_ERROR`

  The MySQL server doesn't implement this command (probably an old server).

- `ER_ACCESS_DENIED_ERROR`

  The user or password was wrong.

- `ER_BAD_DB_ERROR`

  The database didn't exist.

- `ER_DBACCESS_DENIED_ERROR`

The user did not have access rights to the database.

- `ER_WRONG_DB_NAME`

  The database name was too long.

Example

```
if (mysql_change_user(&mysql, "user", "password", "new_database"))
{
   fprintf(stderr, "Failed to change user.  Error: %s\n",
           mysql_error(&mysql));
}
```

20.9.3.4. `mysql_character_set_name()`

`const char *mysql_character_set_name(MYSQL *mysql)`

Description

Returns the default character set name for the current connection.

Return Values

The default character set name

Errors

None.

20.9.3.5. `mysql_close()`

`void mysql_close(MYSQL *mysql)`

Description

Closes a previously opened connection. `mysql_close()` also deallocates the connection handle pointed to by `mysql` if the handle was allocated automatically by `mysql_init()` or `mysql_connect()`.

Return Values

None.

Errors

None.

20.9.3.6. `mysql_commit()`

`my_bool mysql_commit(MYSQL *mysql)`

Description

Commits the current transaction.

The action of this function is subject to the value of the `completion_type` system variable. In particular, if the value of `completion_type` is `RELEASE` (or 2), the server performs a release after terminating a transaction and closes the client connection. The client program should call `mysql_close()` to close the connection from the client side.

Return Values

Zero if successful. Nonzero if an error occurred.

Errors

None.

20.9.3.7. `mysql_connect()`

`MYSQL *mysql_connect(MYSQL *mysql, const char *host, const char *user, const char *passwd)`

Description

This function is deprecated. Use `mysql_real_connect()` instead.

`mysql_connect()` attempts to establish a connection to a MySQL database engine running on `host`. `mysql_connect()` must complete successfully before you can execute any of the other API functions, with the exception of `mysql_get_client_info()`.

The meanings of the parameters are the same as for the corresponding parameters for `mysql_real_connect()` with the difference that the connection parameter may be `NULL`. In this case, the C API allocates memory for the connection structure automatically and frees it when you call `mysql_close()`. The disadvantage of this approach is that you can't retrieve an error message if the connection fails. (To get error information from `mysql_errno()` or `mysql_error()`, you must provide a valid `MYSQL` pointer.)

Return Values

Same as for `mysql_real_connect()`.

Errors

Same as for `mysql_real_connect()`.

20.9.3.8. `mysql_create_db()`

`int mysql_create_db(MYSQL *mysql, const char *db)`

Description

Creates the database named by the `db` parameter.

This function is deprecated. It is preferable to use `mysql_query()` to issue an SQL `CREATE DATABASE` statement instead.

Return Values

Zero if the database was created successfully. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

```
if(mysql_create_db(&mysql, "my_database"))
{
   fprintf(stderr, "Failed to create new database.  Error: %s\n",
           mysql_error(&mysql));
}
```

20.9.3.9. `mysql_data_seek()`

`void mysql_data_seek(MYSQL_RES *result, my_ulonglong offset)`

Description

Seeks to an arbitrary row in a query result set. The `offset` value is a row number and should be in the range from `0` to `mysql_num_rows(result)-1`.

This function requires that the result set structure contains the entire result of the query, so `mysql_data_seek()` may be used only in conjunction with `mysql_store_result()`, not with `mysql_use_result()`.

Return Values

None.

Errors

None.

20.9.3.10. `mysql_debug()`

`void mysql_debug(const char *debug)`

Description

Does a `DBUG_PUSH` with the given string. `mysql_debug()` uses the Fred Fish debug library. To use this function, you must compile the client library to support debugging. See MySQL Internals: Porting.

Return Values

None.

Errors

None.

Example

The call shown here causes the client library to generate a trace file in `/tmp/client.trace` on the client machine:

```
mysql_debug("d:t:O,/tmp/client.trace");
```

20.9.3.11. `mysql_drop_db()`

`int mysql_drop_db(MYSQL *mysql, const char *db)`

Description

Drops the database named by the `db` parameter.

This function is deprecated. It is preferable to use `mysql_query()` to issue an SQL `DROP DATABASE` statement instead.

Return Values

Zero if the database was dropped successfully. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

```
if(mysql_drop_db(&mysql, "my_database"))
  fprintf(stderr, "Failed to drop the database: Error: %s\n",
          mysql_error(&mysql));
```

20.9.3.12. `mysql_dump_debug_info()`

`int mysql_dump_debug_info(MYSQL *mysql)`

Description

Instructs the server to write some debug information to the log. For this to work, the connected user must have the `SUPER` privilege.

Return Values

Zero if the command was successful. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.13. `mysql_eof()`

`my_bool mysql_eof(MYSQL_RES *result)`

Description

This function is deprecated. `mysql_errno()` or `mysql_error()` may be used instead.

`mysql_eof()` determines whether the last row of a result set has been read.

If you acquire a result set from a successful call to `mysql_store_result()`, the client receives the entire set in one operation. In this case, a `NULL` return from `mysql_fetch_row()` always means the end of the result set has been reached and it is unnecessary to call `mysql_eof()`. When used with `mysql_store_result()`, `mysql_eof()` always returns true.

On the other hand, if you use `mysql_use_result()` to initiate a result set retrieval, the rows of the set are obtained from the server one by one as you call `mysql_fetch_row()` repeatedly. Because an error may occur on the connection during this process, a `NULL` return value from `mysql_fetch_row()` does not necessarily mean the end of the result set was reached normally. In this case, you can use `mysql_eof()` to determine what happened. `mysql_eof()` returns a nonzero value if the end of the result set was reached and zero if an error occurred.

Historically, `mysql_eof()` predates the standard MySQL error functions `mysql_errno()` and `mysql_error()`. Because those error functions provide the same information, their use is preferred over `mysql_eof()`, which is deprecated. (In fact, they provide more information, because `mysql_eof()` returns only a boolean value whereas the error functions indicate a reason for the error when one occurs.)

Return Values

Zero if no error occurred. Nonzero if the end of the result set has been reached.

Errors

None.

Example

The following example shows how you might use `mysql_eof()`:

```
mysql_query(&mysql,"SELECT * FROM some_table");
result = mysql_use_result(&mysql);
while((row = mysql_fetch_row(result)))
{
    // do something with data
}
if(!mysql_eof(result))  // mysql_fetch_row() failed due to an error
{
    fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
}
```

However, you can achieve the same effect with the standard MySQL error functions:

```
mysql_query(&mysql,"SELECT * FROM some_table");
result = mysql_use_result(&mysql);
while((row = mysql_fetch_row(result)))
{
    // do something with data
}
if(mysql_errno(&mysql))  // mysql_fetch_row() failed due to an error
{
    fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
}
```

20.9.3.14. `mysql_errno()`

`unsigned int mysql_errno(MYSQL *mysql)`

Description

For the connection specified by `mysql`, `mysql_errno()` returns the error code for the most recently invoked API function that can succeed or fail. A return value of zero means that no error occurred. Client error message numbers are listed in the MySQL `errmsg.h` header file. Server error message numbers are listed in `mysqld_error.h`. Errors also are listed at Appendix C, *Errors, Error Codes, and Common Problems*.

Note that some functions like `mysql_fetch_row()` don't set `mysql_errno()` if they succeed.

A rule of thumb is that all functions that have to ask the server for information reset `mysql_errno()` if they succeed.

MySQL-specific error numbers returned by `mysql_errno()` differ from SQLSTATE values returned by `mysql_sqlstate()`. For example, the `mysql` client program displays errors using the following format, where `1146` is the `mysql_errno()` value and `'42S02'` is the corresponding `mysql_sqlstate()` value:

```
shell> SELECT * FROM no_such_table;
ERROR 1146 (42S02): Table 'test.no_such_table' doesn't exist
```

Return Values

An error code value for the last `mysql_xxx()` call, if it failed. zero means no error occurred.

Errors

None.

20.9.3.15. `mysql_error()`

`const char *mysql_error(MYSQL *mysql)`

Description

For the connection specified by `mysql`, `mysql_error()` returns a null-terminated string containing the error message for the most recently invoked API function that failed. If a function didn't fail, the return value of `mysql_error()` may be the previous error or an empty string to indicate no error.

A rule of thumb is that all functions that have to ask the server for information reset `mysql_error()` if they succeed.

For functions that reset `mysql_error()`, the following two tests are equivalent:

```
if(*mysql_error(&mysql))
{
  // an error occurred
}

if(mysql_error(&mysql)[0])
{
  // an error occurred
}
```

The language of the client error messages may be changed by recompiling the MySQL client library. Currently, you can choose error messages in several different languages. See Section 9.2, “Setting the Error Message Language”.

Return Values

A null-terminated character string that describes the error. An empty string if no error occurred.

Errors

None.

20.9.3.16. `mysql_escape_string()`

You should use `mysql_real_escape_string()` instead!

This function is identical to `mysql_real_escape_string()` except that `mysql_real_escape_string()` takes a connection handler as its first argument and escapes the string according to the current character set. `mysql_escape_string()` does not take a connection argument and does not respect the current character set.

20.9.3.17. `mysql_fetch_field()`

`MYSQL_FIELD *mysql_fetch_field(MYSQL_RES *result)`

Description

Returns the definition of one column of a result set as a `MYSQL_FIELD` structure. Call this function repeatedly to retrieve information about all columns in the result set. `mysql_fetch_field()` returns `NULL` when no more fields are left.

`mysql_fetch_field()` is reset to return information about the first field each time you execute a new `SELECT` query. The field returned by `mysql_fetch_field()` is also affected by calls to `mysql_field_seek()`.

If you've called `mysql_query()` to perform a `SELECT` on a table but have not called `mysql_store_result()`, MySQL returns the default blob length (8KB) if you call `mysql_fetch_field()` to ask for the length of a `BLOB` field. (The 8KB size is chosen because MySQL doesn't know the maximum length for the `BLOB`. This should be made configurable sometime.) Once you've retrieved the result set, `field->max_length` contains the length of the largest value for this column in the specific query.

Return Values

The `MYSQL_FIELD` structure for the current column. `NULL` if no columns are left.

Errors

None.

Example

```
MYSQL_FIELD *field;

while((field = mysql_fetch_field(result)))
{
    printf("field name %s\n", field->name);
}
```

20.9.3.18. `mysql_fetch_field_direct()`

`MYSQL_FIELD *mysql_fetch_field_direct(MYSQL_RES *result, unsigned int fieldnr)`

Description

Given a field number `fieldnr` for a column within a result set, returns that column's field definition as a `MYSQL_FIELD` structure. You may use this function to retrieve the definition for an arbitrary column. The value of `fieldnr` should be in the range from 0 to `mysql_num_fields(result)-1`.

Return Values

The `MYSQL_FIELD` structure for the specified column.

Errors

None.

Example

```
unsigned int num_fields;
unsigned int i;
MYSQL_FIELD *field;

num_fields = mysql_num_fields(result);
for(i = 0; i < num_fields; i++)
{
    field = mysql_fetch_field_direct(result, i);
    printf("Field %u is %s\n", i, field->name);
}
```

20.9.3.19. `mysql_fetch_fields()`

`MYSQL_FIELD *mysql_fetch_fields(MYSQL_RES *result)`

Description

Returns an array of all `MYSQL_FIELD` structures for a result set. Each structure provides the field definition for one column of the result set.

Return Values

An array of `MYSQL_FIELD` structures for all columns of a result set.

Errors

None.

Example

```
unsigned int num_fields;
unsigned int i;
MYSQL_FIELD *fields;

num_fields = mysql_num_fields(result);
fields = mysql_fetch_fields(result);
for(i = 0; i < num_fields; i++)
{
   printf("Field %u is %s\n", i, fields[i].name);
}
```

20.9.3.20. `mysql_fetch_lengths()`

`unsigned long *mysql_fetch_lengths(MYSQL_RES *result)`

Description

Returns the lengths of the columns of the current row within a result set. If you plan to copy field values, this length information is also useful for optimization, because you can avoid calling `strlen()`. In addition, if the result set contains binary data, you **must** use this function to determine the size of the data, because `strlen()` returns incorrect results for any field containing null characters.

The length for empty columns and for columns containing `NULL` values is zero. To see how to distinguish these two cases, see the description for `mysql_fetch_row()`.

Return Values

An array of unsigned long integers representing the size of each column (not including any terminating null characters). `NULL` if an error occurred.

Errors

`mysql_fetch_lengths()` is valid only for the current row of the result set. It returns `NULL` if you call it before calling `mysql_fetch_row()` or after retrieving all rows in the result.

Example

```
MYSQL_ROW row;
unsigned long *lengths;
unsigned int num_fields;
unsigned int i;

row = mysql_fetch_row(result);
if (row)
{
    num_fields = mysql_num_fields(result);
    lengths = mysql_fetch_lengths(result);
    for(i = 0; i < num_fields; i++)
    {
         printf("Column %u is %lu bytes in length.\n",
                i, lengths[i]);
    }
}
```

20.9.3.21. `mysql_fetch_row()`

`MYSQL_ROW mysql_fetch_row(MYSQL_RES *result)`

Description

Retrieves the next row of a result set. When used after `mysql_store_result()`, `mysql_fetch_row()` returns `NULL` when there are no more rows to retrieve. When used after `mysql_use_result()`, `mysql_fetch_row()` returns `NULL` when there are no more rows to retrieve or if an error occurred.

The number of values in the row is given by `mysql_num_fields(result)`. If `row` holds the return value from a call to `mysql_fetch_row()`, pointers to the values are accessed as `row[0]` to `row[mysql_num_fields(result)-1]`. `NULL` values in the row are indicated by `NULL` pointers.

The lengths of the field values in the row may be obtained by calling `mysql_fetch_lengths()`. Empty fields and fields containing `NULL` both have length 0; you can distinguish these by checking the pointer for the field value. If the pointer is `NULL`, the field is `NULL`; otherwise, the field is empty.

Return Values

A `MYSQL_ROW` structure for the next row. `NULL` if there are no more rows to retrieve or if an error occurred.

Errors

Note that error is not reset between calls to `mysql_fetch_row()`

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

```
MYSQL_ROW row;
unsigned int num_fields;
unsigned int i;
```

```
num_fields = mysql_num_fields(result);
while ((row = mysql_fetch_row(result)))
{
   unsigned long *lengths;
   lengths = mysql_fetch_lengths(result);
   for(i = 0; i < num_fields; i++)
   {
       printf("[%.*s] ", (int) lengths[i],
              row[i] ? row[i] : "NULL");
   }
   printf("\n");
}
```

20.9.3.22. `mysql_field_count()`

`unsigned int mysql_field_count(MYSQL *mysql)`

Description

Returns the number of columns for the most recent query on the connection.

The normal use of this function is when `mysql_store_result()` returned `NULL` (and thus you have no result set pointer). In this case, you can call `mysql_field_count()` to determine whether `mysql_store_result()` should have produced a nonempty result. This enables the client program to take proper action without knowing whether the query was a `SELECT` (or `SELECT`-like) statement. The example shown here illustrates how this may be done.

See Section 20.9.11.1, "Why `mysql_store_result()` Sometimes Returns `NULL` After `mysql_query()` Returns Success".

Return Values

An unsigned integer representing the number of columns in a result set.

Errors

None.

Example

```
MYSQL_RES *result;
unsigned int num_fields;
unsigned int num_rows;

if (mysql_query(&mysql,query_string))
{
    // error
}
else // query succeeded, process any data returned by it
{
    result = mysql_store_result(&mysql);
    if (result)  // there are rows
    {
        num_fields = mysql_num_fields(result);
        // retrieve rows, then call mysql_free_result(result)
    }
    else  // mysql_store_result() returned nothing; should it have?
    {
        if(mysql_field_count(&mysql) == 0)
        {
            // query does not return data
            // (it was not a SELECT)
            num_rows = mysql_affected_rows(&mysql);
        }
        else // mysql_store_result() should have returned data
        {
            fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
        }
    }
}
```

An alternative is to replace the `mysql_field_count(&mysql)` call with `mysql_errno(&mysql)`. In this case, you are checking directly for an error from `mysql_store_result()` rather than inferring from the value of `mysql_field_count()` whether the statement was a `SELECT`.

20.9.3.23. `mysql_field_seek()`

`MYSQL_FIELD_OFFSET mysql_field_seek(MYSQL_RES *result, MYSQL_FIELD_OFFSET offset)`

Description

Sets the field cursor to the given offset. The next call to `mysql_fetch_field()` retrieves the field definition of the column associated with that offset.

To seek to the beginning of a row, pass an `offset` value of zero.

Return Values

The previous value of the field cursor.

Errors

None.

20.9.3.24. `mysql_field_tell()`

`MYSQL_FIELD_OFFSET mysql_field_tell(MYSQL_RES *result)`

Description

Returns the position of the field cursor used for the last `mysql_fetch_field()`. This value can be used as an argument to `mysql_field_seek()`.

Return Values

The current offset of the field cursor.

Errors

None.

20.9.3.25. `mysql_free_result()`

`void mysql_free_result(MYSQL_RES *result)`

Description

Frees the memory allocated for a result set by `mysql_store_result()`, `mysql_use_result()`, `mysql_list_dbs()`, and so forth. When you are done with a result set, you must free the memory it uses by calling `mysql_free_result()`.

Do not attempt to access a result set after freeing it.

Return Values

None.

Errors

None.

20.9.3.26. `mysql_get_character_set_info()`

`void mysql_get_character_set_info(MYSQL *mysql, MY_CHARSET_INFO *cs)`

Description

This function provides information about the default client character set. The default character set may be changed with the `mysql_set_character_set()` function.

Example

This example shows the fields that are available in the `MY_CHARSET_INFO` structure:

```
if (!mysql_set_character_set(&mysql, "utf8"))
{
    MY_CHARSET_INFO cs;
    mysql_get_character_set_info(&mysql, &cs);
    printf("character set information:\n");
    printf("character set+collation number: %d\n", cs.number);
    printf("character set name: %s\n", cs.name);
    printf("collation name: %s\n", cs.csname);
    printf("comment: %s\n", cs.comment);
    printf("directory: %s\n", cs.dir);
    printf("multi byte character min. length: %d\n", cs.mbminlen);
    printf("multi byte character max. length: %d\n", cs.mbmaxlen);
}
```

20.9.3.27. `mysql_get_client_info()`

`const char *mysql_get_client_info(void)`

Description

Returns a string that represents the client library version.

Return Values

A character string that represents the MySQL client library version.

Errors

None.

20.9.3.28. `mysql_get_client_version()`

`unsigned long mysql_get_client_version(void)`

Description

Returns an integer that represents the client library version. The value has the format `XYYZZ` where `X` is the major version, `YY` is the release level, and `ZZ` is the version number within the release level. For example, a value of `40102` represents a client library version of `4.1.2`.

Return Values

An integer that represents the MySQL client library version.

Errors

None.

20.9.3.29. `mysql_get_host_info()`

`const char *mysql_get_host_info(MYSQL *mysql)`

Description

Returns a string describing the type of connection in use, including the server host name.

Return Values

A character string representing the server host name and the connection type.

Errors

None.

20.9.3.30. `mysql_get_proto_info()`

`unsigned int mysql_get_proto_info(MYSQL *mysql)`

Description

Returns the protocol version used by current connection.

Return Values

An unsigned integer representing the protocol version used by the current connection.

Errors

None.

20.9.3.31. `mysql_get_server_info()`

`const char *mysql_get_server_info(MYSQL *mysql)`

Description

Returns a string that represents the server version number.

Return Values

A character string that represents the server version number.

Errors

None.

20.9.3.32. `mysql_get_server_version()`

`unsigned long mysql_get_server_version(MYSQL *mysql)`

Description

Returns the version number of the server as an integer.

Return Values

A number that represents the MySQL server version in this format:

```
major_version*10000 + minor_version *100 + sub_version
```

For example, 5.1.5 is returned as 50105.

This function is useful in client programs for quickly determining whether some version-specific server capability exists.

Errors

None.

20.9.3.33. `mysql_get_ssl_cipher()`

`const char *mysql_get_ssl_cipher(MYSQL *mysql)`

Description

`mysql_get_ssl_cipher()` returns the SSL cipher used for the given connection to the server. `mysql` is the connection handler returned from `mysql_init()`.

Return Values

A string naming the SSL cipher used for the connection, or `NULL` if no cipher is being used.

20.9.3.34. `mysql_hex_string()`

`unsigned long mysql_hex_string(char *to, const char *from, unsigned long length)`

Description

This function is used to create a legal SQL string that you can use in an SQL statement. See Section 8.1.1, “Strings”.

The string in `from` is encoded to hexadecimal format, with each character encoded as two hexadecimal digits. The result is placed in `to` and a terminating null byte is appended.

The string pointed to by `from` must be `length` bytes long. You must allocate the `to` buffer to be at least `length*2+1` bytes long. When `mysql_hex_string()` returns, the contents of `to` is a null-terminated string. The return value is the length of the encoded string, not including the terminating null character.

The return value can be placed into an SQL statement using either `0xvalue` or `X'value'` format. However, the return value does not include the `0x` or `X'...'`. The caller must supply whichever of those is desired.

Example

```
char query[1000],*end;

end = strmov(query,"INSERT INTO test_table values(");
end = strmov(end,"0x");
end += mysql_hex_string(end,"What is this",12);
end = strmov(end,",0x");
end += mysql_hex_string(end,"binary data: \0\r\n",16);
*end++ = ')';

if (mysql_real_query(&mysql,query,(unsigned int) (end - query)))
{
   fprintf(stderr, "Failed to insert row, Error: %s\n",
           mysql_error(&mysql));
}
```

The `strmov()` function used in the example is included in the `mysqlclient` library and works like `strcpy()` but returns a pointer to the terminating null of the first parameter.

Return Values

The length of the value placed into `to`, not including the terminating null character.

Errors

None.

20.9.3.35. `mysql_info()`

`const char *mysql_info(MYSQL *mysql)`

Description

Retrieves a string providing information about the most recently executed statement, but only for the statements listed here. For other statements, `mysql_info()` returns `NULL`. The format of the string varies depending on the type of statement, as described here. The numbers are illustrative only; the string contains values appropriate for the statement.

- `INSERT INTO ... SELECT ...`

  String format: `Records: 100 Duplicates: 0 Warnings: 0`

- `INSERT INTO ... VALUES (...),(...),(...)...`

  String format: `Records: 3 Duplicates: 0 Warnings: 0`

- `LOAD DATA INFILE ...`

  String format: `Records: 1 Deleted: 0 Skipped: 0 Warnings: 0`

- `ALTER TABLE`

  String format: `Records: 3 Duplicates: 0 Warnings: 0`

- `UPDATE`

  String format: `Rows matched: 40 Changed: 40 Warnings: 0`

Note that `mysql_info()` returns a non-`NULL` value for `INSERT ... VALUES` only for the multiple-row form of the statement (that is, only if multiple value lists are specified).

Return Values

A character string representing additional information about the most recently executed statement. `NULL` if no information is available for the statement.

Errors

None.

20.9.3.36. `mysql_init()`

`MYSQL *mysql_init(MYSQL *mysql)`

Description

Allocates or initializes a `MYSQL` object suitable for `mysql_real_connect()`. If `mysql` is a `NULL` pointer, the function allocates, initializes, and returns a new object. Otherwise, the object is initialized and the address of the object is returned. If `mysql_init()` allocates a new object, it is freed when `mysql_close()` is called to close the connection.

Return Values

An initialized `MYSQL*` handle. `NULL` if there was insufficient memory to allocate a new object.

Errors

In case of insufficient memory, `NULL` is returned.

20.9.3.37. `mysql_insert_id()`

`my_ulonglong mysql_insert_id(MYSQL *mysql)`

Description

Returns the value generated for an `AUTO_INCREMENT` column by the previous `INSERT` or `UPDATE` statement. Use this function after you have performed an `INSERT` statement into a table that contains an `AUTO_INCREMENT` field, or have used `INSERT` or `UPDATE` to set a column value with `LAST_INSERT_ID(expr)`.

The return value of `mysql_insert_id()` is always zero unless explicitly updated under one of the following conditions:

- `INSERT` statements that store a value into an `AUTO_INCREMENT` column. This is true whether the value is automatically generated by storing the special values `NULL` or `0` into the column, or is an explicit nonspecial value.
- In the case of a multiple-row `INSERT` statement, the return value of `mysql_insert_id()` depends on the MySQL server version.

  `mysql_insert_id()` returns the *first* automatically generated `AUTO_INCREMENT` value that was *successfully* inserted.

  If no rows are successfully inserted, `mysql_insert_id()` returns 0.
- If an `INSERT ... SELECT` statement is executed, and no automatically generated value is successfully inserted, `mysql_insert_id()` returns the ID of the last inserted row.
- If an `INSERT ... SELECT` statement uses `LAST_INSERT_ID(expr)`, `mysql_insert_id()` returns `expr`.
- `INSERT` statements that generate an `AUTO_INCREMENT` value by inserting `LAST_INSERT_ID(expr)` into any column or by updating any column to `LAST_INSERT_ID(expr)`.
- If the previous statement returned an error, the value of `mysql_insert_id()` is undefined.

The return value of `mysql_insert_id()` can be simplified to the following sequence:

1. If there is an `AUTO_INCREMENT` column, and an automatically generated value was successfully inserted, return the first such value.
2. If `LAST_INSERT_ID(expr)` occurred in the statement, return `expr`, even if there was an `AUTO_INCREMENT` column in the affected table.
3. The return value varies depending on the statement used. When called after an `INSERT` statement:

   - If there is an `AUTO_INCREMENT` column in the table, and there were some explicit values for this column that were successfully inserted into the table, return the last of the explicit values.

   When called after an `INSERT ... ON DUPLICATE KEY UPDATE` statement:

- If there is an `AUTO_INCREMENT` column in the table and there were some explicit successfully inserted values, or some updated rows, return the last of the inserted or updated values.

`mysql_insert_id()` returns `0` if the previous statement does not use an `AUTO_INCREMENT` value. If you need to save the value for later, be sure to call `mysql_insert_id()` immediately after the statement that generates the value.

The value of `mysql_insert_id()` is affected only by statements issued within the current client connection. It is not affected by statements issued by other clients.

The `LAST_INSERT_ID()` SQL function will contain the value of the first automatically generated value that was successfully inserted. `LAST_INSERT_ID()` is not reset between statements because the value of that function is maintained in the server. Another difference from `mysql_insert_id()` is that `LAST_INSERT_ID()` is not updated if you set an `AUTO_INCREMENT` column to a specific nonspecial value. See Section 11.14, “Information Functions”.

`mysql_insert_id()` returns `0` following a `CALL` statement for a stored procedure that generates an `AUTO_INCREMENT` value because in this case `mysql_insert_id()` applies to `CALL` and not the statement within the procedure. Within the procedure, you can use `LAST_INSERT_ID()` at the SQL level to obtain the `AUTO_INCREMENT` value.

The reason for the differences between `LAST_INSERT_ID()` and `mysql_insert_id()` is that `LAST_INSERT_ID()` is made easy to use in scripts while `mysql_insert_id()` tries to provide more exact information about what happens to the `AUTO_INCREMENT` column.

Return Values

Described in the preceding discussion.

Errors

None.

20.9.3.38. `mysql_kill()`

```
int mysql_kill(MYSQL *mysql, unsigned long pid)
```

Description

Asks the server to kill the thread specified by `pid`.

This function is deprecated. It is preferable to use `mysql_query()` to issue an SQL `KILL` statement instead.

Return Values

Zero for success. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.39. `mysql_library_end()`

```
void mysql_library_end(void)
```

Description

This function finalizes the MySQL library. You should call it when you are done using the library (for example, after disconnecting from the server). The action taken by the call depends on whether your application is linked to the MySQL client library or the MySQL embedded server library. For a client program linked against the `libmysqlclient` library by using the `-lmysqlclient` flag, `mysql_library_end()` performs some memory management to clean up. For an embedded server application linked against the `libmysqld` library by using the `-lmysqld` flag, `mysql_library_end()` shuts down the embedded server and then cleans up.

For usage information, see Section 20.9.2, "C API Function Overview", and Section 20.9.3.40, "`mysql_library_init()`".

20.9.3.40. `mysql_library_init()`

`int mysql_library_init(int argc, char **argv, char **groups)`

Description

This function should be called to initialize the MySQL library before you call any other MySQL function, whether your application is a regular client program or uses the embedded server. If the application uses the embedded server, this call starts the server and initializes any subsystems (`mysys`, `InnoDB`, and so forth) that the server uses.

After your application is done using the MySQL library, call `mysql_library_end()` to clean up. See Section 20.9.3.39, "`mysql_library_end()`".

The choice of whether the application operates as a regular client or uses the embedded server depends on whether you use the `libmysqlclient` or `libmysqld` library at link time to produce the final executable. For additional information, see Section 20.9.2, "C API Function Overview".

In a nonmulti-threaded environment, the call to `mysql_library_init()` may be omitted, because `mysql_init()` will invoke it automatically as necessary. However, `mysql_library_init()` is not thread-safe in a multi-threaded environment, and thus neither is `mysql_init()`, which calls `mysql_library_init()`. You must either call `mysql_library_init()` prior to spawning any threads, or else use a mutex to protect the call, whether you invoke `mysql_library_init()` or indirectly through `mysql_init()`. This should be done prior to any other client library call.

The `argc` and `argv` arguments are analogous to the arguments to `main()`, and enable passing of options to the embedded server. For convenience, `argc` may be `0` (zero) if there are no command-line arguments for the server. This is the usual case for applications intended for use only as regular (nonembedded) clients, and the call typically is written as `mysql_library_init(0, NULL, NULL)`.

```
#include <mysql.h>
#include <stdlib.h>

int main(void) {
  if (mysql_library_init(0, NULL, NULL)) {
    fprintf(stderr, "could not initialize MySQL library\n");
    exit(1);
  }

  /* Use any MySQL API functions here */

  mysql_library_end();

  return EXIT_SUCCESS;
}
```

When arguments are to be passed (`argc` is greater than `0`), the first element of `argv` is ignored (it typically contains the program name). `mysql_library_init()` makes a copy of the arguments so it is safe to destroy `argv` or `groups` after the call.

For embedded applications, if you want to connect to an external server without starting the embedded server, you have to specify a negative value for `argc`.

The `groups` argument should be an array of strings that indicate the groups in option files from which options should be read. See Section 4.2.3.3, "Using Option Files". The final entry in the array should be `NULL`. For convenience, if the `groups` argument itself is `NULL`, the `[server]` and `[embedded]` groups are used by default.

```
#include <mysql.h>
#include <stdlib.h>

static char *server_args[] = {
  "this_program",       /* this string is not used */
  "--datadir=.",
  "--key_buffer_size=32M"
};
static char *server_groups[] = {
  "embedded",
  "server",
  "this_program_SERVER",
  (char *)NULL
};

int main(void) {
  if (mysql_library_init(sizeof(server_args) / sizeof(char *),
                        server_args, server_groups)) {
    fprintf(stderr, "could not initialize MySQL library\n");
    exit(1);
  }

  /* Use any MySQL API functions here */

  mysql_library_end();

  return EXIT_SUCCESS;
}
```

Return Values

Zero if successful. Nonzero if an error occurred.

20.9.3.41. `mysql_list_dbs()`

`MYSQL_RES *mysql_list_dbs(MYSQL *mysql, const char *wild)`

Description

Returns a result set consisting of database names on the server that match the simple regular expression specified by the `wild` parameter. `wild` may contain the wildcard characters “`%`” or “`_`”, or may be a `NULL` pointer to match all databases. Calling `mysql_list_dbs()` is similar to executing the query `SHOW DATABASES [LIKE *wild*]`.

You must free the result set with `mysql_free_result()`.

Return Values

A `MYSQL_RES` result set for success. `NULL` if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_OUT_OF_MEMORY`

  Out of memory.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.42. `mysql_list_fields()`

`MYSQL_RES *mysql_list_fields(MYSQL *mysql, const char *table, const char *wild)`

Description

Returns a result set consisting of field names in the given table that match the simple regular expression specified by the `wild` parameter. `wild` may contain the wildcard characters “`%`” or “`_`”, or may be a `NULL` pointer to match all fields. Calling `mysql_list_fields()` is similar to executing the query `SHOW COLUMNS FROM *tbl_name* [LIKE *wild*]`.

It is preferable to use `SHOW COLUMNS FROM *tbl_name*` instead of `mysql_list_fields()`.

You must free the result set with `mysql_free_result()`.

Return Values

A `MYSQL_RES` result set for success. `NULL` if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.43. `mysql_list_processes()`

`MYSQL_RES *mysql_list_processes(MYSQL *mysql)`

Description

Returns a result set describing the current server threads. This is the same kind of information as that reported by `mysqladmin processlist` or a `SHOW PROCESSLIST` query.

You must free the result set with `mysql_free_result()`.

Return Values

A `MYSQL_RES` result set for success. `NULL` if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.44. `mysql_list_tables()`

`MYSQL_RES *mysql_list_tables(MYSQL *mysql, const char *wild)`

Description

Returns a result set consisting of table names in the current database that match the simple regular expression specified by the `wild` parameter. `wild` may contain the wildcard characters “`%`” or “`_`”, or may be a `NULL` pointer to match all tables. Calling `mysql_list_tables()` is similar to executing the query `SHOW TABLES [LIKE wild]`.

You must free the result set with `mysql_free_result()`.

Return Values

A `MYSQL_RES` result set for success. `NULL` if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.45. `mysql_more_results()`

`my_bool mysql_more_results(MYSQL *mysql)`

Description

This function is used when you execute multiple statements specified as a single statement string, or when you execute `CALL` statements, which can return multiple result sets.

`mysql_more_results()` true if more results exist from the currently executed statement, in which case the application must call `mysql_next_result()` to fetch the results.

Return Values

`TRUE` (1) if more results exist. `FALSE` (0) if no more results exist.

In most cases, you can call `mysql_next_result()` instead to test whether more results exist and initiate retrieval if so.

See Section 20.9.13, “C API Support for Multiple Statement Execution”, and Section 20.9.3.46, “`mysql_next_result()`”.

Errors

None.

20.9.3.46. `mysql_next_result()`

`int mysql_next_result(MYSQL *mysql)`

Description

This function is used when you execute multiple statements specified as a single statement string, or when you use `CALL` statements to execute stored procedures, which can return multiple result sets.

`mysql_next_result()` reads the next statement result and returns a status to indicate whether more results exist. If `mysql_next_result()` returns an error, there are no more results.

Before each call to `mysql_next_result()`, you must call `mysql_free_result()` for the current statement if it is a statement that returned a result set (rather than just a result status).

After calling `mysql_next_result()` the state of the connection is as if you had called `mysql_real_query()` or `mysql_query()` for the next statement. This means that you can call `mysql_store_result()`, `mysql_warning_count()`, `mysql_affected_rows()`, and so forth.

If your program uses `CALL` statements to execute stored procedures, the `CLIENT_MULTI_RESULTS` flag must be enabled. This is because each `CALL` returns a result to indicate the call status, in addition to any result sets that might be returned by statements executed within the procedure. Because `CALL` can return multiple results, you should process them using a loop that calls `mysql_next_result()` to determine whether there are more results.

`CLIENT_MULTI_RESULTS` can be enabled when you call `mysql_real_connect()`, either explicitly by passing the `CLIENT_MULTI_RESULTS` flag itself, or implicitly by passing `CLIENT_MULTI_STATEMENTS` (which also enables `CLIENT_MULTI_RESULTS`). As of MySQL 5.5.3, `CLIENT_MULTI_RESULTS` is enabled by default.

It is also possible to test whether there are more results by calling `mysql_more_results()`. However, this function does not change the connection state, so if it returns true, you must still call `mysql_next_result()` to advance to the next result.

For an example that shows how to use `mysql_next_result()`, see Section 20.9.13, "C API Support for Multiple Statement Execution".

Return Values

Return Value	Description
0	Successful and there are more results
-1	Successful and there are no more results
>0	An error occurred

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order. For example, if you didn't call `mysql_use_result()` for a previous result set.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.47. `mysql_num_fields()`

`unsigned int mysql_num_fields(MYSQL_RES *result)`

To pass a `MYSQL*` argument instead, use `unsigned int mysql_field_count(MYSQL *mysql)`.

Description

Returns the number of columns in a result set.

Note that you can get the number of columns either from a pointer to a result set or to a connection handle. You would use the connection handle if `mysql_store_result()` or `mysql_use_result()` returned `NULL` (and thus you have no result set pointer). In this case, you can call `mysql_field_count()` to determine whether `mysql_store_result()` should have produced a nonempty result. This enables the client program to take proper action without knowing whether the query was a `SELECT` (or `SELECT`-like) statement. The example shown here illustrates how this may be done.

See Section 20.9.11.1, "Why `mysql_store_result()` Sometimes Returns `NULL` After `mysql_query()` Returns Success".

Return Values

An unsigned integer representing the number of columns in a result set.

Errors

None.

Example

```
MYSQL_RES *result;
unsigned int num_fields;
unsigned int num_rows;

if (mysql_query(&mysql,query_string))
{
    // error
}
else // query succeeded, process any data returned by it
{
    result = mysql_store_result(&mysql);
    if (result)  // there are rows
    {
        num_fields = mysql_num_fields(result);
        // retrieve rows, then call mysql_free_result(result)
    }
    else  // mysql_store_result() returned nothing; should it have?
    {
        if (mysql_errno(&mysql))
        {
           fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
        }
        else if (mysql_field_count(&mysql) == 0)
        {
            // query does not return data
            // (it was not a SELECT)
            num_rows = mysql_affected_rows(&mysql);
        }
    }
}
```

An alternative (if you know that your query should have returned a result set) is to replace the `mysql_errno(&mysql)` call with a check whether `mysql_field_count(&mysql)` returns 0. This happens only if something went wrong.

20.9.3.48. `mysql_num_rows()`

`my_ulonglong mysql_num_rows(MYSQL_RES *result)`

Description

Returns the number of rows in the result set.

The use of `mysql_num_rows()` depends on whether you use `mysql_store_result()` or `mysql_use_result()` to return the result set. If you use `mysql_store_result()`, `mysql_num_rows()` may be called immediately. If you use `mysql_use_result()`, `mysql_num_rows()` does not return the correct value until all the rows in the result set have been retrieved.

`mysql_num_rows()` is intended for use with statements that return a result set, such as `SELECT`. For statements such as `INSERT`, `UPDATE`, or `DELETE`, the number of affected rows can be obtained with `mysql_affected_rows()`.

Return Values

The number of rows in the result set.

Errors

None.

20.9.3.49. `mysql_options()`

`int mysql_options(MYSQL *mysql, enum mysql_option option, const void *arg)`

Description

Can be used to set extra connect options and affect behavior for a connection. This function may be called multiple times to set several options.

`mysql_options()` should be called after `mysql_init()` and before `mysql_connect()` or `mysql_real_connect()`.

The `option` argument is the option that you want to set; the `arg` argument is the value for the option. If the option is an integer, `arg` should point to the value of the integer.

The following list describes the possible options, their effect, and how `arg` is used for each option. Several of the options apply only when the application is linked against the `libmysqld` embedded server library and are unused for applications linked against the `libmysql` client library. For option descriptions that indicate `arg` is unused, its value is irrelevant; it is conventional to pass 0.

- `MYSQL_DEFAULT_AUTH` (argument type: `char *`)

  The name of the authentication plugin to use. This option was added in MySQL 5.5.7.

- `MYSQL_INIT_COMMAND` (argument type: `char *`)

  SQL statement to execute when connecting to the MySQL server. Automatically re-executed if reconnection occurs.

- `MYSQL_OPT_COMPRESS` (argument: not used)

  Use the compressed client/server protocol.

- `MYSQL_OPT_CONNECT_TIMEOUT` (argument type: `unsigned int *`)

  Connect timeout in seconds.

- `MYSQL_OPT_GUESS_CONNECTION` (argument: not used)

  For an application linked against the `libmysqld` embedded server library, this enables the library to guess whether to use the embedded server or a remote server. “Guess” means that if the host name is set and is not `localhost`, it uses a remote server. This behavior is the default. `MYSQL_OPT_USE_EMBEDDED_CONNECTION` and `MYSQL_OPT_USE_REMOTE_CONNECTION` can be used to override it. This option is ignored for applications linked against the `libmysqlclient` client library.

- `MYSQL_OPT_LOCAL_INFILE` (argument type: optional pointer to `unsigned int`)

  If no pointer is given or if pointer points to an `unsigned int` that has a nonzero value, the `LOAD LOCAL INFILE` statement is enabled.

- `MYSQL_OPT_NAMED_PIPE` (argument: not used)

  Use named pipes to connect to a MySQL server on Windows, if the server permits named-pipe connections.

- `MYSQL_OPT_PROTOCOL` (argument type: `unsigned int *`)

  Type of protocol to use. Should be one of the enum values of `mysql_protocol_type` defined in `mysql.h`.

- `MYSQL_OPT_READ_TIMEOUT` (argument type: `unsigned int *`)

  The timeout in seconds for attempts to read from the server. Each attempt uses this timeout value and there are retries if necessary, so the total effective timeout value is three times the option value. You can set the value so that a lost connection can be detected earlier than the TCP/IP `Close_Wait_Timeout` value of 10 minutes.

- `MYSQL_OPT_RECONNECT` (argument type: `my_bool *`)

  Enable or disable automatic reconnection to the server if the connection is found to have been lost. Reconnect is off by default; this option provides a way to set reconnection behavior explicitly.

- `MYSQL_PLUGIN_DIR` (argument type: `char *`)

  The directory in which to look for client plugins. This option was added in MySQL 5.5.7.

- `MYSQL_SET_CLIENT_IP` (argument type: `char *`)

  For an application linked against the `libmysqld` embedded server library (when `libmysqld` is compiled with authentication support), this means that the user is considered to have connected from the specified IP address (specified as a string) for authentication purposes. This option is ignored for applications linked against the `libmysqlclient` client library.

- `MYSQL_OPT_SSL_VERIFY_SERVER_CERT` (argument type: `my_bool *`)

  Enable or disable verification of the server's Common Name value in its certificate against the host name used when connecting to the server. The connection is rejected if there is a mismatch. This feature can be used to prevent man-in-the-middle attacks. Verification is disabled by default.

- `MYSQL_OPT_USE_EMBEDDED_CONNECTION` (argument: not used)

  For an application linked against the `libmysqld` embedded server library, this forces the use of the embedded server for the connection. This option is ignored for applications linked against the `libmysqlclient` client library.

- `MYSQL_OPT_USE_REMOTE_CONNECTION` (argument: not used)

  For an application linked against the `libmysqld` embedded server library, this forces the use of a remote server for the connection. This option is ignored for applications linked against the `libmysqlclient` client library.

- `MYSQL_OPT_USE_RESULT` (argument: not used)

  This option is unused.

- `MYSQL_OPT_WRITE_TIMEOUT` (argument type: `unsigned int *`)

  The timeout in seconds for attempts to write to the server. Each attempt uses this timeout value and there are `net_retry_count` retries if necessary, so the total effective timeout value is `net_retry_count` times the option value.

- `MYSQL_READ_DEFAULT_FILE` (argument type: `char *`)

  Read options from the named option file instead of from `my.cnf`.

- `MYSQL_READ_DEFAULT_GROUP` (argument type: `char *`)

  Read options from the named group from `my.cnf` or the file specified with `MYSQL_READ_DEFAULT_FILE`.

- `MYSQL_REPORT_DATA_TRUNCATION` (argument type: `my_bool *`)

  Enable or disable reporting of data truncation errors for prepared statements using the `error` member of `MYSQL_BIND` structures. (Default: enabled.)

- `MYSQL_SECURE_AUTH` (argument type: `my_bool *`)

  Whether to connect to a server that does not support the password hashing used in MySQL 4.1.1 and later.

- `MYSQL_SET_CHARSET_DIR` (argument type: `char *`)

  The path name to the directory that contains character set definition files.

- `MYSQL_SET_CHARSET_NAME` (argument type: `char *`)

  The name of the character set to use as the default character set. The argument can be `MYSQL_AUTODETECT_CHARSET_NAME` to cause the character set to be autodetected based on the operating system setting (see Section 9.1.4, “Connection Character Sets and Collations”).

- `MYSQL_SHARED_MEMORY_BASE_NAME` (argument type: `char *`)

  The name of the shared-memory object for communication to the server on Windows, if the server supports shared-memory connections. Should have the same value as the `--shared-memory-base-name` option used for the `mysqld` server you want to connect to.

The `client` group is always read if you use `MYSQL_READ_DEFAULT_FILE` or `MYSQL_READ_DEFAULT_GROUP`.

The specified group in the option file may contain the following options.

Option	**Description**
`character-sets-dir=`*`path`*	The directory where character sets are installed.
`compress`	Use the compressed client/server protocol.
`connect-timeout=`*`seconds`*	Connect timeout in seconds. On Linux this timeout is also used for waiting for the first answer from the server.
`database=`*`db_name`*	Connect to this database if no database was specified in the connect command.
`debug`	Debug options.
`default-character-set=`*`charset_name`*	The default character set to use.
`disable-local-infile`	Disable use of `LOAD DATA LOCAL`.
`host=`*`host_name`*	Default host name.
`init-command=`*`stmt`*	Statement to execute when connecting to MySQL server. Automatically re-executed if reconnection occurs.
`interactive-timeout=`*`seconds`*	Same as specifying `CLIENT_INTERACTIVE` to `mysql_real_connect()`. See Section 20.9.3.52, “`mysql_real_connect()`”.
`local-infile[={0|1}]`	If no argument or nonzero argument, enable use of `LOAD DATA LOCAL`; otherwise disable.

Option	Description
`max_allowed_packet=bytes`	Maximum size of packet that client can read from server.
`multi-queries`, `multi-results`	Enable multiple result sets from multiple-statement executions or stored procedures.
`multi-statements`	Enable the client to send multiple statements in a single string (separated by “`;`”).
`password=password`	Default password.
`pipe`	Use named pipes to connect to a MySQL server on Windows.
`port=port_num`	Default port number.
`protocol={TCP|SOCKET|PIPE|MEMORY}`	The protocol to use when connecting to the server.
`return-found-rows`	Tell `mysql_info()` to return found rows instead of updated rows when using `UPDATE`.
`shared-memory-base-name=name`	Shared-memory name to use to connect to server.
`socket=path`	Default socket file.
`ssl-ca=file_name`	Certificate Authority file.
`ssl-capath=path`	Certificate Authority directory.
`ssl-cert=file_name`	Certificate file.
`ssl-cipher=cipher_list`	Permissible SSL ciphers.
`ssl-key=file_name`	Key file.
`timeout=seconds`	Like `connect-timeout`.
`user`	Default user.

`timeout` has been replaced by `connect-timeout`, but `timeout` is still supported in MySQL 5.5 for backward compatibility.

For more information about option files, see Section 4.2.3.3, “Using Option Files”.

Return Values

Zero for success. Nonzero if you specify an unknown option.

Example

The following `mysql_options()` calls request the use of compression in the client/server protocol, cause options to be read from the `[odbc]` group of option files, and disable transaction autocommit mode:

```
MYSQL mysql;

mysql_init(&mysql);
mysql_options(&mysql,MYSQL_OPT_COMPRESS,0);
mysql_options(&mysql,MYSQL_READ_DEFAULT_GROUP,"odbc");
mysql_options(&mysql,MYSQL_INIT_COMMAND,"SET autocommit=0");
if (!mysql_real_connect(&mysql,"host","user","passwd","database",0,NULL,0))
{
    fprintf(stderr, "Failed to connect to database: Error: %s\n",
          mysql_error(&mysql));
}
```

This code requests that the client use the compressed client/server protocol and read the additional options from the `odbc` section in the `my.cnf` file.

20.9.3.50. `mysql_ping()`

`int mysql_ping(MYSQL *mysql)`

Description

Checks whether the connection to the server is working. If the connection has gone down and auto-reconnect is enabled an attempt to reconnect is made. If the connection is down and auto-reconnect is disabled, `mysql_ping()` returns an error.

Auto-reconnect is disabled by default. To enable it, call `mysql_options()` with the `MYSQL_OPT_RECONNECT` option. For details, see Section 20.9.3.49, “`mysql_options()`”.

`mysql_ping()` can be used by clients that remain idle for a long while, to check whether the server has closed the connection and reconnect if necessary.

If `mysql_ping()`) does cause a reconnect, there is no explicit indication of it. To determine whether a reconnect occurs, call `mysql_thread_id()` to get the original connection identifier before calling `mysql_ping()`, then call `mysql_thread_id()` again to see whether the identifier has changed.

If reconnect occurs, some characteristics of the connection will have been reset. For details about these characteristics, see Section 20.9.12, "Controlling Automatic Reconnection Behavior".

Return Values

Zero if the connection to the server is active. Nonzero if an error occurred. A nonzero return does not indicate whether the MySQL server itself is down; the connection might be broken for other reasons such as network problems.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.51. `mysql_query()`

```
int mysql_query(MYSQL *mysql, const char *stmt_str)
```

Description

Executes the SQL statement pointed to by the null-terminated string `stmt_str`. Normally, the string must consist of a single SQL statement and you should not add a terminating semicolon ("`;`") or `\g` to the statement. If multiple-statement execution has been enabled, the string can contain several statements separated by semicolons. See Section 20.9.13, "C API Support for Multiple Statement Execution".

`mysql_query()` cannot be used for statements that contain binary data; you must use `mysql_real_query()` instead. (Binary data may contain the "`\0`" character, which `mysql_query()` interprets as the end of the statement string.)

If you want to know whether the statement should return a result set, you can use `mysql_field_count()` to check for this. See Section 20.9.3.22, "`mysql_field_count()`".

Return Values

Zero if the statement was successful. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.52. `mysql_real_connect()`

`MYSQL *mysql_real_connect(MYSQL *mysql, const char *host, const char *user, const char *passwd, const char *db, unsigned int port, const char *unix_socket, unsigned long client_flag)`

Description

`mysql_real_connect()` attempts to establish a connection to a MySQL database engine running on `host`. `mysql_real_connect()` must complete successfully before you can execute any other API functions that require a valid `MYSQL` connection handle structure.

The parameters are specified as follows:

- The first parameter should be the address of an existing `MYSQL` structure. Before calling `mysql_real_connect()` you must call `mysql_init()` to initialize the `MYSQL` structure. You can change a lot of connect options with the `mysql_options()` call. See Section 20.9.3.49, "`mysql_options()`".
- The value of `host` may be either a host name or an IP address. If `host` is `NULL` or the string `"localhost"`, a connection to the local host is assumed: For Windows, the client connects using a shared-memory connection, if the server has shared-memory connections enabled. Otherwise, TCP/IP is used. For Unix, the client connects using a Unix socket file. For local connections, you can also influence the type of connection to use with the `MYSQL_OPT_PROTOCOL` or `MYSQL_OPT_NAMED_PIPE` options to `mysql_options()`. The type of connection must be supported by the server. For a `host` value of `"."` on Windows, the client connects using a named pipe, if the server has named-pipe connections enabled. If named-pipe connections are not enabled, an error occurs.
- The `user` parameter contains the user's MySQL login ID. If `user` is `NULL` or the empty string `""`, the current user is assumed. Under Unix, this is the current login name. Under Windows ODBC, the current user name must be specified explicitly. See the MyODBC section of Chapter 20, *Connectors and APIs*.
- The `passwd` parameter contains the password for `user`. If `passwd` is `NULL`, only entries in the `user` table for the user that have a blank (empty) password field are checked for a match. This enables the database administrator to set up the MySQL privilege system in such a way that users get different privileges depending on whether they have specified a password.

> **Note**
>
> Do not attempt to encrypt the password before calling `mysql_real_connect()`; password encryption is handled automatically by the client API.

- The `user` and `passwd` parameters use whatever character set has been configured for the `MYSQL` object. By default, this is `latin1`, but can be changed by calling `mysql_options(mysql, MYSQL_SET_CHARSET_NAME, "charset_name")` prior to connecting.
- `db` is the database name. If `db` is not `NULL`, the connection sets the default database to this value.
- If `port` is not 0, the value is used as the port number for the TCP/IP connection. Note that the `host` parameter determines the type of the connection.
- If `unix_socket` is not `NULL`, the string specifies the socket or named pipe that should be used. Note that the `host` parameter determines the type of the connection.
- The value of `client_flag` is usually 0, but can be set to a combination of the following flags to enable certain features.

Flag Name	Flag Description
`CLIENT_COMPRESS`	Use compression protocol.
`CLIENT_FOUND_ROWS`	Return the number of found (matched) rows, not the number of changed rows.
`CLIENT_IGNORE_SIGPIPE`	Prevents the client library from installing a `SIGPIPE` signal handler. This can be used to avoid conflicts with a handler that the application has already installed.
`CLIENT_IGNORE_SPACE`	Permit spaces after function names. Makes all functions names reserved words.
`CLIENT_INTERACTIVE`	Permit `interactive_timeout` seconds (instead of `wait_timeout` seconds) of inactivity before closing the connection. The client's session `wait_timeout` variable is set to the value of the session `interactive_timeout` variable.
`CLIENT_LOCAL_FILES`	Enable `LOAD DATA LOCAL` handling.
`CLIENT_MULTI_RESULTS`	Tell the server that the client can handle multiple result sets from multiple-statement executions or stored procedures. This flag is automatically enabled if `CLIENT_MULTI_STATEMENTS` is enabled. See the note following this table for more information about this flag.
`CLIENT_MULTI_STATEMENTS`	Tell the server that the client may send multiple statements in a single string

Flag Name	Flag Description
	(separated by “`;`”). If this flag is not set, multiple-statement execution is disabled. See the note following this table for more information about this flag.
`CLIENT_NO_SCHEMA`	Do not permit the *`db_name.tbl_name.col_name`* syntax. This is for ODBC. It causes the parser to generate an error if you use that syntax, which is useful for trapping bugs in some ODBC programs.
`CLIENT_ODBC`	Unused.
`CLIENT_SSL`	Use SSL (encrypted protocol). This option should not be set by application programs; it is set internally in the client library. Instead, use `mysql_ssl_set()` before calling `mysql_real_connect()`.
`CLIENT_REMEMBER_OPTIONS`	Remember options specified by calls to `mysql_options()`. Without this option, if `mysql_real_connect()` fails, you must repeat the `mysql_options()` calls before trying to connect again. With this option, the `mysql_options()` calls need not be repeated.

If your program uses `CALL` statements to execute stored procedures, the `CLIENT_MULTI_RESULTS` flag must be enabled. This is because each `CALL` returns a result to indicate the call status, in addition to any result sets that might be returned by statements executed within the procedure. Because `CALL` can return multiple results, you should process them using a loop that calls `mysql_next_result()` to determine whether there are more results.

`CLIENT_MULTI_RESULTS` can be enabled when you call `mysql_real_connect()`, either explicitly by passing the `CLIENT_MULTI_RESULTS` flag itself, or implicitly by passing `CLIENT_MULTI_STATEMENTS` (which also enables `CLIENT_MULTI_RESULTS`). As of MySQL 5.5.3, `CLIENT_MULTI_RESULTS` is enabled by default.

If you enable `CLIENT_MULTI_STATEMENTS` or `CLIENT_MULTI_RESULTS`, you should process the result for every call to `mysql_query()` or `mysql_real_query()` by using a loop that calls `mysql_next_result()` to determine whether there are more results. For an example, see Section 20.9.13, “C API Support for Multiple Statement Execution”.

For some parameters, it is possible to have the value taken from an option file rather than from an explicit value in the `mysql_real_connect()` call. To do this, call `mysql_options()` with the `MYSQL_READ_DEFAULT_FILE` or `MYSQL_READ_DEFAULT_GROUP` option before calling `mysql_real_connect()`. Then, in the `mysql_real_connect()` call, specify the “no-value” value for each parameter to be read from an option file:

- For `host`, specify a value of `NULL` or the empty string (`""`).
- For `user`, specify a value of `NULL` or the empty string.
- For `passwd`, specify a value of `NULL`. (For the password, a value of the empty string in the `mysql_real_connect()` call cannot be overridden in an option file, because the empty string indicates explicitly that the MySQL account must have an empty password.)
- For `db`, specify a value of `NULL` or the empty string.
- For `port`, specify a value of 0.
- For `unix_socket`, specify a value of `NULL`.

If no value is found in an option file for a parameter, its default value is used as indicated in the descriptions given earlier in this section.

Return Values

A `MYSQL*` connection handle if the connection was successful, `NULL` if the connection was unsuccessful. For a successful connection, the return value is the same as the value of the first parameter.

Errors

- `CR_CONN_HOST_ERROR`

  Failed to connect to the MySQL server.

- `CR_CONNECTION_ERROR`

Failed to connect to the local MySQL server.

- `CR_IPSOCK_ERROR`

  Failed to create an IP socket.

- `CR_OUT_OF_MEMORY`

  Out of memory.

- `CR_SOCKET_CREATE_ERROR`

  Failed to create a Unix socket.

- `CR_UNKNOWN_HOST`

  Failed to find the IP address for the host name.

- `CR_VERSION_ERROR`

  A protocol mismatch resulted from attempting to connect to a server with a client library that uses a different protocol version.

- `CR_NAMEDPIPEOPEN_ERROR`

  Failed to create a named pipe on Windows.

- `CR_NAMEDPIPEWAIT_ERROR`

  Failed to wait for a named pipe on Windows.

- `CR_NAMEDPIPESETSTATE_ERROR`

  Failed to get a pipe handler on Windows.

- `CR_SERVER_LOST`

  If `connect_timeout` > 0 and it took longer than `connect_timeout` seconds to connect to the server or if the server died while executing the `init-command`.

- `CR_ALREADY_CONNECTED`

  The `MYSQL` connection handle is already connected.

Example

```
MYSQL mysql;

mysql_init(&mysql);
mysql_options(&mysql,MYSQL_READ_DEFAULT_GROUP,"your_prog_name");
if (!mysql_real_connect(&mysql,"host","user","passwd","database",0,NULL,0))
{
    fprintf(stderr, "Failed to connect to database: Error: %s\n",
          mysql_error(&mysql));
}
```

By using `mysql_options()` the MySQL library reads the `[client]` and `[your_prog_name]` sections in the `my.cnf` file which ensures that your program works, even if someone has set up MySQL in some nonstandard way.

Note that upon connection, `mysql_real_connect()` sets the `reconnect` flag (part of the `MYSQL` structure) to a value of `1` in versions of the API older than 5.0.3, or `0` in newer versions. A value of `1` for this flag indicates that if a statement cannot be performed because of a lost connection, to try reconnecting to the server before giving up. You can use the `MYSQL_OPT_RECONNECT` option to `mysql_options()` to control reconnection behavior.

20.9.3.53. `mysql_real_escape_string()`

`unsigned long mysql_real_escape_string(MYSQL *mysql, char *to, const char *from, unsigned long length)`

Note that `mysql` must be a valid, open connection. This is needed because the escaping depends on the character set in use by the server.

Description

This function is used to create a legal SQL string that you can use in an SQL statement. See Section 8.1.1, “Strings”.

The string in `from` is encoded to an escaped SQL string, taking into account the current character set of the connection. The result is placed in `to` and a terminating null byte is appended. Characters encoded are “`\`”, “`'`”, “`"`”, `NUL` (ASCII 0), “`\n`”, “`\r`”, and Control+Z. Strictly speaking, MySQL requires only that backslash and the quote character used to quote the string in the query be escaped. `mysql_real_escape_string()` quotes the other characters to make them easier to read in log files. For comparison, see the quoting rules for literal strings and the `QUOTE()` SQL function in Section 8.1.1, “Strings”, and Section 11.5, “String Functions”.

The string pointed to by `from` must be `length` bytes long. You must allocate the `to` buffer to be at least `length*2+1` bytes long. (In the worst case, each character may need to be encoded as using two bytes, and you need room for the terminating null byte.) When `mysql_real_escape_string()` returns, the contents of `to` is a null-terminated string. The return value is the length of the encoded string, not including the terminating null character.

If you need to change the character set of the connection, you should use the `mysql_set_character_set()` function rather than executing a `SET NAMES` (or `SET CHARACTER SET`) statement. `mysql_set_character_set()` works like `SET NAMES` but also affects the character set used by `mysql_real_escape_string()`, which `SET NAMES` does not.

Example

```
char query[1000],*end;

end = strmov(query,"INSERT INTO test_table values(");
*end++ = '\'';
end += mysql_real_escape_string(&mysql, end,"What is this",12);
*end++ = '\'';
*end++ = ',';
*end++ = '\'';
end += mysql_real_escape_string(&mysql, end,"binary data: \0\r\n",16);
*end++ = '\'';
*end++ = ')';

if (mysql_real_query(&mysql,query,(unsigned int) (end - query)))
{
   fprintf(stderr, "Failed to insert row, Error: %s\n",
           mysql_error(&mysql));
}
```

The `strmov()` function used in the example is included in the `mysqlclient` library and works like `strcpy()` but returns a pointer to the terminating null of the first parameter.

Return Values

The length of the value placed into `to`, not including the terminating null character.

Errors

None.

20.9.3.54. `mysql_real_query()`

`int mysql_real_query(MYSQL *mysql, const char *stmt_str, unsigned long length)`

Description

Executes the SQL statement pointed to by `stmt_str`, which should be a string `length` bytes long. Normally, the string must consist of a single SQL statement and you should not add a terminating semicolon (“`;`”) or `\g` to the statement. If multiple-statement execution has been enabled, the string can contain several statements separated by semicolons. See Section 20.9.13, “C API Support for Multiple Statement Execution”.

`mysql_query()` cannot be used for statements that contain binary data; you must use `mysql_real_query()` instead. (Binary data may contain the “`\0`” character, which `mysql_query()` interprets as the end of the statement string.) In addition, `mysql_real_query()` is faster than `mysql_query()` because it does not call `strlen()` on the statement string.

If you want to know whether the statement should return a result set, you can use `mysql_field_count()` to check for this. See Section 20.9.3.22, “`mysql_field_count()`”.

Return Values

Zero if the statement was successful. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.55. `mysql_refresh()`

`int mysql_refresh(MYSQL *mysql, unsigned int options)`

Description

This function flushes tables or caches, or resets replication server information. The connected user must have the `RELOAD` privilege.

The `options` argument is a bit mask composed from any combination of the following values. Multiple values can be OR'ed together to perform multiple operations with a single call.

- `REFRESH_GRANT`

  Refresh the grant tables, like `FLUSH PRIVILEGES`.

- `REFRESH_LOG`

  Flush the logs, like `FLUSH LOGS`.

- `REFRESH_TABLES`

  Flush the table cache, like `FLUSH TABLES`.

- `REFRESH_HOSTS`

  Flush the host cache, like `FLUSH HOSTS`.

- `REFRESH_STATUS`

  Reset status variables, like `FLUSH STATUS`.

- `REFRESH_THREADS`

  Flush the thread cache.

- `REFRESH_SLAVE`

  On a slave replication server, reset the master server information and restart the slave, like `RESET SLAVE`.

- `REFRESH_MASTER`

  On a master replication server, remove the binary log files listed in the binary log index and truncate the index file, like `RESET MASTER`.

Return Values

Zero for success. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.56. `mysql_reload()`

`int mysql_reload(MYSQL *mysql)`

Description

Asks the MySQL server to reload the grant tables. The connected user must have the `RELOAD` privilege.

This function is deprecated. It is preferable to use `mysql_query()` to issue an SQL `FLUSH PRIVILEGES` statement instead.

Return Values

Zero for success. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.57. `mysql_rollback()`

`my_bool mysql_rollback(MYSQL *mysql)`

Description

Rolls back the current transaction.

The action of this function is subject to the value of the `completion_type` system variable. In particular, if the value of `completion_type` is `RELEASE` (or 2), the server performs a release after terminating a transaction and closes the client connection. The client program should call `mysql_close()` to close the connection from the client side.

Return Values

Zero if successful. Nonzero if an error occurred.

Errors

None.

20.9.3.58. `mysql_row_seek()`

`MYSQL_ROW_OFFSET mysql_row_seek(MYSQL_RES *result, MYSQL_ROW_OFFSET offset)`

Description

Sets the row cursor to an arbitrary row in a query result set. The `offset` value is a row offset that should be a value returned from `mysql_row_tell()` or from `mysql_row_seek()`. This value is not a row number; if you want to seek to a row within a result set by number, use `mysql_data_seek()` instead.

This function requires that the result set structure contains the entire result of the query, so `mysql_row_seek()` may be used only in conjunction with `mysql_store_result()`, not with `mysql_use_result()`.

Return Values

The previous value of the row cursor. This value may be passed to a subsequent call to `mysql_row_seek()`.

Errors

None.

20.9.3.59. `mysql_row_tell()`

`MYSQL_ROW_OFFSET mysql_row_tell(MYSQL_RES *result)`

Description

Returns the current position of the row cursor for the last `mysql_fetch_row()`. This value can be used as an argument to `mysql_row_seek()`.

You should use `mysql_row_tell()` only after `mysql_store_result()`, not after `mysql_use_result()`.

Return Values

The current offset of the row cursor.

Errors

None.

20.9.3.60. `mysql_select_db()`

`int mysql_select_db(MYSQL *mysql, const char *db)`

Description

Causes the database specified by `db` to become the default (current) database on the connection specified by `mysql`. In subsequent queries, this database is the default for table references that do not include an explicit database specifier.

`mysql_select_db()` fails unless the connected user can be authenticated as having permission to use the database.

Return Values

Zero for success. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.61. `mysql_set_character_set()`

`int mysql_set_character_set(MYSQL *mysql, const char *csname)`

Description

This function is used to set the default character set for the current connection. The string `csname` specifies a valid character set name. The connection collation becomes the default collation of the character set. This function works like the `SET NAMES` statement, but also sets the value of `mysql->charset`, and thus affects the character set used by `mysql_real_escape_string()`

Return Values

Zero for success. Nonzero if an error occurred.

Example

```
MYSQL mysql;

mysql_init(&mysql);
if (!mysql_real_connect(&mysql,"host","user","passwd","database",0,NULL,0))
{
    fprintf(stderr, "Failed to connect to database: Error: %s\n",
          mysql_error(&mysql));
}

if (!mysql_set_character_set(&mysql, "utf8"))
{
    printf("New client character set: %s\n",
           mysql_character_set_name(&mysql));
}
```

20.9.3.62. `mysql_set_local_infile_default()`

`void mysql_set_local_infile_default(MYSQL *mysql);`

Description

Sets the `LOAD LOCAL DATA INFILE` handler callback functions to the defaults used internally by the C client library. The library calls this function automatically if `mysql_set_local_infile_handler()` has not been called or does not supply valid functions for each of its callbacks.

Return Values

None.

Errors

None.

20.9.3.63. `mysql_set_local_infile_handler()`

`void mysql_set_local_infile_handler(MYSQL *mysql, int (*local_infile_init)(void **, const char *, void *), int (*local_infile_read)(void *, char *, unsigned int), void (*local_infile_end)(void *), int (*local_infile_error)(void *, char*, unsigned int), void *userdata);`

Description

This function installs callbacks to be used during the execution of `LOAD DATA LOCAL INFILE` statements. It enables application programs to exert control over local (client-side) data file reading. The arguments are the connection handler, a set of pointers to callback functions, and a pointer to a data area that the callbacks can use to share information.

To use `mysql_set_local_infile_handler()`, you must write the following callback functions:

```
int
local_infile_init(void **ptr, const char *filename, void *userdata);
```

The initialization function. This is called once to do any setup necessary, open the data file, allocate data structures, and so forth. The first `void**` argument is a pointer to a pointer. You can set the pointer (that is, `*ptr`) to a value that will be passed to each of the other callbacks (as a `void*`). The callbacks can use this pointed-to value to maintain state information. The `userdata` argument is the same value that is passed to `mysql_set_local_infile_handler()`.

The initialization function should return zero for success, nonzero for an error.

```
int
local_infile_read(void *ptr, char *buf, unsigned int buf_len);
```

The data-reading function. This is called repeatedly to read the data file. `buf` points to the buffer where the read data should be stored, and `buf_len` is the maximum number of bytes that the callback can read and store in the buffer. (It can read fewer bytes, but should not read more.)

The return value is the number of bytes read, or zero when no more data could be read (this indicates EOF). Return a value less than zero if an error occurs.

```
void
local_infile_end(void *ptr)
```

The termination function. This is called once after `local_infile_read()` has returned zero (EOF) or an error. This function should deallocate any memory allocated by `local_infile_init()` and perform any other cleanup necessary. It is invoked even if the initialization function returns an error.

```
int
local_infile_error(void *ptr,
                   char *error_msg,
                   unsigned int error_msg_len);
```

The error-handling function. This is called to get a textual error message to return to the user in case any of your other functions returns an error. `error_msg` points to the buffer into which the message should be written, and `error_msg_len` is the length of the buffer. The message should be written as a null-terminated string, so the message can be at most `error_msg_len`–1 bytes long.

The return value is the error number.

Typically, the other callbacks store the error message in the data structure pointed to by `ptr`, so that `local_infile_error()` can copy the message from there into `error_msg`.

After calling `mysql_set_local_infile_handler()` in your C code and passing pointers to your callback functions, you can then issue a `LOAD DATA LOCAL INFILE` statement (for example, by using `mysql_query()`). The client library automatically invokes your callbacks. The file name specified in `LOAD DATA LOCAL INFILE` will be passed as the second parameter to the `local_infile_init()` callback.

Return Values

None.

Errors

None.

20.9.3.64. `mysql_set_server_option()`

`int mysql_set_server_option(MYSQL *mysql, enum enum_mysql_set_option option)`

Description

Enables or disables an option for the connection. `option` can have one of the following values.

Option	Description
`MYSQL_OPTION_MULTI_STATEMENTS_ON`	Enable multiple-statement support
`MYSQL_OPTION_MULTI_STATEMENTS_OFF`	Disable multiple-statement support

If you enable multiple-statement support, you should retrieve results from calls to `mysql_query()` or `mysql_real_query()` by using a loop that calls `mysql_next_result()` to determine whether there are more results. For an example, see Section 20.9.13, “C API Support for Multiple Statement Execution”.

Enabling multiple-statement support with `MYSQL_OPTION_MULTI_STATEMENTS_ON` does not have quite the same effect as enabling it by passing the `CLIENT_MULTI_STATEMENTS` flag to `mysql_real_connect()`: `CLIENT_MULTI_STATEMENTS` also enables `CLIENT_MULTI_RESULTS`. If you are using the `CALL` SQL statement in your programs, multiple-result support must be enabled; this means that `MYSQL_OPTION_MULTI_STATEMENTS_ON` by itself is insufficient to permit the use of `CALL`.

Return Values

Zero for success. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `ER_UNKNOWN_COM_ERROR`

  The server didn't support `mysql_set_server_option()` (which is the case that the server is older than 4.1.1) or the server didn't support the option one tried to set.

20.9.3.65. `mysql_shutdown()`

```
int mysql_shutdown(MYSQL *mysql, enum mysql_enum_shutdown_level shutdown_level)
```

Description

Asks the database server to shut down. The connected user must have the `SHUTDOWN` privilege. MySQL 5.5 servers support only one type of shutdown; `shutdown_level` must be equal to `SHUTDOWN_DEFAULT`. Additional shutdown levels are planned to make it possible to choose the desired level. Dynamically linked executables which have been compiled with older versions of the `libmysqlclient` headers and call `mysql_shutdown()` need to be used with the old `libmysqlclient` dynamic library.

The shutdown process is described in Section 5.1.10, “The Shutdown Process”.

Return Values

Zero for success. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.66. `mysql_sqlstate()`

`const char *mysql_sqlstate(MYSQL *mysql)`

Description

Returns a null-terminated string containing the SQLSTATE error code for the most recently executed SQL statement. The error code consists of five characters. `'00000'` means “no error”. The values are specified by ANSI SQL and ODBC. For a list of possible values, see Appendix C, *Errors, Error Codes, and Common Problems*.

SQLSTATE values returned by `mysql_sqlstate()` differ from MySQL-specific error numbers returned by `mysql_errno()`. For example, the `mysql` client program displays errors using the following format, where `1146` is the `mysql_errno()` value and `'42S02'` is the corresponding `mysql_sqlstate()` value:

```
shell> SELECT * FROM no_such_table;
ERROR 1146 (42S02): Table 'test.no_such_table' doesn't exist
```

Not all MySQL error numbers are mapped to SQLSTATE error codes. The value `'HY000'` (general error) is used for unmapped error numbers.

If you call `mysql_sqlstate()` after `mysql_real_connect()` fails, `mysql_sqlstate()` might not return a useful value. For example, this happens if a host is blocked by the server and the connection is closed without any SQLSTATE value being sent to the client.

Return Values

A null-terminated character string containing the SQLSTATE error code.

See Also

See Section 20.9.3.14, “`mysql_errno()`”, Section 20.9.3.15, “`mysql_error()`”, and Section 20.9.7.27, “`mysql_stmt_sqlstate()`”.

20.9.3.67. `mysql_ssl_set()`

`my_bool mysql_ssl_set(MYSQL *mysql, const char *key, const char *cert, const char *ca, const char *capath, const char *cipher)`

Description

`mysql_ssl_set()` is used for establishing secure connections using SSL. It must be called before `mysql_real_connect()`.

`mysql_ssl_set()` does nothing unless SSL support is enabled in the client library.

`mysql` is the connection handler returned from `mysql_init()`. The other parameters are specified as follows:

- `key` is the path name to the key file.
- `cert` is the path name to the certificate file.
- `ca` is the path name to the certificate authority file.
- `capath` is the path name to a directory that contains trusted SSL CA certificates in pem format.
- `cipher` is a list of permissible ciphers to use for SSL encryption.

Any unused SSL parameters may be given as `NULL`.

Return Values

This function always returns `0`. If SSL setup is incorrect, `mysql_real_connect()` returns an error when you attempt to connect.

20.9.3.68. `mysql_stat()`

`const char *mysql_stat(MYSQL *mysql)`

Description

Returns a character string containing information similar to that provided by the `mysqladmin status` command. This includes uptime in seconds and the number of running threads, questions, reloads, and open tables.

Return Values

A character string describing the server status. `NULL` if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.69. `mysql_store_result()`

`MYSQL_RES *mysql_store_result(MYSQL *mysql)`

Description

After invoking `mysql_query()` or `mysql_real_query()`, you must call `mysql_store_result()` or `mysql_use_result()` for every statement that successfully produces a result set (`SELECT`, `SHOW`, `DESCRIBE`, `EXPLAIN`, `CHECK TABLE`, and so forth). You must also call `mysql_free_result()` after you are done with the result set.

You don't have to call `mysql_store_result()` or `mysql_use_result()` for other statements, but it does not do any harm or cause any notable performance degradation if you call `mysql_store_result()` in all cases. You can detect whether the statement has a result set by checking whether `mysql_store_result()` returns a nonzero value (more about this later on).

If you enable multiple-statement support, you should retrieve results from calls to `mysql_query()` or `mysql_real_query()` by using a loop that calls `mysql_next_result()` to determine whether there are more results. For an example, see Section 20.9.13, “C API Support for Multiple Statement Execution”.

If you want to know whether a statement should return a result set, you can use `mysql_field_count()` to check for this. See Section 20.9.3.22, “`mysql_field_count()`”.

`mysql_store_result()` reads the entire result of a query to the client, allocates a `MYSQL_RES` structure, and places the result into this structure.

`mysql_store_result()` returns a null pointer if the statement didn't return a result set (for example, if it was an `INSERT` statement).

`mysql_store_result()` also returns a null pointer if reading of the result set failed. You can check whether an error occurred by checking whether `mysql_error()` returns a nonempty string, `mysql_errno()` returns nonzero, or `mysql_field_count()` returns zero.

An empty result set is returned if there are no rows returned. (An empty result set differs from a null pointer as a return value.)

After you have called `mysql_store_result()` and gotten back a result that isn't a null pointer, you can call `mysql_num_rows()` to find out how many rows are in the result set.

You can call `mysql_fetch_row()` to fetch rows from the result set, or `mysql_row_seek()` and `mysql_row_tell()` to obtain or set the current row position within the result set.

See Section 20.9.11.1, “Why `mysql_store_result()` Sometimes Returns `NULL` After `mysql_query()` Returns Success”.

Return Values

A `MYSQL_RES` result structure with the results. `NULL` (0) if an error occurred.

Errors

`mysql_store_result()` resets `mysql_error()` and `mysql_errno()` if it succeeds.

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_OUT_OF_MEMORY`

  Out of memory.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.70. `mysql_thread_id()`

`unsigned long mysql_thread_id(MYSQL *mysql)`

Description

Returns the thread ID of the current connection. This value can be used as an argument to `mysql_kill()` to kill the thread.

If the connection is lost and you reconnect with `mysql_ping()`, the thread ID changes. This means you should not get the thread ID and store it for later. You should get it when you need it.

Return Values

The thread ID of the current connection.

Errors

None.

20.9.3.71. `mysql_use_result()`

`MYSQL_RES *mysql_use_result(MYSQL *mysql)`

Description

After invoking `mysql_query()` or `mysql_real_query()`, you must call `mysql_store_result()` or `mysql_use_result()` for every statement that successfully produces a result set (`SELECT`, `SHOW`, `DESCRIBE`, `EXPLAIN`, `CHECK TABLE`, and so forth). You must also call `mysql_free_result()` after you are done with the result set.

`mysql_use_result()` initiates a result set retrieval but does not actually read the result set into the client like `mysql_store_result()` does. Instead, each row must be retrieved individually by making calls to `mysql_fetch_row()`. This reads the result of a query directly from the server without storing it in a temporary table or local buffer, which is somewhat faster and uses much less memory than `mysql_store_result()`. The client allocates memory only for the current row and a communication buffer that may grow up to `max_allowed_packet` bytes.

On the other hand, you shouldn't use `mysql_use_result()` if you are doing a lot of processing for each row on the client side, or if the output is sent to a screen on which the user may type a `^S` (stop scroll). This ties up the server and prevent other threads from updating any tables from which the data is being fetched.

When using `mysql_use_result()`, you must execute `mysql_fetch_row()` until a `NULL` value is returned, otherwise, the unfetched rows are returned as part of the result set for your next query. The C API gives the error `Commands out of sync; you can't run this command now` if you forget to do this!

You may not use `mysql_data_seek()`, `mysql_row_seek()`, `mysql_row_tell()`, `mysql_num_rows()`, or `mysql_affected_rows()` with a result returned from `mysql_use_result()`, nor may you issue other queries until `mysql_use_result()` has finished. (However, after you have fetched all the rows, `mysql_num_rows()` accurately returns the number of rows fetched.)

You must call `mysql_free_result()` once you are done with the result set.

When using the `libmysqld` embedded server, the memory benefits are essentially lost because memory usage incrementally increases with each row retrieved until `mysql_free_result()` is called.

Return Values

A `MYSQL_RES` result structure. `NULL` if an error occurred.

Errors

`mysql_use_result()` resets `mysql_error()` and `mysql_errno()` if it succeeds.

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_OUT_OF_MEMORY`

  Out of memory.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.3.72. `mysql_warning_count()`

`unsigned int mysql_warning_count(MYSQL *mysql)`

Description

Returns the number of warnings generated during execution of the previous SQL statement.

Return Values

The warning count.

Errors

None.

20.9.4. C API Prepared Statements

The MySQL client/server protocol provides for the use of prepared statements. This capability uses the `MYSQL_STMT` statement handler data structure returned by the `mysql_stmt_init()` initialization function. Prepared execution is an efficient way to execute a statement more than once. The statement is first parsed to prepare it for execution. Then it is executed one or more times at a later time, using the statement handle returned by the initialization function.

Prepared execution is faster than direct execution for statements executed more than once, primarily because the query is parsed only once. In the case of direct execution, the query is parsed every time it is executed. Prepared execution also can provide a reduction of network traffic because for each execution of the prepared statement, it is necessary only to send the data for the parameters.

Prepared statements might not provide a performance increase in some situations. For best results, test your application both with prepared and nonprepared statements and choose whichever yields best performance.

Another advantage of prepared statements is that it uses a binary protocol that makes data transfer between client and server more efficient.

The following SQL statements can be used as prepared statements:

```
CALL
CREATE TABLE
DELETE
DO
INSERT
REPLACE
SELECT
SET
UPDATE
ANALYZE TABLE
OPTIMIZE TABLE
REPAIR TABLE
CACHE INDEX
CHANGE MASTER
CHECKSUM {TABLE | TABLES}
{CREATE | RENAME | DROP} DATABASE
{CREATE | RENAME | DROP} USER
FLUSH {TABLE | TABLES | TABLES WITH READ LOCK | HOSTS | PRIVILEGES
  | LOGS | STATUS | MASTER | SLAVE | DES_KEY_FILE | USER_RESOURCES}
GRANT
REVOKE
KILL
LOAD INDEX INTO CACHE
RESET {MASTER | SLAVE | QUERY CACHE}
SHOW BINLOG EVENTS
SHOW CREATE {PROCEDURE | FUNCTION | EVENT | TABLE | VIEW}
SHOW {AUTHORS | CONTRIBUTORS | WARNINGS | ERRORS}
SHOW {MASTER | BINARY} LOGS
SHOW {MASTER | SLAVE} STATUS
SLAVE {START | STOP}
INSTALL PLUGIN
UNINSTALL PLUGIN
```

Other statements are not yet supported in MySQL 5.5.

Metadata changes to tables or views referred to by prepared statements are detected and cause automatic repreparation of the statement when it is next executed. For more information, see Section 12.6.4, “Automatic Prepared Statement Repreparation”.

20.9.5. C API Prepared Statement Data Structures

Prepared statements use several data structures:

- To obtain a statement handle, pass a `MYSQL` connection handler to `mysql_stmt_init()`, which returns a pointer to a `MYSQL_STMT` data structure. This structure is used for further operations with the statement. To specify the statement to prepare, pass the `MYSQL_STMT` pointer and the statement string to `mysql_stmt_prepare()`.
- To provide input parameters for a prepared statement, set up `MYSQL_BIND` structures and pass them to `mysql_stmt_bind_param()`. To receive output column values, set up `MYSQL_BIND` structures and pass them to `mysql_stmt_bind_result()`.
- The `MYSQL_TIME` structure is used to transfer temporal data in both directions.

The following discussion describes the prepared statement data types in detail. For examples that show how to use them, see Section 20.9.7.10, “`mysql_stmt_execute()`”, and Section 20.9.7.11, “`mysql_stmt_fetch()`”.

- `MYSQL_STMT`

  This structure is a handle for a prepared statement. A handle is created by calling `mysql_stmt_init()`, which returns a pointer to a `MYSQL_STMT`. The handle is used for all subsequent operations with the statement until you close it with `mysql_stmt_close()`, at which point the handle becomes invalid.

  The `MYSQL_STMT` structure has no members intended for application use. Applications should not try to copy a `MYSQL_STMT` structure. There is no guarantee that such a copy will be usable.

  Multiple statement handles can be associated with a single connection. The limit on the number of handles depends on the available system resources.

- `MYSQL_BIND`

  This structure is used both for statement input (data values sent to the server) and output (result values returned from the server):

- For input, use `MYSQL_BIND` structures with `mysql_stmt_bind_param()` to bind parameter data values to buffers for use by `mysql_stmt_execute()`.
- For output, use `MYSQL_BIND` structures with `mysql_stmt_bind_result()` to bind buffers to result set columns, for use in fetching rows with `mysql_stmt_fetch()`.

To use a `MYSQL_BIND` structure, zero its contents to initialize it, then set its members appropriately. For example, to declare and initialize an array of three `MYSQL_BIND` structures, use this code:

```
MYSQL_BIND bind[3];
memset(bind, 0, sizeof(bind));
```

The `MYSQL_BIND` structure contains the following members for use by application programs. For several of the members, the manner of use depends on whether the structure is used for input or output.

- `enum enum_field_types buffer_type`

  The type of the buffer. This member indicates the data type of the C language variable bound to a statement parameter or result set column. For input, `buffer_type` indicates the type of the variable containing the value to be sent to the server. For output, it indicates the type of the variable into which a value received from the server should be stored. For permissible `buffer_type` values, see Section 20.9.5.1, "C API Prepared Statement Type Codes".

- `void *buffer`

  A pointer to the buffer to be used for data transfer. This is the address of a C language variable.

  For input, `buffer` is a pointer to the variable in which you store the data value for a statement parameter. When you call `mysql_stmt_execute()`, MySQL use the value stored in the variable in place of the corresponding parameter marker in the statement (specified with `?` in the statement string).

  For output, `buffer` is a pointer to the variable in which to return a result set column value. When you call `mysql_stmt_fetch()`, MySQL stores a column value from the current row of the result set in this variable. You can access the value when the call returns.

  To minimize the need for MySQL to perform type conversions between C language values on the client side and SQL values on the server side, use C variables that have types similar to those of the corresponding SQL values:

  - For numeric data types, `buffer` should point to a variable of the proper numeric C type. For integer variables (which can be `char` for single-byte values or an integer type for larger values), you should also indicate whether the variable has the `unsigned` attribute by setting the `is_unsigned` member, described later.
  - For character (nonbinary) and binary string data types, `buffer` should point to a character buffer.
  - For date and time data types, `buffer` should point to a `MYSQL_TIME` structure.

  For guidelines about mapping between C types and SQL types and notes about type conversions, see Section 20.9.5.1, "C API Prepared Statement Type Codes", and Section 20.9.5.2, "C API Prepared Statement Type Conversions".

- `unsigned long buffer_length`

  The actual size of `*buffer` in bytes. This indicates the maximum amount of data that can be stored in the buffer. For character and binary C data, the `buffer_length` value specifies the length of `*buffer` when used with `mysql_stmt_bind_param()` to specify input values, or the maximum number of output data bytes that can be fetched into the buffer when used with `mysql_stmt_bind_result()`.

- `unsigned long *length`

  A pointer to an `unsigned long` variable that indicates the actual number of bytes of data stored in `*buffer`. `length` is used for character or binary C data.

  For input parameter data binding, set `*length` to indicate the actual length of the parameter value stored in `*buffer`. This is used by `mysql_stmt_execute()`.

  For output value binding, MySQL sets `*length` when you call `mysql_stmt_fetch()`. The `mysql_stmt_fetch()` return value determines how to interpret the length:

  - If the return value is 0, `*length` indicates the actual length of the parameter value.

    - If the return value is `MYSQL_DATA_TRUNCATED`, `*length` indicates the nontruncated length of the parameter value. In this case, the minimum of `*length` and `buffer_length` indicates the actual length of the value.

  `length` is ignored for numeric and temporal data types because the `buffer_type` value determines the length of the data value.

  If you must determine the length of a returned value before fetching it, see Section 20.9.7.11, "`mysql_stmt_fetch()`", for some strategies.

  - `my_bool *is_null`

    This member points to a `my_bool` variable that is true if a value is `NULL`, false if it is not `NULL`. For input, set `*is_null` to true to indicate that you are passing a `NULL` value as a statement parameter.

    `is_null` is a *pointer* to a boolean scalar, not a boolean scalar, to provide flexibility in how you specify `NULL` values:

    - If your data values are always `NULL`, use `MYSQL_TYPE_NULL` as the `buffer_type` value when you bind the column. The other `MYSQL_BIND` members, including `is_null`, do not matter.

    - If your data values are always `NOT NULL`, set `is_null = (my_bool*) 0`, and set the other members appropriately for the variable you are binding.

    - In all other cases, set the other members appropriately and set `is_null` to the address of a `my_bool` variable. Set that variable's value to true or false appropriately between executions to indicate whether the corresponding data value is `NULL` or `NOT NULL`, respectively.

    For output, when you fetch a row, MySQL sets the value pointed to by `is_null` to true or false according to whether the result set column value returned from the statement is or is not `NULL`.

  - `my_bool is_unsigned`

    This member applies for C variables with data types that can be `unsigned` (`char`, `short int`, `int`, `long long int`). Set `is_unsigned` to true if the variable pointed to by `buffer` is `unsigned` and false otherwise. For example, if you bind a `signed char` variable to `buffer`, specify a type code of `MYSQL_TYPE_TINY` and set `is_unsigned` to false. If you bind an `unsigned char` instead, the type code is the same but `is_unsigned` should be true. (For `char`, it is not defined whether it is signed or unsigned, so it is best to be explicit about signedness by using `signed char` or `unsigned char`.)

    `is_unsigned` applies only to the C language variable on the client side. It indicates nothing about the signedness of the corresponding SQL value on the server side. For example, if you use an `int` variable to supply a value for a `BIGINT UNSIGNED` column, `is_unsigned` should be false because `int` is a signed type. If you use an `unsigned int` variable to supply a value for a `BIGINT` column, `is_unsigned` should be true because `unsigned int` is an unsigned type. MySQL performs the proper conversion between signed and unsigned values in both directions, although a warning occurs if truncation results.

  - `my_bool *error`

    For output, set this member to point to a `my_bool` variable to have truncation information for the parameter stored there after a row fetching operation. When truncation reporting is enabled, `mysql_stmt_fetch()` returns `MYSQL_DATA_TRUNCATED` and `*error` is true in the `MYSQL_BIND` structures for parameters in which truncation occurred. Truncation indicates loss of sign or significant digits, or that a string was too long to fit in a column. Truncation reporting is enabled by default, but can be controlled by calling `mysql_options()` with the `MYSQL_REPORT_DATA_TRUNCATION` option.

- `MYSQL_TIME`

  This structure is used to send and receive `DATE`, `TIME`, `DATETIME`, and `TIMESTAMP` data directly to and from the server. Set the `buffer` member to point to a `MYSQL_TIME` structure, and set the `buffer_type` member of a `MYSQL_BIND` structure to one of the temporal types (`MYSQL_TYPE_TIME`, `MYSQL_TYPE_DATE`, `MYSQL_TYPE_DATETIME`, `MYSQL_TYPE_TIMESTAMP`).

  The `MYSQL_TIME` structure contains the members listed in the following table.

Member	**Description**
`unsigned int year`	The year
`unsigned int month`	The month of the year
`unsigned int day`	The day of the month

Member	**Description**
`unsigned int hour`	The hour of the day
`unsigned int minute`	The minute of the hour
`unsigned int second`	The second of the minute
`my_bool neg`	A boolean flag indicating whether the time is negative
`unsigned long second_part`	The fractional part of the second in microseconds; currently unused

Only those parts of a `MYSQL_TIME` structure that apply to a given type of temporal value are used. The `year`, `month`, and `day` elements are used for `DATE`, `DATETIME`, and `TIMESTAMP` values. The `hour`, `minute`, and `second` elements are used for `TIME`, `DATETIME`, and `TIMESTAMP` values. See Section 20.9.15, “C API Prepared Statement Handling of Date and Time Values”.

20.9.5.1. C API Prepared Statement Type Codes

The `buffer_type` member of `MYSQL_BIND` structures indicates the data type of the C language variable bound to a statement parameter or result set column. For input, `buffer_type` indicates the type of the variable containing the value to be sent to the server. For output, it indicates the type of the variable into which a value received from the server should be stored.

The following table shows the permissible values for the `buffer_type` member of `MYSQL_BIND` structures for input values sent to the server. The table shows the C variable types that you can use, the corresponding type codes, and the SQL data types for which the supplied value can be used without conversion. Choose the `buffer_type` value according to the data type of the C language variable that you are binding. For the integer types, you should also set the `is_unsigned` member to indicate whether the variable is signed or unsigned.

Input Variable C Type	**`buffer_type` Value**	**SQL Type of Destination Value**
`signed char`	`MYSQL_TYPE_TINY`	`TINYINT`
`short int`	`MYSQL_TYPE_SHORT`	`SMALLINT`
`int`	`MYSQL_TYPE_LONG`	`INT`
`long long int`	`MYSQL_TYPE_LONGLONG`	`BIGINT`
`float`	`MYSQL_TYPE_FLOAT`	`FLOAT`
`double`	`MYSQL_TYPE_DOUBLE`	`DOUBLE`
`MYSQL_TIME`	`MYSQL_TYPE_TIME`	`TIME`
`MYSQL_TIME`	`MYSQL_TYPE_DATE`	`DATE`
`MYSQL_TIME`	`MYSQL_TYPE_DATETIME`	`DATETIME`
`MYSQL_TIME`	`MYSQL_TYPE_TIMESTAMP`	`TIMESTAMP`
`char[]`	`MYSQL_TYPE_STRING`	`TEXT`, `CHAR`, `VARCHAR`
`char[]`	`MYSQL_TYPE_BLOB`	`BLOB`, `BINARY`, `VARBINARY`
	`MYSQL_TYPE_NULL`	`NULL`

Use `MYSQL_TYPE_NULL` as indicated in the description for the `is_null` member in Section 20.9.5, “C API Prepared Statement Data Structures”.

For input string data, use `MYSQL_TYPE_STRING` or `MYSQL_TYPE_BLOB` depending on whether the value is a character (nonbinary) or binary string:

- `MYSQL_TYPE_STRING` indicates character input string data. The value is assumed to be in the character set indicated by the `character_set_client` system variable. If the server stores the value into a column with a different character set, it converts the value to that character set.
- `MYSQL_TYPE_BLOB` indicates binary input string data. The value is treated as having the `binary` character set. That is, it is treated as a byte string and no conversion occurs.

The following table shows the permissible values for the `buffer_type` member of `MYSQL_BIND` structures for output values received from the server. The table shows the SQL types of received values, the corresponding type codes that such values have in result set metadata, and the recommended C language data types to bind to the `MYSQL_BIND` structure to receive the SQL values without conversion. Choose the `buffer_type` value according to the data type of the C language variable that you are binding. For the integer types, you should also set the `is_unsigned` member to indicate whether the variable is signed or unsigned.

SQL Type of Received Value	**`buffer_type` Value**	**Output Variable C Type**
`TINYINT`	`MYSQL_TYPE_TINY`	`signed char`
`SMALLINT`	`MYSQL_TYPE_SHORT`	`short int`
`MEDIUMINT`	`MYSQL_TYPE_INT24`	`int`
`INT`	`MYSQL_TYPE_LONG`	`int`
`BIGINT`	`MYSQL_TYPE_LONGLONG`	`long long int`
`FLOAT`	`MYSQL_TYPE_FLOAT`	`float`
`DOUBLE`	`MYSQL_TYPE_DOUBLE`	`double`
`DECIMAL`	`MYSQL_TYPE_NEWDECIMAL`	`char[]`
`YEAR`	`MYSQL_TYPE_SHORT`	`short int`
`TIME`	`MYSQL_TYPE_TIME`	`MYSQL_TIME`
`DATE`	`MYSQL_TYPE_DATE`	`MYSQL_TIME`
`DATETIME`	`MYSQL_TYPE_DATETIME`	`MYSQL_TIME`
`TIMESTAMP`	`MYSQL_TYPE_TIMESTAMP`	`MYSQL_TIME`
`CHAR`, `BINARY`	`MYSQL_TYPE_STRING`	`char[]`
`VARCHAR`, `VARBINARY`	`MYSQL_TYPE_VAR_STRING`	`char[]`
`TINYBLOB`, `TINYTEXT`	`MYSQL_TYPE_TINY_BLOB`	`char[]`
`BLOB`, `TEXT`	`MYSQL_TYPE_BLOB`	`char[]`
`MEDIUMBLOB`, `MEDIUMTEXT`	`MYSQL_TYPE_MEDIUM_BLOB`	`char[]`
`LONGBLOB`, `LONGTEXT`	`MYSQL_TYPE_LONG_BLOB`	`char[]`
`BIT`	`MYSQL_TYPE_BIT`	`char[]`

20.9.5.2. C API Prepared Statement Type Conversions

Prepared statements transmit data between the client and server using C language variables on the client side that correspond to SQL values on the server side. If there is a mismatch between the C variable type on the client side and the corresponding SQL value type on the server side, MySQL performs implicit type conversions in both directions.

MySQL knows the type code for the SQL value on the server side. The `buffer_type` value in the `MYSQL_BIND` structure indicates the type code of the C variable that holds the value on the client side. The two codes together tell MySQL what conversion must be performed, if any. Here are some examples:

- If you use `MYSQL_TYPE_LONG` with an `int` variable to pass an integer value to the server that is to be stored into a `FLOAT` column, MySQL converts the value to floating-point format before storing it.
- If you fetch an SQL `MEDIUMINT` column value, but specify a `buffer_type` value of `MYSQL_TYPE_LONGLONG` and use a C variable of type `long long int` as the destination buffer, MySQL converts the `MEDIUMINT` value (which requires less than 8 bytes) for storage into the `long long int` (an 8-byte variable).
- If you fetch a numeric column with a value of 255 into a `char[4]` character array and specify a `buffer_type` value of `MYSQL_TYPE_STRING`, the resulting value in the array is a 4-byte string `'255\0'`.
- MySQL returns `DECIMAL` values as the string representation of the original server-side value, which is why the corresponding C type is `char[]`. For example, `12.345` is returned to the client as `'12.345'`. If you specify `MYSQL_TYPE_NEWDECIMAL` and bind a string buffer to the `MYSQL_BIND` structure, `mysql_stmt_fetch()` stores the value in the buffer as a string without conversion. If instead you specify a numeric variable and type code, `mysql_stmt_fetch()` converts the string-format `DECIMAL` value to numeric form.
- For the `MYSQL_TYPE_BIT` type code, `BIT` values are returned into a string buffer, which is why the corresponding C type is `char[]`. The value represents a bit string that requires interpretation on the client side. To return the value as a type that is easier to deal with, you can cause the value to be cast to integer using either of the following types of expressions:

  ```
  SELECT bit_col + 0 FROM t
  SELECT CAST(bit_col AS UNSIGNED) FROM t
  ```

  To retrieve the value, bind an integer variable large enough to hold the value and specify the appropriate corresponding integer type code.

Before binding variables to the `MYSQL_BIND` structures that are to be used for fetching column values, you can check the type codes for each column of the result set. This might be desirable if you want to determine which variable types would be best to use to avoid type conversions. To get the type codes, call `mysql_stmt_result_metadata()` after executing the prepared statement with `mysql_stmt_execute()`. The metadata provides access to the type codes for the result set as described in Section 20.9.7.23, "`mysql_stmt_result_metadata()`", and Section 20.9.1, "C API Data Structures".

To determine whether output string values in a result set returned from the server contain binary or nonbinary data, check whether the `charsetnr` value of the result set metadata is 63 (see Section 20.9.1, "C API Data Structures"). If so, the character set is `binary`, which indicates binary rather than nonbinary data. This enables you to distinguish `BINARY` from `CHAR`, `VARBINARY` from `VARCHAR`, and the `BLOB` types from the `TEXT` types.

If you cause the `max_length` member of the `MYSQL_FIELD` column metadata structures to be set (by calling `mysql_stmt_attr_set()`), be aware that the `max_length` values for the result set indicate the lengths of the longest string representation of the result values, not the lengths of the binary representation. That is, `max_length` does not necessarily correspond to the size of the buffers needed to fetch the values with the binary protocol used for prepared statements. Choose the size of the buffers according to the types of the variables into which you fetch the values. For example, a `TINYINT` column containing the value -128 might have a `max_length` value of 4. But the binary representation of any `TINYINT` value requires only 1 byte for storage, so you can supply a `signed char` variable in which to store the value and set `is_unsigned` to indicate that values are signed.

Metadata changes to tables or views referred to by prepared statements are detected and cause automatic repreparation of the statement when it is next executed. For more information, see Section 12.6.4, "Automatic Prepared Statement Repreparation".

20.9.6. C API Prepared Statement Function Overview

The functions available for prepared statement processing are summarized here and described in greater detail in a later section. See Section 20.9.7, "C API Prepared Statement Function Descriptions".

Function	Description
`mysql_stmt_affected_rows()`	Returns the number of rows changed, deleted, or inserted by prepared `UPDATE`, `DELETE`, or `INSERT` statement
`mysql_stmt_attr_get()`	Gets value of an attribute for a prepared statement
`mysql_stmt_attr_set()`	Sets an attribute for a prepared statement
`mysql_stmt_bind_param()`	Associates application data buffers with the parameter markers in a prepared SQL statement
`mysql_stmt_bind_result()`	Associates application data buffers with columns in a result set
`mysql_stmt_close()`	Frees memory used by a prepared statement
`mysql_stmt_data_seek()`	Seeks to an arbitrary row number in a statement result set
`mysql_stmt_errno()`	Returns the error number for the last statement execution
`mysql_stmt_error()`	Returns the error message for the last statement execution
`mysql_stmt_execute()`	Executes a prepared statement
`mysql_stmt_fetch()`	Fetches the next row of data from a result set and returns data for all bound columns
`mysql_stmt_fetch_column()`	Fetch data for one column of the current row of a result set
`mysql_stmt_field_count()`	Returns the number of result columns for the most recent statement
`mysql_stmt_free_result()`	Free the resources allocated to a statement handle
`mysql_stmt_init()`	Allocates memory for a `MYSQL_STMT` structure and initializes it
`mysql_stmt_insert_id()`	Returns the ID generated for an `AUTO_INCREMENT` column by a prepared statement
`mysql_stmt_next_result()`	Returns/initiates the next result in a multiple-result execution
`mysql_stmt_num_rows()`	Returns the row count from a buffered statement result set
`mysql_stmt_param_count()`	Returns the number of parameters in a prepared statement
`mysql_stmt_param_metadata()`	(Return parameter metadata in the form of a result set) Currently, this function does nothing
`mysql_stmt_prepare()`	Prepares an SQL statement string for execution
`mysql_stmt_reset()`	Resets the statement buffers in the server
`mysql_stmt_result_metadata(`	Returns prepared statement metadata in the form of a result set

Function	Description
`)`	
`mysql_stmt_row_seek()`	Seeks to a row offset in a statement result set, using value returned from `mysql_stmt_row_tell()`
`mysql_stmt_row_tell()`	Returns the statement row cursor position
`mysql_stmt_send_long_data()`	Sends long data in chunks to server
`mysql_stmt_sqlstate()`	Returns the SQLSTATE error code for the last statement execution
`mysql_stmt_store_result()`	Retrieves a complete result set to the client

Call `mysql_stmt_init()` to create a statement handle, then `mysql_stmt_prepare()` to prepare the statement string, `mysql_stmt_bind_param()` to supply the parameter data, and `mysql_stmt_execute()` to execute the statement. You can repeat the `mysql_stmt_execute()` by changing parameter values in the respective buffers supplied through `mysql_stmt_bind_param()`.

You can send text or binary data in chunks to server using `mysql_stmt_send_long_data()`. See Section 20.9.7.26, “`mysql_stmt_send_long_data()`”.

If the statement is a `SELECT` or any other statement that produces a result set, `mysql_stmt_prepare()` also returns the result set metadata information in the form of a `MYSQL_RES` result set through `mysql_stmt_result_metadata()`.

You can supply the result buffers using `mysql_stmt_bind_result()`, so that the `mysql_stmt_fetch()` automatically returns data to these buffers. This is row-by-row fetching.

When statement execution has been completed, close the statement handle using `mysql_stmt_close()` so that all resources associated with it can be freed.

If you obtained a `SELECT` statement's result set metadata by calling `mysql_stmt_result_metadata()`, you should also free the metadata using `mysql_free_result()`.

Execution Steps

To prepare and execute a statement, an application follows these steps:

1. Create a prepared statement handle with `mysql_stmt_init()`. To prepare the statement on the server, call `mysql_stmt_prepare()` and pass it a string containing the SQL statement.
2. If the statement will produce a result set, call `mysql_stmt_result_metadata()` to obtain the result set metadata. This metadata is itself in the form of result set, albeit a separate one from the one that contains the rows returned by the query. The metadata result set indicates how many columns are in the result and contains information about each column.
3. Set the values of any parameters using `mysql_stmt_bind_param()`. All parameters must be set. Otherwise, statement execution returns an error or produces unexpected results.
4. Call `mysql_stmt_execute()` to execute the statement.
5. If the statement produces a result set, bind the data buffers to use for retrieving the row values by calling `mysql_stmt_bind_result()`.
6. Fetch the data into the buffers row by row by calling `mysql_stmt_fetch()` repeatedly until no more rows are found.
7. Repeat steps 3 through 6 as necessary, by changing the parameter values and re-executing the statement.

When `mysql_stmt_prepare()` is called, the MySQL client/server protocol performs these actions:

- The server parses the statement and sends the okay status back to the client by assigning a statement ID. It also sends total number of parameters, a column count, and its metadata if it is a result set oriented statement. All syntax and semantics of the statement are checked by the server during this call.
- The client uses this statement ID for the further operations, so that the server can identify the statement from among its pool of statements.

When `mysql_stmt_execute()` is called, the MySQL client/server protocol performs these actions:

- The client uses the statement handle and sends the parameter data to the server.
- The server identifies the statement using the ID provided by the client, replaces the parameter markers with the newly supplied data, and executes the statement. If the statement produces a result set, the server sends the data back to the client. Otherwise, it sends an okay status and the number of rows changed, deleted, or inserted.

When `mysql_stmt_fetch()` is called, the MySQL client/server protocol performs these actions:

- The client reads the data from the current row of the result set and places it into the application data buffers by doing the necessary conversions. If the application buffer type is same as that of the field type returned from the server, the conversions are straightforward.

If an error occurs, you can get the statement error number, error message, and SQLSTATE code using `mysql_stmt_errno()`, `mysql_stmt_error()`, and `mysql_stmt_sqlstate()`, respectively.

Prepared Statement Logging

For prepared statements that are executed with the `mysql_stmt_prepare()` and `mysql_stmt_execute()` C API functions, the server writes `Prepare` and `Execute` lines to the general query log so that you can tell when statements are prepared and executed.

Suppose that you prepare and execute a statement as follows:

1. Call `mysql_stmt_prepare()` to prepare the statement string `"SELECT ?"`.
2. Call `mysql_stmt_bind_param()` to bind the value `3` to the parameter in the prepared statement.
3. Call `mysql_stmt_execute()` to execute the prepared statement.

As a result of the preceding calls, the server writes the following lines to the general query log:

```
Prepare  [1] SELECT ?
Execute  [1] SELECT 3
```

Each `Prepare` and `Execute` line in the log is tagged with a `[N]` statement identifier so that you can keep track of which prepared statement is being logged. `N` is a positive integer. If there are multiple prepared statements active simultaneously for the client, `N` may be greater than 1. Each `Execute` lines shows a prepared statement after substitution of data values for `?` parameters.

20.9.7. C API Prepared Statement Function Descriptions

To prepare and execute queries, use the functions described in detail in the following sections.

All functions that operate with a `MYSQL_STMT` structure begin with the prefix `mysql_stmt_`.

To create a `MYSQL_STMT` handle, use the `mysql_stmt_init()` function.

20.9.7.1. `mysql_stmt_affected_rows()`

`my_ulonglong mysql_stmt_affected_rows(MYSQL_STMT *stmt)`

Description

`mysql_stmt_affected_rows()` may be called immediately after executing a statement with `mysql_stmt_execute()`. It is like `mysql_affected_rows()` but for prepared statements. For a description of what the affected-rows value returned by this function means, See Section 20.9.3.1, “`mysql_affected_rows()`”.

Errors

None.

Example

See the Example in Section 20.9.7.10, “`mysql_stmt_execute()`”.

20.9.7.2. `mysql_stmt_attr_get()`

`my_bool mysql_stmt_attr_get(MYSQL_STMT *stmt, enum enum_stmt_attr_type option, void *arg)`

Description

Can be used to get the current value for a statement attribute.

The `option` argument is the option that you want to get; the `arg` should point to a variable that should contain the option value. If the option is an integer, `arg` should point to the value of the integer.

See Section 20.9.7.3, “`mysql_stmt_attr_set()`”, for a list of options and option types.

Return Values

Zero if successful. Nonzero if `option` is unknown.

Errors

None.

20.9.7.3. `mysql_stmt_attr_set()`

`my_bool mysql_stmt_attr_set(MYSQL_STMT *stmt, enum enum_stmt_attr_type option, const void *arg)`

Description

Can be used to affect behavior for a prepared statement. This function may be called multiple times to set several options.

The `option` argument is the option that you want to set. The `arg` argument is the value for the option. `arg` should point to a variable that is set to the desired attribute value. The variable type is as indicated in the following table.

The following table shows the possible `option` values.

Option	**Argument Type**	**Function**
`STMT_ATTR_UPDATE_MAX_LENGTH`	`my_bool *`	If set to 1, causes `mysql_stmt_store_result()` to update the metadata `MYSQL_FIELD->max_length` value.
`STMT_ATTR_CURSOR_TYPE`	`unsigned long *`	Type of cursor to open for statement when `mysql_stmt_execute()` is invoked. `*arg` can be `CURSOR_TYPE_NO_CURSOR` (the default) or `CURSOR_TYPE_READ_ONLY`.
`STMT_ATTR_PREFETCH_ROWS`	`unsigned long *`	Number of rows to fetch from server at a time when using a cursor. `*arg` can be in the range from 1 to the maximum value of `unsigned long`. The default is 1.

If you use the `STMT_ATTR_CURSOR_TYPE` option with `CURSOR_TYPE_READ_ONLY`, a cursor is opened for the statement when you invoke `mysql_stmt_execute()`. If there is already an open cursor from a previous `mysql_stmt_execute()` call, it closes the cursor before opening a new one. `mysql_stmt_reset()` also closes any open cursor before preparing the statement for re-execution. `mysql_stmt_free_result()` closes any open cursor.

If you open a cursor for a prepared statement, `mysql_stmt_store_result()` is unnecessary, because that function causes the result set to be buffered on the client side.

Return Values

Zero if successful. Nonzero if `option` is unknown.

Errors

None.

Example

The following example opens a cursor for a prepared statement and sets the number of rows to fetch at a time to 5:

```
MYSQL_STMT *stmt;
int rc;
unsigned long type;
unsigned long prefetch_rows = 5;

stmt = mysql_stmt_init(mysql);
type = (unsigned long) CURSOR_TYPE_READ_ONLY;
rc = mysql_stmt_attr_set(stmt, STMT_ATTR_CURSOR_TYPE, (void*) &type);
/* ... check return value ... */
rc = mysql_stmt_attr_set(stmt, STMT_ATTR_PREFETCH_ROWS,
                         (void*) &prefetch_rows);
/* ... check return value ... */
```

20.9.7.4. `mysql_stmt_bind_param()`

`my_bool mysql_stmt_bind_param(MYSQL_STMT *stmt, MYSQL_BIND *bind)`

Description

`mysql_stmt_bind_param()` is used to bind input data for the parameter markers in the SQL statement that was passed to `mysql_stmt_prepare()`. It uses `MYSQL_BIND` structures to supply the data. `bind` is the address of an array of `MYSQL_BIND` structures. The client library expects the array to contain one element for each “`?`” parameter marker that is present in the query.

Suppose that you prepare the following statement:

```
INSERT INTO mytbl VALUES(?,?,?)
```

When you bind the parameters, the array of `MYSQL_BIND` structures must contain three elements, and can be declared like this:

```
MYSQL_BIND bind[3];
```

Section 20.9.5, “C API Prepared Statement Data Structures”, describes the members of each `MYSQL_BIND` element and how they should be set to provide input values.

Return Values

Zero if the bind operation was successful. Nonzero if an error occurred.

Errors

- `CR_UNSUPPORTED_PARAM_TYPE`

  The conversion is not supported. Possibly the `buffer_type` value is illegal or is not one of the supported types.

- `CR_OUT_OF_MEMORY`

  Out of memory.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

See the Example in Section 20.9.7.10, “`mysql_stmt_execute()`”.

20.9.7.5. `mysql_stmt_bind_result()`

`my_bool mysql_stmt_bind_result(MYSQL_STMT *stmt, MYSQL_BIND *bind)`

Description

`mysql_stmt_bind_result()` is used to associate (that is, bind) output columns in the result set to data buffers and length buffers. When `mysql_stmt_fetch()` is called to fetch data, the MySQL client/server protocol places the data for the bound columns into the specified buffers.

All columns must be bound to buffers prior to calling `mysql_stmt_fetch()`. `bind` is the address of an array of `MYSQL_BIND` structures. The client library expects the array to contain one element for each column of the result set. If you do not bind columns to `MYSQL_BIND` structures, `mysql_stmt_fetch()` simply ignores the data fetch. The buffers should be large enough to hold the data values, because the protocol doesn't return data values in chunks.

A column can be bound or rebound at any time, even after a result set has been partially retrieved. The new binding takes effect the next time `mysql_stmt_fetch()` is called. Suppose that an application binds the columns in a result set and calls `mysql_stmt_fetch()`. The client/server protocol returns data in the bound buffers. Then suppose that the application binds the columns to a different set of buffers. The protocol places data into the newly bound buffers when the next call to `mysql_stmt_fetch()` occurs.

To bind a column, an application calls `mysql_stmt_bind_result()` and passes the type, address, and length of the output buffer into which the value should be stored. Section 20.9.5, “C API Prepared Statement Data Structures”, describes the members of each `MYSQL_BIND` element and how they should be set to receive output values.

Return Values

Zero if the bind operation was successful. Nonzero if an error occurred.

Errors

- `CR_UNSUPPORTED_PARAM_TYPE`

  The conversion is not supported. Possibly the `buffer_type` value is illegal or is not one of the supported types.
- `CR_OUT_OF_MEMORY`

  Out of memory.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

See the Example in Section 20.9.7.11, “`mysql_stmt_fetch()`”.

20.9.7.6. `mysql_stmt_close()`

`my_bool mysql_stmt_close(MYSQL_STMT *)`

Description

Closes the prepared statement. `mysql_stmt_close()` also deallocates the statement handle pointed to by `stmt`.

If the current statement has pending or unread results, this function cancels them so that the next query can be executed.

Return Values

Zero if the statement was freed successfully. Nonzero if an error occurred.

Errors

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

See the Example in Section 20.9.7.10, “`mysql_stmt_execute()`”.

20.9.7.7. `mysql_stmt_data_seek()`

`void mysql_stmt_data_seek(MYSQL_STMT *stmt, my_ulonglong offset)`

Description

Seeks to an arbitrary row in a statement result set. The `offset` value is a row number and should be in the range from `0` to `mysql_stmt_num_rows(stmt)-1`.

This function requires that the statement result set structure contains the entire result of the last executed query, so `mysql_stmt_data_seek()` may be used only in conjunction with `mysql_stmt_store_result()`.

Return Values

None.

Errors

None.

20.9.7.8. `mysql_stmt_errno()`

`unsigned int mysql_stmt_errno(MYSQL_STMT *stmt)`

Description

For the statement specified by `stmt`, `mysql_stmt_errno()` returns the error code for the most recently invoked statement API function that can succeed or fail. A return value of zero means that no error occurred. Client error message numbers are listed in the MySQL `errmsg.h` header file. Server error message numbers are listed in `mysqld_error.h`. Errors also are listed at Appendix C, *Errors, Error Codes, and Common Problems*.

Return Values

An error code value. Zero if no error occurred.

Errors

None.

20.9.7.9. `mysql_stmt_error()`

`const char *mysql_stmt_error(MYSQL_STMT *stmt)`

Description

For the statement specified by `stmt`, `mysql_stmt_error()` returns a null-terminated string containing the error message for the most recently invoked statement API function that can succeed or fail. An empty string (`""`) is returned if no error occurred. This means the following two tests are equivalent:

```
if(*mysql_stmt_errno(stmt))
{
  // an error occurred
}

if (mysql_stmt_error(stmt)[0])
{
  // an error occurred
}
```

The language of the client error messages may be changed by recompiling the MySQL client library. Currently, you can choose error messages in several different languages.

Return Values

A character string that describes the error. An empty string if no error occurred.

Errors

None.

20.9.7.10. `mysql_stmt_execute()`

`int mysql_stmt_execute(MYSQL_STMT *stmt)`

Description

`mysql_stmt_execute()` executes the prepared query associated with the statement handle. The currently bound parameter marker values are sent to server during this call, and the server replaces the markers with this newly supplied data.

Statement processing following `mysql_stmt_execute()` depends on the type of statement:

- For an `UPDATE`, `DELETE`, or `INSERT`, the number of changed, deleted, or inserted rows can be found by calling `mysql_stmt_affected_rows()`.
- For a statement such as `SELECT` that generates a result set, you must call `mysql_stmt_fetch()` to fetch the data prior to calling any other functions that result in query processing. For more information on how to fetch the results, refer to Section 20.9.7.11, "`mysql_stmt_fetch()`".

  Do not following invocation of `mysql_stmt_execute()` with a call to `mysql_store_result()` or `mysql_use_result()`. Those functions are not intended for processing results from prepared statements.

For statements that generate a result set, you can request that `mysql_stmt_execute()` open a cursor for the statement by calling `mysql_stmt_attr_set()` before executing the statement. If you execute a statement multiple times, `mysql_stmt_execute()` closes any open cursor before opening a new one.

Metadata changes to tables or views referred to by prepared statements are detected and cause automatic repreparation of the statement when it is next executed. For more information, see Section 12.6.4, "Automatic Prepared Statement Repreparation".

Return Values

Zero if execution was successful. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_OUT_OF_MEMORY`

  Out of memory.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

The following example demonstrates how to create and populate a table using `mysql_stmt_init()`, `mysql_stmt_prepare()`, `mysql_stmt_param_count()`, `mysql_stmt_bind_param()`, `mysql_stmt_execute()`, and `mysql_stmt_affected_rows()`. The `mysql` variable is assumed to be a valid connection handle. For an example that shows how to retrieve data, see Section 20.9.7.11, "`mysql_stmt_fetch()`".

```
#define STRING_SIZE 50

#define DROP_SAMPLE_TABLE "DROP TABLE IF EXISTS test_table"
#define CREATE_SAMPLE_TABLE "CREATE TABLE test_table(col1 INT,\
                                                 col2 VARCHAR(40),\
                                                 col3 SMALLINT,\
                                                 col4 TIMESTAMP)"
#define INSERT_SAMPLE "INSERT INTO \
                       test_table(col1,col2,col3) \
                       VALUES(?,?,?)"

MYSQL_STMT    *stmt;
MYSQL_BIND    bind[3];
my_ulonglong  affected_rows;
int           param_count;
short         small_data;
int           int_data;
char          str_data[STRING_SIZE];
unsigned long str_length;
my_bool       is_null;

if (mysql_query(mysql, DROP_SAMPLE_TABLE))
{
  fprintf(stderr, " DROP TABLE failed\n");
  fprintf(stderr, " %s\n", mysql_error(mysql));
  exit(0);
}

if (mysql_query(mysql, CREATE_SAMPLE_TABLE))
{
  fprintf(stderr, " CREATE TABLE failed\n");
  fprintf(stderr, " %s\n", mysql_error(mysql));
  exit(0);
}

/* Prepare an INSERT query with 3 parameters */
/* (the TIMESTAMP column is not named; the server */
/*  sets it to the current date and time) */
stmt = mysql_stmt_init(mysql);
if (!stmt)
{
  fprintf(stderr, " mysql_stmt_init(), out of memory\n");
  exit(0);
}
if (mysql_stmt_prepare(stmt, INSERT_SAMPLE, strlen(INSERT_SAMPLE)))
{
  fprintf(stderr, " mysql_stmt_prepare(), INSERT failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}
fprintf(stdout, " prepare, INSERT successful\n");

/* Get the parameter count from the statement */
param_count= mysql_stmt_param_count(stmt);
fprintf(stdout, " total parameters in INSERT: %d\n", param_count);

if (param_count != 3) /* validate parameter count */
{
  fprintf(stderr, " invalid parameter count returned by MySQL\n");
  exit(0);
}

/* Bind the data for all 3 parameters */

memset(bind, 0, sizeof(bind));

/* INTEGER PARAM */
/* This is a number type, so there is no need
   to specify buffer_length */
bind[0].buffer_type= MYSQL_TYPE_LONG;
bind[0].buffer= (char *)&int_data;
bind[0].is_null= 0;
bind[0].length= 0;

/* STRING PARAM */
bind[1].buffer_type= MYSQL_TYPE_STRING;
bind[1].buffer= (char *)str_data;
bind[1].buffer_length= STRING_SIZE;
bind[1].is_null= 0;
bind[1].length= &str_length;

/* SMALLINT PARAM */
bind[2].buffer_type= MYSQL_TYPE_SHORT;
bind[2].buffer= (char *)&small_data;
bind[2].is_null= &is_null;
bind[2].length= 0;

/* Bind the buffers */
if (mysql_stmt_bind_param(stmt, bind))
{
  fprintf(stderr, " mysql_stmt_bind_param() failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}

/* Specify the data values for the first row */
int_data= 10;             /* integer */
strncpy(str_data, "MySQL", STRING_SIZE); /* string  */
str_length= strlen(str_data);

/* INSERT SMALLINT data as NULL */
is_null= 1;

/* Execute the INSERT statement - 1*/
if (mysql_stmt_execute(stmt))
```

```
{
  fprintf(stderr, " mysql_stmt_execute(), 1 failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}

/* Get the number of affected rows */
affected_rows= mysql_stmt_affected_rows(stmt);
fprintf(stdout, " total affected rows(insert 1): %lu\n",
                (unsigned long) affected_rows);

if (affected_rows != 1) /* validate affected rows */
{
  fprintf(stderr, " invalid affected rows by MySQL\n");
  exit(0);
}

/* Specify data values for second row,
   then re-execute the statement */
int_data= 1000;
strncpy(str_data, "
        The most popular Open Source database",
        STRING_SIZE);
str_length= strlen(str_data);
small_data= 1000;         /* smallint */
is_null= 0;               /* reset */

/* Execute the INSERT statement - 2*/
if (mysql_stmt_execute(stmt))
{
  fprintf(stderr, " mysql_stmt_execute, 2 failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}

/* Get the total rows affected */
affected_rows= mysql_stmt_affected_rows(stmt);
fprintf(stdout, " total affected rows(insert 2): %lu\n",
                (unsigned long) affected_rows);

if (affected_rows != 1) /* validate affected rows */
{
  fprintf(stderr, " invalid affected rows by MySQL\n");
  exit(0);
}

/* Close the statement */
if (mysql_stmt_close(stmt))
{
  fprintf(stderr, " failed while closing the statement\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}
```

> **Note**
>
> For complete examples on the use of prepared statement functions, refer to the file `tests/mysql_client_test.c`. This file can be obtained from a MySQL source distribution or from the Bazaar source repository.

20.9.7.11. `mysql_stmt_fetch()`

`int mysql_stmt_fetch(MYSQL_STMT *stmt)`

Description

`mysql_stmt_fetch()` returns the next row in the result set. It can be called only while the result set exists; that is, after a call to `mysql_stmt_execute()` for a statement such as `SELECT` that produces a result set.

`mysql_stmt_fetch()` returns row data using the buffers bound by `mysql_stmt_bind_result()`. It returns the data in those buffers for all the columns in the current row set and the lengths are returned to the `length` pointer. All columns must be bound by the application before it calls `mysql_stmt_fetch()`.

By default, result sets are fetched unbuffered a row at a time from the server. To buffer the entire result set on the client, call `mysql_stmt_store_result()` after binding the data buffers and before calling `mysql_stmt_fetch()`.

If a fetched data value is a `NULL` value, the `*is_null` value of the corresponding `MYSQL_BIND` structure contains TRUE (1). Otherwise, the data and its length are returned in the `*buffer` and `*length` elements based on the buffer type specified by the application. Each numeric and temporal type has a fixed length, as listed in the following table. The length of the string types depends on the length of the actual data value, as indicated by `data_length`.

Type	Length
`MYSQL_TYPE_TINY`	1

Type	Length
`MYSQL_TYPE_SHORT`	2
`MYSQL_TYPE_LONG`	4
`MYSQL_TYPE_LONGLONG`	8
`MYSQL_TYPE_FLOAT`	4
`MYSQL_TYPE_DOUBLE`	8
`MYSQL_TYPE_TIME`	`sizeof(MYSQL_TIME)`
`MYSQL_TYPE_DATE`	`sizeof(MYSQL_TIME)`
`MYSQL_TYPE_DATETIME`	`sizeof(MYSQL_TIME)`
`MYSQL_TYPE_STRING`	`data length`
`MYSQL_TYPE_BLOB`	`data_length`

In some cases you might want to determine the length of a column value before fetching it with `mysql_stmt_fetch()`. For example, the value might be a long string or `BLOB` value for which you want to know how much space must be allocated. To accomplish this, you can use these strategies:

- Before invoking `mysql_stmt_fetch()` to retrieve individual rows, pass `STMT_ATTR_UPDATE_MAX_LENGTH` to `mysql_stmt_attr_set()`, then invoke `mysql_stmt_store_result()` to buffer the entire result on the client side. Setting the `STMT_ATTR_UPDATE_MAX_LENGTH` attribute causes the maximal length of column values to be indicated by the `max_length` member of the result set metadata returned by `mysql_stmt_result_metadata()`.
- Invoke `mysql_stmt_fetch()` with a zero-length buffer for the column in question and a pointer in which the real length can be stored. Then use the real length with `mysql_stmt_fetch_column()`.

```
real_length= 0;

bind[0].buffer= 0;
bind[0].buffer_length= 0;
bind[0].length= &real_length
mysql_stmt_bind_result(stmt, bind);

mysql_stmt_fetch(stmt);
if (real_length > 0)
{
  data= malloc(real_length);
  bind[0].buffer= data;
  bind[0].buffer_length= real_length;
  mysql_stmt_fetch_column(stmt, bind, 0, 0);
}
```

Return Values

Return Value	Description
0	Successful, the data has been fetched to application data buffers.
1	Error occurred. Error code and message can be obtained by calling `mysql_stmt_errno()` and `mysql_stmt_error()`.
`MYSQL_NO_DATA`	No more rows/data exists
`MYSQL_DATA_TRUNCATED`	Data truncation occurred

`MYSQL_DATA_TRUNCATED` is returned when truncation reporting is enabled. To determine which column values were truncated when this value is returned, check the `error` members of the `MYSQL_BIND` structures used for fetching values. Truncation reporting is enabled by default, but can be controlled by calling `mysql_options()` with the `MYSQL_REPORT_DATA_TRUNCATION` option.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_OUT_OF_MEMORY`

Out of memory.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

- `CR_UNSUPPORTED_PARAM_TYPE`

  The buffer type is `MYSQL_TYPE_DATE`, `MYSQL_TYPE_TIME`, `MYSQL_TYPE_DATETIME`, or `MYSQL_TYPE_TIMESTAMP`, but the data type is not `DATE`, `TIME`, `DATETIME`, or `TIMESTAMP`.

- All other unsupported conversion errors are returned from `mysql_stmt_bind_result()`.

Example

The following example demonstrates how to fetch data from a table using `mysql_stmt_result_metadata()`, `mysql_stmt_bind_result()`, and `mysql_stmt_fetch()`. (This example expects to retrieve the two rows inserted by the example shown in Section 20.9.7.10, “`mysql_stmt_execute()`”.) The `mysql` variable is assumed to be a valid connection handle.

```
#define STRING_SIZE 50

#define SELECT_SAMPLE "SELECT col1, col2, col3, col4 \
                       FROM test_table"

MYSQL_STMT    *stmt;
MYSQL_BIND    bind[4];
MYSQL_RES     *prepare_meta_result;
MYSQL_TIME    ts;
unsigned long length[4];
int           param_count, column_count, row_count;
short         small_data;
int           int_data;
char          str_data[STRING_SIZE];
my_bool       is_null[4];
my_bool       error[4];

/* Prepare a SELECT query to fetch data from test_table */
stmt = mysql_stmt_init(mysql);
if (!stmt)
{
  fprintf(stderr, " mysql_stmt_init(), out of memory\n");
  exit(0);
}
if (mysql_stmt_prepare(stmt, SELECT_SAMPLE, strlen(SELECT_SAMPLE)))
{
  fprintf(stderr, " mysql_stmt_prepare(), SELECT failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}
fprintf(stdout, " prepare, SELECT successful\n");

/* Get the parameter count from the statement */
param_count= mysql_stmt_param_count(stmt);
fprintf(stdout, " total parameters in SELECT: %d\n", param_count);

if (param_count != 0) /* validate parameter count */
{
  fprintf(stderr, " invalid parameter count returned by MySQL\n");
  exit(0);
}

/* Fetch result set meta information */
prepare_meta_result = mysql_stmt_result_metadata(stmt);
if (!prepare_meta_result)
{
  fprintf(stderr,
         " mysql_stmt_result_metadata(), \
           returned no meta information\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}

/* Get total columns in the query */
column_count= mysql_num_fields(prepare_meta_result);
fprintf(stdout,
        " total columns in SELECT statement: %d\n",
        column_count);

if (column_count != 4) /* validate column count */
{
  fprintf(stderr, " invalid column count returned by MySQL\n");
  exit(0);
}

/* Execute the SELECT query */
if (mysql_stmt_execute(stmt))
{
  fprintf(stderr, " mysql_stmt_execute(), failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}

/* Bind the result buffers for all 4 columns before fetching them */

memset(bind, 0, sizeof(bind));

/* INTEGER COLUMN */
bind[0].buffer_type= MYSQL_TYPE_LONG;
bind[0].buffer= (char *)&int_data;
bind[0].is_null= &is_null[0];
bind[0].length= &length[0];
bind[0].error= &error[0];

/* STRING COLUMN */
bind[1].buffer_type= MYSQL_TYPE_STRING;
bind[1].buffer= (char *)str_data;
bind[1].buffer_length= STRING_SIZE;
bind[1].is_null= &is_null[1];
bind[1].length= &length[1];
bind[1].error= &error[1];

/* SMALLINT COLUMN */
bind[2].buffer_type= MYSQL_TYPE_SHORT;
bind[2].buffer= (char *)&small_data;
bind[2].is_null= &is_null[2];
bind[2].length= &length[2];
bind[2].error= &error[2];

/* TIMESTAMP COLUMN */
bind[3].buffer_type= MYSQL_TYPE_TIMESTAMP;
bind[3].buffer= (char *)&ts;
bind[3].is_null= &is_null[3];
bind[3].length= &length[3];
bind[3].error= &error[3];

/* Bind the result buffers */
if (mysql_stmt_bind_result(stmt, bind))
{
  fprintf(stderr, " mysql_stmt_bind_result() failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}

/* Now buffer all results to client (optional step) */
if (mysql_stmt_store_result(stmt))
{
  fprintf(stderr, " mysql_stmt_store_result() failed\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}

/* Fetch all rows */
row_count= 0;
fprintf(stdout, "Fetching results ...\n");
while (!mysql_stmt_fetch(stmt))
{
  row_count++;
  fprintf(stdout, "  row %d\n", row_count);

  /* column 1 */
  fprintf(stdout, "   column1 (integer)  : ");
  if (is_null[0])
    fprintf(stdout, " NULL\n");
  else
    fprintf(stdout, " %d(%ld)\n", int_data, length[0]);

  /* column 2 */
  fprintf(stdout, "   column2 (string)   : ");
  if (is_null[1])
    fprintf(stdout, " NULL\n");
  else
    fprintf(stdout, " %s(%ld)\n", str_data, length[1]);

  /* column 3 */
  fprintf(stdout, "   column3 (smallint) : ");
  if (is_null[2])
    fprintf(stdout, " NULL\n");
  else
    fprintf(stdout, " %d(%ld)\n", small_data, length[2]);

  /* column 4 */
  fprintf(stdout, "   column4 (timestamp): ");
  if (is_null[3])
    fprintf(stdout, " NULL\n");
  else
    fprintf(stdout, " %04d-%02d-%02d %02d:%02d:%02d (%ld)\n",
                     ts.year, ts.month, ts.day,
                     ts.hour, ts.minute, ts.second,
                     length[3]);
  fprintf(stdout, "\n");
}

/* Validate rows fetched */
fprintf(stdout, " total rows fetched: %d\n", row_count);
if (row_count != 2)
{
  fprintf(stderr, " MySQL failed to return all rows\n");
  exit(0);
}

/* Free the prepared result metadata */
mysql_free_result(prepare_meta_result);


/* Close the statement */
if (mysql_stmt_close(stmt))
{
  fprintf(stderr, " failed while closing the statement\n");
  fprintf(stderr, " %s\n", mysql_stmt_error(stmt));
  exit(0);
}
```

20.9.7.12. `mysql_stmt_fetch_column()`

`int mysql_stmt_fetch_column(MYSQL_STMT *stmt, MYSQL_BIND *bind, unsigned int column, unsigned long offset)`

Description

Fetch one column from the current result set row. `bind` provides the buffer where data should be placed. It should be set up the same way as for `mysql_stmt_bind_result()`. `column` indicates which column to fetch. The first column is numbered 0. `offset` is the offset within the data value at which to begin retrieving data. This can be used for fetching the data value in pieces. The beginning of the value is offset 0.

Return Values

Zero if the value was fetched successfully. Nonzero if an error occurred.

Errors

- `CR_INVALID_PARAMETER_NO`

  Invalid column number.

- `CR_NO_DATA`

  The end of the result set has already been reached.

20.9.7.13. `mysql_stmt_field_count()`

`unsigned int mysql_stmt_field_count(MYSQL_STMT *stmt)`

Description

Returns the number of columns for the most recent statement for the statement handler. This value is zero for statements such as `INSERT` or `DELETE` that do not produce result sets.

`mysql_stmt_field_count()` can be called after you have prepared a statement by invoking `mysql_stmt_prepare()`.

Return Values

An unsigned integer representing the number of columns in a result set.

Errors

None.

20.9.7.14. `mysql_stmt_free_result()`

`my_bool mysql_stmt_free_result(MYSQL_STMT *stmt)`

Description

Releases memory associated with the result set produced by execution of the prepared statement. If there is a cursor open for the statement, `mysql_stmt_free_result()` closes it.

Return Values

Zero if the result set was freed successfully. Nonzero if an error occurred.

Errors

20.9.7.15. `mysql_stmt_init()`

`MYSQL_STMT *mysql_stmt_init(MYSQL *mysql)`

Description

Create a `MYSQL_STMT` handle. The handle should be freed with `mysql_stmt_close(MYSQL_STMT *)`.

See also Section 20.9.5, "C API Prepared Statement Data Structures", for more information.

Return Values

A pointer to a `MYSQL_STMT` structure in case of success. `NULL` if out of memory.

Errors

- `CR_OUT_OF_MEMORY`

  Out of memory.

20.9.7.16. `mysql_stmt_insert_id()`

`my_ulonglong mysql_stmt_insert_id(MYSQL_STMT *stmt)`

Description

Returns the value generated for an `AUTO_INCREMENT` column by the prepared `INSERT` or `UPDATE` statement. Use this function after you have executed a prepared `INSERT` statement on a table which contains an `AUTO_INCREMENT` field.

See Section 20.9.3.37, "`mysql_insert_id()`", for more information.

Return Values

Value for `AUTO_INCREMENT` column which was automatically generated or explicitly set during execution of prepared statement, or value generated by `LAST_INSERT_ID(expr)` function. Return value is undefined if statement does not set `AUTO_INCREMENT` value.

Errors

None.

20.9.7.17. `mysql_stmt_next_result()`

`int mysql_stmt_next_result(MYSQL_STMT *mysql)`

Description

This function is used when you use prepared `CALL` statements to execute stored procedures, which can return multiple result sets. Use a loop that calls `mysql_stmt_next_result()` to determine whether there are more results. If a procedure has `OUT` or `INOUT` parameters, their values will be returned as a single-row result set following any other result sets. The values will appear in the order in which they are declared in the procedure parameter list.

`mysql_stmt_next_result()` returns a status to indicate whether more results exist. If `mysql_stmt_next_result()` returns an error, there are no more results.

Before each call to `mysql_stmt_next_result()`, you must call `mysql_stmt_free_result()` for the current result if it produced a result set (rather than just a result status).

After calling `mysql_stmt_next_result()` the state of the connection is as if you had called `mysql_stmt_execute()`. This means that you can call `mysql_stmt_bind_result()`, `mysql_stmt_affected_rows()`, and so forth.

It is also possible to test whether there are more results by calling `mysql_more_results()`. However, this function does not change the connection state, so if it returns true, you must still call `mysql_stmt_next_result()` to advance to the next result.

For an example that shows how to use `mysql_stmt_next_result()`, see Section 20.9.16, “C API Support for Prepared `CALL` Statements”.

`mysql_stmt_next_result()` was added in MySQL 5.5.3.

Return Values

Return Value	Description
0	Successful and there are more results
-1	Successful and there are no more results
>0	An error occurred

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.7.18. `mysql_stmt_num_rows()`

```
my_ulonglong mysql_stmt_num_rows(MYSQL_STMT *stmt)
```

Description

Returns the number of rows in the result set.

The use of `mysql_stmt_num_rows()` depends on whether you used `mysql_stmt_store_result()` to buffer the entire result set in the statement handle. If you use `mysql_stmt_store_result()`, `mysql_stmt_num_rows()` may be called immediately. Otherwise, the row count is unavailable unless you count the rows as you fetch them.

`mysql_stmt_num_rows()` is intended for use with statements that return a result set, such as `SELECT`. For statements such as `INSERT`, `UPDATE`, or `DELETE`, the number of affected rows can be obtained with `mysql_stmt_affected_rows()`.

Return Values

The number of rows in the result set.

Errors

None.

20.9.7.19. `mysql_stmt_param_count()`

`unsigned long mysql_stmt_param_count(MYSQL_STMT *stmt)`

Description

Returns the number of parameter markers present in the prepared statement.

Return Values

An unsigned long integer representing the number of parameters in a statement.

Errors

None.

Example

See the Example in Section 20.9.7.10, “`mysql_stmt_execute()`”.

20.9.7.20. `mysql_stmt_param_metadata()`

`MYSQL_RES *mysql_stmt_param_metadata(MYSQL_STMT *stmt)`

This function currently does nothing.

Description

Return Values

Errors

20.9.7.21. `mysql_stmt_prepare()`

`int mysql_stmt_prepare(MYSQL_STMT *stmt, const char *stmt_str, unsigned long length)`

Description

Given the statement handle returned by `mysql_stmt_init()`, prepares the SQL statement pointed to by the string `stmt_str` and returns a status value. The string length should be given by the `length` argument. The string must consist of a single SQL statement. You should not add a terminating semicolon (“`;`”) or `\g` to the statement.

The application can include one or more parameter markers in the SQL statement by embedding question mark (“`?`”) characters into the SQL string at the appropriate positions.

The markers are legal only in certain places in SQL statements. For example, they are permitted in the `VALUES()` list of an `INSERT` statement (to specify column values for a row), or in a comparison with a column in a `WHERE` clause to specify a comparison value. However, they are not permitted for identifiers (such as table or column names), or to specify both operands of a binary operator such as the `=` equal sign. The latter restriction is necessary because it would be impossible to determine the parameter type. In general, parameters are legal only in Data Manipulation Language (DML) statements, and not in Data Definition Language (DDL) statements.

The parameter markers must be bound to application variables using `mysql_stmt_bind_param()` before executing the statement.

Metadata changes to tables or views referred to by prepared statements are detected and cause automatic repreparation of the statement when it is next executed. For more information, see Section 12.6.4, “Automatic Prepared Statement Repreparation”.

Return Values

Zero if the statement was prepared successfully. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_OUT_OF_MEMORY`

  Out of memory.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

If the prepare operation was unsuccessful (that is, `mysql_stmt_prepare()` returns nonzero), the error message can be obtained by calling `mysql_stmt_error()`.

Example

See the Example in Section 20.9.7.10, “`mysql_stmt_execute()`”.

20.9.7.22. `mysql_stmt_reset()`

`my_bool mysql_stmt_reset(MYSQL_STMT *stmt)`

Description

Resets a prepared statement on client and server to state after prepare. It resets the statement on the server, data sent using `mysql_stmt_send_long_data()`, unbuffered result sets and current errors. It does not clear bindings or stored result sets. Stored result sets will be cleared when executing the prepared statement (or closing it).

To re-prepare the statement with another query, use `mysql_stmt_prepare()`.

Return Values

Zero if the statement was reset successfully. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.
- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.
- `CR_SERVER_LOST`

  The connection to the server was lost during the query
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.7.23. `mysql_stmt_result_metadata()`

`MYSQL_RES *mysql_stmt_result_metadata(MYSQL_STMT *stmt)`

Description

If a statement passed to `mysql_stmt_prepare()` is one that produces a result set, `mysql_stmt_result_metadata()` returns the result set metadata in the form of a pointer to a `MYSQL_RES` structure that can be used to process the meta information such as number of fields and individual field information. This result set pointer can be passed as an argument to any of the field-based API functions that process result set metadata, such as:

- `mysql_num_fields()`
- `mysql_fetch_field()`
- `mysql_fetch_field_direct()`
- `mysql_fetch_fields()`
- `mysql_field_count()`
- `mysql_field_seek()`
- `mysql_field_tell()`
- `mysql_free_result()`

The result set structure should be freed when you are done with it, which you can do by passing it to `mysql_free_result()`. This is similar to the way you free a result set obtained from a call to `mysql_store_result()`.

The result set returned by `mysql_stmt_result_metadata()` contains only metadata. It does not contain any row results. The rows are obtained by using the statement handle with `mysql_stmt_fetch()`.

Return Values

A `MYSQL_RES` result structure. `NULL` if no meta information exists for the prepared query.

Errors

- `CR_OUT_OF_MEMORY`

  Out of memory.
- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

See the Example in Section 20.9.7.11, “`mysql_stmt_fetch()`”.

20.9.7.24. `mysql_stmt_row_seek()`

```
MYSQL_ROW_OFFSET mysql_stmt_row_seek(MYSQL_STMT *stmt, MYSQL_ROW_OFFSET offset)
```

Description

Sets the row cursor to an arbitrary row in a statement result set. The `offset` value is a row offset that should be a value returned from `mysql_stmt_row_tell()` or from `mysql_stmt_row_seek()`. This value is not a row number; if you want to seek to a row within a result set by number, use `mysql_stmt_data_seek()` instead.

This function requires that the result set structure contains the entire result of the query, so `mysql_stmt_row_seek()` may be used only in conjunction with `mysql_stmt_store_result()`.

Return Values

The previous value of the row cursor. This value may be passed to a subsequent call to `mysql_stmt_row_seek()`.

Errors

None.

20.9.7.25. `mysql_stmt_row_tell()`

```
MYSQL_ROW_OFFSET mysql_stmt_row_tell(MYSQL_STMT *stmt)
```

Description

Returns the current position of the row cursor for the last `mysql_stmt_fetch()`. This value can be used as an argument to `mysql_stmt_row_seek()`.

You should use `mysql_stmt_row_tell()` only after `mysql_stmt_store_result()`.

Return Values

The current offset of the row cursor.

Errors

None.

20.9.7.26. `mysql_stmt_send_long_data()`

`my_bool mysql_stmt_send_long_data(MYSQL_STMT *stmt, unsigned int parameter_number, const char *data, unsigned long length)`

Description

Enables an application to send parameter data to the server in pieces (or "chunks"). Call this function after `mysql_stmt_bind_param()` and before `mysql_stmt_execute()`. It can be called multiple times to send the parts of a character or binary data value for a column, which must be one of the `TEXT` or `BLOB` data types.

`parameter_number` indicates which parameter to associate the data with. Parameters are numbered beginning with 0. `data` is a pointer to a buffer containing data to be sent, and `length` indicates the number of bytes in the buffer.

> **Note**
>
> The next `mysql_stmt_execute()` call ignores the bind buffer for all parameters that have been used with `mysql_stmt_send_long_data()` since last `mysql_stmt_execute()` or `mysql_stmt_reset()`.

If you want to reset/forget the sent data, you can do it with `mysql_stmt_reset()`. See Section 20.9.7.22, "`mysql_stmt_reset()`".

As of MySQL 5.5.11, the `max_long_data_size` system variable controls the maximum size of parameter values that can be sent with `mysql_stmt_send_long_data()`. If this variable not set at server startup, the default is the value of the `max_allowed_packet` system variable. `max_long_data_size` is deprecated. In MySQL 5.6, it is removed and the maximum parameter size is controlled by `max_allowed_packet`.

Return Values

Zero if the data is sent successfully to server. Nonzero if an error occurred.

Errors

- `CR_INVALID_BUFFER_USE`

  The parameter does not have a string or binary type.

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_OUT_OF_MEMORY`

  Out of memory.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

Example

The following example demonstrates how to send the data for a `TEXT` column in chunks. It inserts the data value `'MySQL - The most popular Open Source database'` into the `text_column` column. The `mysql` variable is assumed to be a valid connection handle.

```
#define INSERT_QUERY "INSERT INTO \
                      test_long_data(text_column) VALUES(?)"

MYSQL_BIND bind[1];
long       length;

stmt = mysql_stmt_init(mysql);
if (!stmt)
{
  fprintf(stderr, " mysql_stmt_init(), out of memory\n");
  exit(0);
}
if (mysql_stmt_prepare(stmt, INSERT_QUERY, strlen(INSERT_QUERY)))
{
  fprintf(stderr, "\n mysql_stmt_prepare(), INSERT failed");
  fprintf(stderr, "\n %s", mysql_stmt_error(stmt));
  exit(0);
}
 memset(bind, 0, sizeof(bind));
 bind[0].buffer_type= MYSQL_TYPE_STRING;
 bind[0].length= &length;
 bind[0].is_null= 0;

/* Bind the buffers */
if (mysql_stmt_bind_param(stmt, bind))
{
  fprintf(stderr, "\n param bind failed");
  fprintf(stderr, "\n %s", mysql_stmt_error(stmt));
  exit(0);
}

 /* Supply data in chunks to server */
 if (mysql_stmt_send_long_data(stmt,0,"MySQL",5))
{
  fprintf(stderr, "\n send_long_data failed");
  fprintf(stderr, "\n %s", mysql_stmt_error(stmt));
  exit(0);
}

 /* Supply the next piece of data */
 if (mysql_stmt_send_long_data(stmt,0,
           " - The most popular Open Source database",40))
{
  fprintf(stderr, "\n send_long_data failed");
  fprintf(stderr, "\n %s", mysql_stmt_error(stmt));
  exit(0);
}

 /* Now, execute the query */
 if (mysql_stmt_execute(stmt))
{
  fprintf(stderr, "\n mysql_stmt_execute failed");
  fprintf(stderr, "\n %s", mysql_stmt_error(stmt));
  exit(0);
}
```

20.9.7.27. `mysql_stmt_sqlstate()`

`const char *mysql_stmt_sqlstate(MYSQL_STMT *stmt)`

Description

For the statement specified by `stmt`, `mysql_stmt_sqlstate()` returns a null-terminated string containing the SQLSTATE error code for the most recently invoked prepared statement API function that can succeed or fail. The error code consists of five characters. `"00000"` means “no error.” The values are specified by ANSI SQL and ODBC. For a list of possible values, see Appendix C, *Errors, Error Codes, and Common Problems*.

Note that not all MySQL errors are yet mapped to SQLSTATE codes. The value `"HY000"` (general error) is used for unmapped errors.

Return Values

A null-terminated character string containing the SQLSTATE error code.

20.9.7.28. `mysql_stmt_store_result()`

`int mysql_stmt_store_result(MYSQL_STMT *stmt)`

Description

Result sets are produced by calling `mysql_stmt_execute()` to executed prepared statements for SQL statements such as `SELECT`, `SHOW`, `DESCRIBE`, and `EXPLAIN`. By default, result sets for successfully executed prepared statements are not buffered on the client and `mysql_stmt_fetch()` fetches them one at a time from the server. To cause the complete result set to be buffered on the client, call `mysql_stmt_store_result()` after binding data buffers with `mysql_stmt_bind_result()` and before calling `mysql_stmt_fetch()` to fetch rows. (For an example, see Section 20.9.7.11, “`mysql_stmt_fetch()`”.)

`mysql_stmt_store_result()` is optional for result set processing, unless you will call `mysql_stmt_data_seek()`, `mysql_stmt_row_seek()`, or `mysql_stmt_row_tell()`. Those functions require a seekable result set.

It is unnecessary to call `mysql_stmt_store_result()` after executing an SQL statement that does not produce a result set, but if you do, it does not harm or cause any notable performance problem. You can detect whether the statement produced a result set by checking if `mysql_stmt_result_metadata()` returns `NULL`. For more information, refer to Section 20.9.7.23, “`mysql_stmt_result_metadata()`”.

> **Note**
>
> MySQL doesn't by default calculate `MYSQL_FIELD->max_length` for all columns in `mysql_stmt_store_result()` because calculating this would slow down `mysql_stmt_store_result()` considerably and most applications don't need `max_length`. If you want `max_length` to be updated, you can call `mysql_stmt_attr_set(MYSQL_STMT, STMT_ATTR_UPDATE_MAX_LENGTH, &flag)` to enable this. See Section 20.9.7.3, “`mysql_stmt_attr_set()`”.

Return Values

Zero if the results are buffered successfully. Nonzero if an error occurred.

Errors

- `CR_COMMANDS_OUT_OF_SYNC`

  Commands were executed in an improper order.

- `CR_OUT_OF_MEMORY`

  Out of memory.

- `CR_SERVER_GONE_ERROR`

  The MySQL server has gone away.

- `CR_SERVER_LOST`

  The connection to the server was lost during the query.

- `CR_UNKNOWN_ERROR`

  An unknown error occurred.

20.9.8. C API Threaded Function Descriptions

To create a threaded client, use the functions described in the following sections. See also Section 20.9.17.2, “How to Write a Threaded Client”.

20.9.8.1. `my_init()`

`void my_init(void)`

Description

`my_init()` initializes some global variables that MySQL needs. It also calls `mysql_thread_init()` for this thread.

It is necessary for `my_init()` to be called early in the initialization phase of a program's use of the MySQL library. However, `my_init()` is automatically called by `mysql_init()`, `mysql_library_init()`, `mysql_server_init()`, and `mysql_connect()`. If you ensure that your program invokes one of those functions before any other MySQL calls, there is no need to invoke `my_init()` explicitly.

To access the prototype for `my_init()`, your program should include these header files:

```
#include <my_global.h>
#include <my_sys.h>
```

Return Values

None.

20.9.8.2. `mysql_thread_end()`

`void mysql_thread_end(void)`

Description

This function needs to be called before calling `pthread_exit()` to free memory allocated by `mysql_thread_init()`.

`mysql_thread_end()` *is not invoked automatically by the client library*. It must be called explicitly to avoid a memory leak.

Return Values

None.

20.9.8.3. `mysql_thread_init()`

`my_bool mysql_thread_init(void)`

Description

This function must be called early within each created thread to initialize thread-specific variables. However, you may not necessarily need to invoke it explicitly: `mysql_thread_init()` is automatically called by `my_init()`, which itself is automatically called by `mysql_init()`, `mysql_library_init()`, `mysql_server_init()`, and `mysql_connect()`. If you invoke any of those functions, `mysql_thread_init()` will be called for you.

Return Values

Zero if successful. Nonzero if an error occurred.

20.9.8.4. `mysql_thread_safe()`

`unsigned int mysql_thread_safe(void)`

Description

This function indicates whether the client library is compiled as thread-safe.

Return Values

1 if the client library is thread-safe, 0 otherwise.

20.9.9. C API Embedded Server Function Descriptions

MySQL applications can be written to use an embedded server. See Section 20.8, “libmysqld, the Embedded MySQL Server Library”. To write such an application, you must link it against the `libmysqld` library by using the `-lmysqld` flag rather than linking it against the `libmysqlclient` client library by using the `-lmysqlclient` flag. However, the calls to initialize and finalize the library are the same whether you write a client application or one that uses the embedded server: Call `mysql_library_init()` to initialize the library and `mysql_library_end()` when you are done with it. See Section 20.9.2, “C API Function Overview”.

20.9.9.1. `mysql_server_init()`

`int mysql_server_init(int argc, char **argv, char **groups)`

Description

This function initializes the MySQL library, which must be done before you call any other MySQL function. However, `mysql_server_init()` is deprecated and you should call `mysql_library_init()` instead. See Section 20.9.3.40, “`mysql_library_init()`”.

Return Values

Zero if successful. Nonzero if an error occurred.

20.9.9.2. `mysql_server_end()`

`void mysql_server_end(void)`

Description

This function finalizes the MySQL library, which should be done when you are done using the library. However, `mysql_server_end()` is deprecated and `mysql_library_end()` should be used instead. See Section 20.9.3.39, “`mysql_library_end()`”.

Return Values

None.

20.9.10. C API Client Plugin Functions

This section describes functions used for the client-side plugin API. They enable management of client plugins. For a description of the `st_mysql_client_plugin` structure used by these functions, see Section 21.2.4.2.3, “Client Plugin Descriptors”.

It is unlikely that a client program needs to call the functions in this section. For example, a client that supports the use of authentication plugins normally causes a plugin to be loaded by calling `mysql_options()` to set the `MYSQL_DEFAULT_AUTH` and `MYSQL_PLUGIN_DIR` options:

```
char *plugin_dir = "path_to_plugin_dir";
char *default_auth = "plugin_name";

/* ... process command-line options ... */

mysql_options(&mysql, MYSQL_PLUGIN_DIR, plugin_dir);
mysql_options(&mysql, MYSQL_DEFAULT_AUTH, default_auth);
```

Typically, the program will also accept `--plugin-dir` and `--default-auth` options that enable users to override the default values.

20.9.10.1. `mysql_client_find_plugin()`

`struct st_mysql_client_plugin *mysql_client_find_plugin(MYSQL *mysql, const char *name, int type)`

Description

Returns a pointer to a loaded plugin, loading the plugin first if necessary. An error occurs if the type is invalid or the plugin cannot be found or loaded.

Specify the parameters as follows:

- `mysql`: A pointer to a `MYSQL` structure. The plugin API does not require a connection to a MySQL server, but this structure must be properly initialized. The structure is used to obtain connection-related information.
- `name`: The plugin name.
- `type`: The plugin type.

This function was added in MySQL 5.5.7.

Return Values

A pointer to the plugin for success. `NULL` if an error occurred.

Errors

To check for errors, call the `mysql_error()` or `mysql_errno()` function. See Section 20.9.3.15, “`mysql_error()`”, and Section 20.9.3.14, “`mysql_errno()`”.

Example

```
MYSQL mysql;
struct st_mysql_client_plugin *p;

if ((p = mysql_client_find_plugin(&mysql, "myplugin",
                                  MYSQL_AUTHENTICATION_PLUGIN, 0)))
{
  printf("Plugin version: %d.%d.%d\n", p->version[0], p->version[1], p->version[2]);
}
```

20.9.10.2. `mysql_client_register_plugin()`

`struct st_mysql_client_plugin *mysql_client_register_plugin(MYSQL *mysql, struct st_mysql_client_plugin *plugin)`

Description

Adds a plugin structure to the list of loaded plugins. An error occurs if the plugin is already loaded.

Specify the parameters as follows:

- `mysql`: A pointer to a `MYSQL` structure. The plugin API does not require a connection to a MySQL server, but this structure must be properly initialized. The structure is used to obtain connection-related information.
- `plugin`: A pointer to the plugin structure.

This function was added in MySQL 5.5.7.

Return Values

A pointer to the plugin for success. `NULL` if an error occurred.

Errors

To check for errors, call the `mysql_error()` or `mysql_errno()` function. See Section 20.9.3.15, “`mysql_error()`”, and Section 20.9.3.14, “`mysql_errno()`”.

20.9.10.3. `mysql_load_plugin()`

`struct st_mysql_client_plugin *mysql_load_plugin(MYSQL *mysql, const char *name, int type, int argc, ...)`

Description

Loads a MySQL client plugin, specified by name and type. An error occurs if the type is invalid or the plugin cannot be loaded.

It is not possible to load multiple plugins of the same type. An error occurs if you try to load a plugin of a type already loaded.

Specify the parameters as follows:

- `mysql`: A pointer to a `MYSQL` structure. The plugin API does not require a connection to a MySQL server, but this structure must be properly initialized. The structure is used to obtain connection-related information.
- `name`: The name of the plugin to load.
- `type`: The type of plugin to load, or –1 to disable type checking. If type is not –1, only plugins matching the type are considered for loading.
- `argc`: The number of following arguments (0 if there are none). Interpretation of any following arguments depends on the plugin type.

This function was added in MySQL 5.5.7.

Another way to cause plugins to be loaded is to set the `LIBMYSQL_PLUGINS` environment variable to a semicolon-separated list of plugin names. For example:

```
shell> export LIBMYSQL_PLUGINS="myplugin1;myplugin2"
```

Plugins named by `LIBMYSQL_PLUGINS` are loaded when the client program calls `mysql_library_init()`. No error is reported if problems occur loading these plugins.

Return Values

A pointer to the plugin if it was loaded successfully. `NULL` if an error occurred.

Errors

To check for errors, call the `mysql_error()` or `mysql_errno()` function. See Section 20.9.3.15, “`mysql_error()`”, and Section 20.9.3.14, “`mysql_errno()`”.

Example

```
MYSQL mysql;

if(!mysql_load_plugin(&mysql, "myplugin",
                      MYSQL_AUTHENTICATION_PLUGIN, 0))
{
    fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
    exit(-1);
}
```

See Also

See also Section 20.9.10.3, “`mysql_load_plugin()`”, Section 20.9.3.15, “`mysql_error()`”, Section 20.9.3.14, “`mysql_errno()`”.

20.9.10.4. `mysql_load_plugin_v()`

`struct st_mysql_client_plugin *mysql_load_plugin_v(MYSQL *mysql, const char *name, int type, int argc, va_list args)`

Description

This function is equivalent to `mysql_load_plugin()`, but it accepts a `va_list` instead of a variable list of parameters.

This function was added in MySQL 5.5.7.

See Also

See also Section 20.9.10.3, “`mysql_load_plugin()`”.

20.9.10.5. `mysql_plugin_options()`

`int mysql_plugin_options(struct st_mysql_client_plugin *plugin, const char *option, const void *value)`

Description

Passes an option type and value to a plugin. This function can be called multiple times to set several options. If the plugin does not have an option handler, an error occurs.

Specify the parameters as follows:

- `plugin`: A pointer to the plugin structure.
- `option`: The option to be set.
- `value`: A pointer to the option value.

This function was added in MySQL 5.5.7.

Return Values

Zero for success, 1 if an error occurred. If the plugin has an option handler, that handler should also return zero for success and 1 if an error occurred.

20.9.11. Common Questions and Problems When Using the C API

20.9.11.1. Why `mysql_store_result()` Sometimes Returns `NULL` After `mysql_query()` Returns Success

It is possible for `mysql_store_result()` to return `NULL` following a successful call to `mysql_query()`. When this happens, it means one of the following conditions occurred:

- There was a `malloc()` failure (for example, if the result set was too large).
- The data couldn't be read (an error occurred on the connection).
- The query returned no data (for example, it was an `INSERT`, `UPDATE`, or `DELETE`).

You can always check whether the statement should have produced a nonempty result by calling `mysql_field_count()`. If `mysql_field_count()` returns zero, the result is empty and the last query was a statement that does not return values (for example, an `INSERT` or a `DELETE`). If `mysql_field_count()` returns a nonzero value, the statement should have produced a nonempty result. See the description of the `mysql_field_count()` function for an example.

You can test for an error by calling `mysql_error()` or `mysql_errno()`.

20.9.11.2. What Results You Can Get from a Query

In addition to the result set returned by a query, you can also get the following information:

- `mysql_affected_rows()` returns the number of rows affected by the last query when doing an `INSERT`, `UPDATE`, or `DELETE`.

  For a fast re-create, use `TRUNCATE TABLE`.
- `mysql_num_rows()` returns the number of rows in a result set. With `mysql_store_result()`, `mysql_num_rows()` may be called as soon as `mysql_store_result()` returns. With `mysql_use_result()`, `mysql_num_rows()` may be called only after you have fetched all the rows with `mysql_fetch_row()`.
- `mysql_insert_id()` returns the ID generated by the last query that inserted a row into a table with an `AUTO_INCREMENT` index. See Section 20.9.3.37, “`mysql_insert_id()`”.
- Some queries (`LOAD DATA INFILE ...`, `INSERT INTO ... SELECT ...`, `UPDATE`) return additional information. The result is returned by `mysql_info()`. See the description for `mysql_info()` for the format of the string that it returns. `mysql_info()` returns a `NULL` pointer if there is no additional information.

20.9.11.3. How to Get the Unique ID for the Last Inserted Row

If you insert a record into a table that contains an `AUTO_INCREMENT` column, you can obtain the value stored into that column by calling the `mysql_insert_id()` function.

You can check from your C applications whether a value was stored in an `AUTO_INCREMENT` column by executing the following code (which assumes that you've checked that the statement succeeded). It determines whether the query was an `INSERT` with an `AUTO_INCREMENT` index:

```
if ((result = mysql_store_result(&mysql)) == 0 &&
    mysql_field_count(&mysql) == 0 &&
    mysql_insert_id(&mysql) != 0)
{
    used_id = mysql_insert_id(&mysql);
}
```

When a new `AUTO_INCREMENT` value has been generated, you can also obtain it by executing a `SELECT LAST_INSERT_ID()` statement with `mysql_query()` and retrieving the value from the result set returned by the statement.

When inserting multiple values, the last automatically incremented value is returned.

For `LAST_INSERT_ID()`, the most recently generated ID is maintained in the server on a per-connection basis. It is not changed by another client. It is not even changed if you update another `AUTO_INCREMENT` column with a nonmagic value (that is, a value that is not `NULL` and not `0`). Using `LAST_INSERT_ID()` and `AUTO_INCREMENT` columns simultaneously from multiple clients is perfectly valid. Each client will receive the last inserted ID for the last statement *that* client executed.

If you want to use the ID that was generated for one table and insert it into a second table, you can use SQL statements like this:

```
INSERT INTO foo (auto,text)
    VALUES(NULL,'text');         # generate ID by inserting NULL
INSERT INTO foo2 (id,text)
    VALUES(LAST_INSERT_ID(),'text');  # use ID in second table
```

Note that `mysql_insert_id()` returns the value stored into an `AUTO_INCREMENT` column, whether that value is automatically generated by storing `NULL` or `0` or was specified as an explicit value. `LAST_INSERT_ID()` returns only automatically generated `AUTO_INCREMENT` values. If you store an explicit value other than `NULL` or `0`, it does not affect the value returned by `LAST_INSERT_ID()`.

For more information on obtaining the last ID in an `AUTO_INCREMENT` column:

- For information on `LAST_INSERT_ID()`, which can be used within an SQL statement, see Section 11.14, “Information Functions”.
- For information on `mysql_insert_id()`, the function you use from within the C API, see Section 20.9.3.37, “`mysql_insert_id()`”.
- For information on obtaining the auto-incremented value when using Connector/J, see Section 20.3.5, “Connector/J Notes and Tips”.
- For information on obtaining the auto-incremented value when using Connector/ODBC, see Section 20.1.7.1.1, “Obtaining Auto-Increment Values”.

20.9.12. Controlling Automatic Reconnection Behavior

The MySQL client library can perform an automatic reconnection to the server if it finds that the connection is down when you attempt to send a statement to the server to be executed. In this case, the library tries once to reconnect to the server and send the statement again.

In MySQL 5.5, auto-reconnect is disabled by default.

If it is important for your application to know that the connection has been dropped (so that is can exit or take action to adjust for the loss of state information), be sure that auto-reconnect is disabled. To ensure this, call `mysql_options()` with the `MYSQL_OPT_RECONNECT` option:

```
my_bool reconnect = 0;
mysql_options(&mysql, MYSQL_OPT_RECONNECT, &reconnect);
```

If the connection has gone down, the effect of `mysql_ping()` depends on the auto-reconnect state. If auto-reconnect is enabled, `mysql_ping()` performs a reconnect. Otherwise, it returns an error.

Some client programs might provide the capability of controlling automatic reconnection. For example, `mysql` reconnects by default, but the `--skip-reconnect` option can be used to suppress this behavior.

If an automatic reconnection does occur (for example, as a result of calling `mysql_ping()`), there is no explicit indication of it. To check for reconnection, call `mysql_thread_id()` to get the original connection identifier before calling `mysql_ping()`, then call `mysql_thread_id()` again to see whether the identifier has changed.

Automatic reconnection can be convenient because you need not implement your own reconnect code, but if a reconnection does occur, several aspects of the connection state are reset on the server side and your application will not know about it. The connection-related state is affected as follows:

- Any active transactions are rolled back and autocommit mode is reset.
- All table locks are released.
- All `TEMPORARY` tables are closed (and dropped).
- Session variables are reinitialized to the values of the corresponding variables. This also affects variables that are set implicitly by statements such as `SET NAMES`.
- User variable settings are lost.
- Prepared statements are released.

- `HANDLER` variables are closed.
- The value of `LAST_INSERT_ID()` is reset to 0.
- Locks acquired with `GET_LOCK()` are released.

If the connection drops, it is possible that the session associated with the connection on the server side will still be running if the server has not yet detected that the client is no longer connected. In this case, any locks held by the original connection still belong to that session, so you may want to kill it by calling `mysql_kill()`.

20.9.13. C API Support for Multiple Statement Execution

By default, `mysql_query()` and `mysql_real_query()` interpret their statement string argument as a single statement to be executed, and you process the result according to whether the statement produces a result set (a set of rows, as for `SELECT`) or an affected-rows count (as for `INSERT`, `UPDATE`, and so forth).

MySQL 5.5 also supports the execution of a string containing multiple statements separated by semicolon (“`;`”) characters. This capability is enabled by special options that are specified either when you connect to the server with `mysql_real_connect()` or after connecting by calling` `mysql_set_server_option()`.

Executing a multiple-statement string can produce multiple result sets or row-count indicators. Processing these results involves a different approach than for the single-statement case: After handling the result from the first statement, it is necessary to check whether more results exist and process them in turn if so. To support multiple-result processing, the C API includes the `mysql_more_results()` and `mysql_next_result()` functions. These functions are used at the end of a loop that iterates as long as more results are available. *Failure to process the result this way may result in a dropped connection to the server.*

Multiple-result processing also is required if you execute `CALL` statements for stored procedures. Results from a stored procedure have these characteristics:

- Statements within the procedure may produce result sets (for example, if it executes `SELECT` statements). These result sets are returned in the order that they are produced as the procedure executes.

  In general, the caller cannot know how many result sets a procedure will return. Procedure execution may depend on loops or conditional statements that cause the execution path to differ from one call to the next. Therefore, you must be prepared to retrieve multiple results.

- The final result from the procedure is a status result that includes no result set. The status indicates whether the procedure succeeded or an error occurred.

The multiple statement and result capabilities can be used only with `mysql_query()` or `mysql_real_query()`. They cannot be used with the prepared statement interface. Prepared statement handles are defined to work only with strings that contain a single statement. See Section 20.9.4, “C API Prepared Statements”.

To enable multiple-statement execution and result processing, the following options may be used:

- The `mysql_real_connect()` function has a `flags` argument for which two option values are relevant:
  - `CLIENT_MULTI_RESULTS` enables the client program to process multiple results. This option *must* be enabled if you execute `CALL` statements for stored procedures that produce result sets. Otherwise, such procedures result in an error `Error 1312 (0A000): PROCEDURE` *`proc_name`* `can't return a result set in the given context`. As of MySQL 5.5.3, `CLIENT_MULTI_RESULTS` is enabled by default.
  - `CLIENT_MULTI_STATEMENTS` enables `mysql_query()` and `mysql_real_query()` to execute statement strings containing multiple statements separated by semicolons. This option also enables `CLIENT_MULTI_RESULTS` implicitly, so a `flags` argument of `CLIENT_MULTI_STATEMENTS` to `mysql_real_connect()` is equivalent to an argument of `CLIENT_MULTI_STATEMENTS | CLIENT_MULTI_RESULTS`. That is, `CLIENT_MULTI_STATEMENTS` is sufficient to enable multiple-statement execution and all multiple-result processing.
- After the connection to the server has been established, you can use the `mysql_set_server_option()` function to enable or disable multiple-statement execution by passing it an argument of `MYSQL_OPTION_MULTI_STATEMENTS_ON` or `MYSQL_OPTION_MULTI_STATEMENTS_OFF`. Enabling multiple-statement execution with this function also enables processing of “simple” results for a multiple-statement string where each statement produces a single result, but is *not* sufficient to permit processing of stored procedures that produce result sets.

The following procedure outlines a suggested strategy for handling multiple statements:

1. Pass `CLIENT_MULTI_STATEMENTS` to `mysql_real_connect()`, to fully enable multiple-statement execution and multiple-result processing.
2. After calling `mysql_query()` or `mysql_real_query()` and verifying that it succeeds, enter a loop within which you process statement results.
3. For each iteration of the loop, handle the current statement result, retrieving either a result set or an affected-rows count. If an error occurs, exit the loop.
4. At the end of the loop, call `mysql_next_result()` to check whether another result exists and initiate retrieval for it if so. If no more results are available, exit the loop.

One possible implementation of the preceding strategy is shown following. The final part of the loop can be reduced to a simple test of whether `mysql_next_result()` returns nonzero. The code as written distinguishes between no more results and an error, which enables a message to be printed for the latter occurrence.

```
/* connect to server with the CLIENT_MULTI_STATEMENTS option */
if (mysql_real_connect (mysql, host_name, user_name, password,
    db_name, port_num, socket_name, CLIENT_MULTI_STATEMENTS) == NULL)
{
  printf("mysql_real_connect() failed\n");
  mysql_close(mysql);
  exit(1);
}

/* execute multiple statements */
status = mysql_query(mysql,
                     "DROP TABLE IF EXISTS test_table;\
                      CREATE TABLE test_table(id INT);\
                      INSERT INTO test_table VALUES(10);\
                      UPDATE test_table SET id=20 WHERE id=10;\
                      SELECT * FROM test_table;\
                      DROP TABLE test_table");
if (status)
{
  printf("Could not execute statement(s)");
  mysql_close(mysql);
  exit(0);
}

/* process each statement result */
do {
  /* did current statement return data? */
  result = mysql_store_result(mysql);
  if (result)
  {
    /* yes; process rows and free the result set */
    process_result_set(mysql, result);
    mysql_free_result(result);
  }
  else          /* no result set or error */
  {
    if (mysql_field_count(mysql) == 0)
    {
      printf("%lld rows affected\n",
            mysql_affected_rows(mysql));
    }
    else  /* some error occurred */
    {
      printf("Could not retrieve result set\n");
      break;
    }
  }
  /* more results? -1 = no, >0 = error, 0 = yes (keep looping) */
  if ((status = mysql_next_result(mysql)) > 0)
    printf("Could not execute statement\n");
} while (status == 0);

mysql_close(mysql);
```

20.9.14. C API Prepared Statement Problems

Here follows a list of the currently known problems with prepared statements:

- `TIME`, `TIMESTAMP`, and `DATETIME` do not support parts of seconds (for example, from `DATE_FORMAT()`).
- When converting an integer to string, `ZEROFILL` is honored with prepared statements in some cases where the MySQL server doesn't print the leading zeros. (For example, with `MIN(`*`number-with-zerofill`*`)`).
- When converting a floating-point number to a string in the client, the rightmost digits of the converted value may differ slightly from those of the original value.

- Prepared statements use the query cache under the conditions described in Section 7.9.3.1, “How the Query Cache Operates”.
- Prepared statements do not support multi-statements (that is, multiple statements within a single string separated by “`;`” characters).
- Before MySQL 5.5.3, prepared `CALL` statements cannot invoke stored procedures that return result sets because prepared statements do not support multiple result sets. Nor can the calling application access a stored procedure's `OUT` or `INOUT` parameters when the procedure returns. As of MySQL 5.5.3, these capabilities are supported as described in Section 20.9.16, “C API Support for Prepared `CALL` Statements”.

20.9.15. C API Prepared Statement Handling of Date and Time Values

The binary (prepared statement) protocol enables you to send and receive date and time values (`DATE`, `TIME`, `DATETIME`, and `TIMESTAMP`), using the `MYSQL_TIME` structure. The members of this structure are described in Section 20.9.5, “C API Prepared Statement Data Structures”.

To send temporal data values, create a prepared statement using `mysql_stmt_prepare()`. Then, before calling `mysql_stmt_execute()` to execute the statement, use the following procedure to set up each temporal parameter:

1. In the `MYSQL_BIND` structure associated with the data value, set the `buffer_type` member to the type that indicates what kind of temporal value you're sending. For `DATE`, `TIME`, `DATETIME`, or `TIMESTAMP` values, set `buffer_type` to `MYSQL_TYPE_DATE`, `MYSQL_TYPE_TIME`, `MYSQL_TYPE_DATETIME`, or `MYSQL_TYPE_TIMESTAMP`, respectively.
2. Set the `buffer` member of the `MYSQL_BIND` structure to the address of the `MYSQL_TIME` structure in which you pass the temporal value.
3. Fill in the members of the `MYSQL_TIME` structure that are appropriate for the type of temporal value to be passed.

Use `mysql_stmt_bind_param()` to bind the parameter data to the statement. Then you can call `mysql_stmt_execute()`.

To retrieve temporal values, the procedure is similar, except that you set the `buffer_type` member to the type of value you expect to receive, and the `buffer` member to the address of a `MYSQL_TIME` structure into which the returned value should be placed. Use `mysql_stmt_bind_result()` to bind the buffers to the statement after calling `mysql_stmt_execute()` and before fetching the results.

Here is a simple example that inserts `DATE`, `TIME`, and `TIMESTAMP` data. The `mysql` variable is assumed to be a valid connection handle.

```
MYSQL_TIME  ts;
MYSQL_BIND  bind[3];
MYSQL_STMT  *stmt;

strmov(query, "INSERT INTO test_table(date_field, time_field, \
                             timestamp_field) VALUES(?,?,?");

stmt = mysql_stmt_init(mysql);
if (!stmt)
{
  fprintf(stderr, " mysql_stmt_init(), out of memory\n");
  exit(0);
}
if (mysql_stmt_prepare(mysql, query, strlen(query)))
{
  fprintf(stderr, "\n mysql_stmt_prepare(), INSERT failed");
  fprintf(stderr, "\n %s", mysql_stmt_error(stmt));
  exit(0);
}

/* set up input buffers for all 3 parameters */
bind[0].buffer_type= MYSQL_TYPE_DATE;
bind[0].buffer= (char *)&ts;
bind[0].is_null= 0;
bind[0].length= 0;
...
bind[1]= bind[2]= bind[0];
...

mysql_stmt_bind_param(stmt, bind);

/* supply the data to be sent in the ts structure */
ts.year= 2002;
ts.month= 02;
ts.day= 03;

ts.hour= 10;
ts.minute= 45;
ts.second= 20;

mysql_stmt_execute(stmt);
..
```

20.9.16. C API Support for Prepared `CALL` Statements

This section describes prepared-statement support in the C API for stored procedures executed using `CALL` statements:

Prior to MySQL 5.5.3, prepared `CALL` statements can be used only for stored procedures that produce at most one result set. Nor can the calling application use placeholders for `OUT` or `INOUT` parameters.

MySQL 5.5.3 expands support for stored procedures executed using prepared `CALL` statements in the following ways:

- A stored procedure can produce any number of result sets. The number of columns and the data types of the columns need not be the same for all result sets.
- The final values of `OUT` and `INOUT` parameters are available to the calling application after the procedure returns. These parameters are returned as an extra single-row result set following any result sets produced by the procedure itself. The row contains the values of the `OUT` and `INOUT` parameters in the order in which they are declared in the procedure parameter list.

The following discussion shows how to use these capabilities through the C API for prepared statements. To use prepared `CALL` statements through the `PREPARE` and `EXECUTE` statements, see Section 12.2.1, “`CALL` Syntax”.

If an application might be compiled or executed in a context where a version of MySQL older than 5.5.3 is used, prepared `CALL` capabilities for multiple result sets and `OUT` or `INOUT` parameters might not be available:

- For the client side, the application will not compile unless the libraries are from MySQL 5.5.3 or higher (the API function and symbols introduced in that version will not be present).
- To verify at runtime that the server is recent enough, a client can use this test:

  ```
  if (mysql_get_server_version(mysql) < 50503)
  {
    fprintf(stderr,
            "Server does not support required CALL capabilities\n");
    mysql_close(mysql);
    exit (1);
  }
  ```

An application that executes a prepared `CALL` statement should use a loop that fetches a result and then invokes `mysql_stmt_next_result()` to determine whether there are more results. The results consist of any result sets produced by the stored procedure followed by a final status value that indicates whether the procedure terminated successfully.

If the procedure has `OUT` or `INOUT` parameters, the result set preceding the final status value contains their values. To determine whether a result set contains parameter values, test whether the `SERVER_PS_OUT_PARAMS` bit is set in the `server_status` member of the `MYSQL` connection handler:

```
mysql->server_status & SERVER_PS_OUT_PARAMS
```

The following example uses a prepared `CALL` statement to execute a stored procedure that produces multiple result sets and that provides parameter values back to the caller by means of `OUT` and `INOUT` parameters. The procedure takes parameters of all three types (`IN`, `OUT`, `INOUT`), displays their initial values, assigns new values, displays the updated values, and returns. The expected return information from the procedure therefore consists of multiple result sets and a final status:

- One result set containing the initial parameter values: `10`, `NULL`, `30`. (The `OUT` parameter is assigned a value by the caller, but this assignment is expected to be ineffective: `OUT` parameters are seen as `NULL` within a procedure until assigned a value within the procedure.)
- One result set containing the modified parameter values: `100`, `200`, `300`.
- One result set containing the final `OUT` and `INOUT` parameter values: `200`, `300`.
- A final status packet.

The code to execute the procedure:

```
MYSQL_STMT *stmt;
MYSQL_BIND ps_params[3];  /* input parameter buffers */
int        int_data[3];   /* input parameter values */
my_bool    is_null[3];    /* input parameter nullability */
int        status;

/* set up stored procedure */
status = mysql_query(mysql, "DROP PROCEDURE IF EXISTS p1");
test_error(mysql, status);

status = mysql_query(mysql,
  "CREATE PROCEDURE p1("
  "  IN p_in INT, "
  "  OUT p_out INT, "
  "  INOUT p_inout INT) "
  "BEGIN "
  "  SELECT p_in, p_out, p_inout; "
  "  SET p_in = 100, p_out = 200, p_inout = 300; "
  "  SELECT p_in, p_out, p_inout; "
  "END");
test_error(mysql, status);

/* initialize and prepare CALL statement with parameter placeholders */
stmt = mysql_stmt_init(mysql);
if (!stmt)
{
  printf("Could not initialize statement\n");
  exit(1);
}
status = mysql_stmt_prepare(stmt, "CALL p1(?, ?, ?)", 16);
test_stmt_error(stmt, status);

/* initialize parameters: p_in, p_out, p_inout (all INT) */
memset(ps_params, 0, sizeof (ps_params));

ps_params[0].buffer_type = MYSQL_TYPE_LONG;
ps_params[0].buffer = (char *) &int_data[0];
ps_params[0].length = 0;
ps_params[0].is_null = 0;

ps_params[1].buffer_type = MYSQL_TYPE_LONG;
ps_params[1].buffer = (char *) &int_data[1];
ps_params[1].length = 0;
ps_params[1].is_null = 0;

ps_params[2].buffer_type = MYSQL_TYPE_LONG;
ps_params[2].buffer = (char *) &int_data[2];
ps_params[2].length = 0;
ps_params[2].is_null = 0;

/* bind parameters */
status = mysql_stmt_bind_param(stmt, ps_params);
test_stmt_error(stmt, status);

/* assign values to parameters and execute statement */
int_data[0]= 10;  /* p_in */
int_data[1]= 20;  /* p_inout */
int_data[2]= 30;  /* p_inout */

status = mysql_stmt_execute(stmt);
test_stmt_error(stmt, status);

/* process results until there are no more */
do {
  int i;
  int num_fields;       /* number of columns in result */
  MYSQL_FIELD *fields;  /* for result set metadata */
  MYSQL_BIND *rs_bind;  /* for output buffers */

  /* the column count is > 0 if there is a result set */
  /* 0 if the result is only the final status packet */
  num_fields = mysql_stmt_field_count(stmt);

  if (num_fields > 0)
  {
    /* there is a result set to fetch */
    printf("Number of columns in result: %d\n", (int) num_fields);

    /* what kind of result set is this? */
    printf("Data: ");
    if(mysql->server_status & SERVER_PS_OUT_PARAMS)
      printf("this result set contains OUT/INOUT parameters\n");
    else
      printf("this result set is produced by the procedure\n");

    MYSQL_RES *rs_metadata = mysql_stmt_result_metadata(stmt);
    test_stmt_error(stmt, rs_metadata == NULL);

    fields = mysql_fetch_fields(rs_metadata);

    rs_bind = (MYSQL_BIND *) malloc(sizeof (MYSQL_BIND) * num_fields);
    if (!rs_bind)
    {
      printf("Cannot allocate output buffers\n");
      exit(1);
    }
    memset(rs_bind, 0, sizeof (MYSQL_BIND) * num_fields);

    /* set up and bind result set output buffers */
    for (i = 0; i < num_fields; ++i)
    {
      rs_bind[i].buffer_type = fields[i].type;
      rs_bind[i].is_null = &is_null[i];

      switch (fields[i].type)
      {
        case MYSQL_TYPE_LONG:
          rs_bind[i].buffer = (char *) &(int_data[i]);
          rs_bind[i].buffer_length = sizeof (int_data);
          break;

        default:
          fprintf(stderr, "ERROR: unexpected type: %d.\n", fields[i].type);
          exit(1);
      }
    }

    status = mysql_stmt_bind_result(stmt, rs_bind);
    test_stmt_error(stmt, status);

    /* fetch and display result set rows */
    while (1)
    {
      status = mysql_stmt_fetch(stmt);

      if (status == 1 || status == MYSQL_NO_DATA)
        break;

      for (i = 0; i < num_fields; ++i)
      {
        switch (rs_bind[i].buffer_type)
        {
          case MYSQL_TYPE_LONG:
            if (*rs_bind[i].is_null)
              printf(" val[%d] = NULL;", i);
            else
              printf(" val[%d] = %ld;",
                     i, (long) *((int *) rs_bind[i].buffer));
            break;

          default:
            printf("  unexpected type (%d)\n",
              rs_bind[i].buffer_type);
        }
      }
      printf("\n");
    }

    mysql_free_result(rs_metadata); /* free metadata */
    free(rs_bind);                  /* free output buffers */
  }
  else
  {
    /* no columns = final status packet */
    printf("End of procedure output\n");
  }

  /* more results? -1 = no, >0 = error, 0 = yes (keep looking) */
  status = mysql_stmt_next_result(stmt);
  if (status > 0)
    test_stmt_error(stmt, status);
} while (status == 0);

mysql_stmt_close(stmt);
```

Execution of the procedure should produce the following output:

```
Number of columns in result: 3
Data: this result set is produced by the procedure
 val[0] = 10; val[1] = NULL; val[2] = 30;
Number of columns in result: 3
Data: this result set is produced by the procedure
 val[0] = 100; val[1] = 200; val[2] = 300;
Number of columns in result: 2
Data: this result set contains OUT/INOUT parameters
 val[0] = 200; val[1] = 300;
End of procedure output
```

The code uses two utility routines, `test_error()` `test_stmt_error()`, to check for errors and terminate after printing diagnostic information if an error occurred:

```
static void test_error(MYSQL *mysql, int status)
{
  if (status)
  {
    printf("Error: %s (errno: %d)\n",
           mysql_error(mysql), mysql_errno(mysql));
    exit(1);
  }
}

static void test_stmt_error(MYSQL_STMT *stmt, int status)
{
  if (status)
  {
    printf("Error: %s (errno: %d)\n",
           mysql_stmt_error(stmt), mysql_stmt_errno(stmt));
    exit(1);
  }
}
```

20.9.17. Building Client Programs

If you compile MySQL clients that you've written yourself or that you obtain from a third-party, they must be linked using the `-lmysqlclient -lz` options in the link command. You may also need to specify a `-L` option to tell the linker where to find the library. For example, if the library is installed in `/usr/local/mysql/lib`, use `-L/usr/local/mysql/lib -lmysqlclient -lz` in the link command.

For clients that use MySQL header files, you may need to specify an `-I` option when you compile them (for example, `-I/usr/local/mysql/include`), so that the compiler can find the header files.

Compiling MySQL Clients on Unix

To make it simpler to compile MySQL programs on Unix, we have provided the `mysql_config` script for you. See Section 4.7.2, “`mysql_config` — Get Compile Options for Compiling Clients”.

You can use it to compile a MySQL client as follows:

```
CFG=/usr/local/mysql/bin/mysql_config
sh -c "gcc -o progname `$CFG --cflags` progname.c `$CFG --libs`"
```

The `sh -c` is needed to get the shell not to treat the output from `mysql_config` as one word.

Compiling MySQL Clients on Microsoft Windows

On Windows, you can link your code with either the dynamic or static client library. The static library is named `mysqlclient` and the dynamic library is named `libmysql`.

If you link with the static library, failure can occur if certain conditions are not satisfied:

- The client application must be compiled with exactly the same version of Visual Studio as that used to compile the library.
- The client application should link the C runtime statically by using the `/MT` compiler option.

If the client application is built in in debug mode and uses the static debug C runtime (`/MTd` compiler option), it can link the `mysqlclient` if that library was built using the same option. If the client application uses the dynamic C runtime (`/MD` option, or `/MDd` option in debug mode), it cannot link with the static client library and must use the dynamic library.

The MSDN page describing the link options can be found here: http://msdn.microsoft.com/en-us/library/2kzt1wy3.aspx

20.9.17.1. Problems Linking to the MySQL Client Library

When linking with the C API, the following errors may occur on some systems:

```
gcc -g -o client test.o -L/usr/local/lib/mysql \
                        -lmysqlclient -lsocket -lnsl

Undefined        first referenced
 symbol          in file
floor            /usr/local/lib/mysql/libmysqlclient.a(password.o)
ld: fatal: Symbol referencing errors. No output written to client
```

If this happens on your system, you must include the math library by adding `-lm` to the end of the compile/link line.

When you are linking an application program to use the MySQL client library, you might get undefined reference errors for symbols that start with `mysql_`, such as those shown here:

```
/tmp/ccFKsdPa.o: In function `main':
```

```
/tmp/ccFKsdPa.o(.text+0xb): undefined reference to `mysql_init'
/tmp/ccFKsdPa.o(.text+0x31): undefined reference to `mysql_real_connect'
/tmp/ccFKsdPa.o(.text+0x57): undefined reference to `mysql_real_connect'
/tmp/ccFKsdPa.o(.text+0x69): undefined reference to `mysql_error'
/tmp/ccFKsdPa.o(.text+0x9a): undefined reference to `mysql_close'
```

You should be able to solve this problem by adding `-Ldir_path -lmysqlclient` at the end of your link command, where `dir_path` represents the path name of the directory where the client library is located. To determine the correct directory, try this command:

```
shell> mysql_config --libs
```

The output from `mysql_config` might indicate other libraries that should be specified on the link command as well.

If you get `undefined reference` errors for the `uncompress` or `compress` function, add `-lz` to the end of your link command and try again.

If you get `undefined reference` errors for a function that should exist on your system, such as `connect`, check the manual page for the function in question to determine which libraries you should add to the link command.

You might get `undefined reference` errors such as the following for functions that don't exist on your system:

```
mf_format.o(.text+0x201): undefined reference to `__lxstat'
```

This usually means that your MySQL client library was compiled on a system that is not 100% compatible with yours. In this case, you should download the latest MySQL source distribution and compile MySQL yourself. See Section 2.9, “Installing MySQL from Source”.

You might get undefined reference errors at runtime when you try to execute a MySQL program. If these errors specify symbols that start with `mysql_` or indicate that the `mysqlclient` library can't be found, it means that your system can't find the shared `libmysqlclient.so` library. The fix for this is to tell your system to search for shared libraries where the library is located. Use whichever of the following methods is appropriate for your system:

- Add the path to the directory where `libmysqlclient.so` is located to the `LD_LIBRARY_PATH` environment variable.
- Add the path to the directory where `libmysqlclient.so` is located to the `LD_LIBRARY` environment variable.
- Copy `libmysqlclient.so` to some directory that is searched by your system, such as `/lib`, and update the shared library information by executing `ldconfig`.

20.9.17.2. How to Write a Threaded Client

The client library is almost thread-safe. The biggest problem is that the subroutines in `net.c` that read from sockets are not interrupt safe. This was done with the thought that you might want to have your own alarm that can break a long read to a server. If you install interrupt handlers for the `SIGPIPE` interrupt, the socket handling should be thread-safe.

To avoid aborting the program when a connection terminates, MySQL blocks `SIGPIPE` on the first call to `mysql_library_init()`, `mysql_init()`, or `mysql_connect()`. If you want to use your own `SIGPIPE` handler, you should first call `mysql_library_init()` and then install your handler.

If “undefined symbol” errors occur when linking against the `libmysqlclient` client library, in most cases this is because you have not included the thread libraries on the link/compile command.

The client library is thread-safe per connection. You can let two threads share the same connection with the following caveats:

- Two threads can't send a query to the MySQL server at the same time on the same connection. In particular, you have to ensure that between calls to `mysql_query()` and `mysql_store_result()` no other thread is using the same connection.
- Many threads can access different result sets that are retrieved with `mysql_store_result()`.
- If you use `mysql_use_result()`, you must ensure that no other thread is using the same connection until the result set is closed. However, it really is best for threaded clients that share the same connection to use `mysql_store_result()`.
- If you want to use multiple threads on the same connection, you must have a mutex lock around your pair of `mysql_query()` and `mysql_store_result()` calls. Once `mysql_store_result()` is ready, the lock can be released and other threads may query the same connection.
- If you use POSIX threads, you can use `pthread_mutex_lock()` and `pthread_mutex_unlock()` to establish and re-

lease a mutex lock.

You need to know the following if you have a thread that did not create the connection to the MySQL database but is calling MySQL functions:

When you call `mysql_init()`, MySQL creates a thread-specific variable for the thread that is used by the debug library (among other things). If you call a MySQL function before the thread has called `mysql_init()`, the thread does not have the necessary thread-specific variables in place and you are likely to end up with a core dump sooner or later. To avoid problems, you must do the following:

1. Call `mysql_library_init()` before any other MySQL functions. It is not thread-safe, so call it before threads are created, or protect the call with a mutex.
2. Arrange for `mysql_thread_init()` to be called early in the thread handler before calling any MySQL function. If you call `mysql_init()`, it will call `mysql_thread_init()` for you.
3. In the thread, call `mysql_thread_end()` before calling `pthread_exit()`. This frees the memory used by MySQL thread-specific variables.

The preceding notes regarding `mysql_init()` also apply to `mysql_connect()`, which calls `mysql_init()`.

20.10. MySQL PHP API

PHP is a server-side, HTML-embedded scripting language that may be used to create dynamic Web pages. It is available for most operating systems and Web servers, and can access most common databases, including MySQL. PHP may be run as a separate program or compiled as a module for use with the Apache Web server.

PHP actually provides two different MySQL API extensions:

- `mysql`: Available for PHP versions 4 and 5, this extension is intended for use with MySQL versions prior to MySQL 4.1. This extension does not support the improved authentication protocol used in MySQL 4.1, nor does it support prepared statements or multiple statements. If you wish to use this extension with MySQL 4.1, you will likely want to configure the MySQL server to use the `--old-passwords` option (see Section C.5.2.4, “`Client does not support authentication protocol`”). This extension is documented on the PHP Web site at http://php.net/mysql.
- Section 20.10.2, “MySQL Improved Extension (`Mysqli`)” - Stands for “MySQL, Improved”; this extension is available only in PHP 5. It is intended for use with MySQL 4.1.1 and later. This extension fully supports the authentication protocol used in MySQL 5.0, as well as the Prepared Statements and Multiple Statements APIs. In addition, this extension provides an advanced, object-oriented programming interface. You can read the documentation for the `mysqli` extension at http://php.net/mysqli. Helpful article can be found at http://devzone.zend.com/node/view/id/686 and http://devzone.zend.com/node/view/id/687.

If you're experiencing problems with enabling both the `mysql` and the `mysqli` extension when building PHP on Linux yourself, see Section 20.10.7, “Enabling Both `mysql` and `mysqli` in PHP”.

The PHP distribution and documentation are available from the PHP Web site.

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20.10.1. MySQL

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These functions allow you to access MySQL database servers. More information about MySQL can be found at http://www.mysql.com/.

Documentation for MySQL can be found at http://dev.mysql.com/doc/.

For an overview of MySQL database connectivity terms and products see Section 20.10.2.2, “Overview”.

20.10.1.1. Installing/Configuring

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20.10.1.1.1. Requirements

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In order to have these functions available, you must compile PHP with MySQL support.

20.10.1.1.2. Installation

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For compiling, simply use the `--with-mysql[=DIR]` configuration option where the optional `[DIR]` points to the MySQL installation directory.

Although this MySQL extension is compatible with MySQL 4.1.0 and greater, it doesn't support the extra functionality that these versions provide. For that, use the MySQLi extension.

If you would like to install the mysql extension along with the mysqli extension you have to use the same client library to avoid any conflicts.

20.10.1.1.2.1. Installation on Linux Systems

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20.10.1.1.2.1.1. PHP 4

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The option `--with-mysql` is enabled by default. This default behavior may be disabled with the `--without-mysql` configure option. If MySQL is enabled without specifying the path to the MySQL install DIR, PHP will use the bundled MySQL client libraries.

Users who run other applications that use MySQL (for example, `auth-mysql`) should not use the bundled library, but rather specify the path to MySQL's install directory, like so: `--with-mysql=/path/to/mysql`. This will force PHP to use the client libraries installed by MySQL, thus avoiding any conflicts.

20.10.1.1.2.1.2. PHP 5.0.x, 5.1.x, 5.2.x

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MySQL is not enabled by default, nor is the MySQL library bundled with PHP. Read this FAQ for details on why. Use the `--with-mysql[=DIR]` configure option to include MySQL support. You can download *headers and libraries* from http://www.mysql.com/.

20.10.1.1.2.1.3. PHP 5.3.0+

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In PHP 5.3.0 and above the MySQL-related database extensions use the MySQL Native Driver by default. This means that the MySQL Client Library (`libmysql`) is no longer required in order to support connection to a MySQL database. The extensions `mysql`, `mysqli`, and `PHP_PDO_MYSQL` are all enabled by default in PHP 5.3.0+, and all use the MySQL Native Driver by default. In each case no further installation steps are required in order to use these extensions, although you may want to set some preferences in `php.ini` depending on your requirements.

20.10.1.1.2.2. Installation on Windows Systems

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20.10.1.1.2.2.1. PHP 4

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The PHP MySQL extension is compiled into PHP.

20.10.1.1.2.2.2. PHP 5.0.x, 5.1.x, 5.2.x

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MySQL is no longer enabled by default, so the `php_mysql.dll` DLL must be enabled inside of `php.ini`. Also, PHP needs access to the MySQL client library. A file named `libmysql.dll` is included in the Windows PHP distribution and in order for PHP to talk to MySQL this file needs to be available to the Windows systems `PATH`. See the FAQ titled "How do I add my PHP directory to the `PATH` on Windows" for information on how to do this. Although copying `libmysql.dll` to the Windows system directory also works (because the system directory is by default in the system's `PATH`), it's not recommended.

As with enabling any PHP extension (such as `php_mysql.dll`), the PHP directive extension_dir should be set to the directory where the PHP extensions are located. See also the Manual Windows Installation Instructions. An example extension_dir value for PHP 5 is `c:\php\ext`

> **Note**
>
> If when starting the web server an error similar to the following occurs: `"Unable to load dynamic library './php_mysql.dll'"`, this is because `php_mysql.dll` and/or `libmysql.dll` cannot be found by the system.

20.10.1.1.2.2.3. PHP 5.3.0+

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Please refer to these notes on installing MySQL support on PHP 5.3.0 and above.

20.10.1.1.2.3. MySQL Installation Notes

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> **Warning**
>
> Crashes and startup problems of PHP may be encountered when loading this extension in conjunction with the recode extension. See the recode extension for more information.

> **Note**
>
> If you need charsets other than *latin* (default), you have to install external (not bundled) libmysql with compiled charset support.

20.10.1.1.3. Runtime Configuration

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The behaviour of these functions is affected by settings in `php.ini`.

Table 20.5. MySQL Configuration Options

Name	Default	Changeable	Changelog
mysql.allow_persistent	"1"	PHP_INI_SYSTEM	
mysql.max_persistent	"-1"	PHP_INI_SYSTEM	
mysql.max_links	"-1"	PHP_INI_SYSTEM	
mysql.trace_mode	"0"	PHP_INI_ALL	Available since PHP 4.3.0.
mysql.default_port	NULL	PHP_INI_ALL	
mysql.default_socket	NULL	PHP_INI_ALL	Available since PHP 4.0.1.
mysql.default_host	NULL	PHP_INI_ALL	
mysql.default_user	NULL	PHP_INI_ALL	
mysql.default_password	NULL	PHP_INI_ALL	
mysql.connect_timeout	"60"	PHP_INI_ALL	PHP_INI_SYSTEM in PHP <= 4.3.2. Available since PHP 4.3.0.

For further details and definitions of the PHP_INI_* modes, see the configuration.changes.modes.

Here's a short explanation of the configuration directives.

`mysql.allow_persistent` boolean	Whether to allow persistent connections to MySQL.
`mysql.max_persistent` integer	The maximum number of persistent MySQL connections per process.
`mysql.max_links` integer	The maximum number of MySQL connections per process, including persistent connections.
`mysql.trace_mode` boolean	Trace mode. When `mysql.trace_mode` is enabled, warnings for table/index scans, non free result sets, and SQL-Errors will be displayed. (Introduced in PHP 4.3.0)
`mysql.default_port` string	The default TCP port number to use when connecting to the database server if no other port is specified. If no default is specified, the port will be obtained from the `MYSQL_TCP_PORT` environment variable, the `mysql-tcp` entry in `/etc/services` or the compile-time `MYSQL_PORT` constant, in that order. Win32 will only use the `MYSQL_PORT` constant.
`mysql.default_socket` string	The default socket name to use when connecting to a local database server if no other socket name is specified.
`mysql.default_host` string	The default server host to use when connecting to the database server if no other host is specified. Doesn't apply in SQL safe mode.
`mysql.default_user` string	The default user name to use when connecting to the database server if no other name is specified. Doesn't apply in SQL safe mode.
`mysql.default_password` string	The default password to use when connecting to the database server if no other password is specified. Doesn't apply in SQL safe mode.
`mysql.connect_timeout` integer	Connect timeout in seconds. On Linux this timeout is also used for waiting for the first answer from the server.

20.10.1.1.4. Resource Types

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There are two resource types used in the MySQL module. The first one is the link identifier for a database connection, the second a resource which holds the result of a query.

20.10.1.2. Predefined Constants

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The constants below are defined by this extension, and will only be available when the extension has either been compiled into PHP or dynamically loaded at runtime.

Since PHP 4.3.0 it is possible to specify additional client flags for the `mysql_connect` and `mysql_pconnect` functions. The following constants are defined:

Table 20.6. MySQL client constants

Constant	Description
`MYSQL_CLIENT_COMPRESS`	Use compression protocol
`MYSQL_CLIENT_IGNORE_SPACE`	Allow space after function names
`MYSQL_CLIENT_INTERACTIVE`	Allow interactive_timeout seconds (instead of `wait_timeout`) of inactivity before closing the connection.
`MYSQL_CLIENT_SSL`	Use SSL encryption. This flag is only available with version 4.x of the MySQL client library or newer. Version 3.23.x is bundled both with PHP 4 and Windows binaries of PHP 5.

The function `mysql_fetch_array` uses a constant for the different types of result arrays. The following constants are defined:

Table 20.7. MySQL fetch constants

Constant	Description
`MYSQL_ASSOC`	Columns are returned into the array having the fieldname as the array index.
`MYSQL_BOTH`	Columns are returned into the array having both a numerical in-

Constant	Description
	dex and the fieldname as the array index.
`MYSQL_NUM`	Columns are returned into the array having a numerical index to the fields. This index starts with 0, the first field in the result.

20.10.1.3. Examples

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20.10.1.3.1. Basic

This simple example shows how to connect, execute a query, print resulting rows and disconnect from a MySQL database.

Example 20.15. MySQL extension overview example

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```
<?php
// Connecting, selecting database
$link = mysql_connect('mysql_host', 'mysql_user', 'mysql_password')
    or die('Could not connect: ' . mysql_error());
echo 'Connected successfully';
mysql_select_db('my_database') or die('Could not select database');

// Performing SQL query
$query = 'SELECT * FROM my_table';
$result = mysql_query($query) or die('Query failed: ' . mysql_error());

// Printing results in HTML
echo "<table>\n";
while ($line = mysql_fetch_array($result, MYSQL_ASSOC)) {
    echo "\t<tr>\n";
    foreach ($line as $col_value) {
        echo "\t\t<td>$col_value</td>\n";
    }
    echo "\t</tr>\n";
}
echo "</table>\n";

// Free resultset
mysql_free_result($result);

// Closing connection
mysql_close($link);
?>
```

20.10.1.4. MySQL Functions

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> **Note**
>
> Most MySQL functions accept *`link_identifier`* as the last optional parameter. If it is not provided, last opened connection is used. If it doesn't exist, connection is tried to establish with default parameters defined in `php.ini`. If it is not successful, functions return `FALSE` .

20.10.1.4.1. `mysql_affected_rows`

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- `mysql_affected_rows`

  Get number of affected rows in previous MySQL operation

Description

```
int mysql_affected_rows(resource link_identifier);
```

Get the number of affected rows by the last INSERT, UPDATE, REPLACE or DELETE query associated with *`link_identifier`*.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns the number of affected rows on success, and -1 if the last query failed.

If the last query was a DELETE query with no WHERE clause, all of the records will have been deleted from the table but this function will return zero with MySQL versions prior to 4.1.2.

When using UPDATE, MySQL will not update columns where the new value is the same as the old value. This creates the possibility that `mysql_affected_rows` may not actually equal the number of rows matched, only the number of rows that were literally affected by the query.

The REPLACE statement first deletes the record with the same primary key and then inserts the new record. This function returns the number of deleted records plus the number of inserted records.

Examples

Example 20.16. `mysql_affected_rows` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
mysql_select_db('mydb');

/* this should return the correct numbers of deleted records */
mysql_query('DELETE FROM mytable WHERE id < 10');
printf("Records deleted: %d\n", mysql_affected_rows());

/* with a where clause that is never true, it should return 0 */
mysql_query('DELETE FROM mytable WHERE 0');
printf("Records deleted: %d\n", mysql_affected_rows());
?>
```

The above example will output something similar to:

```
Records deleted: 10
Records deleted: 0
```

Example 20.17. `mysql_affected_rows` example using transactions

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
mysql_select_db('mydb');

/* Update records */
mysql_query("UPDATE mytable SET used=1 WHERE id < 10");
printf ("Updated records: %d\n", mysql_affected_rows());
```

```
mysql_query("COMMIT");
?>
```

The above example will output something similar to:

```
Updated Records: 10
```

Notes

> **Transactions**
>
> If you are using transactions, you need to call `mysql_affected_rows` after your INSERT, UPDATE, or DELETE query, not after the COMMIT.

> **SELECT Statements**
>
> To retrieve the number of rows returned by a SELECT, it is possible to use `mysql_num_rows`.

> **Cascaded Foreign Keys**
>
> `mysql_affected_rows` does not count rows affected implicitly through the use of ON DELETE CASCADE and/or ON UPDATE CASCADE in foreign key constraints.

See Also

`mysql_num_rows`
`mysql_info`

20.10.1.4.2. `mysql_client_encoding`

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- `mysql_client_encoding`

  Returns the name of the character set

Description

```
string mysql_client_encoding(resource link_identifier);
```

Retrieves the `character_set` variable from MySQL.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns the default character set name for the current connection.

Examples

Example 20.18. `mysql_client_encoding` example

```
<?php
$link    = mysql_connect('localhost', 'mysql_user', 'mysql_password');
$charset = mysql_client_encoding($link);

echo "The current character set is: $charset\n";
?>
```

The above example will output something similar to:

```
The current character set is: latin1
```

See Also

`mysql_set_charset`
`mysql_real_escape_string`

20.10.1.4.3. `mysql_close`

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- `mysql_close`

  Close MySQL connection

Description

```
bool mysql_close(resource link_identifier);
```

`mysql_close` closes the non-persistent connection to the MySQL server that's associated with the specified link identifier. If *`link_identifier`* isn't specified, the last opened link is used.

Using `mysql_close` isn't usually necessary, as non-persistent open links are automatically closed at the end of the script's execution. See also freeing resources.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.19. `mysql_close` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
echo 'Connected successfully';
mysql_close($link);
?>
```

The above example will output:

```
Connected successfully
```

Notes

> **Note**
>
> `mysql_close` will not close persistent links created by `mysql_pconnect`.

See Also

`mysql_connect`
`mysql_free_result`

20.10.1.4.4. `mysql_connect`

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- `mysql_connect`

  Open a connection to a MySQL Server

Description

```
  resource mysql_connect(string server= =ini_get("mysql.default_host"),
                         string username= =ini_get("mysql.default_user"),
                         string password= =ini_get("mysql.default_password"),
                         bool new_link= =false,
                         int client_flags= =0);
```

Opens or reuses a connection to a MySQL server.

Parameters

`server`	The MySQL server. It can also include a port number. e.g. "hostname:port" or a path to a local socket e.g. ":/path/to/socket" for the localhost. If the PHP directive mysql.default_host is undefined (default), then the default value is 'localhost:3306'. In SQL safe mode, this parameter is ignored and value 'localhost:3306' is always used.
`username`	The username. Default value is defined by mysql.default_user. In SQL safe mode, this parameter is ignored and the name of the user that owns the server process is used.
`password`	The password. Default value is defined by mysql.default_password. In SQL safe mode, this parameter is ignored and empty password is used.
`new_link`	If a second call is made to `mysql_connect` with the same arguments, no new link will be established, but instead, the link identifier of the already opened link will be returned. The *`new_link`* parameter modifies this behavior and makes `mysql_connect` always open a new link, even if `mysql_connect` was called before with the same parameters. In SQL safe mode, this parameter is ignored.
`client_flags`	The *`client_flags`* parameter can be a combination of the following constants: 128 (enable `LOAD DATA LOCAL` handling), `MYSQL_CLIENT_SSL` , `MYSQL_CLIENT_COMPRESS` , `MYSQL_CLIENT_IGNORE_SPACE` or `MYSQL_CLIENT_INTERACTIVE` . Read the section about Table 20.6, “MySQL client

constants" for further information. In SQL safe mode, this parameter is ignored.

Return Values

Returns a MySQL link identifier on success or `FALSE` on failure.

Changelog

Version	Description
4.3.0	Added the *`client_flags`* parameter.
4.2.0	Added the *`new_link`* parameter.

Examples

Example 20.20. `mysql_connect` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
echo 'Connected successfully';
mysql_close($link);
?>
```

Example 20.21. `mysql_connect` example using `hostname:port` syntax

```
<?php
// we connect to example.com and port 3307
$link = mysql_connect('example.com:3307', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
echo 'Connected successfully';
mysql_close($link);

// we connect to localhost at port 3307
$link = mysql_connect('127.0.0.1:3307', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
echo 'Connected successfully';
mysql_close($link);
?>
```

Example 20.22. `mysql_connect` example using ":/path/to/socket" syntax

```
<?php
// we connect to localhost and socket e.g. /tmp/mysql.sock

//variant 1: ommit localhost
$link = mysql_connect(':/tmp/mysql', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
echo 'Connected successfully';
mysql_close($link);


// variant 2: with localhost
$link = mysql_connect('localhost:/tmp/mysql.sock', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
echo 'Connected successfully';
mysql_close($link);
?>
```

Notes

> **Note**
>
> Whenever you specify "localhost" or "localhost:port" as server, the MySQL client library will override this and try to connect to a local socket (named pipe on Windows). If you want to use TCP/IP, use "127.0.0.1" instead of "localhost". If the MySQL client library tries to connect to the wrong local socket, you should set the correct path as *`mysql.default_host`* string in your PHP configuration and leave the server field blank.

> **Note**
>
> The link to the server will be closed as soon as the execution of the script ends, unless it's closed earlier by explicitly calling `mysql_close`.

> **Note**
>
> You can suppress the error message on failure by prepending a @ to the function name.

> **Note**
>
> Error "Can't create TCP/IP socket (10106)" usually means that the variables_order configure directive doesn't contain character `E`. On Windows, if the environment is not copied the `SYSTEMROOT` environment variable won't be available and PHP will have problems loading Winsock.

See Also

`mysql_pconnect`
`mysql_close`

20.10.1.4.5. `mysql_create_db`

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- `mysql_create_db`

  Create a MySQL database

Description

```
 bool mysql_create_db(string database_name,
                      resource link_identifier);
```

`mysql_create_db` attempts to create a new database on the server associated with the specified link identifier.

Parameters

`database_name`	The name of the database being created.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.23. `mysql_create_db` alternative example

The function `mysql_create_db` is deprecated. It is preferable to use `mysql_query` to issue an sql `CREATE DATABASE` statement instead.

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}

$sql = 'CREATE DATABASE my_db';
if (mysql_query($sql, $link)) {
    echo "Database my_db created successfully\n";
} else {
    echo 'Error creating database: ' . mysql_error() . "\n";
}
?>
```

The above example will output something similar to:

```
Database my_db created successfully
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_createdb`

> **Note**
>
> This function will not be available if the MySQL extension was built against a MySQL 4.x client library.

See Also

`mysql_query`
`mysql_select_db`

20.10.1.4.6. `mysql_data_seek`

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- `mysql_data_seek`

  Move internal result pointer

Description

```
  bool mysql_data_seek(resource result,
                       int row_number);
```

`mysql_data_seek` moves the internal row pointer of the MySQL result associated with the specified result identifier to point to the specified row number. The next call to a MySQL fetch function, such as `mysql_fetch_assoc`, would return that row.

`row_number` starts at 0. The *`row_number`* should be a value in the range from 0 to `mysql_num_rows` - 1. However if the result set is empty (`mysql_num_rows` == 0), a seek to 0 will fail with a E_WARNING and `mysql_data_seek` will return `FALSE` .

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`row_number`	The desired row number of the new result pointer.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.24. `mysql_data_seek` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
$db_selected = mysql_select_db('sample_db');
if (!$db_selected) {
    die('Could not select database: ' . mysql_error());
}
$query = 'SELECT last_name, first_name FROM friends';
$result = mysql_query($query);
if (!$result) {
    die('Query failed: ' . mysql_error());
}
/* fetch rows in reverse order */
for ($i = mysql_num_rows($result) - 1; $i >= 0; $i--) {
    if (!mysql_data_seek($result, $i)) {
        echo "Cannot seek to row $i: " . mysql_error() . "\n";
        continue;
    }

    if (!($row = mysql_fetch_assoc($result))) {
        continue;
    }

    echo $row['last_name'] . ' ' . $row['first_name'] . "<br />\n";
}

mysql_free_result($result);
?>
```

Notes

> **Note**
>
> The function `mysql_data_seek` can be used in conjunction only with `mysql_query`, not with `mysql_unbuffered_query`.

See Also

`mysql_query`
`mysql_num_rows`
`mysql_fetch_row`
`mysql_fetch_assoc`
`mysql_fetch_array`
`mysql_fetch_object`

20.10.1.4.7. `mysql_db_name`

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- `mysql_db_name`

  Get result data

Description

```
string mysql_db_name(resource result,
                     int row,
                     mixed field);
```

Retrieve the database name from a call to `mysql_list_dbs`.

Parameters

`result`	The result pointer from a call to `mysql_list_dbs`.
`row`	The index into the result set.
`field`	The field name.

Return Values

Returns the database name on success, and `FALSE` on failure. If `FALSE` is returned, use `mysql_error` to determine the nature of the error.

Examples

Example 20.25. `mysql_db_name` example

```
<?php
error_reporting(E_ALL);

$link = mysql_connect('dbhost', 'username', 'password');
$db_list = mysql_list_dbs($link);

$i = 0;
$cnt = mysql_num_rows($db_list);
while ($i < $cnt) {
    echo mysql_db_name($db_list, $i) . "\n";
    $i++;
}
?>
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_dbname`

See Also

`mysql_list_dbs`
`mysql_tablename`

20.10.1.4.8. `mysql_db_query`

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- `mysql_db_query`

  Send a MySQL query

Description

```
resource mysql_db_query(string database,
                        string query,
                        resource link_identifier);
```

`mysql_db_query` selects a database, and executes a query on it.

> **Warning**
>
> This function has been *DEPRECATED* as of PHP 5.3.0. Relying on this feature is highly discouraged.

Parameters

`database`	The name of the database that will be selected.
`query`	The MySQL query. Data inside the query should be properly escaped.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns a positive MySQL result resource to the query result, or `FALSE` on error. The function also returns `TRUE` / `FALSE` for `INSERT`/`UPDATE`/`DELETE` queries to indicate success/failure.

Changelog

Version	Description
5.3.0	This function now throws an E_DEPRECATED notice.
4.0.6	This function is deprecated, do not use this function. Use `mysql_select_db` and `mysql_query` instead.

Examples

Example 20.26. `mysql_db_query` alternative example

```
<?php

if (!$link = mysql_connect('mysql_host', 'mysql_user', 'mysql_password')) {
    echo 'Could not connect to mysql';
    exit;
}

if (!mysql_select_db('mysql_dbname', $link)) {
    echo 'Could not select database';
    exit;
}

$sql    = 'SELECT foo FROM bar WHERE id = 42';
$result = mysql_query($sql, $link);

if (!$result) {
    echo "DB Error, could not query the database\n";
    echo 'MySQL Error: ' . mysql_error();
    exit;
}

while ($row = mysql_fetch_assoc($result)) {
    echo $row['foo'];
}

mysql_free_result($result);

?>
```

Notes

> **Note**
>
> Be aware that this function does *NOT* switch back to the database you were connected before. In other words, you can't use this function to *temporarily* run a sql query on another database, you would have to manually switch back. Users are strongly encouraged to use the `database.table` syntax in their sql queries or `mysql_select_db` instead of this function.

See Also

`mysql_query`
`mysql_select_db`

20.10.1.4.9. `mysql_drop_db`

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- `mysql_drop_db`

  Drop (delete) a MySQL database

Description

```
bool mysql_drop_db(string database_name,
                   resource link_identifier);
```

`mysql_drop_db` attempts to drop (remove) an entire database from the server associated with the specified link identifier. This function is deprecated, it is preferable to use `mysql_query` to issue an sql `DROP DATABASE` statement instead.

Parameters

`database_name`	The name of the database that will be deleted.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.27. `mysql_drop_db` alternative example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}

$sql = 'DROP DATABASE my_db';
if (mysql_query($sql, $link)) {
    echo "Database my_db was successfully dropped\n";
} else {
    echo 'Error dropping database: ' . mysql_error() . "\n";
}
?>
```

Notes

> **Warning**

> This function will not be available if the MySQL extension was built against a MySQL 4.x client library.

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_dropdb`

See Also

`mysql_query`

20.10.1.4.10. `mysql_errno`

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- `mysql_errno`

  Returns the numerical value of the error message from previous MySQL operation

Description

```
int mysql_errno(resource link_identifier);
```

Returns the error number from the last MySQL function.

Errors coming back from the MySQL database backend no longer issue warnings. Instead, use `mysql_errno` to retrieve the error code. Note that this function only returns the error code from the most recently executed MySQL function (not including `mysql_error` and `mysql_errno`), so if you want to use it, make sure you check the value before calling another MySQL function.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns the error number from the last MySQL function, or `0` (zero) if no error occurred.

Examples

Example 20.28. `mysql_errno` example

```
<?php
$link = mysql_connect("localhost", "mysql_user", "mysql_password");

if (!mysql_select_db("nonexistentdb", $link)) {
    echo mysql_errno($link) . ": " . mysql_error($link). "\n";
}

mysql_select_db("kossu", $link);
if (!mysql_query("SELECT * FROM nonexistenttable", $link)) {
    echo mysql_errno($link) . ": " . mysql_error($link) . "\n";
}
?>
```

The above example will output something similar to:

```
1049: Unknown database 'nonexistentdb'
1146: Table 'kossu.nonexistenttable' doesn't exist
```

See Also

`mysql_error`
MySQL error codes

20.10.1.4.11. `mysql_error`

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- `mysql_error`

  Returns the text of the error message from previous MySQL operation

Description

```
string mysql_error(resource link_identifier);
```

Returns the error text from the last MySQL function. Errors coming back from the MySQL database backend no longer issue warnings. Instead, use `mysql_error` to retrieve the error text. Note that this function only returns the error text from the most recently executed MySQL function (not including `mysql_error` and `mysql_errno`), so if you want to use it, make sure you check the value before calling another MySQL function.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns the error text from the last MySQL function, or `''` (empty string) if no error occurred.

Examples

Example 20.29. `mysql_error` example

```
<?php
$link = mysql_connect("localhost", "mysql_user", "mysql_password");

mysql_select_db("nonexistentdb", $link);
echo mysql_errno($link) . ": " . mysql_error($link). "\n";

mysql_select_db("kossu", $link);
mysql_query("SELECT * FROM nonexistenttable", $link);
echo mysql_errno($link) . ": " . mysql_error($link) . "\n";
?>
```

The above example will output something similar to:

```
1049: Unknown database 'nonexistentdb'
1146: Table 'kossu.nonexistenttable' doesn't exist
```

See Also

`mysql_errno`
MySQL error codes

20.10.1.4.12. `mysql_escape_string`

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- `mysql_escape_string`

  Escapes a string for use in a mysql_query

Description

```
string mysql_escape_string(string unescaped_string);
```

This function will escape the *`unescaped_string`*, so that it is safe to place it in a `mysql_query`. This function is deprecated.

This function is identical to `mysql_real_escape_string` except that `mysql_real_escape_string` takes a connection handler and escapes the string according to the current character set. `mysql_escape_string` does not take a connection argument and does not respect the current charset setting.

> **Warning**
>
> This function has been *DEPRECATED* as of PHP 5.3.0. Relying on this feature is highly discouraged.

Parameters

`unescaped_string`	The string that is to be escaped.

Return Values

Returns the escaped string.

Changelog

Version	Description
5.3.0	This function now throws an E_DEPRECATED notice.
4.3.0	This function became deprecated, do not use this function. Instead, use `mysql_real_escape_string`.

Examples

Example 20.30. `mysql_escape_string` example

```
<?php
$item = "Zak's Laptop";
$escaped_item = mysql_escape_string($item);
printf("Escaped string: %s\n", $escaped_item);
?>
```

The above example will output:

```
Escaped string: Zak\'s Laptop
```

Notes

> **Note**
>
> `mysql_escape_string` does not escape `%` and `_`.

See Also

`mysql_real_escape_string`
`addslashes`
The magic_quotes_gpc directive.

20.10.1.4.13. `mysql_fetch_array`

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- `mysql_fetch_array`

  Fetch a result row as an associative array, a numeric array, or both

Description

```
  array mysql_fetch_array(resource result,
                          int result_type= =MYSQL_BOTH);
```

Returns an array that corresponds to the fetched row and moves the internal data pointer ahead.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`result_type`	The type of array that is to be fetched. It's a constant and can take the following values: `MYSQL_ASSOC` , `MYSQL_NUM` , and `MYSQL_BOTH` .

Return Values

Returns an array of strings that corresponds to the fetched row, or `FALSE` if there are no more rows. The type of returned array depends on how *`result_type`* is defined. By using `MYSQL_BOTH` (default), you'll get an array with both associative and number indices. Using `MYSQL_ASSOC` , you only get associative indices (as `mysql_fetch_assoc` works), using `MYSQL_NUM` , you only get number indices (as `mysql_fetch_row` works).

If two or more columns of the result have the same field names, the last column will take precedence. To access the other column(s) of the same name, you must use the numeric index of the column or make an alias for the column. For aliased columns, you cannot access the contents with the original column name.

Examples

Example 20.31. Query with aliased duplicate field names

```
SELECT table1.field AS foo, table2.field AS bar FROM table1, table2
```

Example 20.32. `mysql_fetch_array` with `MYSQL_NUM`

```
<?php
mysql_connect("localhost", "mysql_user", "mysql_password") or
    die("Could not connect: " . mysql_error());
mysql_select_db("mydb");

$result = mysql_query("SELECT id, name FROM mytable");

while ($row = mysql_fetch_array($result, MYSQL_NUM)) {
    printf("ID: %s  Name: %s", $row[0], $row[1]);
}

mysql_free_result($result);
?>
```

Example 20.33. `mysql_fetch_array` with `MYSQL_ASSOC`

```
<?php
mysql_connect("localhost", "mysql_user", "mysql_password") or
    die("Could not connect: " . mysql_error());
mysql_select_db("mydb");

$result = mysql_query("SELECT id, name FROM mytable");

while ($row = mysql_fetch_array($result, MYSQL_ASSOC)) {
    printf("ID: %s  Name: %s", $row["id"], $row["name"]);
}

mysql_free_result($result);
?>
```

Example 20.34. `mysql_fetch_array` with `MYSQL_BOTH`

```
<?php
mysql_connect("localhost", "mysql_user", "mysql_password") or
    die("Could not connect: " . mysql_error());
mysql_select_db("mydb");

$result = mysql_query("SELECT id, name FROM mytable");

while ($row = mysql_fetch_array($result, MYSQL_BOTH)) {
    printf ("ID: %s  Name: %s", $row[0], $row["name"]);
}

mysql_free_result($result);
?>
```

Notes

> ### Performance
>
> An important thing to note is that using `mysql_fetch_array` is *not significantly* slower than using `mysql_fetch_row`, while it provides a significant added value.

> ### Note
>
> Field names returned by this function are *case-sensitive*.

> ### Note
>
> This function sets NULL fields to the PHP `NULL` value.

See Also

`mysql_fetch_row`
`mysql_fetch_assoc`

`mysql_data_seek`
`mysql_query`

20.10.1.4.14. `mysql_fetch_assoc`

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- `mysql_fetch_assoc`

  Fetch a result row as an associative array

Description

```
array mysql_fetch_assoc(resource result);
```

Returns an associative array that corresponds to the fetched row and moves the internal data pointer ahead. `mysql_fetch_assoc` is equivalent to calling `mysql_fetch_array` with MYSQL_ASSOC for the optional second parameter. It only returns an associative array.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.

Return Values

Returns an associative array of strings that corresponds to the fetched row, or `FALSE` if there are no more rows.

If two or more columns of the result have the same field names, the last column will take precedence. To access the other column(s) of the same name, you either need to access the result with numeric indices by using `mysql_fetch_row` or add alias names. See the example at the `mysql_fetch_array` description about aliases.

Examples

Example 20.35. An expanded `mysql_fetch_assoc` example

```
<?php

$conn = mysql_connect("localhost", "mysql_user", "mysql_password");

if (!$conn) {
    echo "Unable to connect to DB: " . mysql_error();
    exit;
}

if (!mysql_select_db("mydbname")) {
    echo "Unable to select mydbname: " . mysql_error();
    exit;
}

$sql = "SELECT id as userid, fullname, userstatus
        FROM   sometable
        WHERE  userstatus = 1";

$result = mysql_query($sql);

if (!$result) {
    echo "Could not successfully run query ($sql) from DB: " . mysql_error();
    exit;
}

if (mysql_num_rows($result) == 0) {
    echo "No rows found, nothing to print so am exiting";
    exit;
}

// While a row of data exists, put that row in $row as an associative array
// Note: If you're expecting just one row, no need to use a loop
// Note: If you put extract($row); inside the following loop, you'll
//       then create $userid, $fullname, and $userstatus
while ($row = mysql_fetch_assoc($result)) {
    echo $row["userid"];
    echo $row["fullname"];
    echo $row["userstatus"];
}
```

```
mysql_free_result($result);
?>
```

Notes

> **Performance**
>
> An important thing to note is that using `mysql_fetch_assoc` is *not significantly* slower than using `mysql_fetch_row`, while it provides a significant added value.

> **Note**
>
> Field names returned by this function are *case-sensitive*.

> **Note**
>
> This function sets NULL fields to the PHP `NULL` value.

See Also

`mysql_fetch_row`
`mysql_fetch_array`
`mysql_data_seek`
`mysql_query`
`mysql_error`

20.10.1.4.15. `mysql_fetch_field`

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- `mysql_fetch_field`

  Get column information from a result and return as an object

Description

```
  object mysql_fetch_field(resource result,
                           int field_offset= =0);
```

Returns an object containing field information. This function can be used to obtain information about fields in the provided query result.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`field_offset`	The numerical field offset. If the field offset is not specified, the next field that was not yet retrieved by this function is retrieved. The *`field_offset`* starts at `0`.

Return Values

Returns an object containing field information. The properties of the object are:

- name - column name
- table - name of the table the column belongs to
- max_length - maximum length of the column

- not_null - 1 if the column cannot be `NULL`
- primary_key - 1 if the column is a primary key
- unique_key - 1 if the column is a unique key
- multiple_key - 1 if the column is a non-unique key
- numeric - 1 if the column is numeric
- blob - 1 if the column is a BLOB
- type - the type of the column
- unsigned - 1 if the column is unsigned
- zerofill - 1 if the column is zero-filled

Examples

Example 20.36. `mysql_fetch_field` example

```
<?php
$conn = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$conn) {
    die('Could not connect: ' . mysql_error());
}
mysql_select_db('database');
$result = mysql_query('select * from table');
if (!$result) {
    die('Query failed: ' . mysql_error());
}
/* get column metadata */
$i = 0;
while ($i < mysql_num_fields($result)) {
    echo "Information for column $i:<br />\n";
    $meta = mysql_fetch_field($result, $i);
    if (!$meta) {
        echo "No information available<br />\n";
    }
    echo "<pre>
blob:         $meta->blob
max_length:   $meta->max_length
multiple_key: $meta->multiple_key
name:         $meta->name
not_null:     $meta->not_null
numeric:      $meta->numeric
primary_key:  $meta->primary_key
table:        $meta->table
type:         $meta->type
unique_key:   $meta->unique_key
unsigned:     $meta->unsigned
zerofill:     $meta->zerofill
</pre>";
    $i++;
}
mysql_free_result($result);
?>
```

Notes

> **Note**
>
> Field names returned by this function are *case-sensitive*.

See Also

`mysql_field_seek`

20.10.1.4.16. `mysql_fetch_lengths`

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- `mysql_fetch_lengths`

  Get the length of each output in a result

Description

```
array mysql_fetch_lengths(resource result);
```

Returns an array that corresponds to the lengths of each field in the last row fetched by MySQL.

`mysql_fetch_lengths` stores the lengths of each result column in the last row returned by `mysql_fetch_row`, `mysql_fetch_assoc`, `mysql_fetch_array`, and `mysql_fetch_object` in an array, starting at offset 0.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.

Return Values

An array of lengths on success or `FALSE` on failure.

Examples

Example 20.37. A `mysql_fetch_lengths` example

```
<?php
$result = mysql_query("SELECT id,email FROM people WHERE id = '42'");
if (!$result) {
    echo 'Could not run query: ' . mysql_error();
    exit;
}
$row     = mysql_fetch_assoc($result);
$lengths = mysql_fetch_lengths($result);

print_r($row);
print_r($lengths);
?>
```

The above example will output something similar to:

```
Array
(
    [id] => 42
    [email] => user@example.com
)
Array
(
    [0] => 2
    [1] => 16
)
```

See Also

`mysql_field_len`
`mysql_fetch_row`
`strlen`

20.10.1.4.17. `mysql_fetch_object`

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- `mysql_fetch_object`

  Fetch a result row as an object

Description

```
  object mysql_fetch_object(resource result,
                            string class_name,
                            array params);
```

Returns an object with properties that correspond to the fetched row and moves the internal data pointer ahead.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`class_name`	The name of the class to instantiate, set the properties of and return. If not specified, a `stdClass` object is returned.
`params`	An optional array of parameters to pass to the constructor for *`class_name`* objects.

Return Values

Returns an object with string properties that correspond to the fetched row, or `FALSE` if there are no more rows.

Changelog

Version	Description
5.0.0	Added the ability to return as a different object.

Examples

Example 20.38. `mysql_fetch_object` example

```
<?php
mysql_connect("hostname", "user", "password");
mysql_select_db("mydb");
$result = mysql_query("select * from mytable");
while ($row = mysql_fetch_object($result)) {
    echo $row->user_id;
    echo $row->fullname;
}
mysql_free_result($result);
?>
```

Example 20.39. `mysql_fetch_object` example

```
<?php
class foo {
    public $name;
}

mysql_connect("hostname", "user", "password");
mysql_select_db("mydb");

$result = mysql_query("select name from mytable limit 1");
$obj = mysql_fetch_object($result, 'foo');
var_dump($obj);
?>
```

Notes

> ### Performance
>
> Speed-wise, the function is identical to `mysql_fetch_array`, and almost as quick as `mysql_fetch_row` (the difference is insignificant).

> ### Note
>
> `mysql_fetch_object` is similar to `mysql_fetch_array`, with one difference - an object is returned, instead of an array. Indirectly, that means that you can only access the data by the field names, and not by their offsets (numbers are illegal property names).

> ### Note
>
> Field names returned by this function are *case-sensitive*.

> ### Note
>
> This function sets NULL fields to the PHP `NULL` value.

See Also

`mysql_fetch_array`
`mysql_fetch_assoc`
`mysql_fetch_row`
`mysql_data_seek`
`mysql_query`

20.10.1.4.18. `mysql_fetch_row`

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- `mysql_fetch_row`

  Get a result row as an enumerated array

Description

```
array mysql_fetch_row(resource result);
```

Returns a numerical array that corresponds to the fetched row and moves the internal data pointer ahead.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.

Return Values

Returns an numerical array of strings that corresponds to the fetched row, or `FALSE` if there are no more rows.

`mysql_fetch_row` fetches one row of data from the result associated with the specified result identifier. The row is returned as an array. Each result column is stored in an array offset, starting at offset 0.

Examples

Example 20.40. Fetching one row with `mysql_fetch_row`

```
<?php
$result = mysql_query("SELECT id,email FROM people WHERE id = '42'");
if (!$result) {
    echo 'Could not run query: ' . mysql_error();
    exit;
}
$row = mysql_fetch_row($result);

echo $row[0]; // 42
echo $row[1]; // the email value
?>
```

Notes

> **Note**
>
> This function sets NULL fields to the PHP `NULL` value.

See Also

`mysql_fetch_array`
`mysql_fetch_assoc`
`mysql_fetch_object`
`mysql_data_seek`
`mysql_fetch_lengths`
`mysql_result`

20.10.1.4.19. `mysql_field_flags`

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- `mysql_field_flags`

  Get the flags associated with the specified field in a result

Description

```
  string mysql_field_flags(resource result,
                           int field_offset);
```

`mysql_field_flags` returns the field flags of the specified field. The flags are reported as a single word per flag separated by a single space, so that you can split the returned value using `explode`.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`field_offset`	The numerical field offset. The *`field_offset`* starts at `0`. If *`field_offset`* does not exist, an error of level `E_WARNING` is also issued.

Return Values

Returns a string of flags associated with the result or `FALSE` on failure.

The following flags are reported, if your version of MySQL is current enough to support them: `"not_null"`, `"primary_key"`, `"unique_key"`, `"multiple_key"`, `"blob"`, `"unsigned"`, `"zerofill"`, `"binary"`, `"enum"`, `"auto_increment"` and `"timestamp"`.

Examples

Example 20.41. A `mysql_field_flags` example

```
<?php
$result = mysql_query("SELECT id,email FROM people WHERE id = '42'");
if (!$result) {
    echo 'Could not run query: ' . mysql_error();
    exit;
}
$flags = mysql_field_flags($result, 0);

echo $flags;
print_r(explode(' ', $flags));
?>
```

The above example will output something similar to:

```
not_null primary_key auto_increment
Array
(
    [0] => not_null
    [1] => primary_key
    [2] => auto_increment
)
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_fieldflags`

See Also

`mysql_field_type`
`mysql_field_len`

20.10.1.4.20. `mysql_field_len`

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- `mysql_field_len`

  Returns the length of the specified field

Description

```
  int mysql_field_len(resource result,
                      int field_offset);
```

`mysql_field_len` returns the length of the specified field.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`field_offset`	The numerical field offset. The *`field_offset`* starts at `0`. If *`field_offset`* does not exist, an error of level `E_WARNING` is also issued.

Return Values

The length of the specified field index on success or `FALSE` on failure.

Examples

Example 20.42. `mysql_field_len` example

```
<?php
$result = mysql_query("SELECT id,email FROM people WHERE id = '42'");
if (!$result) {
    echo 'Could not run query: ' . mysql_error();
    exit;
}

// Will get the length of the id field as specified in the database
// schema.
$length = mysql_field_len($result, 0);
echo $length;
?>
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_fieldlen`

See Also

`mysql_fetch_lengths`
`strlen`

20.10.1.4.21. `mysql_field_name`

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- `mysql_field_name`

  Get the name of the specified field in a result

Description

```
  string mysql_field_name(resource result,
                          int field_offset);
```

`mysql_field_name` returns the name of the specified field index.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`field_offset`	The numerical field offset. The *`field_offset`* starts at `0`. If *`field_offset`* does not exist, an error of level `E_WARNING` is also issued.

Return Values

The name of the specified field index on success or `FALSE` on failure.

Examples

Example 20.43. `mysql_field_name` example

```
<?php
/* The users table consists of three fields:
*   user_id
*   username
*   password.
*/
$link = @mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect to MySQL server: ' . mysql_error());
}
$dbname = 'mydb';
$db_selected = mysql_select_db($dbname, $link);
```

```
if (!$db_selected) {
    die("Could not set $dbname: " . mysql_error());
}
$res = mysql_query('select * from users', $link);

echo mysql_field_name($res, 0) . "\n";
echo mysql_field_name($res, 2);
?>
```

The above example will output:

```
user_id
password
```

Notes

> **Note**
>
> Field names returned by this function are *case-sensitive*.

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_fieldname`

See Also

`mysql_field_type`
`mysql_field_len`

20.10.1.4.22. `mysql_field_seek`

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- `mysql_field_seek`

  Set result pointer to a specified field offset

Description

```
  bool mysql_field_seek(resource result,
                        int field_offset);
```

Seeks to the specified field offset. If the next call to `mysql_fetch_field` doesn't include a field offset, the field offset specified in `mysql_field_seek` will be returned.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`field_offset`	The numerical field offset. The *`field_offset`* starts at `0`. If *`field_offset`* does not exist, an error of level `E_WARNING` is also issued.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

See Also

`mysql_fetch_field`

20.10.1.4.23. `mysql_field_table`

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- `mysql_field_table`

  Get name of the table the specified field is in

Description

```
string mysql_field_table(resource result,
                         int field_offset);
```

Returns the name of the table that the specified field is in.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`field_offset`	The numerical field offset. The *`field_offset`* starts at `0`. If *`field_offset`* does not exist, an error of level `E_WARNING` is also issued.

Return Values

The name of the table on success.

Examples

Example 20.44. A `mysql_field_table` example

```
<?php

$query = "SELECT account.*, country.* FROM account, country WHERE country.name = 'Portugal' AND account.country_id = co

// get the result from the DB
$result = mysql_query($query);

// Lists the table name and then the field name
for ($i = 0; $i < mysql_num_fields($result); ++$i) {
    $table = mysql_field_table($result, $i);
    $field = mysql_field_name($result, $i);

    echo  "$table: $field\n";
}

?>
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_fieldtable`

See Also

`mysql_list_tables`

20.10.1.4.24. `mysql_field_type`

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- `mysql_field_type`

Get the type of the specified field in a result

Description

```
string mysql_field_type(resource result,
                        int field_offset);
```

`mysql_field_type` is similar to the `mysql_field_name` function. The arguments are identical, but the field type is returned instead.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`field_offset`	The numerical field offset. The *`field_offset`* starts at `0`. If *`field_offset`* does not exist, an error of level `E_WARNING` is also issued.

Return Values

The returned field type will be one of `"int"`, `"real"`, `"string"`, `"blob"`, and others as detailed in the MySQL documentation.

Examples

Example 20.45. `mysql_field_type` example

```
<?php
mysql_connect("localhost", "mysql_username", "mysql_password");
mysql_select_db("mysql");
$result = mysql_query("SELECT * FROM func");
$fields = mysql_num_fields($result);
$rows   = mysql_num_rows($result);
$table  = mysql_field_table($result, 0);
echo "Your '" . $table . "' table has " . $fields . " fields and " . $rows . " record(s)\n";
echo "The table has the following fields:\n";
for ($i=0; $i < $fields; $i++) {
    $type  = mysql_field_type($result, $i);
    $name  = mysql_field_name($result, $i);
    $len   = mysql_field_len($result, $i);
    $flags = mysql_field_flags($result, $i);
    echo $type . " " . $name . " " . $len . " " . $flags . "\n";
}
mysql_free_result($result);
mysql_close();
?>
```

The above example will output something similar to:

```
Your 'func' table has 4 fields and 1 record(s)
The table has the following fields:
string name 64 not_null primary_key binary
int ret 1 not_null
string dl 128 not_null
string type 9 not_null enum
```

Notes

Note

For backward compatibility, the following deprecated alias may be used: `mysql_fieldtype`

See Also

`mysql_field_name`
`mysql_field_len`

20.10.1.4.25. `mysql_free_result`

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- `mysql_free_result`

  Free result memory

Description

```
bool mysql_free_result(resource result);
```

`mysql_free_result` will free all memory associated with the result identifier *`result`*.

`mysql_free_result` only needs to be called if you are concerned about how much memory is being used for queries that return large result sets. All associated result memory is automatically freed at the end of the script's execution.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

If a non-resource is used for the *`result`*, an error of level E_WARNING will be emitted. It's worth noting that `mysql_query` only returns a resource for SELECT, SHOW, EXPLAIN, and DESCRIBE queries.

Examples

Example 20.46. A `mysql_free_result` example

```
<?php
$result = mysql_query("SELECT id,email FROM people WHERE id = '42'");
if (!$result) {
    echo 'Could not run query: ' . mysql_error();
    exit;
}
/* Use the result, assuming we're done with it afterwards */
$row = mysql_fetch_assoc($result);

/* Now we free up the result and continue on with our script */
mysql_free_result($result);

echo $row['id'];
echo $row['email'];
?>
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_freeresult`

See Also

`mysql_query`
`is_resource`

20.10.1.4.26. `mysql_get_client_info`

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- `mysql_get_client_info`

  Get MySQL client info

Description

```
  string mysql_get_client_info();
```

`mysql_get_client_info` returns a string that represents the client library version.

Return Values

The MySQL client version.

Examples

Example 20.47. `mysql_get_client_info` example

```
<?php
printf("MySQL client info: %s\n", mysql_get_client_info());
?>
```

The above example will output something similar to:

```
MySQL client info: 3.23.39
```

See Also

`mysql_get_host_info`
`mysql_get_proto_info`
`mysql_get_server_info`

20.10.1.4.27. `mysql_get_host_info`

Copyright 1997-2010 the PHP Documentation Group.

- `mysql_get_host_info`

  Get MySQL host info

Description

```
  string mysql_get_host_info(resource link_identifier);
```

Describes the type of connection in use for the connection, including the server host name.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by

	`mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns a string describing the type of MySQL connection in use for the connection or `FALSE` on failure.

Examples

Example 20.48. `mysql_get_host_info` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
printf("MySQL host info: %s\n", mysql_get_host_info());
?>
```

The above example will output something similar to:

```
MySQL host info: Localhost via UNIX socket
```

See Also

`mysql_get_client_info`
`mysql_get_proto_info`
`mysql_get_server_info`

20.10.1.4.28. `mysql_get_proto_info`

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- `mysql_get_proto_info`

  Get MySQL protocol info

Description

```
  int mysql_get_proto_info(resource link_identifier);
```

Retrieves the MySQL protocol.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns the MySQL protocol on success or `FALSE` on failure.

Examples

Example 20.49. `mysql_get_proto_info` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
printf("MySQL protocol version: %s\n", mysql_get_proto_info());
?>
```

The above example will output something similar to:

```
MySQL protocol version: 10
```

See Also

`mysql_get_client_info`
`mysql_get_host_info`
`mysql_get_server_info`

20.10.1.4.29. `mysql_get_server_info`

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- `mysql_get_server_info`

  Get MySQL server info

Description

```
  string mysql_get_server_info(resource link_identifier);
```

Retrieves the MySQL server version.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns the MySQL server version on success or `FALSE` on failure.

Examples

Example 20.50. `mysql_get_server_info` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
printf("MySQL server version: %s\n", mysql_get_server_info());
?>
```

The above example will output something similar to:

```
MySQL server version: 4.0.1-alpha
```

See Also

`mysql_get_client_info`
`mysql_get_host_info`
`mysql_get_proto_info`
`phpversion`

20.10.1.4.30. `mysql_info`

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- `mysql_info`

  Get information about the most recent query

Description

```
  string mysql_info(resource link_identifier);
```

Returns detailed information about the last query.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns information about the statement on success, or `FALSE` on failure. See the example below for which statements provide information, and what the returned value may look like. Statements that are not listed will return `FALSE` .

Examples

Example 20.51. Relevant MySQL Statements

Statements that return string values. The numbers are only for illustrating purpose; their values will correspond to the query.

```
INSERT INTO ... SELECT ...
String format: Records: 23 Duplicates: 0 Warnings: 0
INSERT INTO ... VALUES (...),(...),(...)...
String format: Records: 37 Duplicates: 0 Warnings: 0
LOAD DATA INFILE ...
String format: Records: 42 Deleted: 0 Skipped: 0 Warnings: 0
ALTER TABLE
String format: Records: 60 Duplicates: 0 Warnings: 0
UPDATE
String format: Rows matched: 65 Changed: 65 Warnings: 0
```

Notes

Note

`mysql_info` returns a non- `FALSE` value for the INSERT ... VALUES statement only if multiple value lists are specified in the statement.

See Also

`mysql_affected_rows`
`mysql_insert_id`
`mysql_stat`

20.10.1.4.31. `mysql_insert_id`

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- `mysql_insert_id`

  Get the ID generated in the last query

Description

```
int mysql_insert_id(resource link_identifier);
```

Retrieves the ID generated for an AUTO_INCREMENT column by the previous query (usually INSERT).

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

The ID generated for an AUTO_INCREMENT column by the previous query on success, `0` if the previous query does not generate an AUTO_INCREMENT value, or `FALSE` if no MySQL connection was established.

Examples

Example 20.52. `mysql_insert_id` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
mysql_select_db('mydb');

mysql_query("INSERT INTO mytable (product) values ('kossu')");
printf("Last inserted record has id %d\n", mysql_insert_id());
?>
```

Notes

Caution

> `mysql_insert_id` will convert the return type of the native MySQL C API function `mysql_insert_id()` to a type of `long` (named int in PHP). If your AUTO_INCREMENT column has a column type of BIGINT (64 bits) the conversion may result in an incorrect value. Instead, use the internal MySQL SQL function LAST_INSERT_ID() in an SQL query. For more information about PHP's maximum integer values, please see the integer documentation.

> **Note**
>
> Because `mysql_insert_id` acts on the last performed query, be sure to call `mysql_insert_id` immediately after the query that generates the value.

> **Note**
>
> The value of the MySQL SQL function `LAST_INSERT_ID()` always contains the most recently generated AUTO_INCREMENT value, and is not reset between queries.

See Also

`mysql_query`
`mysql_info`

20.10.1.4.32. `mysql_list_dbs`

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- `mysql_list_dbs`

  List databases available on a MySQL server

Description

```
resource mysql_list_dbs(resource link_identifier);
```

Returns a result pointer containing the databases available from the current mysql daemon.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns a result pointer resource on success, or `FALSE` on failure. Use the `mysql_tablename` function to traverse this result pointer, or any function for result tables, such as `mysql_fetch_array`.

Examples

Example 20.53. `mysql_list_dbs` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
$db_list = mysql_list_dbs($link);

while ($row = mysql_fetch_object($db_list)) {
     echo $row->Database . "\n";
}
?>
```

The above example will output something similar to:

```
database1
database2
database3
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_listdbs`

See Also

`mysql_db_name`
`mysql_select_db`

20.10.1.4.33. `mysql_list_fields`

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- `mysql_list_fields`

  List MySQL table fields

Description

```
  resource mysql_list_fields(string database_name,
                             string table_name,
                             resource link_identifier);
```

Retrieves information about the given table name.

This function is deprecated. It is preferable to use `mysql_query` to issue an SQL `SHOW COLUMNS FROM table [LIKE 'name']` statement instead.

Parameters

`database_name`	The name of the database that's being queried.
`table_name`	The name of the table that's being queried.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

A result pointer resource on success, or `FALSE` on failure.

The returned result can be used with `mysql_field_flags`, `mysql_field_len`, `mysql_field_name` and `mysql_field_type`.

Examples

Example 20.54. Alternate to deprecated `mysql_list_fields`

```
<?php
$result = mysql_query("SHOW COLUMNS FROM sometable");
if (!$result) {
    echo 'Could not run query: ' . mysql_error();
    exit;
}
if (mysql_num_rows($result) > 0) {
    while ($row = mysql_fetch_assoc($result)) {
        print_r($row);
    }
}
?>
```

The above example will output something similar to:

```


Array
(
    [Field] => id
    [Type] => int(7)
    [Null] =>
    [Key] => PRI
    [Default] =>
    [Extra] => auto_increment
)
Array
(
    [Field] => email
    [Type] => varchar(100)
    [Null] =>
    [Key] =>
    [Default] =>
    [Extra] =>
)
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_listfields`

See Also

`mysql_field_flags`
`mysql_info`

20.10.1.4.34. `mysql_list_processes`

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- `mysql_list_processes`

  List MySQL processes

Description

```
  resource mysql_list_processes(resource link_identifier);
```

Retrieves the current MySQL server threads.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

A result pointer resource on success or `FALSE` on failure.

Examples

Example 20.55. `mysql_list_processes` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');

$result = mysql_list_processes($link);
while ($row = mysql_fetch_assoc($result)){
    printf("%s %s %s %s %s\n", $row["Id"], $row["Host"], $row["db"],
        $row["Command"], $row["Time"]);
}
mysql_free_result($result);
?>
```

The above example will output something similar to:

```
1 localhost test Processlist 0
4 localhost mysql sleep 5
```

See Also

`mysql_thread_id`
`mysql_stat`

20.10.1.4.35. `mysql_list_tables`

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- `mysql_list_tables`

  List tables in a MySQL database

Description

```
  resource mysql_list_tables(string database,
                             resource link_identifier);
```

Retrieves a list of table names from a MySQL database.

This function is deprecated. It is preferable to use `mysql_query` to issue an SQL `SHOW TABLES [FROM db_name] [LIKE 'pattern']` statement instead.

Parameters

`database`	The name of the database
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

A result pointer resource on success or `FALSE` on failure.

Use the `mysql_tablename` function to traverse this result pointer, or any function for result tables, such as `mysql_fetch_array`.

Changelog

Version	Description
4.3.7	This function became deprecated.

Examples

Example 20.56. `mysql_list_tables` alternative example

```
<?php
$dbname = 'mysql_dbname';

if (!mysql_connect('mysql_host', 'mysql_user', 'mysql_password')) {
    echo 'Could not connect to mysql';
    exit;
}

$sql = "SHOW TABLES FROM $dbname";
$result = mysql_query($sql);

if (!$result) {
    echo "DB Error, could not list tables\n";
    echo 'MySQL Error: ' . mysql_error();
    exit;
}

while ($row = mysql_fetch_row($result)) {
    echo "Table: {$row[0]}\n";
}

mysql_free_result($result);
?>
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_listtables`

See Also

`mysql_list_dbs`
`mysql_tablename`

20.10.1.4.36. `mysql_num_fields`

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- `mysql_num_fields`

  Get number of fields in result

Description

```
int mysql_num_fields(resource result);
```

Retrieves the number of fields from a query.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.

Return Values

Returns the number of fields in the result set resource on success or `FALSE` on failure.

Examples

Example 20.57. A `mysql_num_fields` example

```
<?php
$result = mysql_query("SELECT id,email FROM people WHERE id = '42'");
if (!$result) {
    echo 'Could not run query: ' . mysql_error();
    exit;
}

/* returns 2 because id,email === two fields */
echo mysql_num_fields($result);
?>
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_numfields`

See Also

`mysql_select_db`
`mysql_query`
`mysql_fetch_field`
`mysql_num_rows`

20.10.1.4.37. `mysql_num_rows`

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- `mysql_num_rows`

  Get number of rows in result

Description

```
int mysql_num_rows(resource result);
```

Retrieves the number of rows from a result set. This command is only valid for statements like SELECT or SHOW that return an actual result set. To retrieve the number of rows affected by a INSERT, UPDATE, REPLACE or DELETE query, use `mysql_affected_rows`.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.

Return Values

The number of rows in a result set on success or `FALSE` on failure.

Examples

Example 20.58. `mysql_num_rows` example

```
<?php

$link = mysql_connect("localhost", "mysql_user", "mysql_password");
mysql_select_db("database", $link);

$result = mysql_query("SELECT * FROM table1", $link);
$num_rows = mysql_num_rows($result);

echo "$num_rows Rows\n";

?>
```

Notes

> **Note**
>
> If you use `mysql_unbuffered_query`, `mysql_num_rows` will not return the correct value until all the rows in the result set have been retrieved.

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_numrows`

See Also

`mysql_affected_rows`
`mysql_connect`
`mysql_data_seek`
`mysql_select_db`
`mysql_query`

20.10.1.4.38. `mysql_pconnect`

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- `mysql_pconnect`

  Open a persistent connection to a MySQL server

Description

```
  resource mysql_pconnect(string server= =ini_get("mysql.default_host"),
                          string username= =ini_get("mysql.default_user"),
                          string password= =ini_get("mysql.default_password"),
                          int client_flags);
```

Establishes a persistent connection to a MySQL server.

`mysql_pconnect` acts very much like `mysql_connect` with two major differences.

First, when connecting, the function would first try to find a (persistent) link that's already open with the same host, username and password. If one is found, an identifier for it will be returned instead of opening a new connection.

Second, the connection to the SQL server will not be closed when the execution of the script ends. Instead, the link will remain open for future use (`mysql_close` will not close links established by `mysql_pconnect`).

This type of link is therefore called 'persistent'.

Parameters

`server`	The MySQL server. It can also include a port number. e.g. "hostname:port" or a path to a local socket e.g. ":/path/to/socket" for the localhost.

	If the PHP directive mysql.default_host is undefined (default), then the default value is 'localhost:3306'
username	The username. Default value is the name of the user that owns the server process.
password	The password. Default value is an empty password.
client_flags	The *client_flags* parameter can be a combination of the following constants: 128 (enable `LOAD DATA LOCAL` handling), `MYSQL_CLIENT_SSL` , `MYSQL_CLIENT_COMPRESS` , `MYSQL_CLIENT_IGNORE_SPACE` or `MYSQL_CLIENT_INTERACTIVE` .

Return Values

Returns a MySQL persistent link identifier on success, or `FALSE` on failure.

Changelog

Version	Description
4.3.0	Added the *client_flags* parameter.

Notes

> **Note**
>
> Note, that these kind of links only work if you are using a module version of PHP. See the Persistent Database Connections section for more information.

> **Warning**
>
> Using persistent connections can require a bit of tuning of your Apache and MySQL configurations to ensure that you do not exceed the number of connections allowed by MySQL.

> **Note**
>
> You can suppress the error message on failure by prepending a @ to the function name.

See Also

`mysql_connect`
Persistent Database Connections

20.10.1.4.39. `mysql_ping`

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- `mysql_ping`

  Ping a server connection or reconnect if there is no connection

Description

```
bool mysql_ping(resource link_identifier);
```

Checks whether or not the connection to the server is working. If it has gone down, an automatic reconnection is attempted. This function can be used by scripts that remain idle for a long while, to check whether or not the server has closed the connection and reconnect if necessary.

> **Note**
>
> Since MySQL 5.0.13, automatic reconnection feature is disabled.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns `TRUE` if the connection to the server MySQL server is working, otherwise `FALSE` .

Examples

Example 20.59. A `mysql_ping` example

```
<?php
set_time_limit(0);

$conn = mysql_connect('localhost', 'mysqluser', 'mypass');
$db   = mysql_select_db('mydb');

/* Assuming this query will take a long time */
$result = mysql_query($sql);
if (!$result) {
    echo 'Query #1 failed, exiting.';
    exit;
}

/* Make sure the connection is still alive, if not, try to reconnect */
if (!mysql_ping($conn)) {
    echo 'Lost connection, exiting after query #1';
    exit;
}
mysql_free_result($result);

/* So the connection is still alive, let's run another query */
$result2 = mysql_query($sql2);
?>
```

See Also

`mysql_thread_id`
`mysql_list_processes`

20.10.1.4.40. `mysql_query`

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- `mysql_query`

  Send a MySQL query

Description

```
  resource mysql_query(string query,
                       resource link_identifier);
```

`mysql_query` sends a unique query (multiple queries are not supported) to the currently active database on the server that's associated with the specified *`link_identifier`*.

Parameters

`query`	An SQL query The query string should not end with a semicolon. Data inside the query should be properly

	escaped.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

For SELECT, SHOW, DESCRIBE, EXPLAIN and other statements returning resultset, `mysql_query` returns a resource on success, or `FALSE` on error.

For other type of SQL statements, INSERT, UPDATE, DELETE, DROP, etc, `mysql_query` returns `TRUE` on success or `FALSE` on error.

The returned result resource should be passed to `mysql_fetch_array`, and other functions for dealing with result tables, to access the returned data.

Use `mysql_num_rows` to find out how many rows were returned for a SELECT statement or `mysql_affected_rows` to find out how many rows were affected by a DELETE, INSERT, REPLACE, or UPDATE statement.

`mysql_query` will also fail and return `FALSE` if the user does not have permission to access the table(s) referenced by the query.

Examples

Example 20.60. Invalid Query

The following query is syntactically invalid, so `mysql_query` fails and returns `FALSE` .

```
<?php
$result = mysql_query('SELECT * WHERE 1=1');
if (!$result) {
    die('Invalid query: ' . mysql_error());
}

?>
```

Example 20.61. Valid Query

The following query is valid, so `mysql_query` returns a resource.

```
<?php
// This could be supplied by a user, for example
$firstname = 'fred';
$lastname  = 'fox';

// Formulate Query
// This is the best way to perform an SQL query
// For more examples, see mysql_real_escape_string()
$query = sprintf("SELECT firstname, lastname, address, age FROM friends WHERE firstname='%s' AND lastname='%s'",
    mysql_real_escape_string($firstname),
    mysql_real_escape_string($lastname));

// Perform Query
$result = mysql_query($query);

// Check result
// This shows the actual query sent to MySQL, and the error. Useful for debugging.
if (!$result) {
    $message  = 'Invalid query: ' . mysql_error() . "\n";
    $message .= 'Whole query: ' . $query;
    die($message);
}

// Use result
// Attempting to print $result won't allow access to information in the resource
// One of the mysql result functions must be used
// See also mysql_result(), mysql_fetch_array(), mysql_fetch_row(), etc.
while ($row = mysql_fetch_assoc($result)) {
    echo $row['firstname'];
    echo $row['lastname'];
    echo $row['address'];
    echo $row['age'];
}

// Free the resources associated with the result set
// This is done automatically at the end of the script
mysql_free_result($result);
?>
```

See Also

`mysql_connect`
`mysql_error`
`mysql_real_escape_string`
`mysql_result`
`mysql_fetch_assoc`
`mysql_unbuffered_query`

20.10.1.4.41. `mysql_real_escape_string`

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- `mysql_real_escape_string`

  Escapes special characters in a string for use in an SQL statement

Description

```
  string mysql_real_escape_string(string unescaped_string,
                                  resource link_identifier);
```

Escapes special characters in the *`unescaped_string`*, taking into account the current character set of the connection so that it is safe to place it in a `mysql_query`. If binary data is to be inserted, this function must be used.

`mysql_real_escape_string` calls MySQL's library function mysql_real_escape_string, which prepends backslashes to the following characters: `\x00`, `\n`, `\r`, `\`, `'`, `"` and `\x1a`.

This function must always (with few exceptions) be used to make data safe before sending a query to MySQL.

Parameters

`unescaped_string`	The string that is to be escaped.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns the escaped string, or `FALSE` on error.

Examples

Example 20.62. Simple `mysql_real_escape_string` example

```
<?php
// Connect
$link = mysql_connect('mysql_host', 'mysql_user', 'mysql_password')
    OR die(mysql_error());

// Query
$query = sprintf("SELECT * FROM users WHERE user='%s' AND password='%s'",
            mysql_real_escape_string($user),
            mysql_real_escape_string($password));
?>
```

Example 20.63. An example SQL Injection Attack

```
<?php
// Query database to check if there are any matching users
$query = "SELECT * FROM users WHERE user='{$_POST['username']}' AND password='{$_POST['password']}'";
mysql_query($query);

// We didn't check $_POST['password'], it could be anything the user wanted! For example:
$_POST['username'] = 'aidan';
$_POST['password'] = "' OR ''='";

// This means the query sent to MySQL would be:
echo $query;
?>
```

The query sent to MySQL:

```
SELECT * FROM users WHERE user='aidan' AND password='' OR ''=''
```

This would allow anyone to log in without a valid password.

Notes

Note

A MySQL connection is required before using `mysql_real_escape_string` otherwise an error of level `E_WARNING` is generated, and `FALSE` is returned. If *`link_identifier`* isn't defined, the last MySQL connection is used.

Note

If magic_quotes_gpc is enabled, first apply `stripslashes` to the data. Using this function on data which has already been escaped will escape the data twice.

Note

If this function is not used to escape data, the query is vulnerable to SQL Injection Attacks.

Note

`mysql_real_escape_string` does not escape `%` and `_`. These are wildcards in MySQL if combined with `LIKE`, `GRANT`, or `REVOKE`.

See Also

`mysql_client_encoding`
`addslashes`
`stripslashes`
The magic_quotes_gpc directive
The magic_quotes_runtime directive

20.10.1.4.42. `mysql_result`

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- `mysql_result`

  Get result data

Description

```
  string mysql_result(resource result,
                      int row,
                      mixed field= =0);
```

Retrieves the contents of one cell from a MySQL result set.

When working on large result sets, you should consider using one of the functions that fetch an entire row (specified below). As these functions return the contents of multiple cells in one function call, they're MUCH quicker than `mysql_result`. Also, note that specifying a numeric offset for the field argument is much quicker than specifying a fieldname or tablename.fieldname argument.

Parameters

`result`	The result resource that is being evaluated. This result comes from a call to `mysql_query`.
`row`	The row number from the result that's being retrieved. Row numbers start at `0`.
`field`	The name or offset of the field being retrieved. It can be the field's offset, the field's name, or the field's table dot field name (tablename.fieldname). If the column name has been aliased ('select foo as bar from...'), use the alias instead of the column name. If undefined, the first field is retrieved.

Return Values

The contents of one cell from a MySQL result set on success, or `FALSE` on failure.

Examples

Example 20.64. `mysql_result` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Could not connect: ' . mysql_error());
}
if (!mysql_select_db('database_name')) {
    die('Could not select database: ' . mysql_error());
}
$result = mysql_query('SELECT name FROM work.employee');
if (!$result) {
    die('Could not query:' . mysql_error());
}
echo mysql_result($result, 2); // outputs third employee's name

mysql_close($link);
?>
```

Notes

> **Note**
>
> Calls to `mysql_result` should not be mixed with calls to other functions that deal with the result set.

See Also

`mysql_fetch_row`
`mysql_fetch_array`
`mysql_fetch_assoc`

`mysql_fetch_object`

20.10.1.4.43. `mysql_select_db`

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- `mysql_select_db`

  Select a MySQL database

Description

```
  bool mysql_select_db(string database_name,
                       resource link_identifier);
```

Sets the current active database on the server that's associated with the specified link identifier. Every subsequent call to `mysql_query` will be made on the active database.

Parameters

`database_name`	The name of the database that is to be selected.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.65. `mysql_select_db` example

```
<?php

$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
if (!$link) {
    die('Not connected : ' . mysql_error());
}

// make foo the current db
$db_selected = mysql_select_db('foo', $link);
if (!$db_selected) {
    die ('Can\'t use foo : ' . mysql_error());
}
?>
```

Notes

> **Note**
>
> For backward compatibility, the following deprecated alias may be used: `mysql_selectdb`

See Also

`mysql_connect`
`mysql_pconnect`
`mysql_query`

20.10.1.4.44. `mysql_set_charset`

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- `mysql_set_charset`

  Sets the client character set

Description

```
bool mysql_set_charset(string charset,
                       resource link_identifier);
```

Sets the default character set for the current connection.

Parameters

`charset`	A valid character set name.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Notes

> **Note**
>
> This function requires MySQL 5.0.7 or later.

> **Note**
>
> This is the preferred way to change the charset. Using `mysql_query` to execute `SET NAMES ..` is not recommended.

See Also

`mysql_client_encoding`
List of character sets that MySQL supports

20.10.1.4.45. `mysql_stat`

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- `mysql_stat`

  Get current system status

Description

```
string mysql_stat(resource link_identifier);
```

`mysql_stat` returns the current server status.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established,

an `E_WARNING` level error is generated.

Return Values

Returns a string with the status for uptime, threads, queries, open tables, flush tables and queries per second. For a complete list of other status variables, you have to use the `SHOW STATUS` SQL command. If *`link_identifier`* is invalid, `NULL` is returned.

Examples

Example 20.66. `mysql_stat` example

```
<?php
$link   = mysql_connect('localhost', 'mysql_user', 'mysql_password');
$status = explode('  ', mysql_stat($link));
print_r($status);
?>
```

The above example will output something similar to:

```
Array
(
    [0] => Uptime: 5380
    [1] => Threads: 2
    [2] => Questions: 1321299
    [3] => Slow queries: 0
    [4] => Opens: 26
    [5] => Flush tables: 1
    [6] => Open tables: 17
    [7] => Queries per second avg: 245.595
)
```

Example 20.67. Alternative `mysql_stat` example

```
<?php
$link   = mysql_connect('localhost', 'mysql_user', 'mysql_password');
$result = mysql_query('SHOW STATUS', $link);
while ($row = mysql_fetch_assoc($result)) {
    echo $row['Variable_name'] . ' = ' . $row['Value'] . "\n";
}
?>
```

The above example will output something similar to:

```
back_log = 50
basedir = /usr/local/
bdb_cache_size = 8388600
bdb_log_buffer_size = 32768
bdb_home = /var/db/mysql/
bdb_max_lock = 10000
bdb_logdir =
bdb_shared_data = OFF
bdb_tmpdir = /var/tmp/
...
```

See Also

`mysql_get_server_info`
`mysql_list_processes`

20.10.1.4.46. `mysql_tablename`

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- `mysql_tablename`

  Get table name of field

Description

```
string mysql_tablename(resource result,
                       int i);
```

Retrieves the table name from a *`result`*.

This function is deprecated. It is preferable to use `mysql_query` to issue an SQL `SHOW TABLES [FROM db_name] [LIKE 'pattern']` statement instead.

Parameters

`result`	A result pointer resource that's returned from `mysql_list_tables`.
`i`	The integer index (row/table number)

Return Values

The name of the table on success or `FALSE` on failure.

Use the `mysql_tablename` function to traverse this result pointer, or any function for result tables, such as `mysql_fetch_array`.

Examples

Example 20.68. `mysql_tablename` example

```
<?php
mysql_connect("localhost", "mysql_user", "mysql_password");
$result = mysql_list_tables("mydb");
$num_rows = mysql_num_rows($result);
for ($i = 0; $i < $num_rows; $i++) {
    echo "Table: ", mysql_tablename($result, $i), "\n";
}

mysql_free_result($result);
?>
```

Notes

> **Note**
>
> The `mysql_num_rows` function may be used to determine the number of tables in the result pointer.

See Also

`mysql_list_tables`
`mysql_field_table`
`mysql_db_name`

20.10.1.4.47. `mysql_thread_id`

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- `mysql_thread_id`

  Return the current thread ID

Description

```
int mysql_thread_id(resource link_identifier);
```

Retrieves the current thread ID. If the connection is lost, and a reconnect with `mysql_ping` is executed, the thread ID will change. This means only retrieve the thread ID when needed.

Parameters

`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

The thread ID on success or `FALSE` on failure.

Examples

Example 20.69. `mysql_thread_id` example

```
<?php
$link = mysql_connect('localhost', 'mysql_user', 'mysql_password');
$thread_id = mysql_thread_id($link);
if ($thread_id){
    printf("current thread id is %d\n", $thread_id);
}
?>
```

The above example will output something similar to:

```
current thread id is 73
```

See Also

`mysql_ping`
`mysql_list_processes`

20.10.1.4.48. `mysql_unbuffered_query`

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- `mysql_unbuffered_query`

  Send an SQL query to MySQL without fetching and buffering the result rows.

Description

```
resource mysql_unbuffered_query(string query,
                                resource link_identifier);
```

`mysql_unbuffered_query` sends the SQL query *`query`* to MySQL without automatically fetching and buffering the result rows as `mysql_query` does. This saves a considerable amount of memory with SQL queries that produce large result sets, and you can start working on the result set immediately after the first row has been retrieved as you don't have to wait until the complete SQL query has been performed. To use `mysql_unbuffered_query` while multiple database connections are open, you must specify the optional parameter *`link_identifier`* to identify which connection you want to use.

Parameters

`query`	The SQL query to execute. Data inside the query should be properly escaped.
`link_identifier`	The MySQL connection. If the link identifier is not specified, the last link opened by `mysql_connect` is assumed. If no such link is found, it will try to create one as if `mysql_connect` was called with no arguments. If no connection is found or established, an `E_WARNING` level error is generated.

Return Values

For SELECT, SHOW, DESCRIBE or EXPLAIN statements, `mysql_unbuffered_query` returns a resource on success, or `FALSE` on error.

For other type of SQL statements, UPDATE, DELETE, DROP, etc, `mysql_unbuffered_query` returns `TRUE` on success or `FALSE` on error.

Notes

> **Note**
>
> The benefits of `mysql_unbuffered_query` come at a cost: you cannot use `mysql_num_rows` and `mysql_data_seek` on a result set returned from `mysql_unbuffered_query`. You also have to fetch all result rows from an unbuffered SQL query before you can send a new SQL query to MySQL.

See Also

`mysql_query`

20.10.2. MySQL Improved Extension (`Mysqli`)

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The `mysqli` extension allows you to access the functionality provided by MySQL 4.1 and above. More information about the MySQL Database server can be found at http://www.mysql.com/

An overview of software available for using MySQL from PHP can be found at Section 20.10.2.2, “Overview”

Documentation for MySQL can be found at http://dev.mysql.com/doc/.

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20.10.2.1. Examples

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All examples in the `mysqli` documentation use the world database. The world database can be found at http://downloads.mysql.com/docs/world.sql.gz

20.10.2.2. Overview

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This section provides an introduction to the options available to you when developing a PHP application that needs to interact with a MySQL database.

What is an API?

An Application Programming Interface, or API, defines the classes, methods, functions and variables that your application will need to call in order to carry out its desired task. In the case of PHP applications that need to communicate with databases the necessary APIs are usually exposed via PHP extensions.

APIs can be procedural or object-oriented. With a procedural API you call functions to carry out tasks, with the object-oriented API you instantiate classes and then call methods on the resulting objects. Of the two the latter is usually the preferred interface, as it is more modern and leads to better organized code.

When writing PHP applications that need to connect to the MySQL server there are several API options available. This document discusses what is available and how to select the best solution for your application.

What is a Connector?

In the MySQL documentation, the term *connector* refers to a piece of software that allows your application to connect to the MySQL database server. MySQL provides connectors for a variety of languages, including PHP.

If your PHP application needs to communicate with a database server you will need to write PHP code to perform such activities as connecting to the database server, querying the database and other database-related functions. Software is required to provide the API that your PHP application will use, and also handle the communication between your application and the database server, possibly using other intermediate libraries where necessary. This software is known generically as a connector, as it allows your application to *connect* to a database server.

What is a Driver?

A driver is a piece of software designed to communicate with a specific type of database server. The driver may also call a library, such as the MySQL Client Library or the MySQL Native Driver. These libraries implement the low-level protocol used to communicate with the MySQL database server.

By way of an example, the PHP Data Objects (PDO) database abstraction layer may use one of several database-specific drivers. One of the drivers it has available is the PDO MYSQL driver, which allows it to interface with the MySQL server.

Sometimes people use the terms connector and driver interchangeably, this can be confusing. In the MySQL-related documentation the term “driver” is reserved for software that provides the database-specific part of a connector package.

What is an Extension?

In the PHP documentation you will come across another term - *extension*. The PHP code consists of a core, with optional extensions to the core functionality. PHP's MySQL-related extensions, such as the `mysqli` extension, and the `mysql` extension, are implemented using the PHP extension framework.

An extension typically exposes an API to the PHP programmer, to allow its facilities to be used programmatically. However, some extensions which use the PHP extension framework do not expose an API to the PHP programmer.

The PDO MySQL driver extension, for example, does not expose an API to the PHP programmer, but provides an interface to the PDO layer above it.

The terms API and extension should not be taken to mean the same thing, as an extension may not necessarily expose an API to the programmer.

What are the main PHP API offerings for using MySQL?

There are three main API options when considering connecting to a MySQL database server:

- PHP's MySQL Extension
- PHP's mysqli Extension
- PHP Data Objects (PDO)

Each has its own advantages and disadvantages. The following discussion aims to give a brief introduction to the key aspects of each API.

What is PHP's MySQL Extension?

This is the original extension designed to allow you to develop PHP applications that interact with a MySQL database. The `mysql` extension provides a procedural interface and is intended for use only with MySQL versions older than 4.1.3. This extension can be used with versions of MySQL 4.1.3 or newer, but not all of the latest MySQL server features will be available.

> **Note**
>
> If you are using MySQL versions 4.1.3 or later it is *strongly* recommended that you use the `mysqli` extension instead.

The `mysql` extension source code is located in the PHP extension directory `ext/mysql`.

For further information on the `mysql` extension, see Section 20.10.1, “MySQL”.

What is PHP's mysqli Extension?

The `mysqli` extension, or as it is sometimes known, the MySQL *improved* extension, was developed to take advantage of new features found in MySQL systems versions 4.1.3 and newer. The `mysqli` extension is included with PHP versions 5 and later.

The `mysqli` extension has a number of benefits, the key enhancements over the `mysql` extension being:

- Object-oriented interface
- Support for Prepared Statements
- Support for Multiple Statements
- Support for Transactions
- Enhanced debugging capabilities
- Embedded server support

> **Note**
>
> If you are using MySQL versions 4.1.3 or later it is *strongly* recommended that you use this extension.

As well as the object-oriented interface the extension also provides a procedural interface.

The `mysqli` extension is built using the PHP extension framework, its source code is located in the directory `ext/mysqli`.

For further information on the `mysqli` extension, see Section 20.10.2, “MySQL Improved Extension (`Mysqli`)”.

What is PDO?

PHP Data Objects, or PDO, is a database abstraction layer specifically for PHP applications. PDO provides a consistent API for your PHP application regardless of the type of database server your application will connect to. In theory, if you are using the PDO API, you could switch the database server you used, from say Firebird to MySQL, and only need to make minor changes to your PHP code.

Other examples of database abstraction layers include JDBC for Java applications and DBI for Perl.

While PDO has its advantages, such as a clean, simple, portable API, its main disadvantage is that it doesn't allow you to use all of the advanced features that are available in the latest versions of MySQL server. For example, PDO does not allow you to use MySQL's support for Multiple Statements.

PDO is implemented using the PHP extension framework, its source code is located in the directory `ext/pdo`.

For further information on PDO, see the Section 20.10.4, “MySQL Functions (PDO_MYSQL)”.

What is the PDO MYSQL driver?

The PDO MYSQL driver is not an API as such, at least from the PHP programmer's perspective. In fact the PDO MYSQL driver sits in the layer below PDO itself and provides MySQL-specific functionality. The programmer still calls the PDO API, but PDO uses the PDO MYSQL driver to carry out communication with the MySQL server.

The PDO MYSQL driver is one of several available PDO drivers. Other PDO drivers available include those for the Firebird and PostgreSQL database servers.

The PDO MYSQL driver is implemented using the PHP extension framework. Its source code is located in the directory `ext/`

`pdo_mysql`. It does not expose an API to the PHP programmer.

For further information on the PDO MYSQL driver, see Section 20.10.4, “MySQL Functions (PDO_MYSQL)”.

What is PHP's MySQL Native Driver?

In order to communicate with the MySQL database server the `mysql` extension, `mysqli` and the PDO MYSQL driver each use a low-level library that implements the required protocol. In the past, the only available library was the MySQL Client Library, otherwise known as `libmysql`.

However, the interface presented by `libmysql` was not optimized for communication with PHP applications, as `libmysql` was originally designed with C applications in mind. For this reason the MySQL Native Driver, `mysqlnd`, was developed as an alternative to `libmysql` for PHP applications.

The `mysql` extension, the `mysqli` extension and the PDO MySQL driver can each be individually configured to use either `libmysql` or `mysqlnd`. As `mysqlnd` is designed specifically to be utilised in the PHP system it has numerous memory and speed enhancements over `libmysql`. You are strongly encouraged to take advantage of these improvements.

> **Note**
>
> The MySQL Native Driver can only be used with MySQL server versions 4.1.3 and later.

The MySQL Native Driver is implemented using the PHP extension framework. The source code is located in `ext/mysqlnd`. It does not expose an API to the PHP programmer.

Comparison of Features

The following table compares the functionality of the three main methods of connecting to MySQL from PHP:

	PHP's mysqli Extension	**PDO (Using PDO MySQL Driver and MySQL Native Driver)**	**PHP's MySQL Extension**
PHP version introduced	5.0	5.0	Prior to 3.0
Included with PHP 5.x	yes	yes	Yes
MySQL development status	Active development	Active development as of PHP 5.3	Maintenance only
Recommended by MySQL for new projects	Yes - preferred option	Yes	No
API supports Charsets	Yes	Yes	No
API supports server-side Prepared Statements	Yes	Yes	No
API supports client-side Prepared Statements	No	Yes	No
API supports Stored Procedures	Yes	Yes	No
API supports Multiple Statements	Yes	Most	No
Supports all MySQL 4.1+ functionality	Yes	Most	No

20.10.2.3. Installing/Configuring

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20.10.2.3.1. Requirements

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In order to have these functions available, you must compile PHP with support for the mysqli extension.

> **Note**
>
> The mysqli extension is designed to work with MySQL version 4.1.13 or newer, or 5.0.7 or newer. For previous versions, please see the MySQL extension documentation.

20.10.2.3.2. Installation

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The `mysqli` extension was introduced with PHP version 5.0.0. The MySQL Native Driver was included in PHP version 5.3.0.

20.10.2.3.2.1. Installation on Linux

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The common Unix distributions include binary versions of PHP that can be installed. Although these binary versions are typically built with support for MySQL extensions enabled, the extension libraries themselves may need to be installed using an additional package. Check the package manager than comes with your chosen distribution for availability.

Unless your Unix distribution comes with a binary package of PHP with the `mysqli` extension available, you will need to build PHP from source code. Building PHP from source allows you to specify the MySQL extensions you want to use, as well as your choice of client library for each extension.

20.10.2.3.2.1.1. PHP 5.0, 5.1, 5.2

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If building from source code, to ensure that the `mysqli` extension for PHP is enabled, you will need to configure the PHP source code to use `mysqli`. This is achieved by running the `configure` script with the option `--with-mysqli=mysql_config_path/mysql_config`, prior to building PHP. This will enable `mysqli` and it will use the MySQL Client Library (libmysql) to communicate with the MySQL Server.

The `mysql_config_path` represents the location of the `mysql_config` program that comes with MySQL Server.

20.10.2.3.2.1.2. PHP 5.3.0+

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With versions of PHP 5.3.0 and newer, `mysqli` uses MySQL Native Driver by default. This gives a number of benefits over `libmysql`.

This is the recommended option, as using the MySQL Native Driver results in improved performance and gives access to features not available when using the MySQL Client Library. Refer to What is PHP's MySQL Native Driver? for a brief overview of the advantages of MySQL Native Driver.

To use MySQL Native Driver with `mysqli` you need to configure the PHP source code using the `--with-mysqli=mysqlnd` option, prior to building PHP.

Note that it is possible to freely mix MySQL extensions and client libraries. For example, it is possible to enable the MySQL extension to use the MySQL Client Library (libmysql), while configuring the `mysqli` extension to use the MySQL Native Driver. However, all permutations of extension and client library are possible.

The following example builds the MySQL extension to use the MySQL Client Library, and the `mysqli` and PDO MYSQL extensions to use the MySQL Native Driver:

```
./configure --with-mysql=/usr/bin/mysql_config  \
--with-mysqli=mysqlnd \
--with-pdo-mysql=mysqlnd
[other options]
```

20.10.2.3.2.2. Installation on Windows Systems

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On Windows, PHP is most commonly installed using the binary installer.

20.10.2.3.2.2.1. PHP 5.0, 5.1, 5.2

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Once PHP has been installed, some configuration is required to enable `mysqli` and specify the client library you want it to use.

The `mysqli` extension is not enabled by default, so the `php_mysqli.dll` DLL must be enabled inside of `php.ini`. In order to do this you need to find the `php.ini` file (typically located in `c:\php`), and make sure you remove the comment (semi-colon) from the start of the line `extension=php_mysqli.dll`, in the section marked `[PHP_MYSQLI]`.

Also, if you want to use the MySQL Client Library with `mysqli`, you need to make sure PHP can access the client library file. The MySQL Client Library is included as a file named `libmysql.dll` in the Windows PHP distribution. This file needs to be available in the Windows system's `PATH` environment variable, so that it can be successfully loaded. See the FAQ titled "How do I add my PHP directory to the PATH on Windows" for information on how to do this. Copying `libmysql.dll` to the Windows system directory (typically `c:\Windows\system`) also works, as the system directory is by default in the system's `PATH`. However, this practice is strongly discouraged.

As with enabling any PHP extension (such as `php_mysqli.dll`), the PHP directive extension_dir should be set to the directory where the PHP extensions are located. See also the Manual Windows Installation Instructions. An example `extension_dir` value for PHP 5 is `c:\php\ext`.

> **Note**
>
> If when starting the web server an error similar to the following occurs: `"Unable to load dynamic library './php_mysqli.dll'"`, this is because `php_mysqli.dll` and/or `libmysql.dll` cannot be found by the system.

20.10.2.3.2.2.2. PHP 5.3.0+

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On Windows, for PHP versions 5.3 and newer, the `mysqli` extension is enabled and uses the MySQL Native Driver by default. This means you don't need to worry about configuring access to `libmysql.dll`.

20.10.2.3.3. Runtime Configuration

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The behaviour of these functions is affected by settings in `php.ini`.

Table 20.8. MySQLi Configuration Options

Name	Default	Changeable	Changelog
mysqli.allow_persistent	"1"	PHP_INI_SYSTEM	Available since PHP 5.3.0.
mysqli.max_persistent	"-1"	PHP_INI_SYSTEM	Available since PHP 5.3.0.
mysqli.max_links	"-1"	PHP_INI_SYSTEM	Available since PHP 5.0.0.
mysqli.default_port	"3306"	PHP_INI_ALL	Available since PHP 5.0.0.
mysqli.default_socket	NULL	PHP_INI_ALL	Available since PHP 5.0.0.
mysqli.default_host	NULL	PHP_INI_ALL	Available since PHP 5.0.0.
mysqli.default_user	NULL	PHP_INI_ALL	Available since PHP 5.0.0.
mysqli.default_pw	NULL	PHP_INI_ALL	Available since PHP 5.0.0.
mysqli.reconnect	"0"	PHP_INI_SYSTEM	Available since PHP 4.3.5.
mysqli.allow_local_infile	"1"	PHP_INI_SYSTEM	Available since PHP 5.2.4.
mysqli.cache_size	"2000"	PHP_INI_SYSTEM	Available since PHP 5.3.0.

For further details and definitions of the preceding PHP_INI_* constants, see the chapter on configuration changes.

Here's a short explanation of the configuration directives.

`mysqli.allow_persistent` integer	Enable the ability to create persistent connections using `mysqli_connect`.
`mysqli.max_persistent` integer	Maximum of persistent connections that can be made. Set to 0 for unlimited.
`mysqli.max_links` integer	The maximum number of MySQL connections per process.
`mysqli.default_port` integer	The default TCP port number to use when connecting to the database server if no other port is specified. If no default is specified, the port will be obtained from the `MYSQL_TCP_PORT` environment variable, the `mysql-tcp` entry in `/etc/services` or the compile-time `MYSQL_PORT` constant, in that order. Win32 will only use the `MYSQL_PORT` constant.

string	The default socket name to use when connecting to a local database server if no other socket name is specified.
`mysqli.default_host` string	The default server host to use when connecting to the database server if no other host is specified. Doesn't apply in safe mode.
`mysqli.default_user` string	The default user name to use when connecting to the database server if no other name is specified. Doesn't apply in safe mode.
`mysqli.default_pw` string	The default password to use when connecting to the database server if no other password is specified. Doesn't apply in safe mode.
`mysqli.reconnect` integer	Automatically reconnect if the connection was lost.
`mysqli.allow_local_infile` integer	
`mysqli.cache_size` integer	Available only with mysqlnd.

Users cannot set `MYSQL_OPT_READ_TIMEOUT` through an API call or runtime configuration setting. Note that if it were possible there would be differences between how `libmysql` and streams would interpret the value of `MYSQL_OPT_READ_TIMEOUT`.

20.10.2.3.4. Resource Types

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This extension has no resource types defined.

20.10.2.4. The mysqli Extension and Persistent Connections

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Persistent connection support was introduced in PHP 5.3 for the `mysqli` extension. Support was already present in PDO MYSQL and ext/mysql. The idea behind persistent connections is that a connection between a client process and a database can be reused by a client process, rather than being created and destroyed multiple times. This reduces the overhead of creating fresh connections every time one is required, as unused connections are cached and ready to be reused.

Unlike the mysql extension, mysqli does not provide a separate function for opening persistent connections. To open a persistent connection you must prepend `p:` to the hostname when connecting.

The problem with persistent connections is that they can be left in unpredictable states by clients. For example, a table lock might be activated before a client terminates unexpectedly. A new client process reusing this persistent connection will get the connection “as is”. Any cleanup would need to be done by the new client process before it could make good use of the persistent connection, increasing the burden on the programmer.

The persistent connection of the `mysqli` extension however provides built-in cleanup handling code. The cleanup carried out by `mysqli` includes:

- Rollback active transactions
- Close and drop temporary tables
- Unlock tables
- Reset session variables
- Close prepared statements (always happens with PHP)
- Close handler
- Release locks acquired with `GET_LOCK`

This ensures that persistent connections are in a clean state on return from the connection pool, before the client process uses them.

The `mysqli` extension does this cleanup by automatically calling the C-API function `mysql_change_user()`.

The automatic cleanup feature has advantages and disadvantages though. The advantage is that the programmer no longer needs to worry about adding cleanup code, as it is called automatically. However, the disadvantage is that the code could *potentially* be a little slower, as the code to perform the cleanup needs to run each time a connection is returned from the connection pool.

It is possible to switch off the automatic cleanup code, by compiling PHP with `MYSQLI_NO_CHANGE_USER_ON_PCONNECT` defined.

> **Note**
>
> The `mysqli` extension supports persistent connections when using either MySQL Native Driver or MySQL Client Library.

20.10.2.5. Predefined Constants

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`MYSQLI_READ_DEFAULT_GROUP`	Read options from the named group from `my.cnf` or the file specified with `MYSQLI_READ_DEFAULT_FILE`
`MYSQLI_READ_DEFAULT_FILE`	Read options from the named option file instead of from `my.cnf`
`MYSQLI_OPT_CONNECT_TIMEOUT`	Connect timeout in seconds
`MYSQLI_OPT_LOCAL_INFILE`	Enables command `LOAD LOCAL INFILE`
`MYSQLI_INIT_COMMAND`	Command to execute when connecting to MySQL server. Will automatically be re-executed when reconnecting.
`MYSQLI_CLIENT_SSL`	Use SSL (encrypted protocol). This option should not be set by application programs; it is set internally in the MySQL client library
`MYSQLI_CLIENT_COMPRESS`	Use compression protocol
`MYSQLI_CLIENT_INTERACTIVE`	Allow `interactive_timeout` seconds (instead of `wait_timeout` seconds) of inactivity before closing the connection. The client's session `wait_timeout` variable will be set to the value of the session `interactive_timeout` variable.
`MYSQLI_CLIENT_IGNORE_SPACE`	Allow spaces after function names. Makes all functions names reserved words.
`MYSQLI_CLIENT_NO_SCHEMA`	Don't allow the `db_name.tbl_name.col_name` syntax.
`MYSQLI_CLIENT_MULTI_QUERIES`	Allows multiple semicolon-delimited queries in a single `mysqli_query` call.
`MYSQLI_STORE_RESULT`	For using buffered resultsets
`MYSQLI_USE_RESULT`	For using unbuffered resultsets
`MYSQLI_ASSOC`	Columns are returned into the array having the fieldname as the array index.
`MYSQLI_NUM`	Columns are returned into the array having an enumerated index.
`MYSQLI_BOTH`	Columns are returned into the array having both a numerical index and the fieldname as the associative index.
`MYSQLI_NOT_NULL_FLAG`	Indicates that a field is defined as `NOT NULL`
`MYSQLI_PRI_KEY_FLAG`	Field is part of a primary index
`MYSQLI_UNIQUE_KEY_FLAG`	Field is part of a unique index.
`MYSQLI_MULTIPLE_KEY_FLAG`	Field is part of an index.
`MYSQLI_BLOB_FLAG`	Field is defined as `BLOB`
`MYSQLI_UNSIGNED_FLAG`	Field is defined as `UNSIGNED`
`MYSQLI_ZEROFILL_FLAG`	Field is defined as `ZEROFILL`
`MYSQLI_AUTO_INCREMENT_FLAG`	Field is defined as `AUTO_INCREMENT`
`MYSQLI_TIMESTAMP_FLAG`	Field is defined as `TIMESTAMP`
`MYSQLI_SET_FLAG`	Field is defined as `SET`

`MYSQLI_NUM_FLAG`	Field is defined as `NUMERIC`
`MYSQLI_PART_KEY_FLAG`	Field is part of an multi-index
`MYSQLI_GROUP_FLAG`	Field is part of `GROUP BY`
`MYSQLI_TYPE_DECIMAL`	Field is defined as `DECIMAL`
`MYSQLI_TYPE_NEWDECIMAL`	Precision math `DECIMAL` or `NUMERIC` field (MySQL 5.0.3 and up)
`MYSQLI_TYPE_BIT`	Field is defined as `BIT` (MySQL 5.0.3 and up)
`MYSQLI_TYPE_TINY`	Field is defined as `TINYINT`
`MYSQLI_TYPE_SHORT`	Field is defined as `SMALLINT`
`MYSQLI_TYPE_LONG`	Field is defined as `INT`
`MYSQLI_TYPE_FLOAT`	Field is defined as `FLOAT`
`MYSQLI_TYPE_DOUBLE`	Field is defined as `DOUBLE`
`MYSQLI_TYPE_NULL`	Field is defined as `DEFAULT NULL`
`MYSQLI_TYPE_TIMESTAMP`	Field is defined as `TIMESTAMP`
`MYSQLI_TYPE_LONGLONG`	Field is defined as `BIGINT`
`MYSQLI_TYPE_INT24`	Field is defined as `MEDIUMINT`
`MYSQLI_TYPE_DATE`	Field is defined as `DATE`
`MYSQLI_TYPE_TIME`	Field is defined as `TIME`
`MYSQLI_TYPE_DATETIME`	Field is defined as `DATETIME`
`MYSQLI_TYPE_YEAR`	Field is defined as `YEAR`
`MYSQLI_TYPE_NEWDATE`	Field is defined as `DATE`
`MYSQLI_TYPE_INTERVAL`	Field is defined as `INTERVAL`
`MYSQLI_TYPE_ENUM`	Field is defined as `ENUM`
`MYSQLI_TYPE_SET`	Field is defined as `SET`
`MYSQLI_TYPE_TINY_BLOB`	Field is defined as `TINYBLOB`
`MYSQLI_TYPE_MEDIUM_BLOB`	Field is defined as `MEDIUMBLOB`
`MYSQLI_TYPE_LONG_BLOB`	Field is defined as `LONGBLOB`
`MYSQLI_TYPE_BLOB`	Field is defined as `BLOB`
`MYSQLI_TYPE_VAR_STRING`	Field is defined as `VARCHAR`
`MYSQLI_TYPE_STRING`	Field is defined as `STRING`
`MYSQLI_TYPE_CHAR`	Field is defined as `CHAR`
`MYSQLI_TYPE_GEOMETRY`	Field is defined as `GEOMETRY`
`MYSQLI_NEED_DATA`	More data available for bind variable
`MYSQLI_NO_DATA`	No more data available for bind variable
`MYSQLI_DATA_TRUNCATED`	Data truncation occurred. Available since PHP 5.1.0 and MySQL 5.0.5.
`MYSQLI_ENUM_FLAG`	Field is defined as `ENUM`. Available since PHP 5.3.0.
`MYSQLI_CURSOR_TYPE_FOR_UPDATE`	

`RSOR`
`MYSQLI_CURSOR_TYPE_READ_ONLY`
`MYSQLI_CURSOR_TYPE_SCROLLABLE`
`MYSQLI_STMT_ATTR_CURSOR_TYPE`
`MYSQLI_STMT_ATTR_PREFETCH_ROWS`
`MYSQLI_STMT_ATTR_UPDATE_MAX_LENGTH`
`MYSQLI_SET_CHARSET_NAME`

20.10.2.6. The MySQLi Extension Function Summary

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MySQLi Class			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
Properties			
$mysqli->affected_rows	`mysqli_affected_rows`	N/A	Gets the number of affected rows in a previous MySQL operation
$mysqli->client_info	`mysqli_get_client_info`	N/A	Returns the MySQL client version as a string
$mysqli->client_version	`mysqli_get_client_version`	N/A	Returns MySQL client version info as an integer
$mysqli->connect_errno	`mysqli_connect_errno`	N/A	Returns the error code from last connect call
$mysqli->connect_error	`mysqli_connect_error`	N/A	Returns a string description of the last connect error
$mysqli->errno	`mysqli_errno`	N/A	Returns the error code for the most recent function call
$mysqli->error	`mysqli_error`	N/A	Returns a string description of the last error
$mysqli->field_count	`mysqli_field_count`	N/A	Returns the number of columns for the most recent query
$mysqli->host_info	`mysqli_get_host_info`	N/A	Returns a string representing the type of connection used
$mysqli->protocol_version	`mysqli_get_proto_info`	N/A	Returns the version of the MySQL protocol used
$mysqli->server_info	`mysqli_get_server_info`	N/A	Returns the version of the MySQL server
$mysqli->server_version	`mysqli_get_server_version`	N/A	Returns the version of the MySQL server as an integer
$mysqli->info	`mysqli_info`	N/A	Retrieves information about the most recently executed query
$mysqli->insert_id	`mysqli_insert_id`	N/A	Returns the auto generated id used in the last query
$mysqli->sqlstate	`mysqli_sqlstate`	N/A	Returns the SQLSTATE error from previous MySQL operation
$mysqli->warning_count	`mysqli_warning_count`	N/A	Returns the number of warnings from the last query for the given link
Methods			
`mysqli->autocommit`	`mysqli_autocommit`	N/A	Turns on or off auto-committing database modifications
`mysqli->change_user`	`mysqli_change_user`	N/A	Changes the user of the specified database connection
`mysqli->character_set_name`, mysqli->client_encoding	`mysqli_character_set_name`	`mysqli_client_encoding`	Returns the default character set for the database connection
`mysqli->close`	`mysqli_close`	N/A	Closes a previously opened

MySQLi Class			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
			database connection
`mysqli->commit`	`mysqli_commit`	N/A	Commits the current transaction
`mysqli::__construct`	`mysqli_connect`	N/A	Open a new connection to the MySQL server [Note: static (i.e. class) method]
`mysqli->debug`	`mysqli_debug`	N/A	Performs debugging operations
`mysqli->dump_debug_info`	`mysqli_dump_debug_info`	N/A	Dump debugging information into the log
`mysqli->get_charset`	`mysqli_get_charset`	N/A	Returns a character set object
`mysqli->get_connection_stats`	`mysqli_get_connection_stats`	N/A	Returns client connection statistics. Available only with mysqlnd.
`mysqli->get_client_info`	`mysqli_get_client_info`	N/A	Returns the MySQL client version as a string
`mysqli->get_client_stats`	`mysqli_get_client_stats`	N/A	Returns client per-process statistics. Available only with mysqlnd.
`mysqli->get_cache_stats`	`mysqli_get_cache_stats`	N/A	Returns client Zval cache statistics. Available only with mysqlnd.
`mysqli->get_server_info`	`mysqli_get_server_info`	N/A	NOT DOCUMENTED
`mysqli->get_warnings`	`mysqli_get_warnings`	N/A	NOT DOCUMENTED
`mysqli::init`	`mysqli_init`	N/A	Initializes MySQLi and returns a resource for use with mysqli_real_connect. [Not called on an object, as it returns a $mysqli object.]
`mysqli->kill`	`mysqli_kill`	N/A	Asks the server to kill a MySQL thread
`mysqli->more_results`	`mysqli_more_results`	N/A	Check if there are any more query results from a multi query
`mysqli->multi_query`	`mysqli_multi_query`	N/A	Performs a query on the database
`mysqli->next_result`	`mysqli_next_result`	N/A	Prepare next result from multi_query
`mysqli->options`	`mysqli_options`	`mysqli_set_opt`	Set options
`mysqli->ping`	`mysqli_ping`	N/A	Pings a server connection, or tries to reconnect if the connection has gone down
`mysqli->prepare`	`mysqli_prepare`	N/A	Prepare an SQL statement for execution
`mysqli->query`	`mysqli_query`	N/A	Performs a query on the database
`mysqli->real_connect`	`mysqli_real_connect`	N/A	Opens a connection to a mysql server
`mysqli->real_escape_string`, `mysqli->escape_string`	`mysqli_real_escape_string`	`mysqli_escape_string`	Escapes special characters in a string for use in an SQL statement, taking into account the current charset of the connection
`mysqli->real_query`	`mysqli_real_query`	N/A	Execute an SQL query
`mysqli->rollback`	`mysqli_rollback`	N/A	Rolls back current transaction

MySQLi Class			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
`mysqli->select_db`	`mysqli_select_db`	N/A	Selects the default database for database queries
`mysqli->set_charset`	`mysqli_set_charset`	N/A	Sets the default client character set
`mysqli->set_local_infile_default`	`mysqli_set_local_infile_default`	N/A	Unsets user defined handler for load local infile command
`mysqli->set_local_infile_handler`	`mysqli_set_local_infile_handler`	N/A	Set callback function for LOAD DATA LOCAL INFILE command
`mysqli->ssl_set`	`mysqli_ssl_set`	N/A	Used for establishing secure connections using SSL
`mysqli->stat`	`mysqli_stat`	N/A	Gets the current system status
`mysqli->stmt_init`	`mysqli_stmt_init`	N/A	Initializes a statement and returns an object for use with mysqli_stmt_prepare
`mysqli->store_result`	`mysqli_store_result`	N/A	Transfers a result set from the last query
`mysqli->thread_id`	`mysqli_thread_id`	N/A	Returns the thread ID for the current connection
`mysqli->thread_safe`	`mysqli_thread_safe`	N/A	Returns whether thread safety is given or not
`mysqli->use_result`	`mysqli_use_result`	N/A	Initiate a result set retrieval

MySQL_STMT			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
Properties			
$mysqli_stmt->affected_rows	`mysqli_stmt_affected_rows`	N/A	Returns the total number of rows changed, deleted, or inserted by the last executed statement
$mysqli_stmt->errno	`mysqli_stmt_errno`	N/A	Returns the error code for the most recent statement call
$mysqli_stmt->error	`mysqli_stmt_error`	N/A	Returns a string description for last statement error
$mysqli_stmt->field_count	`mysqli_stmt_field_count`	N/A	Returns the number of field in the given statement - not documented
$mysqli_stmt->insert_id	`mysqli_stmt_insert_id`	N/A	Get the ID generated from the previous INSERT operation
$mysqli_stmt->num_rows	`mysqli_stmt_num_rows`	N/A	Return the number of rows in statements result set
$mysqli_stmt->param_count	`mysqli_stmt_param_count`	`mysqli_param_count`	Returns the number of parameter for the given statement
$mysqli_stmt->sqlstate	`mysqli_stmt_sqlstate`	N/A	Returns SQLSTATE error from previous statement operation
Methods			
`mysqli_stmt->attr_get`	`mysqli_stmt_attr_get`	N/A	Used to get the current value of a statement attribute
`mysqli_stmt->attr_set`	`mysqli_stmt_attr_set`	N/A	Used to modify the behavior of a prepared statement
`mysqli_stmt->bind_param`	`mysqli_stmt_bind_param`	`mysqli_bind_param`	Binds variables to a prepared statement as parameters
`mysqli_stmt->bind_res`	`mysqli_stmt_bind_resu`	`mysqli_bind_result`	Binds variables to a prepared

MySQL_STMT			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
`ult`	`lt`		statement for result storage
`mysqli_stmt->close`	`mysqli_stmt_close`	N/A	Closes a prepared statement
`mysqli_stmt->data_seek`	`mysqli_stmt_data_seek`	N/A	Seeks to an arbitrary row in statement result set
`mysqli_stmt->execute`	`mysqli_stmt_execute`	`mysqli_execute`	Executes a prepared Query
`mysqli_stmt->fetch`	`mysqli_stmt_fetch`	`mysqli_fetch`	Fetch results from a prepared statement into the bound variables
`mysqli_stmt->free_result`	`mysqli_stmt_free_result`	N/A	Frees stored result memory for the given statement handle
$mysqli_stmt->get_result()	mysqli_stmt_get_result	N/A	NOT DOCUMENTED Available only with mysqlnd.
`mysqli_stmt->get_warnings`	`mysqli_stmt_get_warnings`	N/A	NOT DOCUMENTED
$mysqli_stmt->more_results()	mysqli_stmt_more_results()	N/A	NOT DOCUMENTED Available only with mysqlnd.
$mysqli_stmt->next_result()	mysqli_stmt_next_result()	N/A	NOT DOCUMENTED Available only with mysqlnd.
`mysqli_stmt->num_rows`	`mysqli_stmt_num_rows`	N/A	See also property $mysqli_stmt->num_rows
`mysqli_stmt->prepare`	`mysqli_stmt_prepare`	N/A	Prepare an SQL statement for execution
`mysqli_stmt->reset`	`mysqli_stmt_reset`	N/A	Resets a prepared statement
`mysqli_stmt->result_metadata`	`mysqli_stmt_result_metadata`	`mysqli_get_metadata`	Returns result set metadata from a prepared statement
`mysqli_stmt->send_long_data`	`mysqli_stmt_send_long_data`	`mysqli_send_long_data`	Send data in blocks
`mysqli_stmt->store_result`	`mysqli_stmt_store_result`	N/A	Transfers a result set from a prepared statement

MySQLi_RESULT			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
Properties			
$mysqli_result->current_field	`mysqli_field_tell`	N/A	Get current field offset of a result pointer
$mysqli_result->field_count	`mysqli_num_fields`	N/A	Get the number of fields in a result
$mysqli_result->lengths	`mysqli_fetch_lengths`	N/A	Returns the lengths of the columns of the current row in the result set
$mysqli_result->num_rows	`mysqli_num_rows`	N/A	Gets the number of rows in a result
Methods			
`mysqli_result->data_seek`	`mysqli_data_seek`	N/A	Adjusts the result pointer to an arbitrary row in the result
`mysqli_result->fetch_all`	`mysqli_fetch_all`	N/A	Fetches all result rows and returns the result set as an associative array, a numeric array, or both. Available only with mysqlnd.
`mysqli_result->fetch_array`	`mysqli_fetch_array`	N/A	Fetch a result row as an associative, a numeric array, or both
`mysqli_result->fetch_assoc`	`mysqli_fetch_assoc`	N/A	Fetch a result row as an associative array

MySQLi_RESULT			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
`mysqli_result->fetch_field_direct`	`mysqli_fetch_field_direct`	N/A	Fetch meta-data for a single field
`mysqli_result->fetch_field`	`mysqli_fetch_field`	N/A	Returns the next field in the result set
`mysqli_result->fetch_fields`	`mysqli_fetch_fields`	N/A	Returns an array of objects representing the fields in a result set
`mysqli_result->fetch_object`	`mysqli_fetch_object`	N/A	Returns the current row of a result set as an object
`mysqli_result->fetch_row`	`mysqli_fetch_row`	N/A	Get a result row as an enumerated array
`mysqli_result->field_seek`	`mysqli_field_seek`	N/A	Set result pointer to a specified field offset
`mysqli_result->free`, mysqli_result->close, mysqli_result->free_result	`mysqli_free_result`	N/A	Frees the memory associated with a result

MySQL_Driver			
OOP Interface	**Procedural Interface**	**Alias (Do not use)**	**Description**
Properties			
N/A			
Methods			
`mysqli_driver->embedded_server_end`	`mysqli_embedded_server_end`	N/A	NOT DOCUMENTED
`mysqli_driver->embedded_server_start`	`mysqli_embedded_server_start`	N/A	NOT DOCUMENTED

> **Note**
>
> Alias functions are provided for backward compatibility purposes only. Do not use them in new projects.

20.10.2.7. The MySQLi class (`MySQLi`)

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Represents a connection between PHP and a MySQL database.

```
MySQLi {
MySQLi

     Properties

 int affected_rows ;


 string client_info ;


 int client_version ;


 string connect_errno ;


 string connect_error ;


 int errno ;


 string error ;


 int field_count ;
```

```
  int client_version ;


  string host_info ;


  string protocol_version ;


  string server_info ;


  int server_version ;


  string info ;


  mixed insert_id ;


  string sqlstate ;


  int thread_id ;


  int warning_count ;
Methods
  int mysqli_affected_rows(mysqli link);


  bool mysqli::autocommit(bool mode);


  bool mysqli::change_user(string user,
                           string password,
                           string database);


  string mysqli::character_set_name();


  string mysqli_get_client_info(mysqli link);


  int mysqli_get_client_version(mysqli link);


  bool mysqli::close();


  bool mysqli::commit();


  int mysqli_connect_errno();


  string mysqli_connect_error();


  mysqli mysqli_connect(string host= =ini_get("mysqli.default_host"),
                        string username= =ini_get("mysqli.default_user"),
                        string passwd= =ini_get("mysqli.default_pw"),
                        string dbname= ="",
                        int port= =ini_get("mysqli.default_port"),
                        string socket= =ini_get("mysqli.default_socket"));


  bool mysqli::debug(string message);


  bool mysqli::dump_debug_info();


  int mysqli_errno(mysqli link);


  string mysqli_error(mysqli link);


  int mysqli_field_count(mysqli link);


  object mysqli::get_charset();
```

```
string mysqli::get_client_info();

array mysqli_get_client_stats();

int mysqli_get_client_version(mysqli link);

bool mysqli::get_connection_stats();

string mysqli_get_host_info(mysqli link);

int mysqli_get_proto_info(mysqli link);

string mysqli_get_server_info(mysqli link);

int mysqli_get_server_version(mysqli link);

mysqli_warning mysqli::get_warnings();

string mysqli_info(mysqli link);

mysqli mysqli::init();

mixed mysqli_insert_id(mysqli link);

bool mysqli::kill(int processid);

bool mysqli::more_results();

bool mysqli::multi_query(string query);

bool mysqli::next_result();

bool mysqli::options(int option,
                     mixed value);

bool mysqli::ping();

public int mysqli::poll(array read,
                        array error,
                        array reject,
                        int sec,
                        int usec);

mysqli_stmt mysqli::prepare(string query);

mixed mysqli::query(string query,
                    int resultmode);

bool mysqli::real_connect(string host,
                          string username,
                          string passwd,
                          string dbname,
                          int port,
                          string socket,
                          int flags);

string mysqli::escape_string(string escapestr);

bool mysqli::real_query(string query);

public mysqli_result mysqli::reap_async_query();

bool mysqli::rollback();
```

```
  bool mysqli::select_db(string dbname);


  bool mysqli::set_charset(string charset);


  void mysqli_set_local_infile_default(mysqli link);


  bool mysqli::set_local_infile_handler(mysqli link,
                                        callback read_func);


  string mysqli_sqlstate(mysqli link);


  bool mysqli::ssl_set(string key,
                       string cert,
                       string ca,
                       string capath,
                       string cipher);


  string mysqli::stat();


  mysqli_stmt mysqli::stmt_init();


  mysqli_result mysqli::store_result();


  int mysqli_thread_id(mysqli link);


  bool mysqli_thread_safe();


  mysqli_result mysqli::use_result();


  int mysqli_warning_count(mysqli link);
}
```

20.10.2.7.1. `mysqli->affected_rows`, `mysqli_affected_rows`

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- `mysqli->affected_rows`

  `mysqli_affected_rows`

  Gets the number of affected rows in a previous MySQL operation

Description

Object oriented style

```
 mysqli {

  int affected_rows ;

}
```

Procedural style

```
  int mysqli_affected_rows(mysqli link);
```

Returns the number of rows affected by the last `INSERT`, `UPDATE`, `REPLACE` or `DELETE` query.

For SELECT statements `mysqli_affected_rows` works like `mysqli_num_rows`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

An integer greater than zero indicates the number of rows affected or retrieved. Zero indicates that no records where updated for an UPDATE statement, no rows matched the `WHERE` clause in the query or that no query has yet been executed. -1 indicates that the query returned an error.

> ### Note
>
> If the number of affected rows is greater than maximal int value, the number of affected rows will be returned as a string.

Examples

Example 20.70. `mysqli->affected_rows` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Insert rows */
$mysqli->query("CREATE TABLE Language SELECT * from CountryLanguage");
printf("Affected rows (INSERT): %d\n", $mysqli->affected_rows);

$mysqli->query("ALTER TABLE Language ADD Status int default 0");

/* update rows */
$mysqli->query("UPDATE Language SET Status=1 WHERE Percentage > 50");
printf("Affected rows (UPDATE): %d\n", $mysqli->affected_rows);

/* delete rows */
$mysqli->query("DELETE FROM Language WHERE Percentage < 50");
printf("Affected rows (DELETE): %d\n", $mysqli->affected_rows);

/* select all rows */
$result = $mysqli->query("SELECT CountryCode FROM Language");
printf("Affected rows (SELECT): %d\n", $mysqli->affected_rows);

$result->close();

/* Delete table Language */
$mysqli->query("DROP TABLE Language");

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

if (!$link) {
    printf("Can't connect to localhost. Error: %s\n", mysqli_connect_error());
    exit();
}

/* Insert rows */
mysqli_query($link, "CREATE TABLE Language SELECT * from CountryLanguage");
printf("Affected rows (INSERT): %d\n", mysqli_affected_rows($link));

mysqli_query($link, "ALTER TABLE Language ADD Status int default 0");

/* update rows */
mysqli_query($link, "UPDATE Language SET Status=1 WHERE Percentage > 50");
printf("Affected rows (UPDATE): %d\n", mysqli_affected_rows($link));

/* delete rows */
mysqli_query($link, "DELETE FROM Language WHERE Percentage < 50");
printf("Affected rows (DELETE): %d\n", mysqli_affected_rows($link));

/* select all rows */
$result = mysqli_query($link, "SELECT CountryCode FROM Language");
```

```
printf("Affected rows (SELECT): %d\n", mysqli_affected_rows($link));

mysqli_free_result($result);

/* Delete table Language */
mysqli_query($link, "DROP TABLE Language");

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Affected rows (INSERT): 984
Affected rows (UPDATE): 168
Affected rows (DELETE): 815
Affected rows (SELECT): 169
```

See Also

`mysqli_num_rows`
`mysqli_info`

20.10.2.7.2. `mysqli::autocommit`, `mysqli_autocommit`

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- `mysqli::autocommit`

  `mysqli_autocommit`

  Turns on or off auto-committing database modifications

Description

Object oriented style

```
bool mysqli::autocommit(bool mode);
```

Procedural style

```
bool mysqli_autocommit(mysqli link,
                       bool mode);
```

Turns on or off auto-commit mode on queries for the database connection.

To determine the current state of autocommit use the SQL command `SELECT @@autocommit`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`mode`	Whether to turn on auto-commit or not.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Notes

> **Note**
>
> This function doesn't work with non transactional table types (like MyISAM or ISAM).

Examples

Example 20.71. `mysqli::autocommit` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* turn autocommit on */
$mysqli->autocommit(TRUE);

if ($result = $mysqli->query("SELECT @@autocommit")) {
    $row = $result->fetch_row();
    printf("Autocommit is %s\n", $row[0]);
    $result->free();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

if (!$link) {
    printf("Can't connect to localhost. Error: %s\n", mysqli_connect_error());
    exit();
}

/* turn autocommit on */
mysqli_autocommit($link, TRUE);

if ($result = mysqli_query($link, "SELECT @@autocommit")) {
    $row = mysqli_fetch_row($result);
    printf("Autocommit is %s\n", $row[0]);
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Autocommit is 1
```

See Also

`mysqli_commit`
`mysqli_rollback`

20.10.2.7.3. `mysqli::change_user`, `mysqli_change_user`

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- `mysqli::change_user`

  `mysqli_change_user`

  Changes the user of the specified database connection

Description

Object oriented style

```
bool mysqli::change_user(string user,
                         string password,
                         string database);
```

Procedural style

```
bool mysqli_change_user(mysqli link,
                        string user,
                        string password,
                        string database);
```

Changes the user of the specified database connection and sets the current database.

In order to successfully change users a valid *`username`* and *`password`* parameters must be provided and that user must have sufficient permissions to access the desired database. If for any reason authorization fails, the current user authentication will remain.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`user`	The MySQL user name.
`password`	The MySQL password.
`database`	The database to change to. If desired, the `NULL` value may be passed resulting in only changing the user and not selecting a database. To select a database in this case use the `mysqli_select_db` function.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Notes

> **Note**
>
> Using this command will always cause the current database connection to behave as if was a completely new database connection, regardless of if the operation was completed successfully. This reset includes performing a rollback on any active transactions, closing all temporary tables, and unlocking all locked tables.

Examples

Example 20.72. `mysqli::change_user` example

Object oriented style

```
<?php

/* connect database test */
$mysqli = new mysqli("localhost", "my_user", "my_password", "test");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}
```

```
/* Set Variable a */
$mysqli->query("SET @a:=1");

/* reset all and select a new database */
$mysqli->change_user("my_user", "my_password", "world");

if ($result = $mysqli->query("SELECT DATABASE()")) {
    $row = $result->fetch_row();
    printf("Default database: %s\n", $row[0]);
    $result->close();
}

if ($result = $mysqli->query("SELECT @a")) {
    $row = $result->fetch_row();
    if ($row[0] === NULL) {
        printf("Value of variable a is NULL\n");
    }
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
/* connect database test */
$link = mysqli_connect("localhost", "my_user", "my_password", "test");

/* check connection */
if (!$link) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Set Variable a */
mysqli_query($link, "SET @a:=1");

/* reset all and select a new database */
mysqli_change_user($link, "my_user", "my_password", "world");

if ($result = mysqli_query($link, "SELECT DATABASE()")) {
    $row = mysqli_fetch_row($result);
    printf("Default database: %s\n", $row[0]);
    mysqli_free_result($result);
}

if ($result = mysqli_query($link, "SELECT @a")) {
    $row = mysqli_fetch_row($result);
    if ($row[0] === NULL) {
        printf("Value of variable a is NULL\n");
    }
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Default database: world
Value of variable a is NULL
```

See Also

`mysqli_connect`
`mysqli_select_db`

20.10.2.7.4. `mysqli::character_set_name`, `mysqli_character_set_name`

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- `mysqli::character_set_name`

  `mysqli_character_set_name`

  Returns the default character set for the database connection

Description

Object oriented style

```
string mysqli::character_set_name();
```

Procedural style

```
string mysqli_character_set_name(mysqli link);
```

Returns the current character set for the database connection.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

The default character set for the current connection

Examples

Example 20.73. `mysqli::character_set_name` example

Object oriented style

```
<?php
/* Open a connection */
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Print current character set */
$charset = $mysqli->character_set_name();
printf ("Current character set is %s\n", $charset);

$mysqli->close();
?>
```

Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (!$link) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Print current character set */
$charset = mysqli_character_set_name($link);
printf ("Current character set is %s\n",$charset);

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Current character set is latin1_swedish_ci
```

See Also

`mysqli_client_encoding`
`mysqli_real_escape_string`

20.10.2.7.5. `mysqli->client_info`, `mysqli_get_client_info`

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- `mysqli->client_info`

  `mysqli_get_client_info`

  Returns the MySQL client version as a string

Description

Object oriented style

```
 mysqli {

  string client_info ;

}
```

Procedural style

```
  string mysqli_get_client_info(mysqli link);
```

Returns a string that represents the MySQL client library version.

Return Values

A string that represents the MySQL client library version

Examples

Example 20.74. mysqli_get_client_info

```
<?php

/* We don't need a connection to determine
   the version of mysql client library */

printf("Client library version: %s\n", mysqli_get_client_info());
?>
```

See Also

`mysqli_get_client_version`
`mysqli_get_server_info`
`mysqli_get_server_version`

20.10.2.7.6. `mysqli->client_version`, `mysqli_get_client_version`

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- `mysqli->client_version`

  `mysqli_get_client_version`

  Get MySQL client info

Description

Object oriented style

```
 mysqli {

  int client_version ;

}
```

Procedural style

```
  int mysqli_get_client_version(mysqli link);
```

Returns client version number as an integer.

Return Values

A number that represents the MySQL client library version in format: `main_version*10000 + minor_version *100 + sub_version`. For example, 4.1.0 is returned as 40100.

This is useful to quickly determine the version of the client library to know if some capability exits.

Examples

Example 20.75. mysqli_get_client_version

```
<?php

/* We don't need a connection to determine
   the version of mysql client library */

printf("Client library version: %d\n", mysqli_get_client_version());
?>
```

See Also

`mysqli_get_client_info`
`mysqli_get_server_info`
`mysqli_get_server_version`

20.10.2.7.7. `mysqli::close`, `mysqli_close`

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- `mysqli::close`

  `mysqli_close`

  Closes a previously opened database connection

Description

Object oriented style

```
bool mysqli::close();
```

Procedural style

```
bool mysqli_close(mysqli link);
```

Closes a previously opened database connection.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

See `mysqli_connect`.

See Also

`mysqli_connect`
`mysqli_init`
`mysqli_real_connect`

20.10.2.7.8. `mysqli::commit`, `mysqli_commit`

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- `mysqli::commit`

  `mysqli_commit`

  Commits the current transaction

Description

Object oriented style

```
bool mysqli::commit();
```

Procedural style

```
bool mysqli_commit(mysqli link);
```

Commits the current transaction for the database connection.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.76. `mysqli::commit` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$mysqli->query("CREATE TABLE Language LIKE CountryLanguage");

/* set autocommit to off */
$mysqli->autocommit(FALSE);

/* Insert some values */
$mysqli->query("INSERT INTO Language VALUES ('DEU', 'Bavarian', 'F', 11.2)");
$mysqli->query("INSERT INTO Language VALUES ('DEU', 'Swabian', 'F', 9.4)");

/* commit transaction */
$mysqli->commit();

/* drop table */
$mysqli->query("DROP TABLE Language");

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "test");

/* check connection */
if (!$link) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* set autocommit to off */
mysqli_autocommit($link, FALSE);

mysqli_query($link, "CREATE TABLE Language LIKE CountryLanguage");

/* Insert some values */
mysqli_query($link, "INSERT INTO Language VALUES ('DEU', 'Bavarian', 'F', 11.2)");
mysqli_query($link, "INSERT INTO Language VALUES ('DEU', 'Swabian', 'F', 9.4)");

/* commit transaction */
mysqli_commit($link);

/* close connection */
mysqli_close($link);
?>
```

See Also

`mysqli_autocommit`
`mysqli_rollback`

20.10.2.7.9. `mysqli->connect_errno`, `mysqli_connect_errno`

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- `mysqli->connect_errno`

  `mysqli_connect_errno`

  Returns the error code from last connect call

Description

Object oriented style

```
mysqli {

  string connect_errno ;

}
```

Procedural style

```
  int mysqli_connect_errno();
```

Returns the last error code number from the last call to `mysqli_connect`.

> **Note**
>
> Client error message numbers are listed in the MySQL `errmsg.h` header file, server error message numbers are listed in `mysqld_error.h`. In the MySQL source distribution you can find a complete list of error messages and error numbers in the file `Docs/mysqld_error.txt`.

Return Values

An error code value for the last call to `mysqli_connect`, if it failed. zero means no error occurred.

Examples

Example 20.77. `mysqli->connect_errno` example

Object oriented style

```
<?php
$mysqli = @new mysqli('localhost', 'fake_user', 'my_password', 'my_db');

if ($mysqli->connect_errno) {
    die('Connect Error: ' . $mysqli->connect_errno);
}
?>
```

Procedural style

```
<?php
$link = @mysqli_connect('localhost', 'fake_user', 'my_password', 'my_db');

if (!$link) {
    die('Connect Error: ' . mysqli_connect_errno());
}
?>
```

The above examples will output:

```
Connect Error: 1045
```

See Also

`mysqli_connect`
`mysqli_connect_error`
`mysqli_errno`
`mysqli_error`
`mysqli_sqlstate`

20.10.2.7.10. `mysqli->connect_error`, `mysqli_connect_error`

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- `mysqli->connect_error`

  `mysqli_connect_error`

  Returns a string description of the last connect error

Description

Object oriented style

```
 mysqli {

  string connect_error ;

}
```

Procedural style

```
  string mysqli_connect_error();
```

Returns the last error message string from the last call to `mysqli_connect`.

Return Values

A string that describes the error. `NULL` is returned if no error occurred.

Examples

Example 20.78. `mysqli->connect_error` example

Object oriented style

```
<?php
$mysqli = @new mysqli('localhost', 'fake_user', 'my_password', 'my_db');

// Works as of PHP 5.2.9 and 5.3.0.
if ($mysqli->connect_error) {
    die('Connect Error: ' . $mysqli->connect_error);
}
?>
```

Procedural style

```
<?php
$link = @mysqli_connect('localhost', 'fake_user', 'my_password', 'my_db');

if (!$link) {
    die('Connect Error: ' . mysqli_connect_error());
}
?>
```

The above examples will output:

```
Connect Error: Access denied for user 'fake_user'@'localhost' (using password: YES)
```

Notes

> **Warning**
>
> The mysqli->connect_error property only works properly as of PHP versions 5.2.9 and 5.3.0. Use the `mysqli_connect_error` function if compatibility with earlier PHP versions is required.

See Also

`mysqli_connect`
`mysqli_connect_errno`
`mysqli_errno`
`mysqli_error`
`mysqli_sqlstate`

20.10.2.7.11. `mysqli::__construct`, `mysqli_connect`

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- `mysqli::__construct`

  `mysqli_connect`

  Open a new connection to the MySQL server

Description

Object oriented style

```
mysqli::__construct(string host= =ini_get("mysqli.default_host"),
                    string username= =ini_get("mysqli.default_user"),
                    string passwd= =ini_get("mysqli.default_pw"),
                    string dbname= ="",
                    int port= =ini_get("mysqli.default_port"),
                    string socket= =ini_get("mysqli.default_socket"));
```

Procedural style

```
mysqli mysqli_connect(string host= =ini_get("mysqli.default_host"),
                      string username= =ini_get("mysqli.default_user"),
                      string passwd= =ini_get("mysqli.default_pw"),
                      string dbname= ="",
                      int port= =ini_get("mysqli.default_port"),
                      string socket= =ini_get("mysqli.default_socket"));
```

Opens a connection to the MySQL Server running on.

Parameters

`host`	Can be either a host name or an IP address. Passing the `NULL` value or the string "localhost" to this parameter, the local host is assumed. When possible, pipes will be used instead of the TCP/IP protocol. Prepending host by `p:` opens a persistent connection. `mysqli_change_user` is automatically called on connections opened from the connection pool.
`username`	The MySQL user name.
`passwd`	If not provided or `NULL` , the MySQL server will attempt to authenticate the user against those user records which have no password only. This allows one username to be used with different permissions (depending on if a password as provided or not).
`dbname`	If provided will specify the default database to be used when performing queries.
`port`	Specifies the port number to attempt to connect to the MySQL server.
`socket`	Specifies the socket or named pipe that should be used.

> **Note**
>
> Specifying the *`socket`* parameter will not explicitly determine the type of connection to be used when connecting to the MySQL server. How the connection is made to the MySQL database is determined by the *`host`* parameter.

Return Values

Returns an object which represents the connection to a MySQL Server.

Changelog

Version	Description
5.3.0	Added the ability of persistent connections.

Examples

Example 20.79. `mysqli::__construct` example

Object oriented style

```
<?php
$mysqli = new mysqli('localhost', 'my_user', 'my_password', 'my_db');

/*
 * This is the "official" OO way to do it,
 * BUT $connect_error was broken until PHP 5.2.9 and 5.3.0.
 */
if ($mysqli->connect_error) {
    die('Connect Error (' . $mysqli->connect_errno . ') '
            . $mysqli->connect_error);
}

/*
 * Use this instead of $connect_error if you need to ensure
 * compatibility with PHP versions prior to 5.2.9 and 5.3.0.
 */
if (mysqli_connect_error()) {
    die('Connect Error (' . mysqli_connect_errno() . ') '
            . mysqli_connect_error());
}

echo 'Success... ' . $mysqli->host_info . "\n";

$mysqli->close();
?>
```

Object oriented style when extending mysqli class

```
<?php

class foo_mysqli extends mysqli {
    public function __construct($host, $user, $pass, $db) {
        parent::__construct($host, $user, $pass, $db);

        if (mysqli_connect_error()) {
            die('Connect Error (' . mysqli_connect_errno() . ') '
                    . mysqli_connect_error());
        }
    }
}

$db = new foo_mysqli('localhost', 'my_user', 'my_password', 'my_db');

echo 'Success... ' . $db->host_info . "\n";

$db->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect('localhost', 'my_user', 'my_password', 'my_db');

if (!$link) {
    die('Connect Error (' . mysqli_connect_errno() . ') '
            . mysqli_connect_error());
}

echo 'Success... ' . mysqli_get_host_info($link) . "\n";

mysqli_close($link);
?>
```

The above examples will output:

```
Success... MySQL host info: localhost via TCP/IP
```

Notes

> **Note**
>
> MySQLnd always assumes the server default charset. This charset is sent during connection hand-shake/authentication, which mysqlnd will use.
>
> Libmysql uses the default charset set in the `my.cnf` or by an explicit call to `mysqli_options` prior to calling `mysqli_real_connect`, but after `mysqli_init`.

> **Note**
>
> OO syntax only: If a connection fails an object is still returned. To check if the connection failed then use either the `mysqli_connect_error` function or the mysqli->connect_error property as in the preceding examples.

> **Note**
>
> If it is necessary to set options, such as the connection timeout, `mysqli_real_connect` must be used instead.

> **Note**
>
> Calling the constructor with no parameters is the same as calling `mysqli_init`.

> **Note**
>
> Error "Can't create TCP/IP socket (10106)" usually means that the variables_order configure directive doesn't contain character `E`. On Windows, if the environment is not copied the `SYSTEMROOT` environment variable won't be available and PHP will have problems loading Winsock.

See Also

`mysqli_real_connect`
`mysqli_options`
`mysqli_connect_errno`
`mysqli_connect_error`
`mysqli_close`

20.10.2.7.12. `mysqli::debug`, `mysqli_debug`

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- `mysqli::debug`

  `mysqli_debug`

  Performs debugging operations

Description

Object oriented style

```
bool mysqli::debug(string message);
```

Procedural style

```
bool mysqli_debug(string message);
```

Performs debugging operations using the Fred Fish debugging library.

Parameters

`message`	A string representing the debugging operation to perform

Return Values

Returns `TRUE` .

Notes

> **Note**
>
> To use the `mysqli_debug` function you must compile the MySQL client library to support debugging.

Examples

Example 20.80. Generating a Trace File

```
<?php
/* Create a trace file in '/tmp/client.trace' on the local (client) machine: */
mysqli_debug("d:t:o,/tmp/client.trace");
?>
```

See Also

`mysqli_dump_debug_info`
`mysqli_report`

20.10.2.7.13. `mysqli::dump_debug_info`, `mysqli_dump_debug_info`

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- `mysqli::dump_debug_info`

  `mysqli_dump_debug_info`

  Dump debugging information into the log

Description

Object oriented style

```
bool mysqli::dump_debug_info();
```

Procedural style

```
bool mysqli_dump_debug_info(mysqli link);
```

This function is designed to be executed by an user with the SUPER privilege and is used to dump debugging information into the log for the MySQL Server relating to the connection.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

See Also

`mysqli_debug`

20.10.2.7.14. `mysqli->errno`, `mysqli_errno`

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- `mysqli->errno`

  `mysqli_errno`

  Returns the error code for the most recent function call

Description

Object oriented style

```
 mysqli {
  int errno ;
}
```

Procedural style

```
  int mysqli_errno(mysqli link);
```

Returns the last error code for the most recent MySQLi function call that can succeed or fail.

Client error message numbers are listed in the MySQL `errmsg.h` header file, server error message numbers are listed in `mysqld_error.h`. In the MySQL source distribution you can find a complete list of error messages and error numbers in the file `Docs/mysqld_error.txt`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

An error code value for the last call, if it failed. zero means no error occurred.

Examples

Example 20.81. `mysqli->errno` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if (!$mysqli->query("SET a=1")) {
    printf("Errorcode: %d\n", $mysqli->errno);
}
```

```
/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if (!mysqli_query($link, "SET a=1")) {
    printf("Errorcode: %d\n", mysqli_errno($link));
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Errorcode: 1193
```

See Also

`mysqli_connect_errno`
`mysqli_connect_error`
`mysqli_error`
`mysqli_sqlstate`

20.10.2.7.15. `mysqli->error`, `mysqli_error`

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- `mysqli->error`

  `mysqli_error`

  Returns a string description of the last error

Description

Object oriented style

```
 mysqli {

  string error ;

}
```

Procedural style

```
  string mysqli_error(mysqli link);
```

Returns the last error message for the most recent MySQLi function call that can succeed or fail.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

A string that describes the error. An empty string if no error occurred.

Examples

Example 20.82. `mysqli->error` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if (!$mysqli->query("SET a=1")) {
    printf("Errormessage: %s\n", $mysqli->error);
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if (!mysqli_query($link, "SET a=1")) {
    printf("Errormessage: %s\n", mysqli_error($link));
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Errormessage: Unknown system variable 'a'
```

See Also

`mysqli_connect_errno`
`mysqli_connect_error`
`mysqli_errno`
`mysqli_sqlstate`

20.10.2.7.16. `mysqli->field_count`, `mysqli_field_count`

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- `mysqli->field_count`

  `mysqli_field_count`

  Returns the number of columns for the most recent query

Description

Object oriented style

```
 mysqli_result {

  int field_count ;

}
```

Procedural style

```
  int mysqli_field_count(mysqli link);
```

Returns the number of columns for the most recent query on the connection represented by the *`link`* parameter. This function can be useful when using the `mysqli_store_result` function to determine if the query should have produced a non-empty result set or not without knowing the nature of the query.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

An integer representing the number of fields in a result set.

Examples

Example 20.83. `mysqli->field_count` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "test");

$mysqli->query( "DROP TABLE IF EXISTS friends");
$mysqli->query( "CREATE TABLE friends (id int, name varchar(20))");

$mysqli->query( "INSERT INTO friends VALUES (1,'Hartmut'), (2, 'Ulf')");


$mysqli->real_query("SELECT * FROM friends");

if ($mysqli->field_count) {
    /* this was a select/show or describe query */
    $result = $mysqli->store_result();

    /* process resultset */
    $row = $result->fetch_row();

    /* free resultset */
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "test");

mysqli_query($link, "DROP TABLE IF EXISTS friends");
mysqli_query($link, "CREATE TABLE friends (id int, name varchar(20))");
mysqli_query($link, "INSERT INTO friends VALUES (1,'Hartmut'), (2, 'Ulf')");

mysqli_real_query($link, "SELECT * FROM friends");

if (mysqli_field_count($link)) {
    /* this was a select/show or describe query */
    $result = mysqli_store_result($link);

    /* process resultset */
    $row = mysqli_fetch_row($result);

    /* free resultset */
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

20.10.2.7.17. `mysqli::get_charset`, `mysqli_get_charset`

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- `mysqli::get_charset`

  `mysqli_get_charset`

  Returns a character set object

Description

Object oriented style

```
object mysqli::get_charset();
```

Procedural style

```
object mysqli_get_charset(mysqli link);
```

Returns a character set object providing several properties of the current active character set.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

The function returns a character set object with the following properties:

`charset`	Character set name
`collation`	Collation name
`dir`	Directory the charset description was fetched from (?) or "" for built-in character sets
`min_length`	Minimum character length in bytes
`max_length`	Maximum character length in bytes
`number`	Internal character set number
`state`	Character set status (?)

Examples

Example 20.84. `mysqli::get_charset` example

Object oriented style

```
<?php
  $db = mysqli_init();
  $db->real_connect("localhost","root","","test");
  var_dump($db->get_charset());
?>
```

Procedural style

```
<?php
  $db = mysqli_init();
  mysqli_real_connect($db, "localhost","root","","test");
  var_dump($db->get_charset());
?>
```

The above examples will output:

```


object(stdClass)#2 (7) {
  ["charset"]=>
  string(6) "latin1"
  ["collation"]=>
  string(17) "latin1_swedish_ci"
  ["dir"]=>
  string(0) ""
  ["min_length"]=>
  int(1)
  ["max_length"]=>
  int(1)
  ["number"]=>
  int(8)
  ["state"]=>
  int(801)
}
```

See Also

`mysqli_character_set_name`
`mysqli_set_charset`

20.10.2.7.18. `mysqli->get_client_info`, `mysqli_get_client_info`

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- `mysqli->get_client_info`

  `mysqli_get_client_info`

  Returns the MySQL client version as a string

Description

Object oriented style

```
string mysqli::get_client_info();
```

Procedural style

```
string mysqli_get_client_info(mysqli link);
```

Returns a string that represents the MySQL client library version.

Return Values

A string that represents the MySQL client library version

Examples

Example 20.85. mysqli_get_client_info

```
<?php

/* We don't need a connection to determine
   the version of mysql client library */

printf("Client library version: %s\n", mysqli_get_client_info());
?>
```

See Also

`mysqli_get_client_version`
`mysqli_get_server_info`
`mysqli_get_server_version`

20.10.2.7.19. `mysqli_get_client_stats`

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- `mysqli_get_client_stats`

  Returns client per-process statistics

Description

```
  array mysqli_get_client_stats();
```

Returns client per-process statistics. Available only with mysqlnd.

Parameters

Return Values

Returns an array with client stats if success, `FALSE` otherwise.

Examples

Example 20.86. A `mysqli_get_client_stats` example

```
<?php
$link = mysqli_connect();
print_r(mysqli_get_client_stats());
?>
```

The above example will output something similar to:

```


Array
(
    [bytes_sent] => 43
    [bytes_received] => 80
    [packets_sent] => 1
    [packets_received] => 2
    [protocol_overhead_in] => 8
    [protocol_overhead_out] => 4
    [bytes_received_ok_packet] => 11
    [bytes_received_eof_packet] => 0
    [bytes_received_rset_header_packet] => 0
    [bytes_received_rset_field_meta_packet] => 0
    [bytes_received_rset_row_packet] => 0
    [bytes_received_prepare_response_packet] => 0
    [bytes_received_change_user_packet] => 0
    [packets_sent_command] => 0
    [packets_received_ok] => 1
    [packets_received_eof] => 0
    [packets_received_rset_header] => 0
    [packets_received_rset_field_meta] => 0
    [packets_received_rset_row] => 0
    [packets_received_prepare_response] => 0
    [packets_received_change_user] => 0
    [result_set_queries] => 0
    [non_result_set_queries] => 0
    [no_index_used] => 0
    [bad_index_used] => 0
    [slow_queries] => 0
    [buffered_sets] => 0
    [unbuffered_sets] => 0
    [ps_buffered_sets] => 0
    [ps_unbuffered_sets] => 0
    [flushed_normal_sets] => 0
    [flushed_ps_sets] => 0
    [ps_prepared_never_executed] => 0
    [ps_prepared_once_executed] => 0
    [rows_fetched_from_server_normal] => 0
    [rows_fetched_from_server_ps] => 0
    [rows_buffered_from_client_normal] => 0
    [rows_buffered_from_client_ps] => 0
    [rows_fetched_from_client_normal_buffered] => 0
    [rows_fetched_from_client_normal_unbuffered] => 0
    [rows_fetched_from_client_ps_buffered] => 0
    [rows_fetched_from_client_ps_unbuffered] => 0
    [rows_fetched_from_client_ps_cursor] => 0
    [rows_skipped_normal] => 0
    [rows_skipped_ps] => 0
    [copy_on_write_saved] => 0
    [copy_on_write_performed] => 0
    [command_buffer_too_small] => 0
    [connect_success] => 1
    [connect_failure] => 0
    [connection_reused] => 0
    [reconnect] => 0
    [pconnect_success] => 0
    [active_connections] => 1
    [active_persistent_connections] => 0
    [explicit_close] => 0
    [implicit_close] => 0
    [disconnect_close] => 0
    [in_middle_of_command_close] => 0
    [explicit_free_result] => 0
    [implicit_free_result] => 0
    [explicit_stmt_close] => 0
    [implicit_stmt_close] => 0
    [mem_emalloc_count] => 0
    [mem_emalloc_ammount] => 0
    [mem_ecalloc_count] => 0
    [mem_ecalloc_ammount] => 0
    [mem_erealloc_count] => 0
    [mem_erealloc_ammount] => 0
    [mem_efree_count] => 0
    [mem_malloc_count] => 0
    [mem_malloc_ammount] => 0
    [mem_calloc_count] => 0
    [mem_calloc_ammount] => 0
    [mem_realloc_count] => 0
    [mem_realloc_ammount] => 0
    [mem_free_count] => 0
    [proto_text_fetched_null] => 0
    [proto_text_fetched_bit] => 0
    [proto_text_fetched_tinyint] => 0
    [proto_text_fetched_short] => 0
    [proto_text_fetched_int24] => 0
    [proto_text_fetched_int] => 0
    [proto_text_fetched_bigint] => 0
    [proto_text_fetched_decimal] => 0
    [proto_text_fetched_float] => 0
    [proto_text_fetched_double] => 0
    [proto_text_fetched_date] => 0
    [proto_text_fetched_year] => 0
    [proto_text_fetched_time] => 0
    [proto_text_fetched_datetime] => 0
    [proto_text_fetched_timestamp] => 0
    [proto_text_fetched_string] => 0
    [proto_text_fetched_blob] => 0
    [proto_text_fetched_enum] => 0
    [proto_text_fetched_set] => 0
    [proto_text_fetched_geometry] => 0
    [proto_text_fetched_other] => 0
    [proto_binary_fetched_null] => 0
    [proto_binary_fetched_bit] => 0
    [proto_binary_fetched_tinyint] => 0
    [proto_binary_fetched_short] => 0
    [proto_binary_fetched_int24] => 0
    [proto_binary_fetched_int] => 0
    [proto_binary_fetched_bigint] => 0
    [proto_binary_fetched_decimal] => 0
    [proto_binary_fetched_float] => 0
    [proto_binary_fetched_double] => 0
    [proto_binary_fetched_date] => 0
    [proto_binary_fetched_year] => 0
    [proto_binary_fetched_time] => 0
    [proto_binary_fetched_datetime] => 0
    [proto_binary_fetched_timestamp] => 0
    [proto_binary_fetched_string] => 0
    [proto_binary_fetched_blob] => 0
    [proto_binary_fetched_enum] => 0
    [proto_binary_fetched_set] => 0
    [proto_binary_fetched_geometry] => 0
    [proto_binary_fetched_other] => 0
)
```

See Also

Stats description

20.10.2.7.20. `mysqli->client_version`, `mysqli_get_client_version`

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- `mysqli->client_version`

  `mysqli_get_client_version`

  Get MySQL client info

Description

Object oriented style

```
 mysqli {

  int client_version ;

}
```

Procedural style

```
  int mysqli_get_client_version(mysqli link);
```

Returns client version number as an integer.

Return Values

A number that represents the MySQL client library version in format: `main_version*10000 + minor_version *100 + sub_version`. For example, 4.1.0 is returned as 40100.

This is useful to quickly determine the version of the client library to know if some capability exits.

Examples

Example 20.87. mysqli_get_client_version

```
<?php

/* We don't need a connection to determine
   the version of mysql client library */

printf("Client library version: %d\n", mysqli_get_client_version());
```

```
?>
```

See Also

`mysqli_get_client_info`
`mysqli_get_server_info`
`mysqli_get_server_version`

20.10.2.7.21. `mysqli::get_connection_stats`, `mysqli_get_connection_stats`

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- `mysqli::get_connection_stats`

  `mysqli_get_connection_stats`

  Returns statistics about the client connection

Description

Object oriented style

```
bool mysqli::get_connection_stats();
```

Procedural style

```
array mysqli_get_connection_stats(mysqli link);
```

Returns statistics about the client connection. Available only with mysqlnd.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns an array with connection stats if success, `FALSE` otherwise.

Examples

Example 20.88. A `mysqli_get_connection_stats` example

```
<?php
$link = mysqli_connect();
print_r(mysqli_get_connection_stats($link));
?>
```

The above example will output something similar to:

```
Array
(
    [bytes_sent] => 43
    [bytes_received] => 80
    [packets_sent] => 1
    [packets_received] => 2
    [protocol_overhead_in] => 8
    [protocol_overhead_out] => 4
    [bytes_received_ok_packet] => 11
    [bytes_received_eof_packet] => 0
    [bytes_received_rset_header_packet] => 0
    [bytes_received_rset_field_meta_packet] => 0
    [bytes_received_rset_row_packet] => 0
    [bytes_received_prepare_response_packet] => 0
    [bytes_received_change_user_packet] => 0
    [packets_sent_command] => 0
    [packets_received_ok] => 1
    [packets_received_eof] => 0
    [packets_received_rset_header] => 0
    [packets_received_rset_field_meta] => 0
    [packets_received_rset_row] => 0
    [packets_received_prepare_response] => 0
    [packets_received_change_user] => 0
    [result_set_queries] => 0
    [non_result_set_queries] => 0
    [no_index_used] => 0
    [bad_index_used] => 0
    [slow_queries] => 0
    [buffered_sets] => 0
    [unbuffered_sets] => 0
    [ps_buffered_sets] => 0
    [ps_unbuffered_sets] => 0
    [flushed_normal_sets] => 0
    [flushed_ps_sets] => 0
    [ps_prepared_never_executed] => 0
    [ps_prepared_once_executed] => 0
    [rows_fetched_from_server_normal] => 0
    [rows_fetched_from_server_ps] => 0
    [rows_buffered_from_client_normal] => 0
    [rows_buffered_from_client_ps] => 0
    [rows_fetched_from_client_normal_buffered] => 0
    [rows_fetched_from_client_normal_unbuffered] => 0
    [rows_fetched_from_client_ps_buffered] => 0
    [rows_fetched_from_client_ps_unbuffered] => 0
    [rows_fetched_from_client_ps_cursor] => 0
    [rows_skipped_normal] => 0
    [rows_skipped_ps] => 0
    [copy_on_write_saved] => 0
    [copy_on_write_performed] => 0
    [command_buffer_too_small] => 0
    [connect_success] => 1
    [connect_failure] => 0
    [connection_reused] => 0
    [reconnect] => 0
    [pconnect_success] => 0
    [active_connections] => 1
    [active_persistent_connections] => 0
    [explicit_close] => 0
    [implicit_close] => 0
    [disconnect_close] => 0
    [in_middle_of_command_close] => 0
    [explicit_free_result] => 0
    [implicit_free_result] => 0
    [explicit_stmt_close] => 0
    [implicit_stmt_close] => 0
    [mem_emalloc_count] => 0
    [mem_emalloc_ammount] => 0
    [mem_ecalloc_count] => 0
    [mem_ecalloc_ammount] => 0
    [mem_erealloc_count] => 0
    [mem_erealloc_ammount] => 0
    [mem_efree_count] => 0
    [mem_malloc_count] => 0
    [mem_malloc_ammount] => 0
    [mem_calloc_count] => 0
    [mem_calloc_ammount] => 0
    [mem_realloc_count] => 0
    [mem_realloc_ammount] => 0
    [mem_free_count] => 0
    [proto_text_fetched_null] => 0
    [proto_text_fetched_bit] => 0
    [proto_text_fetched_tinyint] => 0
    [proto_text_fetched_short] => 0
    [proto_text_fetched_int24] => 0
    [proto_text_fetched_int] => 0
    [proto_text_fetched_bigint] => 0
    [proto_text_fetched_decimal] => 0
    [proto_text_fetched_float] => 0
    [proto_text_fetched_double] => 0
    [proto_text_fetched_date] => 0
    [proto_text_fetched_year] => 0
    [proto_text_fetched_time] => 0
    [proto_text_fetched_datetime] => 0
    [proto_text_fetched_timestamp] => 0
    [proto_text_fetched_string] => 0
    [proto_text_fetched_blob] => 0
    [proto_text_fetched_enum] => 0
    [proto_text_fetched_set] => 0
    [proto_text_fetched_geometry] => 0
    [proto_text_fetched_other] => 0
    [proto_binary_fetched_null] => 0
    [proto_binary_fetched_bit] => 0
    [proto_binary_fetched_tinyint] => 0
    [proto_binary_fetched_short] => 0
    [proto_binary_fetched_int24] => 0
    [proto_binary_fetched_int] => 0
    [proto_binary_fetched_bigint] => 0
    [proto_binary_fetched_decimal] => 0
    [proto_binary_fetched_float] => 0
    [proto_binary_fetched_double] => 0
    [proto_binary_fetched_date] => 0
    [proto_binary_fetched_year] => 0
    [proto_binary_fetched_time] => 0
    [proto_binary_fetched_datetime] => 0
    [proto_binary_fetched_timestamp] => 0
    [proto_binary_fetched_string] => 0
    [proto_binary_fetched_blob] => 0
    [proto_binary_fetched_enum] => 0
    [proto_binary_fetched_set] => 0
    [proto_binary_fetched_geometry] => 0
    [proto_binary_fetched_other] => 0
)
```

See Also

Stats description

20.10.2.7.22. `mysqli->host_info`, `mysqli_get_host_info`

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- `mysqli->host_info`

  `mysqli_get_host_info`

  Returns a string representing the type of connection used

Description

Object oriented style

```
 mysqli {

  string host_info ;

}
```

Procedural style

```
  string mysqli_get_host_info(mysqli link);
```

Returns a string describing the connection represented by the *`link`* parameter (including the server host name).

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

A character string representing the server hostname and the connection type.

Examples

Example 20.89. `mysqli->host_info` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* print host information */
printf("Host info: %s\n", $mysqli->host_info);

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* print host information */
printf("Host info: %s\n", mysqli_get_host_info($link));

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Host info: Localhost via UNIX socket
```

See Also

`mysqli_get_proto_info`

20.10.2.7.23. `mysqli->protocol_version`, `mysqli_get_proto_info`

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- `mysqli->protocol_version`

  `mysqli_get_proto_info`

  Returns the version of the MySQL protocol used

Description

Object oriented style

```
 mysqli {

  string protocol_version ;

}
```

Procedural style

```
  int mysqli_get_proto_info(mysqli link);
```

Returns an integer representing the MySQL protocol version used by the connection represented by the *`link`* parameter.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns an integer representing the protocol version.

Examples

Example 20.90. `mysqli->protocol_version` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* print protocol version */
printf("Protocol version: %d\n", $mysqli->protocol_version);

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* print protocol version */
printf("Protocol version: %d\n", mysqli_get_proto_info($link));

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Protocol version: 10
```

See Also

`mysqli_get_host_info`

20.10.2.7.24. `mysqli->server_info`, `mysqli_get_server_info`

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- `mysqli->server_info`

  `mysqli_get_server_info`

Returns the version of the MySQL server

Description

Object oriented style

```
mysqli {

  string server_info ;

}
```

Procedural style

```
  string mysqli_get_server_info(mysqli link);
```

Returns a string representing the version of the MySQL server that the MySQLi extension is connected to.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

A character string representing the server version.

Examples

Example 20.91. `mysqli->server_info` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* print server version */
printf("Server version: %s\n", $mysqli->server_info);

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* print server version */
printf("Server version: %s\n", mysqli_get_server_info($link));

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Server version: 4.1.2-alpha-debug
```

See Also

`mysqli_get_client_info`
`mysqli_get_client_version`
`mysqli_get_server_version`

20.10.2.7.25. `mysqli->server_version`, `mysqli_get_server_version`

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- `mysqli->server_version`

  `mysqli_get_server_version`

  Returns the version of the MySQL server as an integer

Description

Object oriented style

```
 mysqli {

  int server_version ;

}
```

Procedural style

```
  int mysqli_get_server_version(mysqli link);
```

The `mysqli_get_server_version` function returns the version of the server connected to (represented by the *`link`* parameter) as an integer.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

An integer representing the server version.

The form of this version number is `main_version * 10000 + minor_version * 100 + sub_version` (i.e. version 4.1.0 is 40100).

Examples

Example 20.92. `mysqli->server_version` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}
```

```
/* print server version */
printf("Server version: %d\n", $mysqli->server_version);

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* print server version */
printf("Server version: %d\n", mysqli_get_server_version($link));

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Server version: 40102
```

See Also

`mysqli_get_client_info`
`mysqli_get_client_version`
`mysqli_get_server_info`

20.10.2.7.26. `mysqli::get_warnings`, `mysqli_get_warnings`

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- `mysqli::get_warnings`

  `mysqli_get_warnings`

  Get result of SHOW WARNINGS

Description

Object oriented style

```
mysqli_warning mysqli::get_warnings();
```

Procedural style

```
mysqli_warning mysqli_get_warnings(mysqli link);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

20.10.2.7.27. `mysqli->info`, `mysqli_info`

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- `mysqli->info`

  `mysqli_info`

  Retrieves information about the most recently executed query

Description

Object oriented style

```
 mysqli {
  string info ;
}
```

Procedural style

```
  string mysqli_info(mysqli link);
```

The `mysqli_info` function returns a string providing information about the last query executed. The nature of this string is provided below:

Table 20.9. Possible mysqli_info return values

Query type	Example result string
INSERT INTO...SELECT...	Records: 100 Duplicates: 0 Warnings: 0
INSERT INTO...VALUES (...),(...),(...)	Records: 3 Duplicates: 0 Warnings: 0
LOAD DATA INFILE ...	Records: 1 Deleted: 0 Skipped: 0 Warnings: 0
ALTER TABLE ...	Records: 3 Duplicates: 0 Warnings: 0
UPDATE ...	Rows matched: 40 Changed: 40 Warnings: 0

> **Note**
>
> Queries which do not fall into one of the preceding formats are not supported. In these situations, `mysqli_info` will return an empty string.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

A character string representing additional information about the most recently executed query.

Examples

Example 20.93. `mysqli->info` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}
```

```
$mysqli->query("CREATE TEMPORARY TABLE t1 LIKE City");

/* INSERT INTO .. SELECT */
$mysqli->query("INSERT INTO t1 SELECT * FROM City ORDER BY ID LIMIT 150");
printf("%s\n", $mysqli->info);

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

mysqli_query($link, "CREATE TEMPORARY TABLE t1 LIKE City");

/* INSERT INTO .. SELECT */
mysqli_query($link, "INSERT INTO t1 SELECT * FROM City ORDER BY ID LIMIT 150");
printf("%s\n", mysqli_info($link));

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Records: 150  Duplicates: 0  Warnings: 0
```

See Also

`mysqli_affected_rows`
`mysqli_warning_count`
`mysqli_num_rows`

20.10.2.7.28. `mysqli::init`, `mysqli_init`

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- `mysqli::init`

  `mysqli_init`

  Initializes MySQLi and returns a resource for use with mysqli_real_connect()

Description

Object oriented style

```
mysqli mysqli::init();
```

Procedural style

```
mysqli mysqli_init();
```

Allocates or initializes a MYSQL object suitable for `mysqli_options` and `mysqli_real_connect`.

> **Note**
>
> Any subsequent calls to any mysqli function (except `mysqli_options`) will fail until `mysqli_real_connect` was called.

Return Values

Returns an object.

Examples

See `mysqli_real_connect`.

See Also

`mysqli_options`
`mysqli_close`
`mysqli_real_connect`
`mysqli_connect`

20.10.2.7.29. `mysqli->insert_id`, `mysqli_insert_id`

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- `mysqli->insert_id`

  `mysqli_insert_id`

  Returns the auto generated id used in the last query

Description

Object oriented style

```
 mysqli {

  mixed insert_id ;

}
```

Procedural style

```
  mixed mysqli_insert_id(mysqli link);
```

The `mysqli_insert_id` function returns the ID generated by a query on a table with a column having the AUTO_INCREMENT attribute. If the last query wasn't an INSERT or UPDATE statement or if the modified table does not have a column with the AUTO_INCREMENT attribute, this function will return zero.

> **Note**
>
> Performing an INSERT or UPDATE statement using the LAST_INSERT_ID() function will also modify the value returned by the `mysqli_insert_id` function.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

The value of the `AUTO_INCREMENT` field that was updated by the previous query. Returns zero if there was no previous query on the connection or if the query did not update an `AUTO_INCREMENT` value.

> **Note**
>
> If the number is greater than maximal int value, `mysqli_insert_id` will return a string.

Examples

Example 20.94. `mysqli->insert_id` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$mysqli->query("CREATE TABLE myCity LIKE City");

$query = "INSERT INTO myCity VALUES (NULL, 'Stuttgart', 'DEU', 'Stuttgart', 617000)";
$mysqli->query($query);

printf ("New Record has id %d.\n", $mysqli->insert_id);

/* drop table */
$mysqli->query("DROP TABLE myCity");

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

mysqli_query($link, "CREATE TABLE myCity LIKE City");

$query = "INSERT INTO myCity VALUES (NULL, 'Stuttgart', 'DEU', 'Stuttgart', 617000)";
mysqli_query($link, $query);

printf ("New Record has id %d.\n", mysqli_insert_id($link));

/* drop table */
mysqli_query($link, "DROP TABLE myCity");

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
New Record has id 1.
```

20.10.2.7.30. `mysqli::kill`, `mysqli_kill`

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- `mysqli::kill`

  `mysqli_kill`

  Asks the server to kill a MySQL thread

Description

Object oriented style

```
bool mysqli::kill(int processid);
```

Procedural style

```
bool mysqli_kill(mysqli link,
                 int processid);
```

This function is used to ask the server to kill a MySQL thread specified by the *`processid`* parameter. This value must be retrieved by calling the `mysqli_thread_id` function.

To stop a running query you should use the SQL command `KILL QUERY processid`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.95. `mysqli::kill` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* determine our thread id */
$thread_id = $mysqli->thread_id;

/* Kill connection */
$mysqli->kill($thread_id);

/* This should produce an error */
if (!$mysqli->query("CREATE TABLE myCity LIKE City")) {
    printf("Error: %s\n", $mysqli->error);
    exit;
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* determine our thread id */
$thread_id = mysqli_thread_id($link);

/* Kill connection */
mysqli_kill($link, $thread_id);

/* This should produce an error */
if (!mysqli_query($link, "CREATE TABLE myCity LIKE City")) {
    printf("Error: %s\n", mysqli_error($link));
    exit;
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Error: MySQL server has gone away
```

See Also

`mysqli_thread_id`

20.10.2.7.31. `mysqli::more_results`, `mysqli_more_results`

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- `mysqli::more_results`

  `mysqli_more_results`

  Check if there are any more query results from a multi query

Description

Object oriented style

```
bool mysqli::more_results();
```

Procedural style

```
bool mysqli_more_results(mysqli link);
```

Indicates if one or more result sets are available from a previous call to `mysqli_multi_query`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

See `mysqli_multi_query`.

See Also

`mysqli_multi_query`
`mysqli_next_result`
`mysqli_store_result`
`mysqli_use_result`

20.10.2.7.32. `mysqli::multi_query`, `mysqli_multi_query`

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- `mysqli::multi_query`

  `mysqli_multi_query`

  Performs a query on the database

Description

Object oriented style

```
bool mysqli::multi_query(string query);
```

Procedural style

```
bool mysqli_multi_query(mysqli link,
                        string query);
```

Executes one or multiple queries which are concatenated by a semicolon.

To retrieve the resultset from the first query you can use `mysqli_use_result` or `mysqli_store_result`. All subsequent query results can be processed using `mysqli_more_results` and `mysqli_next_result`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`query`	The query, as a string. Data inside the query should be properly escaped.

Return Values

Returns `FALSE` if the first statement failed. To retrieve subsequent errors from other statements you have to call `mysqli_next_result` first.

Examples

Example 20.96. `mysqli::multi_query` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query  = "SELECT CURRENT_USER();";
$query .= "SELECT Name FROM City ORDER BY ID LIMIT 20, 5";

/* execute multi query */
if ($mysqli->multi_query($query)) {
    do {
        /* store first result set */
        if ($result = $mysqli->store_result()) {
            while ($row = $result->fetch_row()) {
                printf("%s\n", $row[0]);
            }
            $result->free();
        }
        /* print divider */
        if ($mysqli->more_results()) {
            printf("-----------------\n");
        }
    } while ($mysqli->next_result());
}
```

```
/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query  = "SELECT CURRENT_USER();";
$query .= "SELECT Name FROM City ORDER BY ID LIMIT 20, 5";

/* execute multi query */
if (mysqli_multi_query($link, $query)) {
    do {
        /* store first result set */
        if ($result = mysqli_store_result($link)) {
            while ($row = mysqli_fetch_row($result)) {
                printf("%s\n", $row[0]);
            }
            mysqli_free_result($result);
        }
        /* print divider */
        if (mysqli_more_results($link)) {
            printf("-----------------\n");
        }
    } while (mysqli_next_result($link));
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output something similar to:

```
my_user@localhost
-----------------
Amersfoort
Maastricht
Dordrecht
Leiden
Haarlemmermeer
```

See Also

`mysqli_use_result`
`mysqli_store_result`
`mysqli_next_result`
`mysqli_more_results`

20.10.2.7.33. `mysqli::next_result`, `mysqli_next_result`

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- `mysqli::next_result`

  `mysqli_next_result`

  Prepare next result from multi_query

Description

Object oriented style

```
bool mysqli::next_result();
```

Procedural style

```
bool mysqli_next_result(mysqli link);
```

Prepares next result set from a previous call to `mysqli_multi_query` which can be retrieved by `mysqli_store_result` or `mysqli_use_result`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

See `mysqli_multi_query`.

See Also

`mysqli_multi_query`
`mysqli_more_results`
`mysqli_store_result`
`mysqli_use_result`

20.10.2.7.34. `mysqli::options`, `mysqli_options`

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- `mysqli::options`

  `mysqli_options`

  Set options

Description

Object oriented style

```
bool mysqli::options(int option,
                     mixed value);
```

Procedural style

```
bool mysqli_options(mysqli link,
                    int option,
                    mixed value);
```

Used to set extra connect options and affect behavior for a connection.

This function may be called multiple times to set several options.

`mysqli_options` should be called after `mysqli_init` and before `mysqli_real_connect`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

`option`	The option that you want to set. It can be one of the following values:

Table 20.10. Valid options

Name	Description
`MYSQLI_OPT_CONNECT_TIMEOUT`	connection timeout in seconds (supported on Windows with TCP/IP since PHP 5.3.1)
`MYSQLI_OPT_LOCAL_INFILE`	enable/disable use of `LOAD LOCAL INFILE`
`MYSQLI_INIT_COMMAND`	command to execute after when connecting to MySQL server
`MYSQLI_READ_DEFAULT_FILE`	Read options from named option file instead of `my.cnf`
`MYSQLI_READ_DEFAULT_GROUP`	Read options from the named group from `my.cnf` or the file specified with `MYSQL_READ_DEFAULT_FILE` .

`value`	The value for the option.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

See `mysqli_real_connect`.

Notes

> **Note**
>
> MySQLnd always assumes the server default charset. This charset is sent during connection hand-shake/authentication, which mysqlnd will use.
>
> Libmysql uses the default charset set in the `my.cnf` or by an explicit call to `mysqli_options` prior to calling `mysqli_real_connect`, but after `mysqli_init`.

See Also

`mysqli_init`
`mysqli_real_connect`

20.10.2.7.35. `mysqli::ping`, `mysqli_ping`

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- `mysqli::ping`

  `mysqli_ping`

  Pings a server connection, or tries to reconnect if the connection has gone down

Description

Object oriented style

```
bool mysqli::ping();
```

Procedural style

```
bool mysqli_ping(mysqli link);
```

Checks whether the connection to the server is working. If it has gone down, and global option mysqli.reconnect is enabled an automatic reconnection is attempted.

This function can be used by clients that remain idle for a long while, to check whether the server has closed the connection and reconnect if necessary.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.97. `mysqli::ping` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* check if server is alive */
if ($mysqli->ping()) {
    printf ("Our connection is ok!\n");
} else {
    printf ("Error: %s\n", $mysqli->error);
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* check if server is alive */
if (mysqli_ping($link)) {
    printf ("Our connection is ok!\n");
} else {
    printf ("Error: %s\n", mysqli_error($link));
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Our connection is ok!
```

20.10.2.7.36. `mysqli::poll`, `mysqli_poll`

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- `mysqli::poll`

  `mysqli_poll`

  Poll connections

Description

Object oriented style

```
public int mysqli::poll(array read,
                        array error,
                        array reject,
                        int sec,
                        int usec);
```

Procedural style

```
int mysqli_poll(array read,
                array error,
                array reject,
                int sec,
                int usec);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

Poll connections. Available only with mysqlnd.

Parameters

`read`	
`error`	
`reject`	
`sec`	Number of seconds to wait, must be non-negative.
`usec`	Number of microseconds to wait, must be non-negative.

Return Values

Returns number of ready connections in success, `FALSE` otherwise.

Examples

Example 20.98. A `mysqli_poll` example

```
<?php
$link1 = mysqli_connect();
$link1->query("SELECT 'test'", MYSQLI_ASYNC);
$all_links = array($link1);
$processed = 0;
do {
    $links = $errors = $reject = array();
    foreach ($all_links as $link) {
        $links[] = $errors[] = $reject[] = $link;
    }
    if (!mysqli_poll($links, $errors, $reject, 1)) {
        continue;
    }
    foreach ($links as $link) {
        if ($result = $link->reap_async_query()) {
            print_r($result->fetch_row());
            mysqli_free_result($result);
            $processed++;
        }
    }
} while ($processed < count($all_links));
?>
```

The above example will output:

```
Array
(
    [0] => test
)
```

See Also

`mysqli_query`
`mysqli_reap_async_query`

20.10.2.7.37. `mysqli::prepare`, `mysqli_prepare`

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- `mysqli::prepare`

  `mysqli_prepare`

  Prepare an SQL statement for execution

Description

Object oriented style

```
mysqli_stmt mysqli::prepare(string query);
```

Procedural style

```
mysqli_stmt mysqli_prepare(mysqli link,
                           string query);
```

Prepares the SQL query, and returns a statement handle to be used for further operations on the statement. The query must consist of a single SQL statement.

The parameter markers must be bound to application variables using `mysqli_stmt_bind_param` and/or `mysqli_stmt_bind_result` before executing the statement or fetching rows.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`query`	The query, as a string.

> **Note**
>
> You should not add a terminating semicolon or `\g` to the statement.

This parameter can include one or more parameter markers in the SQL statement by embedding question mark (`?`) characters at the appropriate positions.

> **Note**
>
> The markers are legal only in certain places in SQL statements. For example, they are allowed in the `VALUES()` list of an `INSERT` statement (to specify column values for a row), or in a comparison with a column in a `WHERE` clause to specify a comparison value.
>
> However, they are not allowed for identifiers (such as table or column names), in the select list that names the columns to be returned by a `SELECT` statement, or to specify both operands of a binary operator such as the `=` equal sign. The latter restriction is necessary because it would be impossible to determine the parameter type. It's not al-

> lowed to compare marker with `NULL` by `? IS NULL` too. In general, parameters are legal only in Data Manipulation Language (DML) statements, and not in Data Definition Language (DDL) statements.

Return Values

`mysqli_prepare` returns a statement object or `FALSE` if an error occurred.

Examples

Example 20.99. `mysqli::prepare` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$city = "Amersfoort";

/* create a prepared statement */
if ($stmt = $mysqli->prepare("SELECT District FROM City WHERE Name=?")) {

    /* bind parameters for markers */
    $stmt->bind_param("s", $city);

    /* execute query */
    $stmt->execute();

    /* bind result variables */
    $stmt->bind_result($district);

    /* fetch value */
    $stmt->fetch();

    printf("%s is in district %s\n", $city, $district);

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$city = "Amersfoort";

/* create a prepared statement */
if ($stmt = mysqli_prepare($link, "SELECT District FROM City WHERE Name=?")) {

    /* bind parameters for markers */
    mysqli_stmt_bind_param($stmt, "s", $city);

    /* execute query */
    mysqli_stmt_execute($stmt);

    /* bind result variables */
    mysqli_stmt_bind_result($stmt, $district);

    /* fetch value */
    mysqli_stmt_fetch($stmt);

    printf("%s is in district %s\n", $city, $district);

    /* close statement */
    mysqli_stmt_close($stmt);
}
```

```
/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Amersfoort is in district Utrecht
```

See Also

`mysqli_stmt_execute`
`mysqli_stmt_fetch`
`mysqli_stmt_bind_param`
`mysqli_stmt_bind_result`
`mysqli_stmt_close`

20.10.2.7.38. `mysqli::query`, `mysqli_query`

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- `mysqli::query`

  `mysqli_query`

  Performs a query on the database

Description

Object oriented style

```
  mixed mysqli::query(string query,
                      int resultmode);
```

Procedural style

```
  mixed mysqli_query(mysqli link,
                     string query,
                     int resultmode);
```

Performs a *`query`* against the database.

Functionally, using this function is identical to calling `mysqli_real_query` followed either by `mysqli_use_result` or `mysqli_store_result`.

> **Note**
>
> In the case where you pass a statement to `mysqli_query` that is longer than `max_allowed_packet` of the server, the returned error codes are different depending on whether you are using MySQL Native Driver (`mysqlnd`) or MySQL Client Library (`libmysql`). The behavior is as follows:
>
> - `mysqlnd` on Linux returns an error code of 1153. The error message means “got a packet bigger than `max_allowed_packet` bytes”.
> - `mysqlnd` on Windows returns an error code 2006. This error message means “server has gone away”.
> - `libmysql` on all platforms returns an error code 2006. This error message means “server has gone away”.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`query`	The query string. Data inside the query should be properly escaped.
`resultmode`	Either the constant `MYSQLI_USE_RESULT` or `MYSQLI_STORE_RESULT` depending on the desired behavior. By default, `MYSQLI_STORE_RESULT` is used. If you use `MYSQLI_USE_RESULT` all subsequent calls will return error `Commands out of sync` unless you call `mysqli_free_result` With `MYSQLI_ASYNC` (available with mysqlnd), it is possible to perform query asynchronously. `mysqli_poll` is then used to get results from such queries.

Return Values

Returns `FALSE` on failure. For successful `SELECT, SHOW, DESCRIBE` or `EXPLAIN` queries `mysqli_query` will return a result object. For other successful queries `mysqli_query` will return `TRUE` .

Changelog

Version	Description
5.3.0	Added the ability of async queries.

Examples

Example 20.100. `mysqli::query` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Create table doesn't return a resultset */
if ($mysqli->query("CREATE TEMPORARY TABLE myCity LIKE City") === TRUE) {
    printf("Table myCity successfully created.\n");
}

/* Select queries return a resultset */
if ($result = $mysqli->query("SELECT Name FROM City LIMIT 10")) {
    printf("Select returned %d rows.\n", $result->num_rows);

    /* free result set */
    $result->close();
}

/* If we have to retrieve large amount of data we use MYSQLI_USE_RESULT */
if ($result = $mysqli->query("SELECT * FROM City", MYSQLI_USE_RESULT)) {

    /* Note, that we can't execute any functions which interact with the
       server until result set was closed. All calls will return an
       'out of sync' error */
    if (!$mysqli->query("SET @a:='this will not work'")) {
        printf("Error: %s\n", $mysqli->error);
    }
    $result->close();
}

$mysqli->close();
?>
```

Procedural style

```
<?php
```

```
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Create table doesn't return a resultset */
if (mysqli_query($link, "CREATE TEMPORARY TABLE myCity LIKE City") === TRUE) {
    printf("Table myCity successfully created.\n");
}

/* Select queries return a resultset */
if ($result = mysqli_query($link, "SELECT Name FROM City LIMIT 10")) {
    printf("Select returned %d rows.\n", mysqli_num_rows($result));

    /* free result set */
    mysqli_free_result($result);
}

/* If we have to retrieve large amount of data we use MYSQLI_USE_RESULT */
if ($result = mysqli_query($link, "SELECT * FROM City", MYSQLI_USE_RESULT)) {

    /* Note, that we can't execute any functions which interact with the
       server until result set was closed. All calls will return an
       'out of sync' error */
    if (!mysqli_query($link, "SET @a:='this will not work'")) {
        printf("Error: %s\n", mysqli_error($link));
    }
    mysqli_free_result($result);
}

mysqli_close($link);
?>
```

The above examples will output:

```
Table myCity successfully created.
Select returned 10 rows.
Error: Commands out of sync;  You can't run this command now
```

See Also

mysqli_real_query
mysqli_multi_query
mysqli_free_result

20.10.2.7.39. `mysqli::real_connect`, `mysqli_real_connect`

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- `mysqli::real_connect`

  `mysqli_real_connect`

  Opens a connection to a mysql server

Description

Object oriented style

```
  bool mysqli::real_connect(string host,
                            string username,
                            string passwd,
                            string dbname,
                            int port,
                            string socket,
                            int flags);
```

Procedural style

```
bool mysqli_real_connect(mysqli link,
                         string host,
                         string username,
                         string passwd,
                         string dbname,
                         int port,
                         string socket,
                         int flags);
```

Establish a connection to a MySQL database engine.

This function differs from `mysqli_connect`:

- `mysqli_real_connect` needs a valid object which has to be created by function `mysqli_init`.
- With the `mysqli_options` function you can set various options for connection.
- There is a *`flags`* parameter.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`host`	Can be either a host name or an IP address. Passing the `NULL` value or the string "localhost" to this parameter, the local host is assumed. When possible, pipes will be used instead of the TCP/IP protocol.
`username`	The MySQL user name.
`passwd`	If provided or `NULL` , the MySQL server will attempt to authenticate the user against those user records which have no password only. This allows one username to be used with different permissions (depending on if a password as provided or not).
`dbname`	If provided will specify the default database to be used when performing queries.
`port`	Specifies the port number to attempt to connect to the MySQL server.
`socket`	Specifies the socket or named pipe that should be used.

> **Note**
>
> Specifying the *`socket`* parameter will not explicitly determine the type of connection to be used when connecting to the MySQL server. How the connection is made to the MySQL database is determined by the *`host`* parameter.

`flags`	With the parameter *`flags`* you can set different connection options:

Table 20.11. Supported flags

Name	Description
`MYSQLI_CLIENT_COMPRESS`	Use compression protocol
`MYSQLI_CLIENT_FOUND_ROWS`	return number of matched rows, not the number of affected rows
`MYSQLI_CLIENT_IGNORE_SPACE`	Allow spaces after function names. Makes all function names reserved words.
`MYSQLI_CLIENT_INTERACTIVE`	Allow `interactive_timeout` seconds (instead of `wait_timeout` seconds) of inactivity before closing the connection
`MYSQLI_CLIENT_SSL`	Use SSL (encryption)

> **Note**
>
> For security reasons the `MULTI_STATEMENT` flag is not supported in PHP. If you want to execute multiple queries use the `mysqli_multi_query` function.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.101. `mysqli::real_connect` example

Object oriented style

```
<?php

$mysqli = mysqli_init();
if (!$mysqli) {
    die('mysqli_init failed');
}

if (!$mysqli->options(MYSQLI_INIT_COMMAND, 'SET AUTOCOMMIT = 0')) {
    die('Setting MYSQLI_INIT_COMMAND failed');
}

if (!$mysqli->options(MYSQLI_OPT_CONNECT_TIMEOUT, 5)) {
    die('Setting MYSQLI_OPT_CONNECT_TIMEOUT failed');
}

if (!$mysqli->real_connect('localhost', 'my_user', 'my_password', 'my_db')) {
    die('Connect Error (' . mysqli_connect_errno() . ') '
            . mysqli_connect_error());
}

echo 'Success... ' . $mysqli->host_info . "\n";

$mysqli->close();
?>
```

Object oriented style when extending mysqli class

```
<?php

class foo_mysqli extends mysqli {
    public function __construct($host, $user, $pass, $db) {
        parent::init();

        if (!parent::options(MYSQLI_INIT_COMMAND, 'SET AUTOCOMMIT = 0')) {
            die('Setting MYSQLI_INIT_COMMAND failed');
        }

        if (!parent::options(MYSQLI_OPT_CONNECT_TIMEOUT, 5)) {
            die('Setting MYSQLI_OPT_CONNECT_TIMEOUT failed');
        }

        if (!parent::real_connect($host, $user, $pass, $db)) {
            die('Connect Error (' . mysqli_connect_errno() . ') '
                    . mysqli_connect_error());
        }
    }
}

$db = new foo_mysqli('localhost', 'my_user', 'my_password', 'my_db');

echo 'Success... ' . $db->host_info . "\n";

$db->close();
?>
```

Procedural style

```
<?php

$link = mysqli_init();
if (!$link) {
    die('mysqli_init failed');
}

if (!mysqli_options($link, MYSQLI_INIT_COMMAND, 'SET AUTOCOMMIT = 0')) {
    die('Setting MYSQLI_INIT_COMMAND failed');
}

if (!mysqli_options($link, MYSQLI_OPT_CONNECT_TIMEOUT, 5)) {
    die('Setting MYSQLI_OPT_CONNECT_TIMEOUT failed');
}

if (!mysqli_real_connect($link, 'localhost', 'my_user', 'my_password', 'my_db')) {
    die('Connect Error (' . mysqli_connect_errno() . ') '
            . mysqli_connect_error());
}

echo 'Success... ' . mysqli_get_host_info($link) . "\n";

mysqli_close($link);
?>
```

The above examples will output:

```
Success... MySQL host info: localhost via TCP/IP
```

Notes

> ### Note
>
> MySQLnd always assumes the server default charset. This charset is sent during connection hand-shake/authentication, which mysqlnd will use.
>
> Libmysql uses the default charset set in the `my.cnf` or by an explicit call to `mysqli_options` prior to calling `mysqli_real_connect`, but after `mysqli_init`.

See Also

`mysqli_connect`
`mysqli_init`
`mysqli_options`
`mysqli_ssl_set`
`mysqli_close`

20.10.2.7.40. `mysqli::real_escape_string`, `mysqli_real_escape_string`

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- `mysqli::real_escape_string`

  `mysqli_real_escape_string`

  Escapes special characters in a string for use in an SQL statement, taking into account the current charset of the connection

Description

Object oriented style

```
string mysqli::escape_string(string escapestr);
```

```
string mysqli::real_escape_string(string escapestr);
```

Procedural style

```
string mysqli_real_escape_string(mysqli link,
                                 string escapestr);
```

This function is used to create a legal SQL string that you can use in an SQL statement. The given string is encoded to an escaped SQL string, taking into account the current character set of the connection.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`escapestr`	The string to be escaped. Characters encoded are `NUL (ASCII 0), \n, \r, \, ', ", and Control-Z`.

Return Values

Returns an escaped string.

Examples

Example 20.102. `mysqli::real_escape_string` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$mysqli->query("CREATE TEMPORARY TABLE myCity LIKE City");

$city = "'s Hertogenbosch";

/* this query will fail, cause we didn't escape $city */
if (!$mysqli->query("INSERT into myCity (Name) VALUES ('$city')")) {
    printf("Error: %s\n", $mysqli->sqlstate);
}

$city = $mysqli->real_escape_string($city);

/* this query with escaped $city will work */
if ($mysqli->query("INSERT into myCity (Name) VALUES ('$city')")) {
    printf("%d Row inserted.\n", $mysqli->affected_rows);
}

$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

mysqli_query($link, "CREATE TEMPORARY TABLE myCity LIKE City");

$city = "'s Hertogenbosch";

/* this query will fail, cause we didn't escape $city */
if (!mysqli_query($link, "INSERT into myCity (Name) VALUES ('$city')")) {
    printf("Error: %s\n", mysqli_sqlstate($link));
}

$city = mysqli_real_escape_string($link, $city);

/* this query with escaped $city will work */
if (mysqli_query($link, "INSERT into myCity (Name) VALUES ('$city')")) {
    printf("%d Row inserted.\n", mysqli_affected_rows($link));
}

mysqli_close($link);
?>
```

The above examples will output:

```
Error: 42000
1 Row inserted.
```

See Also

`mysqli_character_set_name`

20.10.2.7.41. `mysqli::real_query`, `mysqli_real_query`

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- `mysqli::real_query`

  `mysqli_real_query`

  Execute an SQL query

Description

Object oriented style

```
bool mysqli::real_query(string query);
```

Procedural style

```
bool mysqli_real_query(mysqli link,
                       string query);
```

Executes a single query against the database whose result can then be retrieved or stored using the `mysqli_store_result` or `mysqli_use_result` functions.

In order to determine if a given query should return a result set or not, see `mysqli_field_count`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`query`	The query, as a string. Data inside the query should be properly escaped.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

See Also

`mysqli_query`
`mysqli_store_result`
`mysqli_use_result`

20.10.2.7.42. `mysqli::reap_async_query`, `mysqli_reap_async_query`

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- `mysqli::reap_async_query`

  `mysqli_reap_async_query`

Get result from async query

Description

Object oriented style

```
public mysqli_result mysqli::reap_async_query();
```

Procedural style

```
mysqli_result mysqli_reap_async_query(mysql link);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

Get result from async query. Available only with mysqlnd.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `mysqli_result` in success, `FALSE` otherwise.

See Also

`mysqli_poll`

20.10.2.7.43. `mysqli::rollback`, `mysqli_rollback`

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- `mysqli::rollback`

  `mysqli_rollback`

  Rolls back current transaction

Description

Object oriented style

```
bool mysqli::rollback();
```

Procedural style

```
bool mysqli_rollback(mysqli link);
```

Rollbacks the current transaction for the database.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.103. `mysqli::rollback` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* disable autocommit */
$mysqli->autocommit(FALSE);

$mysqli->query("CREATE TABLE myCity LIKE City");
$mysqli->query("ALTER TABLE myCity Type=InnoDB");
$mysqli->query("INSERT INTO myCity SELECT * FROM City LIMIT 50");

/* commit insert */
$mysqli->commit();

/* delete all rows */
$mysqli->query("DELETE FROM myCity");

if ($result = $mysqli->query("SELECT COUNT(*) FROM myCity")) {
    $row = $result->fetch_row();
    printf("%d rows in table myCity.\n", $row[0]);
    /* Free result */
    $result->close();
}

/* Rollback */
$mysqli->rollback();

if ($result = $mysqli->query("SELECT COUNT(*) FROM myCity")) {
    $row = $result->fetch_row();
    printf("%d rows in table myCity (after rollback).\n", $row[0]);
    /* Free result */
    $result->close();
}

/* Drop table myCity */
$mysqli->query("DROP TABLE myCity");

$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* disable autocommit */
mysqli_autocommit($link, FALSE);

mysqli_query($link, "CREATE TABLE myCity LIKE City");
mysqli_query($link, "ALTER TABLE myCity Type=InnoDB");
mysqli_query($link, "INSERT INTO myCity SELECT * FROM City LIMIT 50");

/* commit insert */
mysqli_commit($link);

/* delete all rows */
mysqli_query($link, "DELETE FROM myCity");

if ($result = mysqli_query($link, "SELECT COUNT(*) FROM myCity")) {
    $row = mysqli_fetch_row($result);
    printf("%d rows in table myCity.\n", $row[0]);
    /* Free result */
    mysqli_free_result($result);
}

/* Rollback */
mysqli_rollback($link);

if ($result = mysqli_query($link, "SELECT COUNT(*) FROM myCity")) {
    $row = mysqli_fetch_row($result);
    printf("%d rows in table myCity (after rollback).\n", $row[0]);
    /* Free result */
    mysqli_free_result($result);
}

/* Drop table myCity */
mysqli_query($link, "DROP TABLE myCity");

mysqli_close($link);
?>
```

The above examples will output:

```
0 rows in table myCity.
50 rows in table myCity (after rollback).
```

See Also

`mysqli_commit`
`mysqli_autocommit`

20.10.2.7.44. `mysqli::select_db`, `mysqli_select_db`

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- `mysqli::select_db`

  `mysqli_select_db`

  Selects the default database for database queries

Description

Object oriented style

```
bool mysqli::select_db(string dbname);
```

Procedural style

```
bool mysqli_select_db(mysqli link,
                      string dbname);
```

Selects the default database to be used when performing queries against the database connection.

> **Note**
>
> This function should only be used to change the default database for the connection. You can select the default database with 4th parameter in `mysqli_connect`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`dbname`	The database name.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.104. `mysqli::select_db` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "test");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* return name of current default database */
if ($result = $mysqli->query("SELECT DATABASE()")) {
    $row = $result->fetch_row();
    printf("Default database is %s.\n", $row[0]);
    $result->close();
}

/* change db to world db */
$mysqli->select_db("world");

/* return name of current default database */
if ($result = $mysqli->query("SELECT DATABASE()")) {
    $row = $result->fetch_row();
    printf("Default database is %s.\n", $row[0]);
    $result->close();
}

$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "test");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* return name of current default database */
if ($result = mysqli_query($link, "SELECT DATABASE()")) {
    $row = mysqli_fetch_row($result);
    printf("Default database is %s.\n", $row[0]);
    mysqli_free_result($result);
}

/* change db to world db */
mysqli_select_db($link, "world");

/* return name of current default database */
if ($result = mysqli_query($link, "SELECT DATABASE()")) {
    $row = mysqli_fetch_row($result);
    printf("Default database is %s.\n", $row[0]);
    mysqli_free_result($result);
}

mysqli_close($link);
?>
```

The above examples will output:

```
Default database is test.
Default database is world.
```

See Also

`mysqli_connect`

`mysqli_real_connect`

20.10.2.7.45. `mysqli::set_charset`, `mysqli_set_charset`

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- `mysqli::set_charset`

  `mysqli_set_charset`

  Sets the default client character set

Description

Object oriented style

```
bool mysqli::set_charset(string charset);
```

Procedural style

```
bool mysqli_set_charset(mysqli link,
                        string charset);
```

Sets the default character set to be used when sending data from and to the database server.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`charset`	The charset to be set as default.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Notes

> **Note**
>
> To use this function on a Windows platform you need MySQL client library version 4.1.11 or above (for MySQL 5.0 you need 5.0.6 or above).

> **Note**
>
> This is the preferred way to change the charset. Using `mysqli::query` to execute `SET NAMES ..` is not recommended.

Examples

Example 20.105. `mysqli::set_charset` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "test");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* change character set to utf8 */
if (!$mysqli->set_charset("utf8")) {
    printf("Error loading character set utf8: %s\n", $mysqli->error);
} else {
    printf("Current character set: %s\n", $mysqli->character_set_name());
}
```

```
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect('localhost', 'my_user', 'my_password', 'test');

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* change character set to utf8 */
if (!mysqli_set_charset($link, "utf8")) {
    printf("Error loading character set utf8: %s\n", mysqli_error($link));
} else {
    printf("Current character set: %s\n", mysqli_character_set_name($link));
}

mysqli_close($link);
?>
```

The above examples will output:

```
Current character set: utf8
```

See Also

`mysqli_character_set_name`
`mysqli_real_escape_string`
List of character sets that MySQL supports

20.10.2.7.46. `mysqli::set_local_infile_default`, `mysqli_set_local_infile_default`

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- `mysqli::set_local_infile_default`

  `mysqli_set_local_infile_default`

  Unsets user defined handler for load local infile command

Description

```
  void mysqli_set_local_infile_default(mysqli link);
```

Deactivates a `LOAD DATA INFILE LOCAL` handler previously set with `mysqli_set_local_infile_handler`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

No value is returned.

Examples

See `mysqli_set_local_infile_handler` examples

See Also

`mysqli_set_local_infile_handler`

20.10.2.7.47. `mysqli::set_local_infile_handler`, `mysqli_set_local_infile_handler`

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- `mysqli::set_local_infile_handler`

  `mysqli_set_local_infile_handler`

  Set callback function for LOAD DATA LOCAL INFILE command

Description

Object oriented style

```
bool mysqli::set_local_infile_handler(mysqli link,
                                      callback read_func);
```

Procedural style

```
bool mysqli_set_local_infile_handler(mysqli link,
                                     callback read_func);
```

Set callback function for LOAD DATA LOCAL INFILE command

The callbacks task is to read input from the file specified in the `LOAD DATA LOCAL INFILE` and to reformat it into the format understood by `LOAD DATA INFILE`.

The returned data needs to match the format specified in the `LOAD DATA`

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`read_func`	A callback function or object method taking the following parameters:

`stream`	A PHP stream associated with the SQL commands INFILE
`&buffer`	A string buffer to store the rewritten input into
`buflen`	The maximum number of characters to be stored in the buffer
`&errormsg`	If an error occurs you can store an error message in here

The callback function should return the number of characters stored in the *`buffer`* or a negative value if an error occurred.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.106. `mysqli::set_local_infile_handler` example

Object oriented style

```
<?php
  $db = mysqli_init();
  $db->real_connect("localhost","root","","test");

  function callme($stream, &$buffer, $buflen, &$errmsg)
  {
    $buffer = fgets($stream);

    echo $buffer;

    // convert to upper case and replace "," delimiter with [TAB]
    $buffer = strtoupper(str_replace(",", "\t", $buffer));

    return strlen($buffer);
  }


  echo "Input:\n";

  $db->set_local_infile_handler("callme");
  $db->query("LOAD DATA LOCAL INFILE 'input.txt' INTO TABLE t1");
  $db->set_local_infile_default();

  $res = $db->query("SELECT * FROM t1");

  echo "\nResult:\n";
  while ($row = $res->fetch_assoc()) {
    echo join(",", $row)."\n";
  }
?>
```

Procedural style

```
<?php
  $db = mysqli_init();
  mysqli_real_connect($db, "localhost","root","","test");

  function callme($stream, &$buffer, $buflen, &$errmsg)
  {
    $buffer = fgets($stream);

    echo $buffer;

    // convert to upper case and replace "," delimiter with [TAB]
    $buffer = strtoupper(str_replace(",", "\t", $buffer));

    return strlen($buffer);
  }


  echo "Input:\n";

  mysqli_set_local_infile_handler($db, "callme");
  mysqli_query($db, "LOAD DATA LOCAL INFILE 'input.txt' INTO TABLE t1");
  mysqli_set_local_infile_default($db);

  $res = mysqli_query($db, "SELECT * FROM t1");


  echo "\nResult:\n";
  while ($row = mysqli_fetch_assoc($res)) {
    echo join(",", $row)."\n";
  }
?>
```

The above examples will output:

```
Input:
23,foo
42,bar

Output:
23,FOO
42,BAR
```

See Also

`mysqli_set_local_infile_default`

20.10.2.7.48. `mysqli->sqlstate`, `mysqli_sqlstate`

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- `mysqli->sqlstate`

  `mysqli_sqlstate`

  Returns the SQLSTATE error from previous MySQL operation

Description

Object oriented style

```
 mysqli {

  string sqlstate ;

}
```

Procedural style

```
  string mysqli_sqlstate(mysqli link);
```

Returns a string containing the SQLSTATE error code for the last error. The error code consists of five characters. `'00000'` means no error. The values are specified by ANSI SQL and ODBC. For a list of possible values, see http://dev.mysql.com/doc/mysql/en/error-handling.html.

> **Note**
>
> Note that not all MySQL errors are yet mapped to SQLSTATE's. The value `HY000` (general error) is used for unmapped errors.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns a string containing the SQLSTATE error code for the last error. The error code consists of five characters. `'00000'` means no error.

Examples

Example 20.107. `mysqli->sqlstate` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Table City already exists, so we should get an error */
if (!$mysqli->query("CREATE TABLE City (ID INT, Name VARCHAR(30))")) {
    printf("Error - SQLSTATE %s.\n", $mysqli->sqlstate);
}

$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* Table City already exists, so we should get an error */
if (!mysqli_query($link, "CREATE TABLE City (ID INT, Name VARCHAR(30))")) {
    printf("Error - SQLSTATE %s.\n", mysqli_sqlstate($link));
}

mysqli_close($link);
?>
```

The above examples will output:

```
Error - SQLSTATE 42S01.
```

See Also

`mysqli_errno`
`mysqli_error`

20.10.2.7.49. `mysqli::ssl_set`, `mysqli_ssl_set`

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- `mysqli::ssl_set`

  `mysqli_ssl_set`

  Used for establishing secure connections using SSL

Description

Object oriented style

```
  bool mysqli::ssl_set(string key,
                       string cert,
                       string ca,
                       string capath,
                       string cipher);
```

Procedural style

```
  bool mysqli_ssl_set(mysqli link,
                      string key,
                      string cert,
                      string ca,
                      string capath,
                      string cipher);
```

Used for establishing secure connections using SSL. It must be called before `mysqli_real_connect`. This function does nothing unless OpenSSL support is enabled.

Note that MySQL Native Driver does not support SSL, so calling this function when using MySQL Native Driver will result in an error. MySQL Native Driver is enabled by default on Microsoft Windows from PHP version 5.3 onwards.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`
`key`	The path name to the key file.
`cert`	The path name to the certificate file.
`ca`	The path name to the certificate authority file.
`capath`	The pathname to a directory that contains trusted SSL CA certificates in PEM format.
`cipher`	A list of allowable ciphers to use for SSL encryption.

Any unused SSL parameters may be given as `NULL`

Return Values

This function always returns `TRUE` value. If SSL setup is incorrect `mysqli_real_connect` will return an error when you attempt to connect.

See Also

`mysqli_options`
`mysqli_real_connect`

20.10.2.7.50. `mysqli::stat`, `mysqli_stat`

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- `mysqli::stat`

  `mysqli_stat`

  Gets the current system status

Description

Object oriented style

```
string mysqli::stat();
```

Procedural style

```
string mysqli_stat(mysqli link);
```

`mysqli_stat` returns a string containing information similar to that provided by the 'mysqladmin status' command. This includes uptime in seconds and the number of running threads, questions, reloads, and open tables.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

A string describing the server status. `FALSE` if an error occurred.

Examples

Example 20.108. `mysqli::stat` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

printf ("System status: %s\n", $mysqli->stat());

$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

printf("System status: %s\n", mysqli_stat($link));

mysqli_close($link);
?>
```

The above examples will output:

```
System status: Uptime: 272  Threads: 1  Questions: 5340  Slow queries: 0
Opens: 13  Flush tables: 1  Open tables: 0  Queries per second avg: 19.632
Memory in use: 8496K  Max memory used: 8560K
```

See Also

`mysqli_get_server_info`

20.10.2.7.51. `mysqli::stmt_init`, `mysqli_stmt_init`

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- `mysqli::stmt_init`

  `mysqli_stmt_init`

  Initializes a statement and returns an object for use with mysqli_stmt_prepare

Description

Object oriented style

```
mysqli_stmt mysqli::stmt_init();
```

Procedural style

```
mysqli_stmt mysqli_stmt_init(mysqli link);
```

Allocates and initializes a statement object suitable for `mysqli_stmt_prepare`.

Note

> Any subsequent calls to any mysqli_stmt function will fail until `mysqli_stmt_prepare` was called.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns an object.

See Also

`mysqli_stmt_prepare`

20.10.2.7.52. `mysqli::store_result`, `mysqli_store_result`

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- `mysqli::store_result`

  `mysqli_store_result`

  Transfers a result set from the last query

Description

Object oriented style

```
mysqli_result mysqli::store_result();
```

Procedural style

```
mysqli_result mysqli_store_result(mysqli link);
```

Transfers the result set from the last query on the database connection represented by the *`link`* parameter to be used with the `mysqli_data_seek` function.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns a buffered result object or `FALSE` if an error occurred.

> **Note**
>
> `mysqli_store_result` returns `FALSE` in case the query didn't return a result set (if the query was, for example an INSERT statement). This function also returns `FALSE` if the reading of the result set failed. You can check if you have got an error by checking if `mysqli_error` doesn't return an empty string, if `mysqli_errno` returns a non zero value, or if `mysqli_field_count` returns a non zero value. Also possible reason for this function returning `FALSE` after successful call to `mysqli_query` can be too large result set (memory for it cannot be allocated). If `mysqli_field_count` returns a non-zero value, the statement should have produced a non-empty result set.

Notes

> **Note**
>
> Although it is always good practice to free the memory used by the result of a query using the `mysqli_free_result` function, when transferring large result sets using the `mysqli_store_result` this becomes particularly important.

Examples

See `mysqli_multi_query`.

See Also

`mysqli_real_query`
`mysqli_use_result`

20.10.2.7.53. `mysqli->thread_id`, `mysqli_thread_id`

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- `mysqli->thread_id`

  `mysqli_thread_id`

  Returns the thread ID for the current connection

Description

Object oriented style

```
 mysqli {

  int thread_id ;

}
```

Procedural style

```
  int mysqli_thread_id(mysqli link);
```

The `mysqli_thread_id` function returns the thread ID for the current connection which can then be killed using the `mysqli_kill` function. If the connection is lost and you reconnect with `mysqli_ping`, the thread ID will be other. Therefore you should get the thread ID only when you need it.

> **Note**
>
> The thread ID is assigned on a connection-by-connection basis. Hence, if the connection is broken and then re-established a new thread ID will be assigned.
>
> To kill a running query you can use the SQL command `KILL QUERY processid`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Returns the Thread ID for the current connection.

Examples

Example 20.109. `mysqli->thread_id` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}
```

```
/* determine our thread id */
$thread_id = $mysqli->thread_id;

/* Kill connection */
$mysqli->kill($thread_id);

/* This should produce an error */
if (!$mysqli->query("CREATE TABLE myCity LIKE City")) {
    printf("Error: %s\n", $mysqli->error);
    exit;
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* determine our thread id */
$thread_id = mysqli_thread_id($link);

/* Kill connection */
mysqli_kill($link, $thread_id);

/* This should produce an error */
if (!mysqli_query($link, "CREATE TABLE myCity LIKE City")) {
    printf("Error: %s\n", mysqli_error($link));
    exit;
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Error: MySQL server has gone away
```

See Also

`mysqli_kill`

20.10.2.7.54. `mysqli::thread_safe`, `mysqli_thread_safe`

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- `mysqli::thread_safe`

  `mysqli_thread_safe`

  Returns whether thread safety is given or not

Description

Procedural style

```
bool mysqli_thread_safe();
```

Tells whether the client library is compiled as thread-safe.

Return Values

`TRUE` if the client library is thread-safe, otherwise `FALSE` .

20.10.2.7.55. `mysqli::use_result`, `mysqli_use_result`

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- `mysqli::use_result`

  `mysqli_use_result`

  Initiate a result set retrieval

Description

Object oriented style

```
mysqli_result mysqli::use_result();
```

Procedural style

```
mysqli_result mysqli_use_result(mysqli link);
```

Used to initiate the retrieval of a result set from the last query executed using the `mysqli_real_query` function on the database connection.

Either this or the `mysqli_store_result` function must be called before the results of a query can be retrieved, and one or the other must be called to prevent the next query on that database connection from failing.

> **Note**
>
> The `mysqli_use_result` function does not transfer the entire result set from the database and hence cannot be used functions such as `mysqli_data_seek` to move to a particular row within the set. To use this functionality, the result set must be stored using `mysqli_store_result`. One should not use `mysqli_use_result` if a lot of processing on the client side is performed, since this will tie up the server and prevent other threads from updating any tables from which the data is being fetched.

Return Values

Returns an unbuffered result object or `FALSE` if an error occurred.

Examples

Example 20.110. `mysqli::use_result` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query  = "SELECT CURRENT_USER();";
$query .= "SELECT Name FROM City ORDER BY ID LIMIT 20, 5";

/* execute multi query */
if ($mysqli->multi_query($query)) {
    do {
        /* store first result set */
        if ($result = $mysqli->use_result()) {
            while ($row = $result->fetch_row()) {
                printf("%s\n", $row[0]);
            }
            $result->close();
        }
        /* print divider */
        if ($mysqli->more_results()) {
            printf("-----------------\n");
        }
    } while ($mysqli->next_result());
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query  = "SELECT CURRENT_USER();";
$query .= "SELECT Name FROM City ORDER BY ID LIMIT 20, 5";

/* execute multi query */
if (mysqli_multi_query($link, $query)) {
    do {
        /* store first result set */
        if ($result = mysqli_use_result($link)) {
            while ($row = mysqli_fetch_row($result)) {
                printf("%s\n", $row[0]);
            }
            mysqli_free_result($result);
        }
        /* print divider */
        if (mysqli_more_results($link)) {
            printf("-----------------\n");
        }
    } while (mysqli_next_result($link));
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
my_user@localhost
-----------------
Amersfoort
Maastricht
Dordrecht
Leiden
Haarlemmermeer
```

See Also

`mysqli_real_query`
`mysqli_store_result`

20.10.2.7.56. `mysqli->warning_count`, `mysqli_warning_count`

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- `mysqli->warning_count`

  `mysqli_warning_count`

  Returns the number of warnings from the last query for the given link

Description

Object oriented style

```
 mysqli {

  int warning_count ;

}
```

Procedural style

```
  int mysqli_warning_count(mysqli link);
```

Returns the number of warnings from the last query in the connection.

> **Note**
>
> For retrieving warning messages you can use the SQL command `SHOW WARNINGS [limit row_count]`.

Parameters

`link`	Procedural style only: A link identifier returned by `mysqli_connect` or `mysqli_init`

Return Values

Number of warnings or zero if there are no warnings.

Examples

Example 20.111. `mysqli->warning_count` example

Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$mysqli->query("CREATE TABLE myCity LIKE City");

/* a remarkable city in Wales */
$query = "INSERT INTO myCity (CountryCode, Name) VALUES('GBR',
        'Llanfairpwllgwyngyllgogerychwyrndrobwllllantysiliogogogoch')";

$mysqli->query($query);

if ($mysqli->warning_count) {
    if ($result = $mysqli->query("SHOW WARNINGS")) {
        $row = $result->fetch_row();
        printf("%s (%d): %s\n", $row[0], $row[1], $row[2]);
        $result->close();
    }
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}
```

```
mysqli_query($link, "CREATE TABLE myCity LIKE City");

/* a remarkable long city name in Wales */
$query = "INSERT INTO myCity (CountryCode, Name) VALUES('GBR',
        'Llanfairpwllgwyngyllgogerychwyrndrobwllllantysiliogogogoch')";

mysqli_query($link, $query);

if (mysqli_warning_count($link)) {
    if ($result = mysqli_query($link, "SHOW WARNINGS")) {
        $row = mysqli_fetch_row($result);
        printf("%s (%d): %s\n", $row[0], $row[1], $row[2]);
        mysqli_free_result($result);
    }
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Warning (1264): Data truncated for column 'Name' at row 1
```

See Also

`mysqli_errno`
`mysqli_error`
`mysqli_sqlstate`

20.10.2.8. The MySQLi_STMT class (`MySQLi_STMT`)

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Represents a prepared statement.

```
 MySQLi_STMT {
 MySQLi_STMT

      Properties

  int affected_rows ;


  int errno ;


  string error ;


  int field_count ;


  int insert_id ;


  int num_rows ;


  int param_count ;


  string sqlstate ;

Methods

  int mysqli_stmt_affected_rows(mysqli_stmt stmt);


  int mysqli_stmt::attr_get(int attr);


  bool mysqli_stmt::attr_set(int attr,
                           int mode);
  bool mysqli_stmt::bind_param(string types,
                               mixed var1,
                               mixed ...);


  bool mysqli_stmt::bind_result(mixed var1,
                                mixed ...);


  bool mysqli_stmt::close();


  void mysqli_stmt::data_seek(int offset);


  int mysqli_stmt_errno(mysqli_stmt stmt);


  string mysqli_stmt_error(mysqli_stmt stmt);


  bool mysqli_stmt::execute();


  bool mysqli_stmt::fetch();


  int mysqli_stmt_field_count(mysqli_stmt stmt);


  void mysqli_stmt::free_result();


  object mysqli_stmt::get_warnings(mysqli_stmt stmt);


  mixed mysqli_stmt_insert_id(mysqli_stmt stmt);


  int mysqli_stmt_num_rows(mysqli_stmt stmt);


  int mysqli_stmt_param_count(mysqli_stmt stmt);


  mixed mysqli_stmt::prepare(string query);


  bool mysqli_stmt::reset();


  mysqli_result mysqli_stmt::result_metadata();


  bool mysqli_stmt::send_long_data(int param_nr,
                                   string data);


  string mysqli_stmt_sqlstate(mysqli_stmt stmt);


  bool mysqli_stmt::store_result();
}
```

20.10.2.8.1. `mysqli_stmt->affected_rows`, `mysqli_stmt_affected_rows`

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- `mysqli_stmt->affected_rows`

  `mysqli_stmt_affected_rows`

  Returns the total number of rows changed, deleted, or inserted by the last executed statement

Description

Object oriented style

```
mysqli_stmt {
  int affected_rows ;
}
```

Procedural style

```
  int mysqli_stmt_affected_rows(mysqli_stmt stmt);
```

Returns the number of rows affected by `INSERT`, `UPDATE`, or `DELETE` query.

This function only works with queries which update a table. In order to get the number of rows from a SELECT query, use `mysqli_stmt_num_rows` instead.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

An integer greater than zero indicates the number of rows affected or retrieved. Zero indicates that no records where updated for an UPDATE/DELETE statement, no rows matched the WHERE clause in the query or that no query has yet been executed. -1 indicates that the query has returned an error. NULL indicates an invalid argument was supplied to the function.

> **Note**
>
> If the number of affected rows is greater than maximal PHP int value, the number of affected rows will be returned as a string value.

Examples

Example 20.112. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* create temp table */
$mysqli->query("CREATE TEMPORARY TABLE myCountry LIKE Country");

$query = "INSERT INTO myCountry SELECT * FROM Country WHERE Code LIKE ?";

/* prepare statement */
if ($stmt = $mysqli->prepare($query)) {

    /* Bind variable for placeholder */
    $code = 'A%';
    $stmt->bind_param("s", $code);

    /* execute statement */
    $stmt->execute();

    printf("rows inserted: %d\n", $stmt->affected_rows);

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Example 20.113. Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");
```

```
/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* create temp table */
mysqli_query($link, "CREATE TEMPORARY TABLE myCountry LIKE Country");

$query = "INSERT INTO myCountry SELECT * FROM Country WHERE Code LIKE ?";

/* prepare statement */
if ($stmt = mysqli_prepare($link, $query)) {

    /* Bind variable for placeholder */
    $code = 'A%';
    mysqli_stmt_bind_param($stmt, "s", $code);

    /* execute statement */
    mysqli_stmt_execute($stmt);

    printf("rows inserted: %d\n", mysqli_stmt_affected_rows($stmt));

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
rows inserted: 17
```

See Also

`mysqli_stmt_num_rows`
`mysqli_prepare`

20.10.2.8.2. `mysqli_stmt::attr_get`, `mysqli_stmt_attr_get`

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- `mysqli_stmt::attr_get`

  `mysqli_stmt_attr_get`

  Used to get the current value of a statement attribute

Description

Object oriented style

```
int mysqli_stmt::attr_get(int attr);
```

Procedural style

```
int mysqli_stmt_attr_get(mysqli_stmt stmt,
                         int attr);
```

Gets the current value of a statement attribute.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.
`attr`	The attribute that you want to get.

Return Values

Returns `FALSE` if the attribute is not found, otherwise returns the value of the attribute.

20.10.2.8.3. `mysqli_stmt::attr_set`, `mysqli_stmt_attr_set`

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- `mysqli_stmt::attr_set`

  `mysqli_stmt_attr_set`

  Used to modify the behavior of a prepared statement

Description

Object oriented style

```
bool mysqli_stmt::attr_set(int attr,
                           int mode);
```

Procedural style

```
bool mysqli_stmt_attr_set(mysqli_stmt stmt,
                          int attr,
                          int mode);
```

Used to modify the behavior of a prepared statement. This function may be called multiple times to set several attributes.

Parameters

`stmt` Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

`attr` The attribute that you want to set. It can have one of the following values:

Table 20.12. Attribute values

Character	**Description**
MYSQLI_STMT_ATTR_UPDATE_MAX_LENGTH	If set to 1, causes `mysqli_stmt_store_result` to update the metadata `MYSQL_FIELD->max_length` value.
MYSQLI_STMT_ATTR_CURSOR_TYPE	Type of cursor to open for statement when `mysqli_stmt_execute` is invoked. *`mode`* can be `MYSQLI_CURSOR_TYPE_NO_CURSOR` (the default) or `MYSQLI_CURSOR_TYPE_READ_ONLY`.
MYSQLI_STMT_ATTR_PREFETCH_ROWS	Number of rows to fetch from server at a time when using a cursor. *`mode`* can be in the range from 1 to the maximum value of unsigned long. The default is 1.

If you use the `MYSQLI_STMT_ATTR_CURSOR_TYPE` option with `MYSQLI_CURSOR_TYPE_READ_ONLY`, a cursor is opened for the statement when you invoke `mysqli_stmt_execute`. If there is already an open cursor from a previous `mysqli_stmt_execute` call, it closes the cursor before opening a new one. `mysqli_stmt_reset` also closes any open cursor before preparing the statement for re-execution. `mysqli_stmt_free_result` closes any open cursor.

If you open a cursor for a prepared statement, `mysqli_stmt_store_result` is unnecessary.

`mode` The value to assign to the attribute.

20.10.2.8.4. `mysqli_stmt::bind_param`, `mysqli_stmt_bind_param`

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- `mysqli_stmt::bind_param`

  `mysqli_stmt_bind_param`

  Binds variables to a prepared statement as parameters

Description

Object oriented style

```
bool mysqli_stmt::bind_param(string types,
                             mixed var1,
                             mixed ...);
```

Procedural style

```
bool mysqli_stmt_bind_param(mysqli_stmt stmt,
                            string types,
                            mixed var1,
                            mixed ...);
```

Bind variables for the parameter markers in the SQL statement that was passed to `mysqli_prepare`.

> **Note**
>
> If data size of a variable exceeds max. allowed packet size (max_allowed_packet), you have to specify `b` in *`types`* and use `mysqli_stmt_send_long_data` to send the data in packets.

> **Note**
>
> Care must be taken when using `mysqli_stmt_bind_param` in conjunction with `call_user_func_array`. Note that `mysqli_stmt_bind_param` requires parameters to be passed by reference, whereas `call_user_func_array` can accept as a parameter a list of variables that can represent references or values.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.
`types`	A string that contains one or more characters which specify the types for the corresponding bind variables:

Table 20.13. Type specification chars

Character	Description
i	corresponding variable has type integer
d	corresponding variable has type double
s	corresponding variable has type string
b	corresponding variable is a blob and will be sent in packets

`var1`	The number of variables and length of string *`types`* must match the parameters in the statement.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.114. Object oriented style

```
<?php
$mysqli = new mysqli('localhost', 'my_user', 'my_password', 'world');

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$stmt = $mysqli->prepare("INSERT INTO CountryLanguage VALUES (?, ?, ?, ?)");
$stmt->bind_param('sssd', $code, $language, $official, $percent);

$code = 'DEU';
$language = 'Bavarian';
$official = "F";
$percent = 11.2;

/* execute prepared statement */
$stmt->execute();

printf("%d Row inserted.\n", $stmt->affected_rows);

/* close statement and connection */
$stmt->close();

/* Clean up table CountryLanguage */
$mysqli->query("DELETE FROM CountryLanguage WHERE Language='Bavarian'");
printf("%d Row deleted.\n", $mysqli->affected_rows);

/* close connection */
$mysqli->close();
?>
```

Example 20.115. Procedural style

```
<?php
$link = mysqli_connect('localhost', 'my_user', 'my_password', 'world');

/* check connection */
if (!$link) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$stmt = mysqli_prepare($link, "INSERT INTO CountryLanguage VALUES (?, ?, ?, ?)");
mysqli_stmt_bind_param($stmt, 'sssd', $code, $language, $official, $percent);

$code = 'DEU';
$language = 'Bavarian';
$official = "F";
$percent = 11.2;

/* execute prepared statement */
mysqli_stmt_execute($stmt);

printf("%d Row inserted.\n", mysqli_stmt_affected_rows($stmt));

/* close statement and connection */
mysqli_stmt_close($stmt);

/* Clean up table CountryLanguage */
mysqli_query($link, "DELETE FROM CountryLanguage WHERE Language='Bavarian'");
printf("%d Row deleted.\n", mysqli_affected_rows($link));

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
1 Row inserted.
1 Row deleted.
```

See Also

`mysqli_stmt_bind_result`
`mysqli_stmt_execute`
`mysqli_stmt_fetch`
`mysqli_prepare`
`mysqli_stmt_send_long_data`
`mysqli_stmt_errno`
`mysqli_stmt_error`

20.10.2.8.5. `mysqli_stmt::bind_result`, `mysqli_stmt_bind_result`

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- `mysqli_stmt::bind_result`

  `mysqli_stmt_bind_result`

  Binds variables to a prepared statement for result storage

Description

Object oriented style

```
  bool mysqli_stmt::bind_result(mixed var1,
                                mixed ...);
```

Procedural style

```
  bool mysqli_stmt_bind_result(mysqli_stmt stmt,
                               mixed var1,
                               mixed ...);
```

Binds columns in the result set to variables.

When `mysqli_stmt_fetch` is called to fetch data, the MySQL client/server protocol places the data for the bound columns into the specified variables *`var1, ...`*.

> **Note**
>
> Note that all columns must be bound after `mysqli_stmt_execute` and prior to calling `mysqli_stmt_fetch`. Depending on column types bound variables can silently change to the corresponding PHP type.
>
> A column can be bound or rebound at any time, even after a result set has been partially retrieved. The new binding takes effect the next time `mysqli_stmt_fetch` is called.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.
`var1`	The variable to be bound.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.116. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* prepare statement */
if ($stmt = $mysqli->prepare("SELECT Code, Name FROM Country ORDER BY Name LIMIT 5")) {
    $stmt->execute();

    /* bind variables to prepared statement */
    $stmt->bind_result($col1, $col2);

    /* fetch values */
    while ($stmt->fetch()) {
        printf("%s %s\n", $col1, $col2);
    }

    /* close statement */
    $stmt->close();
}
/* close connection */
$mysqli->close();

?>
```

Example 20.117. Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (!$link) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* prepare statement */
if ($stmt = mysqli_prepare($link, "SELECT Code, Name FROM Country ORDER BY Name LIMIT 5")) {
    mysqli_stmt_execute($stmt);

    /* bind variables to prepared statement */
    mysqli_stmt_bind_result($stmt, $col1, $col2);

    /* fetch values */
    while (mysqli_stmt_fetch($stmt)) {
        printf("%s %s\n", $col1, $col2);
    }

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
AFG Afghanistan
ALB Albania
DZA Algeria
ASM American Samoa
AND Andorra
```

See Also

`mysqli_stmt_bind_param`
`mysqli_stmt_execute`
`mysqli_stmt_fetch`
`mysqli_prepare`
`mysqli_stmt_prepare`
`mysqli_stmt_init`
`mysqli_stmt_errno`

`mysqli_stmt_error`

20.10.2.8.6. `mysqli_stmt::close`, `mysqli_stmt_close`

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- `mysqli_stmt::close`

  `mysqli_stmt_close`

  Closes a prepared statement

Description

Object oriented style

```
bool mysqli_stmt::close();
```

Procedural style

```
bool mysqli_stmt_close(mysqli_stmt stmt);
```

Closes a prepared statement. `mysqli_stmt_close` also deallocates the statement handle. If the current statement has pending or unread results, this function cancels them so that the next query can be executed.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

See Also

`mysqli_prepare`

20.10.2.8.7. `mysqli_stmt::data_seek`, `mysqli_stmt_data_seek`

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- `mysqli_stmt::data_seek`

  `mysqli_stmt_data_seek`

  Seeks to an arbitrary row in statement result set

Description

Object oriented style

```
void mysqli_stmt::data_seek(int offset);
```

Procedural style

```
void mysqli_stmt_data_seek(mysqli_stmt stmt,
                           int offset);
```

Seeks to an arbitrary result pointer in the statement result set.

`mysqli_stmt_store_result` must be called prior to `mysqli_stmt_data_seek`.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.
`offset`	Must be between zero and the total number of rows minus one (0.. `mysqli_stmt_num_rows` - 1).

Return Values

No value is returned.

Examples

Example 20.118. Object oriented style

```
<?php
/* Open a connection */
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name";
if ($stmt = $mysqli->prepare($query)) {

    /* execute query */
    $stmt->execute();

    /* bind result variables */
    $stmt->bind_result($name, $code);

    /* store result */
    $stmt->store_result();

    /* seek to row no. 400 */
    $stmt->data_seek(399);

    /* fetch values */
    $stmt->fetch();

    printf ("City: %s  Countrycode: %s\n", $name, $code);

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Example 20.119. Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name";
if ($stmt = mysqli_prepare($link, $query)) {

    /* execute query */
    mysqli_stmt_execute($stmt);

    /* bind result variables */
    mysqli_stmt_bind_result($stmt, $name, $code);

    /* store result */
    mysqli_stmt_store_result($stmt);

    /* seek to row no. 400 */
    mysqli_stmt_data_seek($stmt, 399);
    /* fetch values */
    mysqli_stmt_fetch($stmt);

    printf ("City: %s  Countrycode: %s\n", $name, $code);

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
City: Benin City  Countrycode: NGA
```

See Also

`mysqli_prepare`

20.10.2.8.8. `mysqli_stmt->errno`, `mysqli_stmt_errno`

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- `mysqli_stmt->errno`

  `mysqli_stmt_errno`

  Returns the error code for the most recent statement call

Description

Object oriented style

```
 mysqli_stmt {

  int errno ;

}
```

Procedural style

```
  int mysqli_stmt_errno(mysqli_stmt stmt);
```

Returns the error code for the most recently invoked statement function that can succeed or fail.

Client error message numbers are listed in the MySQL `errmsg.h` header file, server error message numbers are listed in `mysqld_error.h`. In the MySQL source distribution you can find a complete list of error messages and error numbers in the file `Docs/mysqld_error.txt`.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

An error code value. Zero means no error occurred.

Examples

Example 20.120. Object oriented style

```
<?php
/* Open a connection */
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$mysqli->query("CREATE TABLE myCountry LIKE Country");
$mysqli->query("INSERT INTO myCountry SELECT * FROM Country");


$query = "SELECT Name, Code FROM myCountry ORDER BY Name";
if ($stmt = $mysqli->prepare($query)) {

    /* drop table */
    $mysqli->query("DROP TABLE myCountry");

    /* execute query */
    $stmt->execute();

    printf("Error: %d.\n", $stmt->errno);

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Example 20.121. Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

mysqli_query($link, "CREATE TABLE myCountry LIKE Country");
mysqli_query($link, "INSERT INTO myCountry SELECT * FROM Country");


$query = "SELECT Name, Code FROM myCountry ORDER BY Name";
if ($stmt = mysqli_prepare($link, $query)) {

    /* drop table */
    mysqli_query($link, "DROP TABLE myCountry");

    /* execute query */
    mysqli_stmt_execute($stmt);

    printf("Error: %d.\n", mysqli_stmt_errno($stmt));

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Error: 1146.
```

See Also

`mysqli_stmt_error`
`mysqli_stmt_sqlstate`

20.10.2.8.9. `mysqli_stmt->error`, `mysqli_stmt_error`

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- `mysqli_stmt->error`

  `mysqli_stmt_error`

  Returns a string description for last statement error

Description

Object oriented style

```
 mysqli_stmt {

  string error ;

}
```

Procedural style

```
  string mysqli_stmt_error(mysqli_stmt stmt);
```

Returns a containing the error message for the most recently invoked statement function that can succeed or fail.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

A string that describes the error. An empty string if no error occurred.

Examples

Example 20.122. Object oriented style

```
<?php
/* Open a connection */
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$mysqli->query("CREATE TABLE myCountry LIKE Country");
$mysqli->query("INSERT INTO myCountry SELECT * FROM Country");


$query = "SELECT Name, Code FROM myCountry ORDER BY Name";
if ($stmt = $mysqli->prepare($query)) {

    /* drop table */
    $mysqli->query("DROP TABLE myCountry");

    /* execute query */
    $stmt->execute();

    printf("Error: %s.\n", $stmt->error);

    /* close statement */
    $stmt->close();
}
```

```
/* close connection */
$mysqli->close();
?>
```

Example 20.123. Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

mysqli_query($link, "CREATE TABLE myCountry LIKE Country");
mysqli_query($link, "INSERT INTO myCountry SELECT * FROM Country");


$query = "SELECT Name, Code FROM myCountry ORDER BY Name";
if ($stmt = mysqli_prepare($link, $query)) {

    /* drop table */
    mysqli_query($link, "DROP TABLE myCountry");

    /* execute query */
    mysqli_stmt_execute($stmt);

    printf("Error: %s.\n", mysqli_stmt_error($stmt));

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Error: Table 'world.myCountry' doesn't exist.
```

See Also

`mysqli_stmt_errno`
`mysqli_stmt_sqlstate`

20.10.2.8.10. `mysqli_stmt::execute`, `mysqli_stmt_execute`

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- `mysqli_stmt::execute`

  `mysqli_stmt_execute`

  Executes a prepared Query

Description

Object oriented style

```
bool mysqli_stmt::execute();
```

Procedural style

```
bool mysqli_stmt_execute(mysqli_stmt stmt);
```

Executes a query that has been previously prepared using the `mysqli_prepare` function. When executed any parameter markers which exist will automatically be replaced with the appropriate data.

If the statement is `UPDATE`, `DELETE`, or `INSERT`, the total number of affected rows can be determined by using the `mysqli_stmt_affected_rows` function. Likewise, if the query yields a result set the `mysqli_stmt_fetch` function is used.

> **Note**
>
> When using `mysqli_stmt_execute`, the `mysqli_stmt_fetch` function must be used to fetch the data prior to performing any additional queries.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.124. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$mysqli->query("CREATE TABLE myCity LIKE City");

/* Prepare an insert statement */
$query = "INSERT INTO myCity (Name, CountryCode, District) VALUES (?,?,?)";
$stmt = $mysqli->prepare($query);

$stmt->bind_param("sss", $val1, $val2, $val3);

$val1 = 'Stuttgart';
$val2 = 'DEU';
$val3 = 'Baden-Wuerttemberg';

/* Execute the statement */
$stmt->execute();

$val1 = 'Bordeaux';
$val2 = 'FRA';
$val3 = 'Aquitaine';

/* Execute the statement */
$stmt->execute();

/* close statement */
$stmt->close();

/* retrieve all rows from myCity */
$query = "SELECT Name, CountryCode, District FROM myCity";
if ($result = $mysqli->query($query)) {
    while ($row = $result->fetch_row()) {
        printf("%s (%s,%s)\n", $row[0], $row[1], $row[2]);
    }
    /* free result set */
    $result->close();
}

/* remove table */
$mysqli->query("DROP TABLE myCity");

/* close connection */
$mysqli->close();
?>
```

Example 20.125. Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

mysqli_query($link, "CREATE TABLE myCity LIKE City");

/* Prepare an insert statement */
$query = "INSERT INTO myCity (Name, CountryCode, District) VALUES (?,?,?)";
$stmt = mysqli_prepare($link, $query);

mysqli_stmt_bind_param($stmt, "sss", $val1, $val2, $val3);

$val1 = 'Stuttgart';
$val2 = 'DEU';
$val3 = 'Baden-Wuerttemberg';

/* Execute the statement */
mysqli_stmt_execute($stmt);

$val1 = 'Bordeaux';
$val2 = 'FRA';
$val3 = 'Aquitaine';

/* Execute the statement */
mysqli_stmt_execute($stmt);

/* close statement */
mysqli_stmt_close($stmt);

/* retrieve all rows from myCity */
$query = "SELECT Name, CountryCode, District FROM myCity";
if ($result = mysqli_query($link, $query)) {
    while ($row = mysqli_fetch_row($result)) {
        printf("%s (%s,%s)\n", $row[0], $row[1], $row[2]);
    }
    /* free result set */
    mysqli_free_result($result);
}

/* remove table */
mysqli_query($link, "DROP TABLE myCity");

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Stuttgart (DEU,Baden-Wuerttemberg)
Bordeaux (FRA,Aquitaine)
```

See Also

`mysqli_prepare`
`mysqli_stmt_bind_param`

20.10.2.8.11. `mysqli_stmt::fetch`, `mysqli_stmt_fetch`

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- `mysqli_stmt::fetch`

  `mysqli_stmt_fetch`

  Fetch results from a prepared statement into the bound variables

Description

Object oriented style

```
bool mysqli_stmt::fetch();
```

Procedural style

```
bool mysqli_stmt_fetch(mysqli_stmt stmt);
```

Fetch the result from a prepared statement into the variables bound by `mysqli_stmt_bind_result`.

> **Note**
>
> Note that all columns must be bound by the application before calling `mysqli_stmt_fetch`.

> **Note**
>
> Data are transferred unbuffered without calling `mysqli_stmt_store_result` which can decrease performance (but reduces memory cost).

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Table 20.14. Return Values

Value	Description
`TRUE`	Success. Data has been fetched
`FALSE`	Error occurred
`NULL`	No more rows/data exists or data truncation occurred

Examples

Example 20.126. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 150,5";

if ($stmt = $mysqli->prepare($query)) {

    /* execute statement */
    $stmt->execute();

    /* bind result variables */
    $stmt->bind_result($name, $code);

    /* fetch values */
    while ($stmt->fetch()) {
        printf ("%s (%s)\n", $name, $code);
    }

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Example 20.127. Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 150,5";

if ($stmt = mysqli_prepare($link, $query)) {

    /* execute statement */
    mysqli_stmt_execute($stmt);

    /* bind result variables */
    mysqli_stmt_bind_result($stmt, $name, $code);

    /* fetch values */
    while (mysqli_stmt_fetch($stmt)) {
        printf ("%s (%s)\n", $name, $code);
    }

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Rockford (USA)
Tallahassee (USA)
Salinas (USA)
Santa Clarita (USA)
Springfield (USA)
```

See Also

`mysqli_prepare`
`mysqli_stmt_errno`
`mysqli_stmt_error`
`mysqli_stmt_bind_result`

20.10.2.8.12. `mysqli_stmt->field_count`, `mysqli_stmt_field_count`

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- `mysqli_stmt->field_count`

  `mysqli_stmt_field_count`

  Returns the number of field in the given statement

Description

Object oriented style

```
 mysqli_stmt {

  int field_count ;

}
```

Procedural style

```
int mysqli_stmt_field_count(mysqli_stmt stmt);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

20.10.2.8.13. `mysqli_stmt::free_result`, `mysqli_stmt_free_result`

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- `mysqli_stmt::free_result`

  `mysqli_stmt_free_result`

  Frees stored result memory for the given statement handle

Description

Object oriented style

```
void mysqli_stmt::free_result();
```

Procedural style

```
void mysqli_stmt_free_result(mysqli_stmt stmt);
```

Frees the result memory associated with the statement, which was allocated by `mysqli_stmt_store_result`.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

No value is returned.

See Also

`mysqli_stmt_store_result`

20.10.2.8.14. `mysqli_stmt::get_warnings`, `mysqli_stmt_get_warnings`

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- `mysqli_stmt::get_warnings`

  `mysqli_stmt_get_warnings`

  Get result of SHOW WARNINGS

Description

Object oriented style

```
object mysqli_stmt::get_warnings(mysqli_stmt stmt);
```

Procedural style

```
object mysqli_stmt_get_warnings(mysqli_stmt stmt);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

20.10.2.8.15. `mysqli_stmt->insert_id`, `mysqli_stmt_insert_id`

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- `mysqli_stmt->insert_id`

  `mysqli_stmt_insert_id`

  Get the ID generated from the previous INSERT operation

Description

Object oriented style

```
 mysqli_stmt {
  int insert_id ;
}
```

Procedural style

```
  mixed mysqli_stmt_insert_id(mysqli_stmt stmt);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

20.10.2.8.16. `mysqli_stmt::num_rows`, `mysqli_stmt_num_rows`

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- `mysqli_stmt::num_rows`

  `mysqli_stmt_num_rows`

  Return the number of rows in statements result set

Description

Object oriented style

```
 mysqli_stmt {
  int num_rows ;
}
```

Procedural style

```
  int mysqli_stmt_num_rows(mysqli_stmt stmt);
```

Returns the number of rows in the result set. The use of `mysqli_stmt_num_rows` depends on whether or not you used `mysqli_stmt_store_result` to buffer the entire result set in the statement handle.

If you use `mysqli_stmt_store_result`, `mysqli_stmt_num_rows` may be called immediately.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

An integer representing the number of rows in result set.

Examples

Example 20.128. Object oriented style

```
<?php
/* Open a connection */
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name LIMIT 20";
if ($stmt = $mysqli->prepare($query)) {

    /* execute query */
    $stmt->execute();

    /* store result */
    $stmt->store_result();

    printf("Number of rows: %d.\n", $stmt->num_rows);

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Example 20.129. Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name LIMIT 20";
if ($stmt = mysqli_prepare($link, $query)) {

    /* execute query */
    mysqli_stmt_execute($stmt);

    /* store result */
    mysqli_stmt_store_result($stmt);

    printf("Number of rows: %d.\n", mysqli_stmt_num_rows($stmt));

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Number of rows: 20.
```

See Also

`mysqli_stmt_affected_rows`
`mysqli_prepare`
`mysqli_stmt_store_result`

20.10.2.8.17. `mysqli_stmt->param_count`, `mysqli_stmt_param_count`

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- `mysqli_stmt->param_count`

  `mysqli_stmt_param_count`

  Returns the number of parameter for the given statement

Description

Object oriented style

```
 mysqli_stmt {

  int param_count ;

}
```

Procedural style

```
  int mysqli_stmt_param_count(mysqli_stmt stmt);
```

Returns the number of parameter markers present in the prepared statement.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Returns an integer representing the number of parameters.

Examples

Example 20.130. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if ($stmt = $mysqli->prepare("SELECT Name FROM Country WHERE Name=? OR Code=?")) {

    $marker = $stmt->param_count;
    printf("Statement has %d markers.\n", $marker);

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Example 20.131. Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if ($stmt = mysqli_prepare($link, "SELECT Name FROM Country WHERE Name=? OR Code=?")) {

    $marker = mysqli_stmt_param_count($stmt);
    printf("Statement has %d markers.\n", $marker);

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Statement has 2 markers.
```

See Also

`mysqli_prepare`

20.10.2.8.18. `mysqli_stmt::prepare`, `mysqli_stmt_prepare`

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- `mysqli_stmt::prepare`

  `mysqli_stmt_prepare`

  Prepare an SQL statement for execution

Description

Object oriented style

```
mixed mysqli_stmt::prepare(string query);
```

Procedural style

```
bool mysqli_stmt_prepare(mysqli_stmt stmt,
                         string query);
```

Prepares the SQL query pointed to by the null-terminated string query.

The parameter markers must be bound to application variables using `mysqli_stmt_bind_param` and/or `mysqli_stmt_bind_result` before executing the statement or fetching rows.

> **Note**
>
> In the case where you pass a statement to `mysqli_stmt_prepare` that is longer than `max_allowed_packet` of the server, the returned error codes are different depending on whether you are using MySQL Native Driver (`mysqlnd`) or MySQL Client Library (`libmysql`). The behavior is as follows:

- `mysqlnd` on Linux returns an error code of 1153. The error message means “got a packet bigger than `max_allowed_packet` bytes”.
- `mysqlnd` on Windows returns an error code 2006. This error message means “server has gone away”.
- `libmysql` on all platforms returns an error code 2006. This error message means “server has gone away”.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.
`query`	The query, as a string. It must consist of a single SQL statement. You can include one or more parameter markers in the SQL statement by embedding question mark (`?`) characters at the appropriate positions.

Note

You should not add a terminating semicolon or `\g` to the statement.

Note

The markers are legal only in certain places in SQL statements. For example, they are allowed in the VALUES() list of an INSERT statement (to specify column values for a row), or in a comparison with a column in a WHERE clause to specify a comparison value.

However, they are not allowed for identifiers (such as table or column names), in the select list that names the columns to be returned by a SELECT statement), or to specify both operands of a binary operator such as the `=` equal sign. The latter restriction is necessary because it would be impossible to determine the parameter type. In general, parameters are legal only in Data Manipulation Language (DML) statements, and not in Data Definition Language (DDL) statements.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.132. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$city = "Amersfoort";

/* create a prepared statement */
$stmt =  $mysqli->stmt_init();
if ($stmt->prepare("SELECT District FROM City WHERE Name=?")) {

    /* bind parameters for markers */
    $stmt->bind_param("s", $city);

    /* execute query */
    $stmt->execute();

    /* bind result variables */
    $stmt->bind_result($district);

    /* fetch value */
    $stmt->fetch();

    printf("%s is in district %s\n", $city, $district);

    /* close statement */
    $stmt->close();
}

/* close connection */
```

```
$mysqli->close();
?>
```

Example 20.133. Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$city = "Amersfoort";

/* create a prepared statement */
$stmt = mysqli_stmt_init($link);
if (mysqli_stmt_prepare($stmt, 'SELECT District FROM City WHERE Name=?')) {

    /* bind parameters for markers */
    mysqli_stmt_bind_param($stmt, "s", $city);

    /* execute query */
    mysqli_stmt_execute($stmt);

    /* bind result variables */
    mysqli_stmt_bind_result($stmt, $district);

    /* fetch value */
    mysqli_stmt_fetch($stmt);

    printf("%s is in district %s\n", $city, $district);

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Amersfoort is in district Utrecht
```

See Also

`mysqli_stmt_init`, `mysqli_stmt_execute`, `mysqli_stmt_fetch`, `mysqli_stmt_bind_param`, `mysqli_stmt_bind_result` `mysqli_stmt_close`.

20.10.2.8.19. `mysqli_stmt::reset`, `mysqli_stmt_reset`

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- `mysqli_stmt::reset`

  `mysqli_stmt_reset`

  Resets a prepared statement

Description

Object oriented style

```
bool mysqli_stmt::reset();
```

Procedural style

```
bool mysqli_stmt_reset(mysqli_stmt stmt);
```

Resets a prepared statement on client and server to state after prepare.

It resets the statement on the server, data sent using `mysqli_stmt_send_long_data`, unbuffered result sets and current errors. It does not clear bindings or stored result sets. Stored result sets will be cleared when executing the prepared statement (or closing it).

To prepare a statement with another query use function `mysqli_stmt_prepare`.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

See Also

`mysqli_prepare`

20.10.2.8.20. `mysqli_stmt::result_metadata`, `mysqli_stmt_result_metadata`

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- `mysqli_stmt::result_metadata`

  `mysqli_stmt_result_metadata`

  Returns result set metadata from a prepared statement

Description

Object oriented style

```
mysqli_result mysqli_stmt::result_metadata();
```

Procedural style

```
mysqli_result mysqli_stmt_result_metadata(mysqli_stmt stmt);
```

If a statement passed to `mysqli_prepare` is one that produces a result set, `mysqli_stmt_result_metadata` returns the result object that can be used to process the meta information such as total number of fields and individual field information.

> **Note**
>
> This result set pointer can be passed as an argument to any of the field-based functions that process result set metadata, such as:
>
> - `mysqli_num_fields`
> - `mysqli_fetch_field`
> - `mysqli_fetch_field_direct`
> - `mysqli_fetch_fields`
> - `mysqli_field_count`
> - `mysqli_field_seek`

> - `mysqli_field_tell`
> - `mysqli_free_result`

The result set structure should be freed when you are done with it, which you can do by passing it to `mysqli_free_result`

> **Note**
>
> The result set returned by `mysqli_stmt_result_metadata` contains only metadata. It does not contain any row results. The rows are obtained by using the statement handle with `mysqli_stmt_fetch`.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Returns a result object or `FALSE` if an error occurred.

Examples

Example 20.134. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "test");

$mysqli->query("DROP TABLE IF EXISTS friends");
$mysqli->query("CREATE TABLE friends (id int, name varchar(20))");

$mysqli->query("INSERT INTO friends VALUES (1,'Hartmut'), (2, 'Ulf')");

$stmt = $mysqli->prepare("SELECT id, name FROM friends");
$stmt->execute();

/* get resultset for metadata */
$result = $stmt->result_metadata();

/* retrieve field information from metadata result set */
$field = $result->fetch_field();

printf("Fieldname: %s\n", $field->name);

/* close resultset */
$result->close();

/* close connection */
$mysqli->close();
?>
```

Example 20.135. Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "test");

mysqli_query($link, "DROP TABLE IF EXISTS friends");
mysqli_query($link, "CREATE TABLE friends (id int, name varchar(20))");

mysqli_query($link, "INSERT INTO friends VALUES (1,'Hartmut'), (2, 'Ulf')");

$stmt = mysqli_prepare($link, "SELECT id, name FROM friends");
mysqli_stmt_execute($stmt);

/* get resultset for metadata */
$result = mysqli_stmt_result_metadata($stmt);

/* retrieve field information from metadata result set */
$field = mysqli_fetch_field($result);

printf("Fieldname: %s\n", $field->name);

/* close resultset */
mysqli_free_result($result);
```

```
/* close connection */
mysqli_close($link);
?>
```

See Also

`mysqli_prepare`
`mysqli_free_result`

20.10.2.8.21. `mysqli_stmt::send_long_data`, `mysqli_stmt_send_long_data`

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- `mysqli_stmt::send_long_data`

  `mysqli_stmt_send_long_data`

  Send data in blocks

Description

Object oriented style

```
  bool mysqli_stmt::send_long_data(int param_nr,
                                   string data);
```

Procedural style

```
  bool mysqli_stmt_send_long_data(mysqli_stmt stmt,
                                  int param_nr,
                                  string data);
```

Allows to send parameter data to the server in pieces (or chunks), e.g. if the size of a blob exceeds the size of `max_allowed_packet`. This function can be called multiple times to send the parts of a character or binary data value for a column, which must be one of the TEXT or BLOB datatypes.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.
`param_nr`	Indicates which parameter to associate the data with. Parameters are numbered beginning with 0.
`data`	A string containing data to be sent.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.136. Object oriented style

```
<?php
$stmt = $mysqli->prepare("INSERT INTO messages (message) VALUES (?)");
$null = NULL;
$stmt->bind_param("b", $null);
$fp = fopen("messages.txt", "r");
while (!feof($fp)) {
    $stmt->send_long_data(0, fread($fp, 8192));
}
fclose($fp);
$stmt->execute();
?>
```

```

```

See Also

`mysqli_prepare`
`mysqli_stmt_bind_param`

20.10.2.8.22. `mysqli_stmt::sqlstate`, `mysqli_stmt_sqlstate`

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- `mysqli_stmt::sqlstate`

  `mysqli_stmt_sqlstate`

  Returns SQLSTATE error from previous statement operation

Description

Object oriented style

```
 mysqli_stmt {

  string sqlstate ;

}
```

Procedural style

```
  string mysqli_stmt_sqlstate(mysqli_stmt stmt);
```

Returns a string containing the SQLSTATE error code for the most recently invoked prepared statement function that can succeed or fail. The error code consists of five characters. `'00000'` means no error. The values are specified by ANSI SQL and ODBC. For a list of possible values, see http://dev.mysql.com/doc/mysql/en/error-handling.html.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Returns a string containing the SQLSTATE error code for the last error. The error code consists of five characters. `'00000'` means no error.

Notes

> **Note**
>
> Note that not all MySQL errors are yet mapped to SQLSTATE's. The value `HY000` (general error) is used for unmapped errors.

Examples

Example 20.137. Object oriented style

```
<?php
/* Open a connection */
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}
```

```
$mysqli->query("CREATE TABLE myCountry LIKE Country");
$mysqli->query("INSERT INTO myCountry SELECT * FROM Country");


$query = "SELECT Name, Code FROM myCountry ORDER BY Name";
if ($stmt = $mysqli->prepare($query)) {

    /* drop table */
    $mysqli->query("DROP TABLE myCountry");

    /* execute query */
    $stmt->execute();

    printf("Error: %s.\n", $stmt->sqlstate);

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

mysqli_query($link, "CREATE TABLE myCountry LIKE Country");
mysqli_query($link, "INSERT INTO myCountry SELECT * FROM Country");


$query = "SELECT Name, Code FROM myCountry ORDER BY Name";
if ($stmt = mysqli_prepare($link, $query)) {

    /* drop table */
    mysqli_query($link, "DROP TABLE myCountry");

    /* execute query */
    mysqli_stmt_execute($stmt);

    printf("Error: %s.\n", mysqli_stmt_sqlstate($stmt));

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Error: 42S02.
```

See Also

`mysqli_stmt_errno`
`mysqli_stmt_error`

20.10.2.8.23. `mysqli_stmt::store_result`, `mysqli_stmt_store_result`

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- `mysqli_stmt::store_result`

`mysqli_stmt_store_result`

Transfers a result set from a prepared statement

Description

Object oriented style

```
bool mysqli_stmt::store_result();
```

Procedural style

```
bool mysqli_stmt_store_result(mysqli_stmt stmt);
```

You must call `mysqli_stmt_store_result` for every query that successfully produces a result set (`SELECT, SHOW, DESCRIBE, EXPLAIN`), and only if you want to buffer the complete result set by the client, so that the subsequent `mysqli_stmt_fetch` call returns buffered data.

> **Note**
>
> It is unnecessary to call `mysqli_stmt_store_result` for other queries, but if you do, it will not harm or cause any notable performance in all cases. You can detect whether the query produced a result set by checking if `mysqli_stmt_result_metadata` returns NULL.

Parameters

`stmt`	Procedural style only: A statement identifier returned by `mysqli_stmt_init`.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.138. Object oriented style

```
<?php
/* Open a connection */
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name LIMIT 20";
if ($stmt = $mysqli->prepare($query)) {

    /* execute query */
    $stmt->execute();

    /* store result */
    $stmt->store_result();

    printf("Number of rows: %d.\n", $stmt->num_rows);

    /* free result */
    $stmt->free_result();

    /* close statement */
    $stmt->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name LIMIT 20";
if ($stmt = mysqli_prepare($link, $query)) {

    /* execute query */
    mysqli_stmt_execute($stmt);

    /* store result */
    mysqli_stmt_store_result($stmt);

    printf("Number of rows: %d.\n", mysqli_stmt_num_rows($stmt));

    /* free result */
    mysqli_stmt_free_result($stmt);

    /* close statement */
    mysqli_stmt_close($stmt);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Number of rows: 20.
```

See Also

`mysqli_prepare`
`mysqli_stmt_result_metadata`
`mysqli_stmt_fetch`

20.10.2.9. The MySQLi_Result class (`MySQLi_Result`)

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Represents the result set obtained from a query against the database.

```
 MySQLi_Result {
 MySQLi_Result

      Properties

  int current_field ;


  int field_count ;


  array lengths ;


  int num_rows ;

Methods

  int mysqli_field_tell(mysqli_result result);


  bool mysqli_result::data_seek(int offset);


  mixed mysqli_result::fetch_all(int resulttype= =MYSQLI_NUM);
  mixed mysqli_result::fetch_array(int resulttype= =MYSQLI_BOTH);

  array mysqli_result::fetch_assoc();

  object mysqli_result::fetch_field_direct(int fieldnr);

  object mysqli_result::fetch_field();

  array mysqli_result::fetch_fields();

  object mysqli_result::fetch_object(string class_name,
                                     array params);

  mixed mysqli_result::fetch_row();

  int mysqli_num_fields(mysqli_result result);

  bool mysqli_result::field_seek(int fieldnr);

  void mysqli_result::free();

  array mysqli_fetch_lengths(mysqli_result result);

  int mysqli_num_rows(mysqli_result result);
}
```

20.10.2.9.1. `mysqli_result->current_field`, `mysqli_field_tell`

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- `mysqli_result->current_field`

  `mysqli_field_tell`

  Get current field offset of a result pointer

Description

Object oriented style

```
 mysqli_result {
  int current_field ;
}
```

Procedural style

```
  int mysqli_field_tell(mysqli_result result);
```

Returns the position of the field cursor used for the last `mysqli_fetch_field` call. This value can be used as an argument to `mysqli_field_seek`.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

Returns current offset of field cursor.

Examples

Example 20.139. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = $mysqli->query($query)) {

    /* Get field information for all columns */
    while ($finfo = $result->fetch_field()) {

        /* get fieldpointer offset */
        $currentfield = $result->current_field;

        printf("Column %d:\n", $currentfield);
        printf("Name:     %s\n", $finfo->name);
        printf("Table:    %s\n", $finfo->table);
        printf("max. Len: %d\n", $finfo->max_length);
        printf("Flags:    %d\n", $finfo->flags);
        printf("Type:     %d\n\n", $finfo->type);
    }
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = mysqli_query($link, $query)) {

    /* Get field information for all fields */
    while ($finfo = mysqli_fetch_field($result)) {

        /* get fieldpointer offset */
        $currentfield = mysqli_field_tell($result);

        printf("Column %d:\n", $currentfield);
        printf("Name:     %s\n", $finfo->name);
        printf("Table:    %s\n", $finfo->table);
        printf("max. Len: %d\n", $finfo->max_length);
        printf("Flags:    %d\n", $finfo->flags);
        printf("Type:     %d\n\n", $finfo->type);
    }
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```


Column 1:
Name:     Name
Table:    Country
max. Len: 11
Flags:    1
Type:     254
```

```
Column 2:
Name:     SurfaceArea
Table:    Country
max. Len: 10
Flags:    32769
Type:     4
```

See Also

`mysqli_fetch_field`
`mysqli_field_seek`

20.10.2.9.2. `mysqli_result::data_seek`, `mysqli_data_seek`

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- `mysqli_result::data_seek`

  `mysqli_data_seek`

  Adjusts the result pointer to an arbitrary row in the result

Description

Object oriented style

```
bool mysqli_result::data_seek(int offset);
```

Procedural style

```
bool mysqli_data_seek(mysqli_result result,
                      int offset);
```

The `mysqli_data_seek` function seeks to an arbitrary result pointer specified by the *`offset`* in the result set.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.
`offset`	The field offset. Must be between zero and the total number of rows minus one (0..`mysqli_num_rows` - 1).

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Notes

> **Note**
>
> This function can only be used with buffered results attained from the use of the `mysqli_store_result` or `mysqli_query` functions.

Examples

Example 20.140. Object oriented style

```
<?php
/* Open a connection */
```

```
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name";
if ($result = $mysqli->query( $query)) {

    /* seek to row no. 400 */
    $result->data_seek(399);

    /* fetch row */
    $row = $result->fetch_row();

    printf ("City: %s  Countrycode: %s\n", $row[0], $row[1]);

    /* free result set*/
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
/* Open a connection */
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (!$link) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER BY Name";

if ($result = mysqli_query($link, $query)) {

    /* seek to row no. 400 */
    mysqli_data_seek($result, 399);

    /* fetch row */
    $row = mysqli_fetch_row($result);

    printf ("City: %s  Countrycode: %s\n", $row[0], $row[1]);

    /* free result set*/
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
City: Benin City  Countrycode: NGA
```

See Also

`mysqli_store_result`
`mysqli_fetch_row`
`mysqli_fetch_array`
`mysqli_fetch_assoc`
`mysqli_fetch_object`
`mysqli_query`
`mysqli_num_rows`

20.10.2.9.3. `mysqli_result::fetch_all`, `mysqli_fetch_all`

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- `mysqli_result::fetch_all`

  `mysqli_fetch_all`

  Fetches all result rows as an associative array, a numeric array, or both

Description

Object oriented style

```
mixed mysqli_result::fetch_all(int resulttype= =MYSQLI_NUM);
```

Procedural style

```
mixed mysqli_fetch_all(mysqli_result result,
                       int resulttype= =MYSQLI_NUM);
```

`mysqli_fetch_all` fetches all result rows and returns the result set as an associative array, a numeric array, or both.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.
`resulttype`	This optional parameter is a constant indicating what type of array should be produced from the current row data. The possible values for this parameter are the constants `MYSQLI_ASSOC` , `MYSQLI_NUM` , or `MYSQLI_BOTH` .

Return Values

Returns an array of associative or numeric arrays holding result rows.

MySQL Native Driver Only

Available only with mysqlnd.

As `mysqli_fetch_all` returns all the rows as an array in a single step, it may consume more memory than some similar functions such as `mysqli_fetch_array`, which only returns one row at a time from the result set. Further, if you need to iterate over the result set, you will need a looping construct that will further impact performance. For these reasons `mysqli_fetch_all` should only be used in those situations where the fetched result set will be sent to another layer for processing.

See Also

`mysqli_fetch_array`
`mysqli_query`

20.10.2.9.4. `mysqli_result::fetch_array`, `mysqli_fetch_array`

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- `mysqli_result::fetch_array`

  `mysqli_fetch_array`

  Fetch a result row as an associative, a numeric array, or both

Description

Object oriented style

```
mixed mysqli_result::fetch_array(int resulttype= =MYSQLI_BOTH);
```

Procedural style

```
mixed mysqli_fetch_array(mysqli_result result,
                         int resulttype= =MYSQLI_BOTH);
```

Returns an array that corresponds to the fetched row or `NULL` if there are no more rows for the resultset represented by the *`result`* parameter.

`mysqli_fetch_array` is an extended version of the `mysqli_fetch_row` function. In addition to storing the data in the numeric indices of the result array, the `mysqli_fetch_array` function can also store the data in associative indices, using the field names of the result set as keys.

> **Note**
>
> Field names returned by this function are *case-sensitive*.

> **Note**
>
> This function sets NULL fields to the PHP `NULL` value.

If two or more columns of the result have the same field names, the last column will take precedence and overwrite the earlier data. In order to access multiple columns with the same name, the numerically indexed version of the row must be used.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.
`resulttype`	This optional parameter is a constant indicating what type of array should be produced from the current row data. The possible values for this parameter are the constants `MYSQLI_ASSOC` , `MYSQLI_NUM` , or `MYSQLI_BOTH` . By using the `MYSQLI_ASSOC` constant this function will behave identically to the `mysqli_fetch_assoc`, while `MYSQLI_NUM` will behave identically to the `mysqli_fetch_row` function. The final option `MYSQLI_BOTH` will create a single array with the attributes of both.

Return Values

Returns an array of strings that corresponds to the fetched row or `NULL` if there are no more rows in resultset.

Examples

Example 20.141. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID LIMIT 3";
$result = $mysqli->query($query);

/* numeric array */
$row = $result->fetch_array(MYSQLI_NUM);
printf ("%s (%s)\n", $row[0], $row[1]);

/* associative array */
$row = $result->fetch_array(MYSQLI_ASSOC);
printf ("%s (%s)\n", $row["Name"], $row["CountryCode"]);

/* associative and numeric array */
$row = $result->fetch_array(MYSQLI_BOTH);
printf ("%s (%s)\n", $row[0], $row["CountryCode"]);
```

```
/* free result set */
$result->close();

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID LIMIT 3";
$result = mysqli_query($link, $query);

/* numeric array */
$row = mysqli_fetch_array($result, MYSQLI_NUM);
printf ("%s (%s)\n", $row[0], $row[1]);

/* associative array */
$row = mysqli_fetch_array($result, MYSQLI_ASSOC);
printf ("%s (%s)\n", $row["Name"], $row["CountryCode"]);

/* associative and numeric array */
$row = mysqli_fetch_array($result, MYSQLI_BOTH);
printf ("%s (%s)\n", $row[0], $row["CountryCode"]);

/* free result set */
mysqli_free_result($result);

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Kabul (AFG)
Qandahar (AFG)
Herat (AFG)
```

See Also

`mysqli_fetch_assoc`
`mysqli_fetch_row`
`mysqli_fetch_object`
`mysqli_query`
`mysqli_data_seek`

20.10.2.9.5. `mysqli_result::fetch_assoc`, `mysqli_fetch_assoc`

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- `mysqli_result::fetch_assoc`

  `mysqli_fetch_assoc`

  Fetch a result row as an associative array

Description

Object oriented style

```
array mysqli_result::fetch_assoc();
```

Procedural style

```
array mysqli_fetch_assoc(mysqli_result result);
```

Returns an associative array that corresponds to the fetched row or `NULL` if there are no more rows.

> **Note**
>
> Field names returned by this function are *case-sensitive*.

> **Note**
>
> This function sets NULL fields to the PHP `NULL` value.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

Returns an associative array of strings representing the fetched row in the result set, where each key in the array represents the name of one of the result set's columns or `NULL` if there are no more rows in resultset.

If two or more columns of the result have the same field names, the last column will take precedence. To access the other column(s) of the same name, you either need to access the result with numeric indices by using `mysqli_fetch_row` or add alias names.

Examples

Example 20.142. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 50,5";

if ($result = $mysqli->query($query)) {

    /* fetch associative array */
    while ($row = $result->fetch_assoc()) {
        printf ("%s (%s)\n", $row["Name"], $row["CountryCode"]);
    }

    /* free result set */
    $result->free();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}
$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 50,5";

if ($result = mysqli_query($link, $query)) {

    /* fetch associative array */
    while ($row = mysqli_fetch_assoc($result)) {
        printf ("%s (%s)\n", $row["Name"], $row["CountryCode"]);
    }

    /* free result set */
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Pueblo (USA)
Arvada (USA)
Cape Coral (USA)
Green Bay (USA)
Santa Clara (USA)
```

See Also

`mysqli_fetch_array`
`mysqli_fetch_row`
`mysqli_fetch_object`
`mysqli_query`
`mysqli_data_seek`

20.10.2.9.6. `mysqli_result::fetch_field_direct`, `mysqli_fetch_field_direct`

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- `mysqli_result::fetch_field_direct`

  `mysqli_fetch_field_direct`

  Fetch meta-data for a single field

Description

Object oriented style

```
  object mysqli_result::fetch_field_direct(int fieldnr);
```

Procedural style

```
  object mysqli_fetch_field_direct(mysqli_result result,
                                   int fieldnr);
```

Returns an object which contains field definition information from the specified result set.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.
`fieldnr`	The field number. This value must be in the range from `0` to `number of fields - 1`.

Return Values

Returns an object which contains field definition information or `FALSE` if no field information for specified `fieldnr` is available.

Table 20.15. Object attributes

Attribute	Description
name	The name of the column
orgname	Original column name if an alias was specified
table	The name of the table this field belongs to (if not calculated)
orgtable	Original table name if an alias was specified
def	The default value for this field, represented as a string
max_length	The maximum width of the field for the result set.
length	The width of the field, as specified in the table definition.
charsetnr	The character set number for the field.
flags	An integer representing the bit-flags for the field.
type	The data type used for this field
decimals	The number of decimals used (for integer fields)

Examples

Example 20.143. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Name LIMIT 5";

if ($result = $mysqli->query($query)) {

    /* Get field information for column 'SurfaceArea' */
    $finfo = $result->fetch_field_direct(1);

    printf("Name:     %s\n", $finfo->name);
    printf("Table:    %s\n", $finfo->table);
    printf("max. Len: %d\n", $finfo->max_length);
    printf("Flags:    %d\n", $finfo->flags);
    printf("Type:     %d\n", $finfo->type);

    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Name LIMIT 5";

if ($result = mysqli_query($link, $query)) {

    /* Get field information for column 'SurfaceArea' */
    $finfo = mysqli_fetch_field_direct($result, 1);
    printf("Name:     %s\n", $finfo->name);
    printf("Table:    %s\n", $finfo->table);
    printf("max. Len: %d\n", $finfo->max_length);
    printf("Flags:    %d\n", $finfo->flags);
    printf("Type:     %d\n", $finfo->type);

    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Name:     SurfaceArea
Table:    Country
max. Len: 10
Flags:    32769
Type:     4
```

See Also

`mysqli_num_fields`
`mysqli_fetch_field`
`mysqli_fetch_fields`

20.10.2.9.7. `mysqli_result::fetch_field`, `mysqli_fetch_field`

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- `mysqli_result::fetch_field`

  `mysqli_fetch_field`

  Returns the next field in the result set

Description

Object oriented style

```
object mysqli_result::fetch_field();
```

Procedural style

```
object mysqli_fetch_field(mysqli_result result);
```

Returns the definition of one column of a result set as an object. Call this function repeatedly to retrieve information about all columns in the result set.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

Returns an object which contains field definition information or `FALSE` if no field information is available.

Table 20.16. Object properties

Property	Description
name	The name of the column
orgname	Original column name if an alias was specified
table	The name of the table this field belongs to (if not calculated)
orgtable	Original table name if an alias was specified
max_length	The maximum width of the field for the result set.
length	The width of the field, as specified in the table definition.
charsetnr	The character set number for the field.
flags	An integer representing the bit-flags for the field.
type	The data type used for this field
decimals	The number of decimals used (for integer fields)

Examples

Example 20.144. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = $mysqli->query($query)) {

    /* Get field information for all columns */
    while ($finfo = $result->fetch_field()) {

        printf("Name:     %s\n", $finfo->name);
        printf("Table:    %s\n", $finfo->table);
        printf("max. Len: %d\n", $finfo->max_length);
        printf("Flags:    %d\n", $finfo->flags);
        printf("Type:     %d\n\n", $finfo->type);
    }
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = mysqli_query($link, $query)) {

    /* Get field information for all fields */
    while ($finfo = mysqli_fetch_field($result)) {

        printf("Name:     %s\n", $finfo->name);
        printf("Table:    %s\n", $finfo->table);
        printf("max. Len: %d\n", $finfo->max_length);
        printf("Flags:    %d\n", $finfo->flags);
        printf("Type:     %d\n\n", $finfo->type);
    }
    mysqli_free_result($result);
}
```

```
/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```


Name:     Name
Table:    Country
max. Len: 11
Flags:    1
Type:     254

Name:     SurfaceArea
Table:    Country
max. Len: 10
Flags:    32769
Type:     4
```

See Also

`mysqli_num_fields`
`mysqli_fetch_field_direct`
`mysqli_fetch_fields`
`mysqli_field_seek`

20.10.2.9.8. `mysqli_result::fetch_fields`, `mysqli_fetch_fields`

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- `mysqli_result::fetch_fields`

  `mysqli_fetch_fields`

  Returns an array of objects representing the fields in a result set

Description

Object oriented style

```
array mysqli_result::fetch_fields();
```

Procedural style

```
array mysqli_fetch_fields(mysqli_result result);
```

This function serves an identical purpose to the `mysqli_fetch_field` function with the single difference that, instead of returning one object at a time for each field, the columns are returned as an array of objects.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

Returns an array of objects which contains field definition information or `FALSE` if no field information is available.

Table 20.17. Object properties

Property	Description
name	The name of the column
orgname	Original column name if an alias was specified
table	The name of the table this field belongs to (if not calculated)
orgtable	Original table name if an alias was specified
max_length	The maximum width of the field for the result set.
length	The width of the field, as specified in the table definition.
charsetnr	The character set number for the field.
flags	An integer representing the bit-flags for the field.
type	The data type used for this field
decimals	The number of decimals used (for integer fields)

Examples

Example 20.145. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = $mysqli->query($query)) {

    /* Get field information for all columns */
    $finfo = $result->fetch_fields();

    foreach ($finfo as $val) {
        printf("Name:     %s\n", $val->name);
        printf("Table:    %s\n", $val->table);
        printf("max. Len: %d\n", $val->max_length);
        printf("Flags:    %d\n", $val->flags);
        printf("Type:     %d\n\n", $val->type);
    }
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = mysqli_query($link, $query)) {

    /* Get field information for all columns */
    $finfo = mysqli_fetch_fields($result);

    foreach ($finfo as $val) {
        printf("Name:     %s\n", $val->name);
        printf("Table:    %s\n", $val->table);
        printf("max. Len: %d\n", $val->max_length);
        printf("Flags:    %d\n", $val->flags);
        printf("Type:     %d\n\n", $val->type);
    }
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
```

```
?>
```

The above examples will output:

```


Name:     Name
Table:    Country
max. Len: 11
Flags:    1
Type:     254

Name:     SurfaceArea
Table:    Country
max. Len: 10
Flags:    32769
Type:     4
```

See Also

`mysqli_num_fields`
`mysqli_fetch_field_direct`
`mysqli_fetch_field`

20.10.2.9.9. `mysqli_result::fetch_object`, `mysqli_fetch_object`

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- `mysqli_result::fetch_object`

  `mysqli_fetch_object`

  Returns the current row of a result set as an object

Description

Object oriented style

```
  object mysqli_result::fetch_object(string class_name,
                                     array params);
```

Procedural style

```
  object mysqli_fetch_object(mysqli_result result,
                             string class_name,
                             array params);
```

The `mysqli_fetch_object` will return the current row result set as an object where the attributes of the object represent the names of the fields found within the result set.

Note that `mysqli_fetch_object` sets the properties of the object before calling the object constructor.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.
`class_name`	The name of the class to instantiate, set the properties of and return. If not specified, a `stdClass` object is returned.
`params`	An optional array of parameters to pass to the constructor for *`class_name`* objects.

Return Values

Returns an object with string properties that corresponds to the fetched row or `NULL` if there are no more rows in resultset.

> **Note**
>
> Field names returned by this function are *case-sensitive*.

> **Note**
>
> This function sets NULL fields to the PHP `NULL` value.

Changelog

Version	Description
5.0.0	Added the ability to return as a different object.

Examples

Example 20.146. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 50,5";

if ($result = $mysqli->query($query)) {

    /* fetch object array */
    while ($obj = $result->fetch_object()) {
        printf ("%s (%s)\n", $obj->Name, $obj->CountryCode);
    }

    /* free result set */
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 50,5";

if ($result = mysqli_query($link, $query)) {

    /* fetch associative array */
    while ($obj = mysqli_fetch_object($result)) {
        printf ("%s (%s)\n", $obj->Name, $obj->CountryCode);
    }

    /* free result set */
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Pueblo (USA)
Arvada (USA)
Cape Coral (USA)
Green Bay (USA)
Santa Clara (USA)
```

See Also

`mysqli_fetch_array`
`mysqli_fetch_assoc`
`mysqli_fetch_row`
`mysqli_query`
`mysqli_data_seek`

20.10.2.9.10. `mysqli_result::fetch_row`, `mysqli_fetch_row`

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- `mysqli_result::fetch_row`

  `mysqli_fetch_row`

  Get a result row as an enumerated array

Description

Object oriented style

```
mixed mysqli_result::fetch_row();
```

Procedural style

```
mixed mysqli_fetch_row(mysqli_result result);
```

Fetches one row of data from the result set and returns it as an enumerated array, where each column is stored in an array offset starting from 0 (zero). Each subsequent call to this function will return the next row within the result set, or `NULL` if there are no more rows.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

`mysqli_fetch_row` returns an array of strings that corresponds to the fetched row or `NULL` if there are no more rows in result set.

> **Note**
>
> This function sets NULL fields to the PHP `NULL` value.

Examples

Example 20.147. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 50,5";

if ($result = $mysqli->query($query)) {

    /* fetch object array */
    while ($row = $result->fetch_row()) {
        printf ("%s (%s)\n", $row[0], $row[1]);
    }

    /* free result set */
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, CountryCode FROM City ORDER by ID DESC LIMIT 50,5";

if ($result = mysqli_query($link, $query)) {

    /* fetch associative array */
    while ($row = mysqli_fetch_row($result)) {
        printf ("%s (%s)\n", $row[0], $row[1]);
    }

    /* free result set */
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Pueblo (USA)
Arvada (USA)
Cape Coral (USA)
Green Bay (USA)
Santa Clara (USA)
```

See Also

`mysqli_fetch_array`
`mysqli_fetch_assoc`
`mysqli_fetch_object`
`mysqli_query`
`mysqli_data_seek`

20.10.2.9.11. `mysqli_result->field_count`, `mysqli_num_fields`

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- `mysqli_result->field_count`

  `mysqli_num_fields`

  Get the number of fields in a result

Description

Object oriented style

```
 mysqli_result {

  int field_count ;

}
```

Procedural style

```
  int mysqli_num_fields(mysqli_result result);
```

Returns the number of fields from specified result set.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

The number of fields from a result set.

Examples

Example 20.148. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if ($result = $mysqli->query("SELECT * FROM City ORDER BY ID LIMIT 1")) {

    /* determine number of fields in result set */
    $field_cnt = $result->field_count;

    printf("Result set has %d fields.\n", $field_cnt);

    /* close result set */
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if ($result = mysqli_query($link, "SELECT * FROM City ORDER BY ID LIMIT 1")) {
    /* determine number of fields in result set */
    $field_cnt = mysqli_num_fields($result);

    printf("Result set has %d fields.\n", $field_cnt);

    /* close result set */
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Result set has 5 fields.
```

See Also

`mysqli_fetch_field`

20.10.2.9.12. `mysqli_result::field_seek`, `mysqli_field_seek`

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- `mysqli_result::field_seek`

  `mysqli_field_seek`

  Set result pointer to a specified field offset

Description

Object oriented style

```
  bool mysqli_result::field_seek(int fieldnr);
```

Procedural style

```
  bool mysqli_field_seek(mysqli_result result,
                         int fieldnr);
```

Sets the field cursor to the given offset. The next call to `mysqli_fetch_field` will retrieve the field definition of the column associated with that offset.

> **Note**
>
> To seek to the beginning of a row, pass an offset value of zero.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.
`fieldnr`	The field number. This value must be in the range from `0` to `number of fields - 1`.

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Examples

Example 20.149. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = $mysqli->query($query)) {

    /* Get field information for 2nd column */
    $result->field_seek(1);
    $finfo = $result->fetch_field();

    printf("Name:     %s\n", $finfo->name);
    printf("Table:    %s\n", $finfo->table);
    printf("max. Len: %d\n", $finfo->max_length);
    printf("Flags:    %d\n", $finfo->flags);
    printf("Type:     %d\n\n", $finfo->type);

    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT Name, SurfaceArea from Country ORDER BY Code LIMIT 5";

if ($result = mysqli_query($link, $query)) {

    /* Get field information for 2nd column */
    mysqli_field_seek($result, 1);
    $finfo = mysqli_fetch_field($result);

    printf("Name:     %s\n", $finfo->name);
    printf("Table:    %s\n", $finfo->table);
    printf("max. Len: %d\n", $finfo->max_length);
    printf("Flags:    %d\n", $finfo->flags);
    printf("Type:     %d\n\n", $finfo->type);

    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Name:     SurfaceArea
Table:    Country
max. Len: 10
Flags:    32769
Type:     4
```

See Also

`mysqli_fetch_field`

20.10.2.9.13. `mysqli_result::free`, `mysqli_free_result`

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- `mysqli_result::free`

  `mysqli_free_result`

  Frees the memory associated with a result

Description

Object oriented style

```
void mysqli_result::free();
```

```
void mysqli_result::close();
```

```
void mysqli_result::free_result();
```

Procedural style

```
void mysqli_free_result(mysqli_result result);
```

Frees the memory associated with the result.

> **Note**
>
> You should always free your result with `mysqli_free_result`, when your result object is not needed anymore.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

No value is returned.

See Also

`mysqli_query`
`mysqli_stmt_store_result`
`mysqli_store_result`
`mysqli_use_result`

20.10.2.9.14. `mysqli_result->lengths`, `mysqli_fetch_lengths`

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- `mysqli_result->lengths`

  `mysqli_fetch_lengths`

  Returns the lengths of the columns of the current row in the result set

Description

Object oriented style

```
 mysqli_result {

  array lengths ;

}
```

Procedural style

```
  array mysqli_fetch_lengths(mysqli_result result);
```

The `mysqli_fetch_lengths` function returns an array containing the lengths of every column of the current row within the result set.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

An array of integers representing the size of each column (not including any terminating null characters). `FALSE` if an error occurred.

`mysqli_fetch_lengths` is valid only for the current row of the result set. It returns `FALSE` if you call it before calling mysqli_fetch_row/array/object or after retrieving all rows in the result.

Examples

Example 20.150. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT * from Country ORDER BY Code LIMIT 1";

if ($result = $mysqli->query($query)) {

    $row = $result->fetch_row();

    /* display column lengths */
    foreach ($result->lengths as $i => $val) {
        printf("Field %2d has Length %2d\n", $i+1, $val);
    }
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

$query = "SELECT * from Country ORDER BY Code LIMIT 1";

if ($result = mysqli_query($link, $query)) {

    $row = mysqli_fetch_row($result);
    /* display column lengths */
    foreach (mysqli_fetch_lengths($result) as $i => $val) {
        printf("Field %2d has Length %2d\n", $i+1, $val);
    }
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Field  1 has Length  3
Field  2 has Length  5
Field  3 has Length 13
Field  4 has Length  9
Field  5 has Length  6
Field  6 has Length  1
Field  7 has Length  6
Field  8 has Length  4
Field  9 has Length  6
Field 10 has Length  6
Field 11 has Length  5
Field 12 has Length 44
Field 13 has Length  7
Field 14 has Length  3
Field 15 has Length  2
```

20.10.2.9.15. `mysqli_result->num_rows`, `mysqli_num_rows`

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- `mysqli_result->num_rows`

  `mysqli_num_rows`

  Gets the number of rows in a result

Description

Object oriented style

```
 mysqli_result {

  int num_rows ;

}
```

Procedural style

```
  int mysqli_num_rows(mysqli_result result);
```

Returns the number of rows in the result set.

The use of `mysqli_num_rows` depends on whether you use buffered or unbuffered result sets. In case you use unbuffered result-sets `mysqli_num_rows` will not return the correct number of rows until all the rows in the result have been retrieved.

Parameters

`result`	Procedural style only: A result set identifier returned by `mysqli_query`, `mysqli_store_result` or `mysqli_use_result`.

Return Values

Returns number of rows in the result set.

> **Note**
>
> If the number of rows is greater than maximal int value, the number will be returned as a string.

Examples

Example 20.151. Object oriented style

```
<?php
$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if ($result = $mysqli->query("SELECT Code, Name FROM Country ORDER BY Name")) {

    /* determine number of rows result set */
    $row_cnt = $result->num_rows;

    printf("Result set has %d rows.\n", $row_cnt);

    /* close result set */
    $result->close();
}

/* close connection */
$mysqli->close();
?>
```

Procedural style

```
<?php
$link = mysqli_connect("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

if ($result = mysqli_query($link, "SELECT Code, Name FROM Country ORDER BY Name")) {

    /* determine number of rows result set */
    $row_cnt = mysqli_num_rows($result);

    printf("Result set has %d rows.\n", $row_cnt);

    /* close result set */
    mysqli_free_result($result);
}

/* close connection */
mysqli_close($link);
?>
```

The above examples will output:

```
Result set has 239 rows.
```

See Also

`mysqli_affected_rows`
`mysqli_store_result`
`mysqli_use_result`

`mysqli_query`

20.10.2.10. The MySQLi_Driver class (`MySQLi_Driver`)

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MySQLi Driver.

```
 MySQLi_Driver {
 MySQLi_Driver

      Properties

  public readonly string client_info ;


  public readonly string client_version ;


  public readonly string driver_version ;


  public readonly string embedded ;


  public bool reconnect ;


  public int report_mode ;

Methods

  void mysqli_driver::embedded_server_end();


  bool mysqli_driver::embedded_server_start(bool start,
                                            array arguments,
                                            array groups);

}
```

`client_info`	The Client API header version
`client_version`	The Client version
`driver_version`	The MySQLi Driver version
`embedded`	Whether MySQLi Embedded support is enabled
`reconnect`	Allow or prevent reconnect (see the mysqli.reconnect INI directive)
`report_mode`	Set to `MYSQLI_REPORT_OFF` , `MYSQLI_REPORT_ALL` or any combination of `MYSQLI_REPORT_STRICT` (throw Exceptions for errors), `MYSQLI_REPORT_ERROR` (report errors) and `MYSQLI_REPORT_INDEX` (errors regarding indexes). See also `mysqli_report`.

20.10.2.10.1. `mysqli_driver::embedded_server_end`, `mysqli_embedded_server_end`

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- `mysqli_driver::embedded_server_end`

  `mysqli_embedded_server_end`

  Stop embedded server

Description

Object oriented style

```
  void mysqli_driver::embedded_server_end();
```

Procedural style

```
void mysqli_embedded_server_end();
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

20.10.2.10.2. `mysqli_driver::embedded_server_start`, `mysqli_embedded_server_start`

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- `mysqli_driver::embedded_server_start`

  `mysqli_embedded_server_start`

  Initialize and start embedded server

Description

Object oriented style

```
bool mysqli_driver::embedded_server_start(bool start,
                                          array arguments,
                                          array groups);
```

Procedural style

```
bool mysqli_embedded_server_start(bool start,
                                  array arguments,
                                  array groups);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

20.10.2.11. The MySQLi_Warning class (`MySQLi_Warning`)

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Represents a MySQL warning.

```
 mysqli_warning {
 mysqli_warning

      Properties

  public message ;


  public sqlstate ;


  public errno ;

Methods

  __construct();


  public void next();

}
```

`message`	Message string
`sqlstate`	SQL state
`errno`	Error number

20.10.2.11.1. `mysqli_warning::__construct`

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- `mysqli_warning::__construct`

  The __construct purpose

Description

```
mysqli_warning::__construct();
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

Parameters

This function has no parameters.

Return Values

20.10.2.11.2. `mysqli_warning::next`

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- `mysqli_warning::next`

  The next purpose

Description

```
public void mysqli_warning::next();
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

Parameters

This function has no parameters.

Return Values

20.10.2.12. Aliases and deprecated Mysqli Functions

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20.10.2.12.1. `mysqli_bind_param`

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- `mysqli_bind_param`

  Alias for `mysqli_stmt_bind_param`

Description

This function is an alias of `mysqli_stmt_bind_param`.

Notes

> **Note**
>
> `mysqli_bind_param` is deprecated and will be removed.

See Also

`mysqli_stmt_bind_param`

20.10.2.12.2. `mysqli_bind_result`

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- `mysqli_bind_result`

  Alias for `mysqli_stmt_bind_result`

Description

This function is an alias of `mysqli_stmt_bind_result`.

Notes

> **Note**
>
> `mysqli_bind_result` is deprecated and will be removed.

See Also

`mysqli_stmt_bind_result`

20.10.2.12.3. `mysqli_client_encoding`

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- `mysqli_client_encoding`

  Alias of `mysqli_character_set_name`

Description

This function is an alias of `mysqli_character_set_name`.

See Also

`mysqli_real_escape_string`

20.10.2.12.4. `mysqli_connect`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_connect`

  Alias of `mysqli::__construct`

Description

This function is an alias of: `mysqli::__construct`

20.10.2.12.5. `mysqli_disable_reads_from_master`, `mysqli->disable_reads_from_master`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_disable_reads_from_master`

  `mysqli->disable_reads_from_master`

  Disable reads from master

Description

Object oriented style

```
void mysqli::disable_reads_from_master();
```

Procedural style

```
bool mysqli_disable_reads_from_master(mysqli link);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.6. `mysqli_disable_rpl_parse`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_disable_rpl_parse`

  Disable RPL parse

Description

```
bool mysqli_disable_rpl_parse(mysqli link);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.7. `mysqli_enable_reads_from_master`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_enable_reads_from_master`

  Enable reads from master

Description

```
bool mysqli_enable_reads_from_master(mysqli link);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.8. `mysqli_enable_rpl_parse`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_enable_rpl_parse`

  Enable RPL parse

Description

```
bool mysqli_enable_rpl_parse(mysqli link);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.9. `mysqli_escape_string`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_escape_string`

  Alias of `mysqli_real_escape_string`

Description

This function is an alias of: `mysqli_real_escape_string`.

20.10.2.12.10. `mysqli_execute`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_execute`

  Alias for `mysqli_stmt_execute`

Description

This function is an alias of `mysqli_stmt_execute`.

Notes

> **Note**
>
> `mysqli_execute` is deprecated and will be removed.

See Also

`mysqli_stmt_execute`

20.10.2.12.11. `mysqli_fetch`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_fetch`

  Alias for `mysqli_stmt_fetch`

Description

This function is an alias of `mysqli_stmt_fetch`.

Notes

> **Note**
>
> `mysqli_fetch` is deprecated and will be removed.

See Also

`mysqli_stmt_fetch`

20.10.2.12.12. `mysqli_get_cache_stats`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_get_cache_stats`

  Returns client Zval cache statistics

Description

```
array mysqli_get_cache_stats();
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

Returns client Zval cache statistics. Available only with mysqlnd.

Parameters

Return Values

Returns an array with client Zval cache stats if success, `FALSE` otherwise.

Examples

Example 20.152. A `mysqli_get_cache_stats` example

```
<?php
$link = mysqli_connect();
print_r(mysqli_get_cache_stats());
?>
```

The above example will output something similar to:

```
Array
(
    [bytes_sent] => 43
    [bytes_received] => 80
    [packets_sent] => 1
    [packets_received] => 2
    [protocol_overhead_in] => 8
    [protocol_overhead_out] => 4
    [bytes_received_ok_packet] => 11
    [bytes_received_eof_packet] => 0
    [bytes_received_rset_header_packet] => 0
    [bytes_received_rset_field_meta_packet] => 0
    [bytes_received_rset_row_packet] => 0
    [bytes_received_prepare_response_packet] => 0
    [bytes_received_change_user_packet] => 0
    [packets_sent_command] => 0
    [packets_received_ok] => 1
    [packets_received_eof] => 0
    [packets_received_rset_header] => 0
    [packets_received_rset_field_meta] => 0
    [packets_received_rset_row] => 0
    [packets_received_prepare_response] => 0
    [packets_received_change_user] => 0
    [result_set_queries] => 0
    [non_result_set_queries] => 0
    [no_index_used] => 0
    [bad_index_used] => 0
    [slow_queries] => 0
    [buffered_sets] => 0
    [unbuffered_sets] => 0
    [ps_buffered_sets] => 0
    [ps_unbuffered_sets] => 0
    [flushed_normal_sets] => 0
    [flushed_ps_sets] => 0
    [ps_prepared_never_executed] => 0
    [ps_prepared_once_executed] => 0
    [rows_fetched_from_server_normal] => 0
    [rows_fetched_from_server_ps] => 0
    [rows_buffered_from_client_normal] => 0
    [rows_buffered_from_client_ps] => 0
    [rows_fetched_from_client_normal_buffered] => 0
    [rows_fetched_from_client_normal_unbuffered] => 0
    [rows_fetched_from_client_ps_buffered] => 0
    [rows_fetched_from_client_ps_unbuffered] => 0
    [rows_fetched_from_client_ps_cursor] => 0
    [rows_skipped_normal] => 0
    [rows_skipped_ps] => 0
    [copy_on_write_saved] => 0
    [copy_on_write_performed] => 0
    [command_buffer_too_small] => 0
    [connect_success] => 1
    [connect_failure] => 0
    [connection_reused] => 0
    [reconnect] => 0
    [pconnect_success] => 0
    [active_connections] => 1
    [active_persistent_connections] => 0
    [explicit_close] => 0
    [implicit_close] => 0
    [disconnect_close] => 0
    [in_middle_of_command_close] => 0
    [explicit_free_result] => 0
    [implicit_free_result] => 0
    [explicit_stmt_close] => 0
    [implicit_stmt_close] => 0
    [mem_emalloc_count] => 0
    [mem_emalloc_ammount] => 0
    [mem_ecalloc_count] => 0
    [mem_ecalloc_ammount] => 0
    [mem_erealloc_count] => 0
    [mem_erealloc_ammount] => 0
    [mem_efree_count] => 0
    [mem_malloc_count] => 0
    [mem_malloc_ammount] => 0
    [mem_calloc_count] => 0
    [mem_calloc_ammount] => 0
    [mem_realloc_count] => 0
    [mem_realloc_ammount] => 0
    [mem_free_count] => 0
    [proto_text_fetched_null] => 0
    [proto_text_fetched_bit] => 0
    [proto_text_fetched_tinyint] => 0
    [proto_text_fetched_short] => 0
    [proto_text_fetched_int24] => 0
    [proto_text_fetched_int] => 0
    [proto_text_fetched_bigint] => 0
    [proto_text_fetched_decimal] => 0
    [proto_text_fetched_float] => 0
    [proto_text_fetched_double] => 0
    [proto_text_fetched_date] => 0
    [proto_text_fetched_year] => 0
    [proto_text_fetched_time] => 0
    [proto_text_fetched_datetime] => 0
    [proto_text_fetched_timestamp] => 0
    [proto_text_fetched_string] => 0
    [proto_text_fetched_blob] => 0
    [proto_text_fetched_enum] => 0
    [proto_text_fetched_set] => 0
    [proto_text_fetched_geometry] => 0
    [proto_text_fetched_other] => 0
    [proto_binary_fetched_null] => 0
    [proto_binary_fetched_bit] => 0
    [proto_binary_fetched_tinyint] => 0
    [proto_binary_fetched_short] => 0
    [proto_binary_fetched_int24] => 0
    [proto_binary_fetched_int] => 0
    [proto_binary_fetched_bigint] => 0
    [proto_binary_fetched_decimal] => 0
    [proto_binary_fetched_float] => 0
    [proto_binary_fetched_double] => 0
    [proto_binary_fetched_date] => 0
    [proto_binary_fetched_year] => 0
    [proto_binary_fetched_time] => 0
    [proto_binary_fetched_datetime] => 0
    [proto_binary_fetched_timestamp] => 0
    [proto_binary_fetched_string] => 0
    [proto_binary_fetched_blob] => 0
    [proto_binary_fetched_enum] => 0
    [proto_binary_fetched_set] => 0
    [proto_binary_fetched_geometry] => 0
    [proto_binary_fetched_other] => 0
)
```

See Also

Stats description

20.10.2.12.13. `mysqli_get_metadata`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_get_metadata`

  Alias for `mysqli_stmt_result_metadata`

Description

This function is an alias of `mysqli_stmt_result_metadata`.

Notes

> **Note**
>
> `mysqli_get_metadata` is deprecated and will be removed.

See Also

`mysqli_stmt_result_metadata`

20.10.2.12.14. `mysqli_master_query`

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- `mysqli_master_query`

  Enforce execution of a query on the master in a master/slave setup

Description

```
  bool mysqli_master_query(mysqli link,
                           string query);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.15. `mysqli_param_count`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_param_count`

Alias for `mysqli_stmt_param_count`

Description

This function is an alias of `mysqli_stmt_param_count`.

Notes

> **Note**
>
> `mysqli_param_count` is deprecated and will be removed.

See Also

`mysqli_stmt_param_count`

20.10.2.12.16. `mysqli_report`

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- `mysqli_report`

  Enables or disables internal report functions

Description

```
bool mysqli_report(int flags);
```

`mysqli_report` is a powerful function to improve your queries and code during development and testing phase. Depending on the flags it reports errors from mysqli function calls or queries which don't use an index (or use a bad index).

Parameters

`flags`

Table 20.18. Supported flags

Name	Description
`MYSQLI_REPORT_OFF`	Turns reporting off
`MYSQLI_REPORT_ERROR`	Report errors from mysqli function calls
`MYSQLI_REPORT_STRICT`	Throw `mysqli_sql_exception` for errors instead of warnings
`MYSQLI_REPORT_INDEX`	Report if no index or bad index was used in a query
`MYSQLI_REPORT_ALL`	Set all options (report all)

Return Values

Returns `TRUE` on success or `FALSE` on failure.

Changelog

Version	Description
5.2.15 & 5.3.4	Changing the reporting mode is now be per-request, rather than per-process.

Examples

Example 20.153. Object oriented style

```
<?php
/* activate reporting */
mysqli_report(MYSQLI_REPORT_ALL);

$mysqli = new mysqli("localhost", "my_user", "my_password", "world");

/* check connection */
if (mysqli_connect_errno()) {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
}

/* this query should report an error */
$result = $mysqli->query("SELECT Name FROM Nonexistingtable WHERE population > 50000");

/* this query should report a bad index */
$result = $mysqli->query("SELECT Name FROM City WHERE population > 50000");
$result->close();

$mysqli->close();
?>
```

See Also

MySQLi_Driver::$report_mode
`mysqli_debug`
`mysqli_dump_debug_info`

20.10.2.12.17. `mysqli_rpl_parse_enabled`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_rpl_parse_enabled`

  Check if RPL parse is enabled

Description

```
int mysqli_rpl_parse_enabled(mysqli link);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.18. `mysqli_rpl_probe`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_rpl_probe`

  RPL probe

Description

```
bool mysqli_rpl_probe(mysqli link);
```

> **Warning**

This function is currently not documented; only its argument list is available.

Warning

This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.19. `mysqli_rpl_query_type`, `mysqli->rpl_query_type`

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- `mysqli_rpl_query_type`

  `mysqli->rpl_query_type`

  Returns RPL query type

Description

Object oriented style

```
mysqli {

  int rpl_query_type(string query);

}
```

Procedural style

```
  int mysqli_rpl_query_type(mysqli link,
                            string query);
```

Returns `MYSQLI_RPL_MASTER` , `MYSQLI_RPL_SLAVE` or `MYSQLI_RPL_ADMIN` depending on a query type. `INSERT`, `UPDATE` and similar are *master* queries, `SELECT` is *slave*, and `FLUSH`, `REPAIR` and similar are *admin*.

Warning

This function is currently not documented; only its argument list is available.

Warning

This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.20. `mysqli_send_long_data`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_send_long_data`

  Alias for `mysqli_stmt_send_long_data`

Description

This function is an alias of `mysqli_stmt_send_long_data`.

Notes

Note

`mysqli_send_long_data` is deprecated and will be removed.

See Also

`mysqli_stmt_send_long_data`

20.10.2.12.21. `mysqli_send_query`, `mysqli->send_query`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_send_query`

  `mysqli->send_query`

  Send the query and return

Description

Object oriented style

```
 mysqli {

  bool send_query(string query);

}
```

Procedural style

```
  bool mysqli_send_query(mysqli link,
                         string query);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.2.12.22. `mysqli_set_opt`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_set_opt`

  Alias of `mysqli_options`

Description

This function is an alias of `mysqli_options`.

20.10.2.12.23. `mysqli_slave_query`

Copyright 1997-2010 the PHP Documentation Group.

- `mysqli_slave_query`

  Force execution of a query on a slave in a master/slave setup

Description

```
  bool mysqli_slave_query(mysqli link,
                          string query);
```

> **Warning**
>
> This function is currently not documented; only its argument list is available.

> **Warning**
>
> This function has been *DEPRECATED* and *REMOVED* as of PHP 5.3.0.

20.10.3. MySQL Native Driver (`Mysqlnd`)

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This section of the manual provides an overview of the MySQL Native Driver.

20.10.3.1. Overview

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MySQL Native Driver is a replacement for the MySQL Client Library (libmysql). MySQL Native Driver is part of the official PHP sources as of PHP 5.3.0.

The MySQL database extensions MySQL extension, `mysqli` and PDO MYSQL all communicate with the MySQL server. In the past, this was done by the extension using the services provided by the MySQL Client Library. The extensions were compiled against the MySQL Client Library in order to use its client-server protocol.

With MySQL Native Driver there is now an alternative, as the MySQL database extensions can be compiled to use MySQL Native Driver instead of the MySQL Client Library.

MySQL Native Driver is written in C as a PHP extension.

What it is not

Although MySQL Native Driver is written as a PHP extension, it is important to note that it does not provide a new API to the PHP programmer. The programmer APIs for MySQL database connectivity are provided by the MySQL extension, `mysqli` and PDO MYSQL. These extensions can now use the services of MySQL Native Driver to communicate with the MySQL Server. Therefore, you should not think of MySQL Native Driver as an API.

Why use it?

Using the MySQL Native Driver offers a number of advantages over using the MySQL Client Library.

The older MySQL Client Library was written by MySQL AB (now Oracle Corporation) and so was released under the MySQL license. This ultimately led to MySQL support being disabled by default in PHP. However, the MySQL Native Driver has been developed as part of the PHP project, and is therefore released under the PHP license. This removes licensing issues that have been problematic in the past.

Also, in the past, you needed to build the MySQL database extensions against a copy of the MySQL Client Library. This typically meant you needed to have MySQL installed on a machine where you were building the PHP source code. Also, when your PHP application was running, the MySQL database extensions would call down to the MySQL Client library file at run time, so the file needed to be installed on your system. With MySQL Native Driver that is no longer the case as it is included as part of the standard distribution. So you do not need MySQL installed in order to build PHP or run PHP database applications.

Because MySQL Native Driver is written as a PHP extension, it is tightly coupled to the workings of PHP. This leads to gains in efficiency, especially when it comes to memory usage, as the driver uses the PHP memory management system. It also supports the PHP memory limit. Using MySQL Native Driver leads to comparable or better performance than using MySQL Client Library, it always ensures the most efficient use of memory. One example of the memory efficiency is the fact that when using the MySQL Client Library, each row is stored in memory twice, whereas with the MySQL Native Driver each row is only stored once in memory.

Special features

MySQL Native Driver also provides some special features not available when the MySQL database extensions use MySQL Client Library. These special features are listed below:

- Improved persistent connections
- The special function `mysqli_fetch_all`
- Performance statistics calls: `mysqli_get_cache_stats`, `mysqli_get_client_stats`, `mysqli_get_connection_stats`

The performance statistics facility can prove to be very useful in identifying performance bottlenecks.

MySQL Native Driver also allows for persistent connections when used with the `mysqli` extension.

SSL Support

MySQL Native Driver has supported SSL since PHP version 5.3.3

Compressed Protocol Support

As of PHP 5.3.2 MySQL Native Driver supports the compressed client server protocol. MySQL Native Driver did not support this in 5.3.0 and 5.3.1. Extensions such as `ext/mysql`, `ext/mysqli`, that are configured to use MySQL Native Driver, can also take advantage of this feature. Note that `PDO_MYSQL` does *NOT* support compression when used together with mysqlnd.

Named Pipes Support

Named pipes support for Windows was added in PHP version 5.4.0.

20.10.3.2. Installation

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Installation on Unix

By default the MySQL database extensions are configured to use MySQL Client Library. In order to use the MySQL Native Driver, PHP needs to be built specifying that the MySQL database extensions are compiled with MySQL Native Driver support. This is done through configuration options prior to building the PHP source code.

For example, to build the MySQL extension, `mysqli` and PDO MYSQL using the MySQL Native Driver, the following command would be given:

```
./configure --with-mysql=mysqlnd \
--with-mysqli=mysqlnd \
--with-pdo-mysql=mysqlnd \
[other options]
```

Installation on Windows

In the official PHP distributions from 5.3 onwards, MySQL Native Driver is enabled by default, so no additional configuration is required to use it. All MySQL database extensions will use MySQL Native Driver in this case.

20.10.3.3. Runtime Configuration

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The behaviour of these functions is affected by settings in `php.ini`.

Table 20.19. MySQL Native Driver Configuration Options

Name	Default	Changeable	Changelog
mysqlnd.collect_statistics	"1"	PHP_INI_SYSTEM	Available since PHP 5.3.0.
mysqlnd.collect_memory_statistics	"0"	PHP_INI_SYSTEM	Available since PHP 5.3.0.
mysqlnd.debug	"0"	PHP_INI_SYSTEM	Available since PHP 5.3.0.
mysqlnd.net_read_timeout	"31536000"	PHP_INI_SYSTEM	Available since PHP 5.3.0.
mysqlnd.net_cmd_buffer_size	5.3.0 - "2048", 5.3.1 - "4096"	PHP_INI_SYSTEM	Available since PHP 5.3.0.
mysqlnd.net_read_buffer_size	"32768"	PHP_INI_SYSTEM	Available since PHP 5.3.0.

For further details and definitions of the PHP_INI_* modes, see the configuration.changes.modes.

Here's a short explanation of the configuration directives.

`mysqlnd.collect_statistics` boolean
: Enables the collection of various client statistics which can be accessed through `mysqli_get_client_stats`, `mysqli_get_connection_stats`, `mysqli_get_cache_stats` and are shown in `mysqlnd` section of the output of the `phpinfo` function as well.

This configuration setting enables all MySQL Native Driver statistics except those relating to memory management.

`mysqlnd.collect_memory_statistics` boolean
: Enable the collection of various memory statistics which can be accessed through `mysqli_get_client_stats`, `mysqli_get_connection_stats`,

`mysqli_get_cache_stats` and are shown in `mysqlnd` section of the output of the `phpinfo` function as well.

This configuration setting enables the memory management statistics within the overall set of MySQL Native Driver statistics.

`mysqlnd.debug` string

Records communication from all extensions using `mysqlnd` to the specified log file.

The format of the directive is `mysqlnd.debug = "option1[,parameter_option1][:option2[,parameter_option2]]"`.

The options for the format string are as follows:

- A[,file] - Appends trace output to specified file. Also ensures that data is written after each write. This is done by closing and reopening the trace file (this is slow). It helps ensure a complete log file should the application crash.
- a[,file] - Appends trace output to the specified file.
- d - Enables output from DBUG_<N> macros for the current state. May be followed by a list of keywords which selects output only for the DBUG macros with that keyword. An empty list of keywords implies output for all macros.
- f[,functions] - Limits debugger actions to the specified list of functions. An empty list of functions implies that all functions are selected.
- F - Marks each debugger output line with the name of the source file containing the macro causing the output.
- i - Marks each debugger output line with the PID of the current process.
- L - Marks each debugger output line with the name of the source file line number of the macro causing the output.
- n - Marks each debugger output line with the current function nesting depth
- o[,file] - Similar to a[,file] but overwrites old file, and does not append.
- O[,file] - Similar to A[,file] but overwrites old file, and does not append.
- t[,N] - Enables function control flow tracing. The maximum nesting depth is specified by N, and defaults to 200.
- x - This option activates profiling.

Example:

```
d:t:x:O,/tmp/mysqlnd.trace
```

> **Note**
>
> This feature is only available with a debug build of PHP. Works on Microsoft Windows if using a debug build of PHP and PHP was built using Microsoft Visual C version 9 and above.

`mysqlnd.net_read_timeout` integer

`mysqlnd` and the MySQL Client Library, `libmysql` use different networking APIs. `mysqlnd` uses PHP streams, whereas `libmysql` uses its own wrapper around the operating level network calls. PHP, by default, sets a read timeout of 60s for streams. This is set via `php.ini`, `default_socket_timeout`. This default applies to all streams that set no other timeout value. `mysqlnd` does not set any other value and therefore connections of long running queries can be disconnected after `default_socket_timeout` seconds resulting in an error message “2006 - MySQL Server has gone away”. The MySQL Client Library sets a default timeout of 365 * 24 * 3600 seconds (1 year) and waits for other timeouts to occur, such as TCP/IP timeouts. `mysqlnd` now uses the same very long timeout. The value is configurable through a new `php.ini` setting: `mysqlnd.net_read_timeout`. `mysqlnd.net_read_timeout` gets used by any extension (`ext/mysql`, `ext/mysqli`, `PDO_MySQL`) that uses `mysqlnd`. `mysqlnd` tells PHP Streams to use `mysqlnd.net_read_timeout`. Please note that there may be subtle differences between `MYSQL_OPT_READ_TIMEOUT` from the MySQL Client Library and PHP Streams, for example `MYSQL_OPT_READ_TIMEOUT` is documented to work only for TCP/

	IP connections and, prior to MySQL 5.1.2, only for Windows. PHP streams may not have this limitation. Please check the streams documentation, if in doubt.
`mysqlnd.net_cmd_buffer_size` long	`mysqlnd` allocates an internal command/network buffer of `mysqlnd.net_cmd_buffer_size` (in `php.ini`) bytes for every connection. If a MySQL Client Server protocol command, for example, `COM_QUERY` ("normal" query), does not fit into the buffer, `mysqlnd` will grow the buffer to the size required for sending the command. Whenever the buffer gets extended for one connection, `command_buffer_too_small` will be incremented by one. If `mysqlnd` has to grow the buffer beyond its initial size of `mysqlnd.net_cmd_buffer_size` bytes for almost every connection, you should consider increasing the default size to avoid re-allocations. The default buffer size is 2048 bytes in PHP 5.3.0. In later versions the default is 4096 bytes. The default can changed either through the `php.ini` setting `mysqlnd.net_cmd_buffer_size` or using `mysqli_options(MYSQLI_OPT_NET_CMD_BUFFER_SIZE, int size)`. It is recommended that the buffer size be set to no less than 4096 bytes because `mysqlnd` also uses it when reading certain communication packet from MySQL. In PHP 5.3.0, `mysqlnd` will not grow the buffer if MySQL sends a packet that is larger than the current size of the buffer. As a consequence, `mysqlnd` is unable to decode the packet and the client application will get an error. There are only two situations when the packet can be larger than the 2048 bytes default of `mysqlnd.net_cmd_buffer_size` in PHP 5.3.0: the packet transports a very long error message, or the packet holds column meta data from `COM_LIST_FIELD` (`mysql_list_fields()` and the meta data come from a string column with a very long default value (>1900 bytes). As of PHP 5.3.2 mysqlnd does not allow setting buffers smaller than 4096 bytes. The value can also be set using `mysqli_option(link, MYSQLI_OPT_NET_CMD_BUFFER_SIZE, size)`.
`mysqlnd.net_read_buffer_size` long	Maximum read chunk size in bytes when reading the body of a MySQL command packet. The MySQL client server protocol encapsulates all its commands in packets. The packets consist of a small header and a body with the actual payload. The size of the body is encoded in the header. `mysqlnd` reads the body in chunks of `MIN(header.size, mysqlnd.net_read_buffer_size)` bytes. If a packet body is larger than `mysqlnd.net_read_buffer_size` bytes, `mysqlnd` has to call `read()` multiple times. The value can also be set using `mysqli_optionS(link, MYSQLI_OPT_NET_READ_BUFFER_SIZE, size)`.

20.10.3.4. Persistent Connections

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Using Persistent Connections

If `mysqli` is used with `mysqlnd`, when a persistent connection is created it generates a `COM_CHANGE_USER` (`mysql_change_user()`) call on the server. This ensures that re-authentication of the connection takes place.

As there is some overhead associated with the `COM_CHANGE_USER` call, it is possible to switch this off at compile time. Reusing a persistent connection will then generate a `COM_PING` (`mysql_ping`) call to simply test the connection is reusable.

Generation of `COM_CHANGE_USER` can be switched off with the compile flag `MYSQLI_NO_CHANGE_USER_ON_PCONNECT`. For example:

```
shell# CFLAGS="-DMYSQLI_NO_CHANGE_USER_ON_PCONNECT" ./configure --with-mysql=/usr/local/mysql/ --with-mysqli=/usr/loca
```

Or alternatively:

```
shell# export CFLAGS="-DMYSQLI_NO_CHANGE_USER_ON_PCONNECT"
shell# configure --whatever-option
shell# make clean
shell# make
```

Note that only `mysqli` on `mysqlnd` uses `COM_CHANGE_USER`. Other extension-driver combinations use `COM_PING` on initial use of a persistent connection.

20.10.3.5. Statistics

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Using Statistical Data

MySQL Native Driver contains support for gathering statistics on the communication between the client and the server. The statistics gathered are of three main types:

- Client statistics
- Connection statistics
- Zval cache statistics

If you are using the `mysqli` extension, these statistics can be obtained through three API calls:

- `mysqli_get_client_stats`
- `mysqli_get_connection_stats`
- `mysqli_get_cache_stats`

> **Note**
>
> Statistics are aggregated among all extensions that use MySQL Native Driver. For example, when compiling both `ext/mysql` and `ext/mysqli` against MySQL Native Driver, both function calls of `ext/mysql` and `ext/mysqli` will change the statistics. There is no way to find out how much a certain API call of any extension that has been compiled against MySQL Native Driver has impacted a certain statistic. You can configure the PDO MySQL Driver, `ext/mysql` and `ext/mysqli` to optionally use the MySQL Native Driver. When doing so, all three extensions will change the statistics.

Accessing Client Statistics

To access client statistics, you need to call `mysqli_get_client_stats`. The function call does not require any parameters.

The function returns an associative array that contains the name of the statistic as the key and the statistical data as the value.

Client statistics can also be accessed by calling the `phpinfo` function.

Accessing Connection Statistics

To access connection statistics call `mysqli_get_connection_stats`. This takes the database connection handle as the parameter.

The function returns an associative array that contains the name of the statistic as the key and the statistical data as the value.

Accessing Zval Cache Statistics

The MySQL Native Driver also collects statistics from its internal Zval cache. These statistics can be accessed by calling `mysqli_get_cache_stats`.

The Zval cache statistics obtained may lead to a tweaking of `php.ini` settings related to the Zval cache, resulting in better performance.

Buffered and Unbuffered Result Sets

Result sets can be buffered or unbuffered. Using default settings, `ext/mysql` and `ext/mysqli` work with buffered result sets for normal (non prepared statement) queries. Buffered result sets are cached on the client. After the query execution all results are fetched from the MySQL Server and stored in a cache on the client. The big advantage of buffered result sets is that they allow the server to free all resources allocated to a result set, once the results have been fetched by the client.

Unbuffered result sets on the other hand are kept much longer on the server. If you want to reduce memory consumption on the client, but increase load on the server, use unbuffered results. If you experience a high server load and the figures for unbuffered result sets are high, you should consider moving the load to the clients. Clients typically scale better than servers. “Load” does not only refer to memory buffers - the server also needs to keep other resources open, for example file handles and threads, before a result set can be freed.

Prepared Statements use unbuffered result sets by default. However, you can use `mysqli_stmt_store_result` to enable buffered result sets.

Statistics returned by MySQL Native Driver

The following tables show a list of statistics returned by the `mysqli_get_client_stats`, `mysqli_get_connection_stats` and `mysqli_get_cache_stats` functions.

Network

Statistic	**Scope**	**Description**	**Notes**
`bytes_sent`	Connection	Number of bytes sent from PHP to the MySQL server	Can be used to check the efficiency of the compression protocol
`bytes_received`	Connection	Number of bytes received from MySQL server	Can be used to check the efficiency of the compression protocol
`packets_sent`	Connection	Number of MySQL Client Server protocol packets sent	Used for debugging Client Server protocol implementation
`packets_received`	Connection	Number of MySQL Client Server protocol packets received	Used for debugging Client Server protocol implementation
`protocol_overhead_in`	Connection	MySQL Client Server protocol overhead in bytes for incoming traffic. Currently only the Packet Header (4 bytes) is considered as overhead. protocol_overhead_in = packets_received * 4	Used for debugging Client Server protocol implementation
`protocol_overhead_out`	Connection	MySQL Client Server protocol overhead in bytes for outgoing traffic. Currently only the Packet Header (4 bytes) is considered as overhead. protocol_overhead_out = packets_sent * 4	Used for debugging Client Server protocol implementation
`bytes_received_ok_packet`	Connection	Total size of bytes of MySQL Client Server protocol OK packets received. OK packets can contain a status message. The length of the status message can vary and thus the size of an OK packet is not fixed.	Used for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`packets_received_ok`	Connection	Number of MySQL Client Server protocol OK packets received.	Used for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`bytes_received_eof_packet`	Connection	Total size in bytes of MySQL Client Server protocol EOF packets received. EOF can vary in size depending on the server version. Also, EOF can transport an error message.	Used for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`packets_received_eof`	Connection	Number of MySQL Client Server protocol EOF packets. Like with other packet statistics the number of packets will be increased even if PHP does not receive the expected packet but, for example, an error mes-	Used for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).

Statistic	Scope	Description	Notes
		sage.	
`bytes_received_rset_header_packet`	Connection	Total size in bytes of MySQL Client Server protocol result set header packets. The size of the packets varies depending on the payload (`LOAD LOCAL INFILE`, `INSERT`, `UPDATE`, `SELECT`, error message).	Used for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`packets_received_rset_header`	Connection	Number of MySQL Client Server protocol result set header packets.	Used for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`bytes_received_rset_field_meta_packet`	Connection	Total size in bytes of MySQL Client Server protocol result set meta data (field information) packets. Of course the size varies with the fields in the result set. The packet may also transport an error or an EOF packet in case of COM_LIST_FIELDS.	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`packets_received_rset_field_meta`	Connection	Number of MySQL Client Server protocol result set meta data (field information) packets.	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`bytes_received_rset_row_packet`	Connection	Total size in bytes of MySQL Client Server protocol result set row data packets. The packet may also transport an error or an EOF packet. You can reverse engineer the number of error and EOF packets by subtracting `rows_fetched_from_server_normal` and `rows_fetched_from_server_ps` from `bytes_received_rset_row_packet`.	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`packets_received_rset_row`	Connection	Number of MySQL Client Server protocol result set row data packets and their total size in bytes.	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`bytes_received_prepare_response_packet`	Connection	Total size in bytes of MySQL Client Server protocol OK for Prepared Statement Initialization packets (prepared statement init packets). The packet may also transport an error. The packet size depends on the MySQL version: 9 bytes with MySQL 4.1 and 12 bytes from MySQL 5.0 on. There is no safe way to know how many errors happened. You may be able to guess that an error has occurred if, for example, you always connect to MySQL 5.0 or newer and, `bytes_received_prepar`	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).

Statistic	Scope	Description	Notes
		`e_response_packet` != `packets_received_prepare_response` * 12. See also `ps_prepared_never_executed`, `ps_prepared_once_executed`.	
`packets_received_prepare_response`	Connection	Number of MySQL Client Server protocol OK for Prepared Statement Initialization packets (prepared statement init packets).	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`bytes_received_change_user_packet`	Connection	Total size in bytes of MySQL Client Server protocol COM_CHANGE_USER packets. The packet may also transport an error or EOF.	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`packets_received_change_user`	Connection	Number of MySQL Client Server protocol COM_CHANGE_USER packets	Only useful for debugging CS protocol implementation. Note that the total size in bytes includes the size of the header packet (4 bytes, see protocol overhead).
`packets_sent_command`	Connection	Number of MySQL Client Server protocol commands sent from PHP to MySQL. There is no way to know which specific commands and how many of them have been sent. At its best you can use it to check if PHP has sent any commands to MySQL to know if you can consider to disable MySQL support in your PHP binary. There is also no way to reverse engineer the number of errors that may have occurred while sending data to MySQL. The only error recoded is command_buffer_too_small (see below).	Only useful for debugging CS protocol implementation.

`bytes_received_real_data_normal`	Connection	Number of bytes of payload fetched by the PHP client from `mysqlnd` using the text protocol.	This is the size of the actual data contained in result sets that do not originate from prepared statements and which have been fetched by the PHP client. Note that although a full result set may have been pulled from MySQL by `mysqlnd`, this statistic only counts actual data pulled from `mysqlnd` by the PHP client. An example of a code sequence that will increase the value is as follows:
			`$mysqli = new mysqli();`
			`$res = $mysqli->query("SELECT 'abc'`
			`$res->fetch_assoc();`
			`$res->close();`
			Every fetch operation will increase the value.

Statistic	Scope	Description	Notes

			The statistic will not be increased if the result set is only buffered on the client, but not fetched, such as in the following example:
			`$mysqli = new mysqli();`
			`$res = $mysqli->query("SELECT 'abc''`
			`$res->close();`
			This statistic is available as of PHP version 5.3.4.

`bytes_received_real_data_ps`	Connection	Number of bytes of the payload fetched by the PHP client from `mysqlnd` using the prepared statement protocol.	This is the size of the actual data contained in result sets that originate from prepared statements and which has been fetched by the PHP client. The value will not be increased if the result set is not subsequently read by the PHP client. Note that although a full result set may have been pulled from MySQL by `mysqlnd`, this statistic only counts actual data pulled from `mysqlnd` by the PHP client. See also `bytes_received_real_data_normal`. This statistic is available as of PHP version 5.3.4.

Result Set

Statistic	Scope	Description	Notes
`result_set_queries`	Connection	Number of queries that have generated a result set. Examples of queries that generate a result set: `SELECT`, `SHOW`. The statistic will not be incremented if there is an error reading the result set header packet from the line.	You may use it as an indirect measure for the number of queries PHP has sent to MySQL, for example, to identify a client that causes a high database load.
`non_result_set_queries`	Connection	Number of queries that did not generate a result set. Examples of queries that do not generate a result set: `INSERT`, `UPDATE`, `LOAD DATA`, `SHOW`. The statistic will not be incremented if there is an error reading the result set header packet from the line.	You may use it an an indirect measure for the number of queries PHP has sent to MySQL, for example, to identify a client that causes a high database load.
`no_index_used`	Connection	Number of queries that have generated a result set but did not use an index (see also mysqld start option –log-queries-not-using-indexes). If you want these queries to be reported you can use mysqli_report(MYSQLI_REPORT_INDEX) to make ext/mysqli throw an exception. If you prefer a warning instead of an exception use mysqli_report(MYSQLI_REP	

Statistic	Scope	Description	Notes
		ORT_INDEX ^ MYSQLI_REPORT_STRICT).	
`bad_index_used`	Connection	Number of queries that have generated a result set and did not use a good index (see also mysqld start option –log-slow-queries).	If you want these queries to be reported you can use mysqli_report(MYSQLI_REPORT_INDEX) to make ext/mysqli throw an exception. If you prefer a warning instead of an exception use mysqli_report(MYSQLI_REPORT_INDEX ^ MYSQLI_REPORT_STRICT)
`slow_queries`	Connection	SQL statements that took more than `long_query_time` seconds to execute and required at least `min_examined_row_limit` rows to be examined.	Not reported through `mysqli_report`
`buffered_sets`	Connection	Number of buffered result sets returned by “normal” queries. “Normal” means “not prepared statement” in the following notes.	Examples of API calls that will buffer result sets on the client: `mysql_query`, `mysqli_query`, `mysqli_store_result`, `mysqli_stmt_get_result`. Buffering result sets on the client ensures that server resources are freed as soon as possible and it makes result set scrolling easier. The downside is the additional memory consumption on the client for buffering data. Note that mysqlnd (unlike the MySQL Client Library) respects the PHP memory limit because it uses PHP internal memory management functions to allocate memory. This is also the reason why `memory_get_usage` reports a higher memory consumption when using mysqlnd instead of the MySQL Client Library. `memory_get_usage` does not measure the memory consumption of the MySQL Client Library at all because the MySQL Client Library does not use PHP internal memory management functions monitored by the function!
`unbuffered_sets`	Connection	Number of unbuffered result sets returned by normal (non prepared statement) queries.	Examples of API calls that will not buffer result sets on the client: `mysqli_use_result`
`ps_buffered_sets`	Connection	Number of buffered result sets returned by prepared statements. By default prepared statements are unbuffered.	Examples of API calls that will not buffer result sets on the client: `mysqli_stmt_store_result`
`ps_unbuffered_sets`	Connection	Number of unbuffered result sets returned by prepared statements.	By default prepared statements are unbuffered.
`flushed_normal_sets`	Connection	Number of result sets from normal (non prepared statement) queries with unread data which have been flushed silently for	Unbuffered result sets must be fetched completely before a new query can be run on the connection otherwise MySQL

Statistic	Scope	Description	Notes
		you. Flushing happens only with unbuffered result sets.	will throw an error. If the application does not fetch all rows from an unbuffered result set, mysqlnd does implicitly fetch the result set to clear the line. See also `rows_skipped_normal`, `rows_skipped_ps`. Some possible causes for an implicit flush: • Faulty client application • Client stopped reading after it found what it was looking for but has made MySQL calculate more records than needed • Client application has stopped unexpectedly
`flushed_ps_sets`	Connection	Number of result sets from prepared statements with unread data which have been flushed silently for you. Flushing happens only with unbuffered result sets.	Unbuffered result sets must be fetched completely before a new query can be run on the connection otherwise MySQL will throw an error. If the application does not fetch all rows from an unbuffered result set, mysqlnd does implicitly fetch the result set to clear the line. See also `rows_skipped_normal`, `rows_skipped_ps`. Some possible causes for an implicit flush: • Faulty client application • Client stopped reading after it found what it was looking for but has made MySQL calculate more records than needed • Client application has stopped unexpectedly
`ps_prepared_never_executed`	Connection	Number of statements prepared but never executed.	Prepared statements occupy server resources. You should not prepare a statement if you do not plan to execute it.
`ps_prepared_once_executed`	Connection	Number of prepared statements executed only one.	One of the ideas behind prepared statements is that the same query gets executed over and over again (with different parameters) and some parsing and other preparation work can be saved, if statement execution is split up in separate prepare and execute stages. The idea is to prepare once and “cache” results, for example, the parse tree to be reused during multiple statement execu-

Statistic	Scope	Description	Notes
			tions. If you execute a prepared statement only once the two stage processing can be inefficient compared to “normal” queries because all the caching means extra work and it takes (limited) server resources to hold the cached information. Consequently, prepared statements that are executed only once may cause performance hurts.
`rows_fetched_from_server_normal`, `rows_fetched_from_server_ps`	Connection	Total number of result set rows successfully fetched from MySQL regardless if the client application has consumed them or not. Some of the rows may not have been fetched by the client application but have been flushed implicitly.	See also `packets_received_rset_row`
`rows_buffered_from_client_normal`, `rows_buffered_from_client_ps`	Connection	Total number of successfully buffered rows originating from a "normal" query or a prepared statement. This is the number of rows that have been fetched from MySQL and buffered on client. Note that there are two distinct statistics on rows that have been buffered (MySQL to mysqlnd internal buffer) and buffered rows that have been fetched by the client application (mysqlnd internal buffer to client application). If the number of buffered rows is higher than the number of fetched buffered rows it can mean that the client application runs queries that cause larger result sets than needed resulting in rows not read by the client.	Examples of queries that will buffer results: `mysqli_query`, `mysqli_store_result`
`rows_fetched_from_client_normal_buffered`, `rows_fetched_from_client_ps_buffered`	Connection	Total number of rows fetched by the client from a buffered result set created by a normal query or a prepared statement.	
`rows_fetched_from_cli`	Connection	Total number of rows fetched by the client from a unbuffered result set created by a "normal" query or a prepared statement.	

Statistic	Scope	Description	Notes
, `rows_fetched_from_client_ps_unbuffered`			
`rows_fetched_from_client_ps_cursor`	Connection	Total number of rows fetch by the client from a cursor created by a prepared statement.	
`rows_skipped_normal`, `rows_skipped_ps`	Connection	Reserved for future use (currently not supported)	
`copy_on_write_saved`, `copy_on_write_performed`	Process	With mysqlnd, variables returned by the extensions point into mysqlnd internal network result buffers. If you do not change the variables, fetched data will be kept only once in memory. If you change the variables, mysqlnd has to perform a copy-on-write to protect the internal network result buffers from being changed. With the MySQL Client Library you always hold fetched data twice in memory. Once in the internal MySQL Client Library buffers and once in the variables returned by the extensions. In theory mysqlnd can save up to 40% memory. However, note that the memory saving cannot be measured using `memory_get_usage`.	
`explicit_free_result`, `implicit_free_result`	Connection, Process (only during prepared statement cleanup)	Total number of freed result sets.	The free is always considered explicit but for result sets created by an init command, for example, `mysqli_options(MYSQLI_INIT_COMMAND , ...)`
`proto_text_fetched_null`, `proto_text_fetched_bit`, `proto_text_fetched_tinyint` `proto_text_fetched_short`, `proto_text_fetched_int24`, `proto_text_fetched_int` `proto_text_fetched_bigint`, `proto_text_fetched_decimal`, `proto_text_fetched_float` `proto_text_fetched_double`, `proto_text_fetched_date`, `proto_text_fetched_year` `proto_text_fetched_time`, `proto_text_fetched_datetime`, `proto_text_fetched_ti`	Connection	Total number of columns of a certain type fetched from a normal query (MySQL text protocol).	Mapping from C API / MySQL meta data type to statistics name: • `MYSQL_TYPE_NULL` - proto_text_fetched_null • `MYSQL_TYPE_BIT` - proto_text_fetched_bit • `MYSQL_TYPE_TINY` - proto_text_fetched_tinyint • `MYSQL_TYPE_SHORT` - proto_text_fetched_short • `MYSQL_TYPE_INT24` - proto_text_fetched_int24 • `MYSQL_TYPE_LONG` - proto_text_fetched_int • `MYSQL_TYPE_LONGLONG` - proto_text_fetched_bigint • `MYSQL_TYPE_DECIMAL`, `MYSQL_TYPE_NEWDECIMAL` -

Statistic	Scope	Description	Notes

`mestamp`
`proto_text_fetched_string`,
`proto_text_fetched_blob`,
`proto_text_fetched_enum`
`proto_text_fetched_set`,
`proto_text_fetched_geometry`,
`proto_text_fetched_other`
			proto_text_fetched_decimal
			• `MYSQL_TYPE_FLOAT` - proto_text_fetched_float
			• `MYSQL_TYPE_DOUBLE` - proto_text_fetched_double
			• `MYSQL_TYPE_DATE`, `MYSQL_TYPE_NEWDATE` - proto_text_fetched_date
			• `MYSQL_TYPE_YEAR` - proto_text_fetched_year
			• `MYSQL_TYPE_TIME` - proto_text_fetched_time
			• `MYSQL_TYPE_DATETIME` - proto_text_fetched_datetime
			• `MYSQL_TYPE_TIMESTAMP` - proto_text_fetched_timestamp
			• `MYSQL_TYPE_STRING`, `MYSQL_TYPE_VARSTRING`, `MYSQL_TYPE_VARCHAR` - proto_text_fetched_string
			• `MYSQL_TYPE_TINY_BLOB`, `MYSQL_TYPE_MEDIUM_BLOB`, `MYSQL_TYPE_LONG_BLOB`, `MYSQL_TYPE_BLOB` - proto_text_fetched_blob
			• `MYSQL_TYPE_ENUM` - proto_text_fetched_enum
			• `MYSQL_TYPE_SET` - proto_text_fetched_set
			• `MYSQL_TYPE_GEOMETRY` - proto_text_fetched_geometry
			• Any `MYSQL_TYPE_*` not listed before (there should be none) - proto_text_fetched_other
			Note that the MYSQL_*-type constants may not be associated with the very same SQL column types in every version of MySQL.

`proto_binary_fetched_null`, `proto_binary_fetched_bit`,	Connection	Total number of columns of a certain type fetched from a prepared statement (MySQL binary protocol).	For type mapping see `proto_text_*` described in the preceding text.

Statistic	Scope	Description	Notes
`proto_binary_fetched_tinyint` `proto_binary_fetched_short`, `proto_binary_fetched_int24`, `proto_binary_fetched_int`, `proto_binary_fetched_bigint`, `proto_binary_fetched_decimal`, `proto_binary_fetched_float`, `proto_binary_fetched_double`, `proto_binary_fetched_date`, `proto_binary_fetched_year`, `proto_binary_fetched_time`, `proto_binary_fetched_datetime`, `proto_binary_fetched_timestamp`, `proto_binary_fetched_string`, `proto_binary_fetched_blob`, `proto_binary_fetched_enum`, `proto_binary_fetched_set`, `proto_binary_fetched_geometry`, `proto_binary_fetched_other`			

Connection

Statistic	Scope	Description	Notes
`connect_success`, `connect_failure`	Connection	Total number of successful / failed connection attempt.	Reused connections and all other kinds of connections are included.
`reconnect`	Process	Total number of (real_)connect attempts made on an already opened connection handle.	The code sequence `$link = new mysqli(...); $link->real_connect(...)` will cause a reconnect. But `$link = new mysqli(...); $link->connect(...)` will not because `$link->connect(...)` will explicitly close the existing connection before a new connection is established.
`pconnect_success`	Connection	Total number of successful persistent connection attempts.	Note that `connect_success` holds the sum of successful persistent and non-persistent connection attempts. The number of successful non-persistent connection attempts is `connect_success` - `pcon-`

Statistic	Scope	Description	Notes
			`nect_success`.
`active_connections`	Connection	Total number of active persistent and non-persistent connections.	
`active_persistent_connections`	Connection	Total number of active persistent connections.	The total number of active non-persistent connections is `active_connections` - `active_persistent_connections`.

`explicit_close`	Connection	Total number of explicitly closed connections (ext/mysqli only).	Examples of code snippets that cause an explicit close :
			`$link = new mysqli(...); $link->clos`
			`$link = new mysqli(...); $link->conn`

`implicit_close`	Connection	Total number of implicitly closed connections (ext/mysqli only).	Examples of code snippets that cause an implicit close : • `$link = new mysqli(...); $link->real_connect(...)` • `unset($link)` • Persistent connection: pooled connection has been created with real_connect and there may be unknown options set - close implicitly to avoid returning a connection with unknown options • Persistent connection: ping/change_user fails and ext/mysqli closes the connection • end of script execution: close connections that have not been closed by the user
`disconnect_close`	Connection	Connection failures indicated by the C API call `mysql_real_connect` during an attempt to establish a connection.	It is called `disconnect_close` because the connection handle passed to the C API call will be closed.
`in_middle_of_command_close`	Process	A connection has been closed in the middle of a command execution (outstanding result sets not fetched, after sending a query and before retrieving an answer, while fetching data, while transferring data with LOAD DATA).	Unless you use asynchronous queries this should only happen if your script stops unexpectedly and PHP shuts down the connections for you.
`init_command_executed_count`	Connection	Total number of init command executions, for example, `mysqli_options(MYSQLI_INIT_COMMAND , ...)`.	The number of successful executions is `init_command_executed_count` - `init_command_failed_count`.
`init_command_failed_c`	Connection	Total number of failed init	

Statistic	Scope	Description	Notes
`ount`		commands.	

COM_* Commands

Statistic	Scope	Description	Notes
`com_quit`, `com_init_db`, `com_query`, `com_field_list`, `com_create_db`, `com_drop_db`, `com_refresh`, `com_shutdown`, `com_statistics`, `com_process_info`, `com_connect`, `com_process_kill`, `com_debug`, `com_ping`, `com_time`, `com_delayed_insert`, `com_change_user`, `com_binlog_dump`, `com_table_dump`, `com_connect_out`, `com_register_slave`, `com_stmt_prepare`, `com_stmt_execute`, `com_stmt_send_long_data`, `com_stmt_close`, `com_stmt_reset`, `com_stmt_set_option`, `com_stmt_fetch`, `com_daemon`	Connection	Total number of attempts to send a certain COM_* command from PHP to MySQL.	The statistics are incremented after checking the line and immediately before sending the corresponding MySQL client server protocol packet. If mysqlnd fails to send the packet over the wire the statistics will not be decremented. In case of a failure mysqlnd emits a PHP warning “Error while sending %s packet. PID=%d.” Usage examples: • Check if PHP sends certain commands to MySQL, for example, check if a client sends `COM_PROCESS_KILL` • Calculate the average number of prepared statement executions by comparing `COM_EXECUTE` with `COM_PREPARE` • Check if PHP has run any non-prepared SQL statements by checking if `COM_QUERY` is zero • Identify PHP scripts that run an excessive number of SQL statements by checking `COM_QUERY` and `COM_EXECUTE`

Miscellaneous

Statistic	Scope	Description	Notes
`explicit_stmt_close`, `implicit_stmt_close`	Process	Total number of close prepared statements.	A close is always considered explicit but for a failed prepare.
`mem_emalloc_count`, `mem_emalloc_ammount`, `mem_ecalloc_count`, `mem_ecalloc_ammount`, `mem_erealloc_count`, `mem_erealloc_ammount`, `mem_efree_count`, `mem_malloc_count`, `mem_malloc_ammount`, `mem_calloc_count`, `mem_calloc_ammount`, `mem_realloc_count`, `mem_realloc_ammount`, `mem_free_count`	Process	Memory management calls.	Development only.

Statistic	Scope	Description	Notes
`command_buffer_too_small`	Connection	Number of network command buffer extensions while sending commands from PHP to MySQL.	mysqlnd allocates an internal command/network buffer of `mysqlnd.net_cmd_buffer_size` (`php.ini`) bytes for every connection. If a MySQL Client Server protocol command, for example, `COM_QUERY` (normal query), does not fit into the buffer, mysqlnd will grow the buffer to what is needed for sending the command. Whenever the buffer gets extended for one connection `command_buffer_too_small` will be incremented by one. If mysqlnd has to grow the buffer beyond its initial size of `mysqlnd.net_cmd_buffer_size` (`php.ini`) bytes for almost every connection, you should consider to increase the default size to avoid re-allocations. The default buffer size is 2048 bytes in PHP 5.3.0. In future versions the default will be 4kB or larger. The default can changed either through the `php.ini` setting `mysqlnd.net_cmd_buffer_size` or using `mysqli_options(MYSQLI_OPT_NET_CMD_BUFFER_SIZE, int size)`. It is recommended to set the buffer size to no less than 4096 bytes because mysqlnd also uses it when reading certain communication packet from MySQL. In PHP 5.3.0, mysqlnd will not grow the buffer if MySQL sends a packet that is larger than the current size of the buffer. As a consequence mysqlnd is unable to decode the packet and the client application will get an error. There are only two situations when the packet can be larger than the 2048 bytes default of `mysqlnd.net_cmd_buffer_size` in PHP 5.3.0: the packet transports a very long error message or the packet holds column meta data from `COM_LIST_FIELD` (`mysql_list_fields`) and the meta data comes from a string column with a very long default value (>1900 bytes). No bug report on this exists - it should happen rarely.

Statistic	Scope	Description	Notes
			As of PHP 5.3.2 mysqlnd does not allow setting buffers smaller than 4096 bytes.
`connection_reused`			

20.10.3.6. Notes

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This section provides a collection of miscellaneous notes on MySQL Native Driver usage.

- Using `mysqlnd` means using PHP streams for underlying connectivity. For `mysqlnd`, the PHP streams documentation (book.stream) should be consulted on such details as timeout settings, not the documentation for the MySQL Client Library.

20.10.3.7. MySQL Native Driver Plugin API

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The MySQL Native Driver Plugin API is a feature of MySQL Native Driver, or `mysqlnd`. `Mysqlnd` plugins operate in the layer between PHP applications and the MySQL server. This is comparable to MySQL Proxy. MySQL Proxy operates on a layer between any MySQL client application, for example, a PHP application and, the MySQL server. `Mysqlnd` plugins can undertake typical MySQL Proxy tasks such as load balancing, monitoring and performance optimizations. Due to the different architecture and location, `mysqlnd` plugins do not have some of MySQL Proxy's disadvantages. For example, with plugins, there is no single point of failure, no dedicated proxy server to deploy, and no new programming language to learn (Lua).

A `mysqlnd` plugin can be thought of as an extension to `mysqlnd`. Plugins can intercept the majority of `mysqlnd` functions. The `mysqlnd` functions are called by the PHP MySQL extensions such as `ext/mysql`, `ext/mysqli`, and `PDO_MYSQL`. As a result, it is possible for a `mysqlnd` plugin to intercept all calls made to these extensions from the client application.

Internal `mysqlnd` function calls can also be intercepted, or replaced. There are no restrictions on manipulating `mysqlnd` internal function tables. It is possible to set things up so that when certain `mysqlnd` functions are called by the extensions that use `mysqlnd`, the call is directed to the appropriate function in the `mysqlnd` plugin. The ability to manipulate `mysqlnd` internal function tables in this way allows maximum flexibility for plugins.

`Mysqlnd` plugins are in fact PHP Extensions, written in C, that use the `mysqlnd` plugin API (which is built into MySQL Native Driver, `mysqlnd`). Plugins can be made 100% transparent to PHP applications. No application changes are needed because plugins operate on a different layer. The `mysqlnd` plugin can be thought of as operating in a layer below `mysqlnd`.

The following list represents some possible applications of `mysqlnd` plugins.

- Load Balancing
  - Read/Write Splitting. An example of this is the PECL/mysqlnd_ms (Master Slave) extension. This extension splits read/write queries for a replication setup.
  - Failover
  - Round-Robin, least loaded
- Monitoring
  - Query Logging
  - Query Analysis
  - Query Auditing. An example of this is the PECL/mysqlnd_sip (SQL Injection Protection) extension. This extension inspects queries and executes only those that are allowed according to a ruleset.
- Performance
  - Caching. An example of this is the PECL/mysqlnd_qc (Query Cache) extension.
  - Throttling

- Sharding. An example of this is the PECL/mysqlnd_mc (Multi Connect) extension. This extension will attempt to split a SELECT statement into n-parts, using SELECT ... LIMIT part_1, SELECT LIMIT part_n. It sends the queries to distinct MySQL servers and merges the result at the client.

MySQL Native Driver Plugins Available

There are a number of mysqlnd plugins already available. These include:

- *PECL/mysqlnd_mc* - Multi Connect plugin.
- *PECL/mysqlnd_ms* - Master Slave plugin.
- *PECL/mysqlnd_qc* - Query Cache plugin.
- *PECL/mysqlnd_pscache* - Prepared Statement Handle Cache plugin.
- *PECL/mysqlnd_sip* - SQL Injection Protection plugin.
- *PECL/mysqlnd_uh* - User Handler plugin.

20.10.3.7.1. A comparison of mysqlnd plugins with MySQL Proxy

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`Mysqlnd` plugins and MySQL Proxy are different technologies using different approaches. Both are valid tools for solving a variety of common tasks such as load balancing, monitoring, and performance enhancements. An important difference is that MySQL Proxy works with all MySQL clients, whereas `mysqlnd` plugins are specific to PHP applications.

As a PHP Extension, a `mysqlnd` plugin gets installed on the PHP application server, along with the rest of PHP. MySQL Proxy can either be run on the PHP application server or can be installed on a dedicated machine to handle multiple PHP application servers.

Deploying MySQL Proxy on the application server has two advantages:

1. No single point of failure
2. Easy to scale out (horizontal scale out, scale by client)

MySQL Proxy (and `mysqlnd` plugins) can solve problems easily which otherwise would have required changes to existing applications.

However, MySQL Proxy does have some disadvantages:

- MySQL Proxy is a new component and technology to master and deploy.
- MySQL Proxy requires knowledge of the Lua scripting language.

MySQL Proxy can be customized with C and Lua programming. Lua is the preferred scripting language of MySQL Proxy. For most PHP experts Lua is a new language to learn. A `mysqlnd` plugin can be written in C. It is also possible to write plugins in PHP using PECL/mysqlnd_uh.

MySQL Proxy runs as a daemon - a background process. MySQL Proxy can recall earlier decisions, as all state can be retained. However, a `mysqlnd` plugin is bound to the request-based lifecycle of PHP. MySQL Proxy can also share one-time computed results among multiple application servers. A `mysqlnd` plugin would need to store data in a persistent medium to be able to do this. Another daemon would need to be used for this purpose, such as Memcache. This gives MySQL Proxy an advantage in this case.

MySQL Proxy works on top of the wire protocol. With MySQL Proxy you have to parse and reverse engineer the MySQL Client Server Protocol. Actions are limited to those that can be achieved by manipulating the communication protocol. If the wire protocol changes (which happens very rarely) MySQL Proxy scripts would need to be changed as well.

`Mysqlnd` plugins work on top of the C API, which mirrors the `libmysql` client and Connector/C APIs. This C API is basically a wrapper around the MySQL Client Server protocol, or wire protocol, as it is sometimes called. You can intercept all C API calls. PHP makes use of the C API, therefore you can hook all PHP calls, without the need to program at the level of the wire protocol.

`Mysqlnd` implements the wire protocol. Plugins can therefore parse, reverse engineer, manipulate and even replace the communication protocol. However, this is usually not required.

As plugins allow you to create implementations that use two levels (C API and wire protocol), they have greater flexibility than MySQL Proxy. If a `mysqlnd` plugin is implemented using the C API, any subsequent changes to the wire protocol do not require changes to the plugin itself.

20.10.3.7.2. Obtaining the mysqlnd plugin API

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The `mysqlnd` plugin API is simply part of the MySQL Native Driver PHP extension, `ext/mysqlnd`. Development started on the `mysqlnd` plugin API in December 2009. It is developed as part of the PHP source repository, and as such is available to the public either via SVN, or through source snapshot downloads.

The following table shows PHP versions and the corresponding `mysqlnd` version contained within.

PHP Version	MySQL Native Driver version
5.3.0	5.0.5
5.3.1	5.0.5
5.3.2	5.0.7
5.3.3	5.0.7
5.3.4	5.0.7

Plugin developers can determine the `mysqlnd` version through accessing `MYSQLND_VERSION`, which is a string of the format “mysqlnd 5.0.7-dev - 091210 - $Revision: 300535”, or through `MYSQLND_VERSION_ID`, which is an integer such as 50007. Developers can calculate the version number as follows:

Version (part)	Example
Major*10000	5*10000 = 50000
Minor*100	0*100 = 0
Patch	7 = 7
MYSQLND_VERSION_ID	50007

During development, developers should refer to the `mysqlnd` version number for compatibility and version tests, as several iterations of `mysqlnd` could occur during the lifetime of a PHP development branch with a single PHP version number.

20.10.3.7.3. MySQL Native Driver Plugin Architecture

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This section provides an overview of the `mysqlnd` plugin architecture.

MySQL Native Driver Overview

Before developing `mysqlnd` plugins, it is useful to know a little of how `mysqlnd` itself is organized. `Mysqlnd` consists of the following modules:

Modules Statistics	mysqlnd_statistics.c
Connection	mysqlnd.c
Resultset	mysqlnd_result.c
Resultset Metadata	mysqlnd_result_meta.c
Statement	mysqlnd_ps.c
Network	mysqlnd_net.c
Wire protocol	mysqlnd_wireprotocol.c

C Object Oriented Paradigm

At the code level, `mysqlnd` uses a C pattern for implementing object orientation.

In C you use a `struct` to represent an object. Members of the struct represent object properties. Struct members pointing to functions represent methods.

Unlike with other languages such as C++ or Java, there are no fixed rules on inheritance in the C object oriented paradigm. However, there are some conventions that need to be followed that will be discussed later.

The PHP Life Cycle

When considering the PHP life cycle there are two basic cycles:

- PHP engine startup and shutdown cycle
- Request cycle

When the PHP engine starts up it will call the module initialization (MINIT) function of each registered extension. This allows each module to setup variables and allocate resources that will exist for the lifetime of the PHP engine process. When the PHP engine shuts down it will call the module shutdown (MSHUTDOWN) function of each extension.

During the lifetime of the PHP engine it will receive a number of requests. Each request constitutes another life cycle. On each request the PHP engine will call the request initialization function of each extension. The extension can perform any variable setup and resource allocation required for request processing. As the request cycle ends the engine calls the request shutdown (RSHUTDOWN) function of each extension so the extension can perform any cleanup required.

How a plugin works

A `mysqlnd` plugin works by intercepting calls made to `mysqlnd` by extensions that use `mysqlnd`. This is achieved by obtaining the `mysqlnd` function table, backing it up, and replacing it by a custom function table, which calls the functions of the plugin as required.

The following code shows how the `mysqlnd` function table is replaced:

```
/* a place to store original function table */
struct st_mysqlnd_conn_methods org_methods;

void minit_register_hooks(TSRMLS_D) {
  /* active function table */
  struct st_mysqlnd_conn_methods * current_methods
    = mysqlnd_conn_get_methods();

  /* backup original function table */
  memcpy(&org_methods, current_methods,
    sizeof(struct st_mysqlnd_conn_methods);

  /* install new methods */
  current_methods->query = MYSQLND_METHOD(my_conn_class, query);
}
```

Connection function table manipulations must be done during Module Initialization (MINIT). The function table is a global shared resource. In an multi-threaded environment, with a TSRM build, the manipulation of a global shared resource during the request processing will almost certainly result in conflicts.

> **Note**
>
> Do not use any fixed-size logic when manipulating the `mysqlnd` function table: new methods may be added at the end of the function table. The function table may change at any time in the future.

Calling parent methods

If the original function table entries are backed up, it is still possible to call the original function table entries - the parent methods.

In some cases, such as for `Connection::stmt_init()`, it is vital to call the parent method prior to any other activity in the derived method.

```
MYSQLND_METHOD(my_conn_class, query)(MYSQLND *conn,
  const char *query, unsigned int query_len TSRMLS_DC) {

  php_printf("my_conn_class::query(query = %s)\n", query);

  query = "SELECT 'query rewritten' FROM DUAL";
  query_len = strlen(query);

  return org_methods.query(conn, query, query_len); /* return with call to parent */
}
```

Extending properties

A `mysqlnd` object is represented by a C struct. It is not possible to add a member to a C struct at run time. Users of `mysqlnd` objects cannot simply add properties to the objects.

Arbitrary data (properties) can be added to a `mysqlnd` objects using an appropriate function of the `mysqlnd_plugin_get_plugin_<object>_data()` family. When allocating an object `mysqlnd` reserves space at the end of the object to hold a `void *` pointer to arbitrary data. `mysqlnd` reserves space for one `void *` pointer per plugin.

The following table shows how to calculate the position of the pointer for a specific plugin:

Memory address	Contents
0	Beginning of the mysqlnd object C struct
n	End of the mysqlnd object C struct
n + (m x sizeof(void*))	void* to object data of the m-th plugin

If you plan to subclass any of the `mysqlnd` object constructors, which is allowed, you must keep this in mind!

The following code shows extending properties:

```
/* any data we want to associate */
typedef struct my_conn_properties {
  unsigned long query_counter;
} MY_CONN_PROPERTIES;

/* plugin id */
unsigned int my_plugin_id;

void minit_register_hooks(TSRMLS_D) {
  /* obtain unique plugin ID */
  my_plugin_id = mysqlnd_plugin_register();
  /* snip - see Extending Connection: methods */
}

static MY_CONN_PROPERTIES** get_conn_properties(const MYSQLND *conn TSRMLS_DC) {
  MY_CONN_PROPERTIES** props;
  props = (MY_CONN_PROPERTIES**)mysqlnd_plugin_get_plugin_connection_data(
    conn, my_plugin_id);
  if (!props || !(*props)) {
    *props = mnd_pecalloc(1, sizeof(MY_CONN_PROPERTIES), conn->persistent);
    (*props)->query_counter = 0;
  }
  return props;
}
```

The plugin developer is responsible for the management of plugin data memory.

Use of the `mysqlnd` memory allocator is recommended for plugin data. These functions are named using the convention: `mnd_*loc()`. The `mysqlnd` allocator has some useful features, such as the ability to use a debug allocator in a non-debug build.

When and how to subclass

	When to subclass?	Each instance has its own private function table?	How to subclass?
Connection (MYSQLND)	MINIT	No	mysqlnd_conn_get_methods()
Resultset (MYSQLND_RES)	MINIT or later	Yes	mysqlnd_result_get_methods() or object method function table manipulation
Resultset Meta (MYSQLND_RES_METADATA)	MINIT	No	mysqlnd_result_metadata_get_methods()
Statement (MYSQLND_STMT)	MINIT	No	mysqlnd_stmt_get_methods()
Network (MYSQLND_NET)	MINIT or later	Yes	mysqlnd_net_get_methods() or object method function table manipulation
Wire protocol	MINIT or later	Yes	mysqlnd_protocol_get_method

(MYSQLND_PROTOCOL)			s() or object method function table manipulation

You must not manipulate function tables at any time later than MINIT if it is not allowed according to the above table.

Some classes contain a pointer to the method function table. All instances of such a class will share the same function table. To avoid chaos, in particular in threaded environments, such function tables must only be manipulated during MINIT.

Other classes use copies of a globally shared function table. The class function table copy is created together with the object. Each object uses its own function table. This gives you two options: you can manipulate the default function table of an object at MINIT, and you can additionally refine methods of an object without impacting other instances of the same class.

The advantage of the shared function table approach is performance. There is no need to copy a function table for each and every object.

Constructors

	Allocation, construction, reset	Can be modified?	Caller
Connection (MYSQLND)	mysqlnd_init()	No	mysqlnd_connect()
Resultset(MYSQLND_RES)	Allocation: • Connection::result_init() Reset and re-initialized during: • Result::use_result() • Result::store_result	Yes, but call parent!	• Connection::list_fields() • Statement::get_result() • Statement::prepare() (Metadata only) • Statement::resultMetaData()
Resultset Meta (MYSQLND_RES_METADATA)	Connection::result_meta_init()	Yes, but call parent!	Result::read_result_metadata()
Statement (MYSQLND_STMT)	Connection::stmt_init()	Yes, but call parent!	Connection::stmt_init()
Network (MYSQLND_NET)	mysqlnd_net_init()	No	Connection::init()
Wire protocol (MYSQLND_PROTOCOL)	mysqlnd_protocol_init()	No	Connection::init()

It is strongly recommended that you do not entirely replace a constructor. The constructors perform memory allocations. The memory allocations are vital for the `mysqlnd` plugin API and the object logic of `mysqlnd`. If you do not care about warnings and insist on hooking the constructors, you should at least call the parent constructor before doing anything in your constructor.

Regardless of all warnings, it can be useful to subclass constructors. Constructors are the perfect place for modifying the function tables of objects with non-shared object tables, such as Resultset, Network, Wire Protocol.

Destruction

	Derived method must call parent?	Destructor
Connection	yes, after method execution	free_contents(), end_psession()
Resultset	yes, after method execution	free_result()
Resultset Meta	yes, after method execution	free()
Statement	yes, after method execution	dtor(), free_stmt_content()
Network	yes, after method execution	free()
Wire protocol	yes, after method execution	free()

The destructors are the appropriate place to free properties, `mysqlnd_plugin_get_plugin_<object>_data()`.

The listed destructors may not be equivalent to the actual `mysqlnd` method freeing the object itself. However, they are the best possible place for you to hook in and free your plugin data. As with constructors you may replace the methods entirely but this is not recommended. If multiple methods are listed in the above table you will need to hook all of the listed methods and free your plugin data in whichever method is called first by `mysqlnd`.

The recommended method for plugins is to simply hook the methods, free your memory and call the parent implementation immediately following this.

> **Caution**
>
> Due to a bug in PHP versions 5.3.0 to 5.3.3, plugins do not associate plugin data with a persistent connection. This is because `ext/mysql` and `ext/mysqli` do not trigger all the necessary `mysqlnd` `end_psession()` method calls and the plugin may therefore leak memory. This has been fixed in PHP 5.3.4.

20.10.3.7.4. The mysqlnd plugin API

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The following is a list of functions provided in the `mysqlnd` plugin API:

- mysqlnd_plugin_register()
- mysqlnd_plugin_count()
- mysqlnd_plugin_get_plugin_connection_data()
- mysqlnd_plugin_get_plugin_result_data()
- mysqlnd_plugin_get_plugin_stmt_data()
- mysqlnd_plugin_get_plugin_net_data()
- mysqlnd_plugin_get_plugin_protocol_data()
- mysqlnd_conn_get_methods()
- mysqlnd_result_get_methods()
- mysqlnd_result_meta_get_methods()
- mysqlnd_stmt_get_methods()
- mysqlnd_net_get_methods()
- mysqlnd_protocol_get_methods()

There is no formal definition of what a plugin is and how a plugin mechanism works.

Components often found in plugins mechanisms are:

- A plugin manager
- A plugin API
- Application services (or modules)
- Application service APIs (or module APIs)

The `mysqlnd` plugin concept employs these features, and additionally enjoys an open architecture.

No Restrictions

A plugin has full access to the inner workings of `mysqlnd`. There are no security limits or restrictions. Everything can be overwritten to implement friendly or hostile algorithms. It is recommended you only deploy plugins from a trusted source.

As discussed previously, plugins can use pointers freely. These pointers are not restricted in any way, and can point into another plugin's data. Simple offset arithmetic can be used to read another plugin's data.

It is recommended that you write cooperative plugins, and that you always call the parent method. The plugins should always cooperate with `mysqlnd` itself.

Issues: an example of chaining and cooperation

Extension	mysqlnd.query() pointer	call stack if calling parent
ext/mysqlnd	mysqlnd.query()	mysqlnd.query
ext/mysqlnd_cache	mysqlnd_cache.query()	1. mysqlnd_cache.query() 2. mysqlnd.query
ext/mysqlnd_monitor	mysqlnd_monitor.query()	1. mysqlnd_monitor.query() 2. mysqlnd_cache.query() 3. mysqlnd.query

In this scenario, a cache (`ext/mysqlnd_cache`) and a monitor (`ext/mysqlnd_monitor`) plugin are loaded. Both subclass `Connection::query()`. Plugin registration happens at `MINIT` using the logic shown previously. PHP calls extensions in alphabetical order by default. Plugins are not aware of each other and do not set extension dependencies.

By default the plugins call the parent implementation of the query method in their derived version of the method.

PHP Extension Recap

This is a recap of what happens when using an example plugin, `ext/mysqlnd_plugin`, which exposes the `mysqlnd` C plugin API to PHP:

- Any PHP MySQL application tries to establish a connection to 192.168.2.29
- The PHP application will either use `ext/mysql`, `ext/mysqli` or `PDO_MYSQL`. All three PHP MySQL extensions use `mysqlnd` to establish the connection to 192.168.2.29.
- `Mysqlnd` calls its connect method, which has been subclassed by `ext/mysqlnd_plugin`.
- `ext/mysqlnd_plugin` calls the userspace hook `proxy::connect()` registered by the user.
- The userspace hook changes the connection host IP from 192.168.2.29 to 127.0.0.1 and returns the connection established by `parent::connect()`.
- `ext/mysqlnd_plugin` performs the equivalent of `parent::connect(127.0.0.1)` by calling the original `mysqlnd` method for establishing a connection.
- `ext/mysqlnd` establishes a connection and returns to `ext/mysqlnd_plugin`. `ext/mysqlnd_plugin` returns as well.
- Whatever PHP MySQL extension had been used by the application, it receives a connection to 127.0.0.1. The PHP MySQL extension itself returns to the PHP application. The circle is closed.

20.10.3.7.5. Getting started building a mysqlnd plugin

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It is important to remember that a `mysqlnd` plugin is itself a PHP extension.

The following code shows the basic structure of the MINIT function that will be used in the typical `mysqlnd` plugin:

```
/* my_php_mysqlnd_plugin.c */

 static PHP_MINIT_FUNCTION(mysqlnd_plugin) {
  /* globals, ini entries, resources, classes */

  /* register mysqlnd plugin */
  mysqlnd_plugin_id = mysqlnd_plugin_register();

  conn_m = mysqlnd_get_conn_methods();
  memcpy(org_conn_m, conn_m,
    sizeof(struct st_mysqlnd_conn_methods));
  conn_m->query = MYSQLND_METHOD(mysqlnd_plugin_conn, query);
  conn_m->connect = MYSQLND_METHOD(mysqlnd_plugin_conn, connect);
}
```

```
/* my_mysqlnd_plugin.c */

 enum_func_status MYSQLND_METHOD(mysqlnd_plugin_conn, query)(/* ... */) {
  /* ... */
}
enum_func_status MYSQLND_METHOD(mysqlnd_plugin_conn, connect)(/* ... */) {
  /* ... */
}
```

Task analysis: from C to userspace

```
 class proxy extends mysqlnd_plugin_connection {
  public function connect($host, ...) { .. }
}
mysqlnd_plugin_set_conn_proxy(new proxy());
```

Process:

1. PHP: user registers plugin callback
2. PHP: user calls any PHP MySQL API to connect to MySQL
3. C: ext/*mysql* calls mysqlnd method
4. C: mysqlnd ends up in ext/mysqlnd_plugin
5. C: ext/mysqlnd_plugin
    a. Calls userspace callback
    b. Or original `mysqlnd` method, if userspace callback not set

You need to carry out the following:

1. Write a class "mysqlnd_plugin_connection" in C
2. Accept and register proxy object through "mysqlnd_plugin_set_conn_proxy()"
3. Call userspace proxy methods from C (optimization - zend_interfaces.h)

Userspace object methods can either be called using `call_user_function()` or you can operate at a level closer to the Zend Engine and use `zend_call_method()`.

Optimization: calling methods from C using zend_call_method

The following code snippet shows the prototype for the `zend_call_method` function, taken from `zend_interfaces.h`.

```
 ZEND_API zval* zend_call_method(
  zval **object_pp, zend_class_entry *obj_ce,
  zend_function **fn_proxy, char *function_name,
  int function_name_len, zval **retval_ptr_ptr,
  int param_count, zval* arg1, zval* arg2 TSRMLS_DC
);
```

Zend API supports only two arguments. You may need more, for example:

```
 enum_func_status (*func_mysqlnd_conn__connect)(
  MYSQLND *conn, const char *host,
  const char * user, const char * passwd,
  unsigned int passwd_len, const char * db,
  unsigned int db_len, unsigned int port,
  const char * socket, unsigned int mysql_flags TSRMLS_DC
```

```
);
```

To get around this problem you will need to make a copy of `zend_call_method()` and add a facility for additional parameters. You can do this by creating a set of `MY_ZEND_CALL_METHOD_WRAPPER` macros.

Calling PHP userspace

This code snippet shows the optimized method for calling a userspace function from C:

```
/* my_mysqlnd_plugin.c */

MYSQLND_METHOD(my_conn_class,connect)(
  MYSQLND *conn, const char *host /* ... */ TSRMLS_DC) {
  enum_func_status ret = FAIL;
  zval * global_user_conn_proxy = fetch_userspace_proxy();
  if (global_user_conn_proxy) {
    /* call userspace proxy */
    ret = MY_ZEND_CALL_METHOD_WRAPPER(global_user_conn_proxy, host, /*...*/);
  } else {
    /* or original mysqlnd method = do nothing, be transparent */
    ret = org_methods.connect(conn, host, user, passwd,
          passwd_len, db, db_len, port,
          socket, mysql_flags TSRMLS_CC);
  }
  return ret;
}
```

Calling userspace: simple arguments

```
/* my_mysqlnd_plugin.c */

 MYSQLND_METHOD(my_conn_class,connect)(
  /* ... */, const char *host, /* ...*/) {
  /* ... */
  if (global_user_conn_proxy) {
    /* ... */
    zval* zv_host;
    MAKE_STD_ZVAL(zv_host);
    ZVAL_STRING(zv_host, host, 1);
    MY_ZEND_CALL_METHOD_WRAPPER(global_user_conn_proxy, zv_retval, zv_host /*, ...*/);
    zval_ptr_dtor(&zv_host);
    /* ... */
  }
  /* ... */
}
```

Calling userspace: structs as arguments

```
/* my_mysqlnd_plugin.c */

MYSQLND_METHOD(my_conn_class, connect)(
  MYSQLND *conn, /* ...*/) {
  /* ... */
  if (global_user_conn_proxy) {
    /* ... */
    zval* zv_conn;
    ZEND_REGISTER_RESOURCE(zv_conn, (void *)conn, le_mysqlnd_plugin_conn);
    MY_ZEND_CALL_METHOD_WRAPPER(global_user_conn_proxy, zv_retval, zv_conn, zv_host /*, ...*/);
    zval_ptr_dtor(&zv_conn);
    /* ... */
  }
  /* ... */
}
```

The first argument of many `mysqlnd` methods is a C "object". For example, the first argument of the connect() method is a pointer to `MYSQLND`. The struct MYSQLND represents a `mysqlnd` connection object.

The `mysqlnd` connection object pointer can be compared to a standard I/O file handle. Like a standard I/O file handle a `mysqlnd` connection object shall be linked to the userspace using the PHP resource variable type.

From C to userspace and back

```
 class proxy extends mysqlnd_plugin_connection {
  public function connect($conn, $host, ...) {
    /* "pre" hook */
    printf("Connecting to host = '%s'\n", $host);
    debug_print_backtrace();
    return parent::connect($conn);
  }

  public function query($conn, $query) {
    /* "post" hook */
    $ret = parent::query($conn, $query);
    printf("Query = '%s'\n", $query);
    return $ret;
  }
}
mysqlnd_plugin_set_conn_proxy(new proxy());
```

PHP users must be able to call the parent implementation of an overwritten method.

As a result of subclassing it is possible to refine only selected methods and you can choose to have "pre" or "post" hooks.

Buildin class: mysqlnd_plugin_connection::connect()

```
/*  my_mysqlnd_plugin_classes.c */

 PHP_METHOD("mysqlnd_plugin_connection", connect) {
  /* ... simplified! ... */
  zval* mysqlnd_rsrc;
  MYSQLND* conn;
  char* host; int host_len;
  if (zend_parse_parameters(ZEND_NUM_ARGS() TSRMLS_CC, "rs",
    &mysqlnd_rsrc, &host, &host_len) == FAILURE) {
    RETURN_NULL();
  }
  ZEND_FETCH_RESOURCE(conn, MYSQLND* conn, &mysqlnd_rsrc, -1,
    "Mysqlnd Connection", le_mysqlnd_plugin_conn);
  if (PASS == org_methods.connect(conn, host, /* simplified! */ TSRMLS_CC))
    RETVAL_TRUE;
  else
    RETVAL_FALSE;
}
```

20.10.4. MySQL Functions (PDO_MYSQL)

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PDO_MYSQL is a driver that implements the PHP Data Objects (PDO) interface to enable access from PHP to MySQL 3.x, 4.x and 5.x databases.

PDO_MYSQL will take advantage of native prepared statement support present in MySQL 4.1 and higher. If you're using an older version of the mysql client libraries, PDO will emulate them for you.

> **Warning**
>
> Beware: Some MySQL table types (storage engines) do not support transactions. When writing transactional database code using a table type that does not support transactions, MySQL will pretend that a transaction was initiated successfully. In addition, any DDL queries issued will implicitly commit any pending transactions.

Use `--with-pdo-mysql[=DIR]` to install the PDO MySQL extension, where the optional `[=DIR]` is the MySQL base install directory. If mysqlnd is passed as `[=DIR]`, then the MySQL native driver will be used.

Optionally, the `--with-mysql-sock[=DIR]` sets to location to the MySQL unix socket pointer for all MySQL extensions, including PDO_MYSQL. If unspecified, the default locations are searched.

Optionally, the `--with-zlib-dir[=DIR]` is used to set the path to the libz install prefix.

```
$ ./configure --with-pdo-mysql --with-mysql-sock=/var/mysql/mysql.sock
```

The constants below are defined by this driver, and will only be available when the extension has been either compiled into PHP or dynamically loaded at runtime. In addition, these driver-specific constants should only be used if you are using this driver. Using driver-specific attributes with another driver may result in unexpected behaviour. `PDO::getAttribute` may be used to obtain the `PDO_ATTR_DRIVER_NAME` attribute to check the driver, if your code can run against multiple drivers.

`PDO::MYSQL_ATTR_USE_BUFFERED_QUERY` (integer)	If this attribute is set to `TRUE` on a `PDOStatement`, the MySQL driver will use the buffered versions of the MySQL API. If you're writing portable code, you should use `PDOStatement::fetchAll` instead.

Example 20.154. Forcing queries to be buffered in mysql

```
<?php
if ($db->getAttribute(PDO::ATTR_DRIVER_NAME) == 'mysql') {
    $stmt = $db->prepare('select * from foo',
        array(PDO::MYSQL_ATTR_USE_BUFFERED_QUERY => true));
} else {
    die("my application only works with mysql; I should use \$stmt->fetchAll() instead
}
?>
```

`PDO::MYSQL_ATTR_LOCAL_INFILE` (integer)	Enable `LOAD LOCAL INFILE`. Note, this constant can only be used in the *`driver_options`* array when constructing a new database handle.
`PDO::MYSQL_ATTR_INIT_COMMAND` (integer)	Command to execute when connecting to the MySQL server. Will automatically be re-executed when reconnecting. Note, this constant can only be used in the *`driver_options`* array when constructing a new database handle.
`PDO::MYSQL_ATTR_READ_DEFAULT_FILE` (integer)	Read options from the named option file instead of from `my.cnf`. This option is not available if mysqlnd is used, because mysqlnd does not read the mysql configuration files.
`PDO::MYSQL_ATTR_READ_DEFAULT_GROUP` (integer)	Read options from the named group from `my.cnf` or the file specified with `MYSQL_READ_DEFAULT_FILE` . This option is not available if mysqlnd is used, because mysqlnd does not read the mysql configuration files.
`PDO::MYSQL_ATTR_MAX_BUFFER_SIZE` (integer)	Maximum buffer size. Defaults to 1 MiB. This constant is not supported when compiled against mysqlnd.
`PDO::MYSQL_ATTR_DIRECT_QUERY` (integer)	Perform direct queries, don't use prepared statements.
`PDO::MYSQL_ATTR_FOUND_ROWS` (integer)	Return the number of found (matched) rows, not the number of changed rows.
`PDO::MYSQL_ATTR_IGNORE_SPACE` (integer)	Permit spaces after function names. Makes all functions names reserved words.
`PDO::MYSQL_ATTR_COMPRESS` (integer)	Enable network communication compression. This is not supported when compiled against mysqlnd.

The behaviour of these functions is affected by settings in `php.ini`.

Table 20.20. PDO_MYSQL Configuration Options

Name	Default	Changeable
pdo_mysql.default_socket	"/tmp/mysql.sock"	PHP_INI_SYSTEM
pdo_mysql.debug	NULL	PHP_INI_SYSTEM

For further details and definitions of the PHP_INI_* modes, see the configuration.changes.modes.

Here's a short explanation of the configuration directives.

`pdo_mysql.default_socket` string	Sets a Unix domain socket. This value can either be set at compile time if a domain socket is found at configure. This ini setting is Unix only.
`pdo_mysql.debug` boolean	Enables debugging for PDO_MYSQL. This setting is only available when PDO_MYSQL is compiled against mysqlnd and in PDO debug mode.

20.10.4.1. `PDO_MYSQL DSN`

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- `PDO_MYSQL DSN`

  Connecting to MySQL databases

Description

The PDO_MYSQL Data Source Name (DSN) is composed of the following elements:

DSN prefix	The DSN prefix is **`mysql:`**.
`host`	The hostname on which the database server resides.
`port`	The port number where the database server is listening.
`dbname`	The name of the database.
`unix_socket`	The MySQL Unix socket (shouldn't be used with `host` or `port`).
`charset`	Currently ignored.

Examples

Example 20.155. PDO_MYSQL DSN examples

The following example shows a PDO_MYSQL DSN for connecting to MySQL databases:

```
mysql:host=localhost;dbname=testdb
```

More complete examples:

```
mysql:host=localhost;port=3307;dbname=testdb
mysql:unix_socket=/tmp/mysql.sock;dbname=testdb
```

Notes

> **Unix only:**
>
> When the host name is set to `"localhost"`, then the connection to the server is made thru a domain socket. If PDO_MYSQL is compiled against libmysql then the location of the socket file is at libmysql's compiled in location. If PDO_MYSQL is compiled against mysqlnd a default socket can be set thru the pdo_mysql.default_socket setting.

20.10.5. Connector/PHP

The MySQL Connector/PHP is a version of the `mysql` and `mysqli` extensions for PHP optimized for the Windows operating system. Later versions of the main PHP `mysql`/`mysqli` drivers are compatible with Windows and a separate, Windows specific driver is no longer required.

For PHP for all platforms, including Windows, you should use the `mysql` or `mysqli` extensions shipped with the PHP sources. See Section 20.10, “MySQL PHP API”.

20.10.6. Common Problems with MySQL and PHP

- `Error: Maximum Execution Time Exceeded`: This is a PHP limit; go into the `php.ini` file and set the maximum execution time up from 30 seconds to something higher, as needed. It is also not a bad idea to double the RAM allowed per script to 16MB instead of 8MB.

- `Fatal error: Call to unsupported or undefined function mysql_connect() in ...`: This means that your PHP version isn't compiled with MySQL support. You can either compile a dynamic MySQL module and load it into PHP or recompile PHP with built-in MySQL support. This process is described in detail in the PHP manual.
- `Error: Undefined reference to 'uncompress'`: This means that the client library is compiled with support for a compressed client/server protocol. The fix is to add `-lz` last when linking with `-lmysqlclient`.
- `Error: Client does not support authentication protocol`: This is most often encountered when trying to use the older `mysql` extension with MySQL 4.1.1 and later. Possible solutions are: downgrade to MySQL 4.0; switch to PHP 5 and the newer `mysqli` extension; or configure the MySQL server with `--old-passwords`. (See Section C.5.2.4, “`Client does not support authentication protocol`”, for more information.)

Those with PHP4 legacy code can make use of a compatibility layer for the old and new MySQL libraries, such as this one: http://www.coggeshall.org/oss/mysql2i.

20.10.7. Enabling Both `mysql` and `mysqli` in PHP

If you're experiencing problems with enabling both the `mysql` and the `mysqli` extension when building PHP on Linux yourself, you should try the following procedure.

1. Configure PHP like this:

   ```
   ./configure --with-mysqli=/usr/bin/mysql_config --with-mysql=/usr
   ```

2. Edit the `Makefile` and search for a line that starts with `EXTRA_LIBS`. It might look like this (all on one line):

   ```
   EXTRA_LIBS = -lcrypt -lcrypt -lmysqlclient -lz -lresolv -lm -ldl -lnsl
   -lxml2 -lz -lm -lxml2 -lz -lm -lmysqlclient -lz -lcrypt -lnsl -lm
   -lxml2 -lz -lm -lcrypt -lxml2 -lz -lm -lcrypt
   ```

   Remove all duplicates, so that the line looks like this (all on one line):

   ```
   EXTRA_LIBS = -lcrypt -lcrypt -lmysqlclient -lz -lresolv -lm -ldl -lnsl
   -lxml2
   ```

3. Build and install PHP:

   ```
   make
   make install
   ```

20.11. MySQL Perl API

The Perl `DBI` module provides a generic interface for database access. You can write a DBI script that works with many different database engines without change. To use DBI, you must install the `DBI` module, as well as a DataBase Driver (DBD) module for each type of server you want to access. For MySQL, this driver is the `DBD::mysql` module.

Perl DBI is the recommended Perl interface. It replaces an older interface called `mysqlperl`, which should be considered obsolete.

Installation instructions for Perl DBI support are given in Section 2.13, “Perl Installation Notes”.

DBI information is available at the command line, online, or in printed form:

- Once you have the `DBI` and `DBD::mysql` modules installed, you can get information about them at the command line with the `perldoc` command:

  ```
  shell> perldoc DBI
  shell> perldoc DBI::FAQ
  shell> perldoc DBD::mysql
  ```

  You can also use `pod2man`, `pod2html`, and so forth to translate this information into other formats.

- For online information about Perl DBI, visit the DBI Web site, http://dbi.perl.org/. That site hosts a general DBI mailing list. Oracle Corporation hosts a list specifically about `DBD::mysql`; see Section 1.6.1, “MySQL Mailing Lists”.

- For printed information, the official DBI book is *Programming the Perl DBI* (Alligator Descartes and Tim Bunce, O'Reilly & Associates, 2000). Information about the book is available at the DBI Web site, http://dbi.perl.org/.

  For information that focuses specifically on using DBI with MySQL, see *MySQL and Perl for the Web* (Paul DuBois, New Riders, 2001). This book's Web site is http://www.kitebird.com/mysql-perl/.

20.12. MySQL Python API

`MySQLdb` provides MySQL support for Python, compliant with the Python DB API version 2.0. It can be found at http://sourceforge.net/projects/mysql-python/.

20.13. MySQL Ruby APIs

Two APIs available for Ruby programmers. The MySQL/Ruby API is based on the `libmysql` API library. The Ruby/MySQL API is written to use the native MySQL network protocol (a native driver).

For more information on Ruby, see Ruby Programming Language.

For information on installing and using the MySQL/Ruby API, see Section 20.13.1, “The MySQL/Ruby API”.

For information on installing and using the Ruby/MySQL API, see Section 20.13.2, “The Ruby/MySQL API”.

20.13.1. The MySQL/Ruby API

The MySQL/Ruby module provides access to MySQL databases using Ruby through `libmysql`.

For information on installing the module, and the functions exposed, see MySQL/Ruby.

20.13.2. The Ruby/MySQL API

The Ruby/MySQL module provides access to MySQL databases using Ruby through a native driver interface using the MySQL network protocol.

For information on installing the module, and the functions exposed, see Ruby/MySQL.

20.14. MySQL Tcl API

`MySQLtcl` is a simple API for accessing a MySQL database server from the Tcl programming language. It can be found at http://www.xdobry.de/mysqltcl/.

20.15. MySQL Eiffel Wrapper

Eiffel MySQL is an interface to the MySQL database server using the Eiffel programming language, written by Michael Ravits. It can be found at http://efsa.sourceforge.net/archive/ravits/mysql.htm.

Chapter 21. Extending MySQL

21.1. MySQL Internals

This chapter describes a lot of things that you need to know when working on the MySQL code. To track or contribute to MySQL development, follow the instructions in Section 2.9.3, “Installing MySQL from a Development Source Tree”. If you are interested in MySQL internals, you should also subscribe to our `internals` mailing list. This list has relatively low traffic. For details on how to subscribe, please see Section 1.6.1, “MySQL Mailing Lists”. Many MySQL developers at Oracle Corporation are on the `internals` list and we help other people who are working on the MySQL code. Feel free to use this list both to ask questions about the code and to send patches that you would like to contribute to the MySQL project!

21.1.1. MySQL Threads

The MySQL server creates the following threads:

- Connection manager threads handle client connection requests on the network interfaces that the server listens to. On all platforms, one manager thread handles TCP/IP connection requests. On Unix, this manager thread also handles Unix socket file connection requests. On Windows, a manager thread handles shared-memory connection requests, and another handles named-pipe connection requests. The server does not create threads to handle interfaces that it does not listen to. For example, a Windows server that does not have support for named-pipe connections enabled does not create a thread to handle them.

- Connection manager threads associate each client connection with a thread dedicated to it that handles authentication and request processing for that connection. Manager threads create a new thread when necessary but try to avoid doing so by consulting the thread cache first to see whether it contains a thread that can be used for the connection. When a connection ends, its thread is returned to the thread cache if the cache is not full.

  For information about tuning the parameters that control thread resources, see Section 7.11.5.1, “How MySQL Uses Threads for Client Connections”.

- On a master replication server, connections from slave servers are handled like client connections: There is one thread per connected slave.

- On a slave replication server, an I/O thread is started to connect to the master server and read updates from it. An SQL thread is started to apply updates read from the master. These two threads run independently and can be started and stopped independently.

- A signal thread handles all signals. This thread also normally handles alarms and calls `process_alarm()` to force timeouts on connections that have been idle too long.

- If `InnoDB` is used, there will be additional read and write threads by default. The number of these are controlled by the `innodb_read_io_threads` and `innodb_write_io_threads` parameters. See Section 13.3.4, “`InnoDB` Startup Options and System Variables”.

- If `mysqld` is compiled with `-DUSE_ALARM_THREAD`, a dedicated thread that handles alarms is created. This is only used on some systems where there are problems with `sigwait()` or if you want to use the `thr_alarm()` code in your application without a dedicated signal handling thread.

- If the server is started with the `--flush_time=val` option, a dedicated thread is created to flush all tables every *`val`* seconds.

- Each table for which `INSERT DELAYED` statements are issued gets its own thread. See Section 12.2.5.2, “`INSERT DELAYED` Syntax”.

- If the event scheduler is active, there is one thread for the scheduler, and a thread for each event currently running. See Section 17.4.1, “Event Scheduler Overview”.

`mysqladmin processlist` only shows the connection, `INSERT DELAYED`, replication, and event threads.

21.1.2. The MySQL Test Suite

The test system that is included in Unix source and binary distributions makes it possible for users and developers to perform regression tests on the MySQL code. These tests can be run on Unix.

You can also write your own test cases. For information about the MySQL Test Framework, including system requirements, see the manual available at http://dev.mysql.com/doc/.

The current set of test cases doesn't test everything in MySQL, but it should catch most obvious bugs in the SQL processing code, operating system or library issues, and is quite thorough in testing replication. Our goal is to have the tests cover 100% of the code. We welcome contributions to our test suite. You may especially want to contribute tests that examine the functionality critical to your system because this ensures that all future MySQL releases work well with your applications.

The test system consists of a test language interpreter (`mysqltest`), a Perl script to run all tests (`mysql-test-run.pl`), the actual test cases written in a special test language, and their expected results. To run the test suite on your system after a build, type `make test` from the source root directory, or change location to the `mysql-test` directory and type `./mysql-test-run.pl`. If you have installed a binary distribution, change location to the `mysql-test` directory under the installation root directory (for example, `/usr/local/mysql/mysql-test`), and run `./mysql-test-run.pl`. All tests should succeed. If any do not, feel free to try to find out why and report the problem if it indicates a bug in MySQL. See Section 1.7, “How to Report Bugs or Problems”.

If one test fails, you should run `mysql-test-run.pl` with the `--force` option to check whether any other tests fail.

If you have a copy of `mysqld` running on the machine where you want to run the test suite, you do not have to stop it, as long as it is not using ports `9306` or `9307`. If either of those ports is taken, you should set the `MTR_BUILD_THREAD` environment variable to an appropriate value, and the test suite will use a different set of ports for master, slave, and NDB). For example:

```
shell> export MTR_BUILD_THREAD=31
shell> ./mysql-test-run.pl [options] [test_name]
```

In the `mysql-test` directory, you can run an individual test case with `./mysql-test-run.pl test_name`.

If you have a question about the test suite, or have a test case to contribute, send an email message to the MySQL `internals` mailing list. See Section 1.6.1, “MySQL Mailing Lists”. This list does not accept attachments, so you should FTP all the relevant files to: ftp://ftp.mysql.com/pub/mysql/upload/

21.2. The MySQL Plugin API

MySQL supports a plugin API that enables creation of server components. Plugins can be loaded at server startup, or loaded and unloaded at runtime without restarting the server. The API is generic and does not specify what plugins can do. The components supported by this interface include, but are not limited to, storage engines, full-text parser plugins, partitioning support, and server extensions.

For example, full-text parser plugins can be used to replace or augment the built-in full-text parser. A plugin can parse text into words using rules that differ from those used by the built-in parser. This can be useful if you need to parse text with characteristics different from those expected by the built-in parser.

The plugin interface is intended as the successor to the older user-defined function (UDF) interface.

The plugin interface uses the `plugin` table in the `mysql` database to record information about plugins that have been installed permanently with the `INSTALL PLUGIN` statement. This table is created as part of the MySQL installation process. Plugins can also be installed for a single server invocation with the `--plugin-load` option. Plugins installed this way are not recorded in the `plugin` table. See Section 5.1.7.1, “Installing and Uninstalling Plugins”.

MySQL 5.5.7 and up supports an API for client plugins in addition to that for server plugins. This is used, for example, by authentication plugins where a server-side plugin and a client-side plugin cooperate to enable clients to connect to the server through a variety of authentication methods.

Additional Resources

The book *MySQL 5.1 Plugin Development* by Sergei Golubchik and Andrew Hutchings provides a wealth of detail about the plugin API. Despite the title says 5.1, most of the information applies to later versions as well.

21.2.1. Plugin API Characteristics

The server plugin API has these characteristics:

- All plugins have several things in common.

  Each plugin has a name that it can be referred to in SQL statements, as well as other metadata such as an author and a description that provide other information. This information can be examined in the `INFORMATION_SCHEMA.PLUGINS` table or using the `SHOW PLUGINS` statement.

- The plugin framework is extendable to accommodate different kinds of plugins.

  Although some aspects of the plugin API are common to all types of plugins, the API also permits type-specific interface elements so that different types of plugins can be created. A plugin with one purpose can have an interface most appropriate to its own requirements and not the requirements of some other plugin type.

Interfaces for several types of plugins exist, such as storage engines, full-text parser, and `INFORMATION_SCHEMA` tables. Others can be added.

- Plugins can expose information to users.

  A plugin can implement system and status variables that are available through the `SHOW VARIABLES` and `SHOW STATUS` statements.

- The plugin API includes versioning information.

  The version information included in the plugin API enables a plugin library and each plugin that it contains to be self-identifying with respect to the API version that was used to build the library. If the API changes over time, the version numbers will change, but a server can examine a given plugin library's version information to determine whether it supports the plugins in the library.

  There are two types of version numbers. The first is the version for the general plugin framework itself. Each plugin library includes this kind of version number. The second type of version applies to individual plugins. Each specific type of plugin has a version for its interface, so each plugin in a library has a type-specific version number. For example, a library containing a full-text parser plugin has a general plugin API version number, and the plugin has a version number specific to the full-text plugin interface.

- The plugin API implements security restrictions.

  A plugin library must be installed in a specific dedicated directory for which the location is controlled by the server and cannot be changed at runtime. Also, the library must contain specific symbols that identify it as a plugin library. The server will not load something as a plugin if it was not built as a plugin.

- Plugins have access to server services.

  The services interface exposes server functionality that plugins can access using ordinary function calls. For details, see Section 21.2.5, “MySQL Services for Plugins”.

In some respects, the server plugin API is similar to the older user-defined function (UDF) API that it supersedes, but the plugin API has several advantages over the older interface. For example, UDFs had no versioning information. Also, the newer plugin interface eliminates the security issues of the older UDF interface. The older interface for writing nonplugin UDFs permitted libraries to be loaded from any directory searched by the system's dynamic linker, and the symbols that identified the UDF library were relatively nonspecific.

The client plugin API has similar architectural characteristics, but client plugins have no direct access to the server the way server plugins do.

21.2.2. Plugin API Components

The server plugin implementation comprises several components.

SQL statements:

- `INSTALL PLUGIN` registers a plugin in the `mysql.plugin` table and loads the plugin code.
- `UNINSTALL PLUGIN` unregisters a plugin from the `mysql.plugin` table and unloads the plugin code.
- The `WITH PARSER` clause for full-text index creation associates a full-text parser plugin with a given `FULLTEXT` index.
- `SHOW PLUGINS` displays information about server plugins.

Command-line options and system variables:

- The `--plugin-load` option enables plugins to be loaded at server startup time.
- The `plugin_dir` system variable indicates the location of the directory where all plugins must be installed. The value of this variable can be specified at server startup with a `--plugin_dir=`*`path`* option. `mysql_config --plugindir` displays the default plugin directory path name.

For additional information about plugin loading, see Section 5.1.7.1, “Installing and Uninstalling Plugins”.

Plugin-related tables:

- The `INFORMATION_SCHEMA.PLUGINS` table contains plugin information.
- The `mysql.plugin` table lists each plugin that was installed with `INSTALL PLUGIN` and is required for plugin use. For new MySQL installations, this table is created during the installation process.

The client plugin implementation is simpler:

- For the `mysql_options()` C API function, the `MYSQL_DEFAULT_AUTH` and `MYSQL_PLUGIN_DIR` options enable client programs to load authentication plugins.
- There are C API functions that enable management of client plugins.

To examine how MySQL implements plugins, consult the following source files in a MySQL source distribution:

- In the `include/mysql` directory, `plugin.h` exposes the public plugin API. This file should be examined by anyone who wants to write a plugin library. `plugin_xxx.h` files provide additional information that pertains to specific types of plugins. `client_plugin.h` contains information specific to client plugins.
- In the `sql` directory, `sql_plugin.h` and `sql_plugin.cc` comprise the internal plugin implementation. `sql_acl.cc` is where the server uses authentication plugins. These files need not be consulted by plugin developers. They may be of interest for those who want to know more about how the server handles plugins.
- In the `sql-common` directory, `client_plugin.h` implements the C API client plugin functions, and `client.c` implements client authentication support. These files need not be consulted by plugin developers. They may be of interest for those who want to know more about how the server handles plugins.

21.2.3. Types of Plugins

The plugin API enables creation of plugins that implement several capabilities:

- Storage engines
- Full-text parsers
- Daemons
- `INFORMATION_SCHEMA` tables
- Semisynchronous replication
- Auditing
- Authentication

The following sections provide an overview of these plugin types.

21.2.3.1. Storage Engine Plugins

The pluggable storage engine architecture used by MySQL Server enables storage engines to be written as plugins and loaded into and unloaded from a running server. For a description of this architecture, see Section 13.2, “Overview of MySQL Storage Engine Architecture”.

For information on how to use the plugin API to write storage engines, see MySQL Internals: Custom Engine.

21.2.3.2. Full-Text Parser Plugins

MySQL has a built-in parser that it uses by default for full-text operations (parsing text to be indexed, or parsing a query string to determine the terms to be used for a search). For full-text processing, “parsing” means extracting words from text or a query string based on rules that define which character sequences make up a word and where word boundaries lie.

When parsing for indexing purposes, the parser passes each word to the server, which adds it to a full-text index. When parsing a query string, the parser passes each word to the server, which accumulates the words for use in a search.

The parsing properties of the built-in full-text parser are described in Section 11.9, “Full-Text Search Functions”. These properties include rules for determining how to extract words from text. The parser is influenced by certain system variables such as `ft_min_word_len` and `ft_max_word_len` that cause words shorter or longer to be excluded, and by the stopword list that identifies common words to be ignored.

The plugin API enables you to provide a full-text parser of your own so that you have control over the basic duties of a parser. A parser plugin can operate in either of two roles:

- The plugin can replace the built-in parser. In this role, the plugin reads the input to be parsed, splits it up into words, and passes the words to the server (either for indexing or for word accumulation).

  One reason to use a parser this way is that you need to use different rules from those of the built-in parser for determining how to split up input into words. For example, the built-in parser considers the text “case-sensitive” to consist of two words “case” and “sensitive,” whereas an application might need to treat the text as a single word.

- The plugin can act in conjunction with the built-in parser by serving as a front end for it. In this role, the plugin extracts text from the input and passes the text to the parser, which splits up the text into words using its normal parsing rules. In particular, this parsing will be affected by the `ft_xxx` system variables and the stopword list.

  One reason to use a parser this way is that you need to index content such as PDF documents, XML documents, or `.doc` files. The built-in parser is not intended for those types of input but a plugin can pull out the text from these input sources and pass it to the built-in parser.

It is also possible for a parser plugin to operate in both roles. That is, it could extract text from nonplaintext input (the front end role), and also parse the text into words (thus replacing the built-in parser).

A full-text plugin is associated with full-text indexes on a per-index basis. That is, when you install a parser plugin initially, that does not cause it to be used for any full-text operations. It simply becomes available. For example, a full-text parser plugin becomes available to be named in a `WITH PARSER` clause when creating individual `FULLTEXT` indexes. To create such an index at table-creation time, do this:

```
CREATE TABLE t
(
  doc CHAR(255),
  FULLTEXT INDEX (doc) WITH PARSER my_parser
) ENGINE=MyISAM;
```

Or you can add the index after the table has been created:

```
ALTER TABLE t ADD FULLTEXT INDEX (doc) WITH PARSER my_parser;
```

The only SQL change for associating the parser with the index is the `WITH PARSER` clause. Searches are specified as before, with no changes needed for queries.

When you associate a parser plugin with a `FULLTEXT` index, the plugin is required for using the index. If the parser plugin is dropped, any index associated with it becomes unusable. Any attempt to use it a table for which a plugin is not available results in an error, although `DROP TABLE` is still possible.

For more information about full-text plugins, see Section 21.2.4.4, “Writing Full-Text Parser Plugins”.

21.2.3.3. Daemon Plugins

A daemon plugin is a simple type of plugin used for code that should be run by the server but that does not communicate with it. MySQL distributions include an example daemon plugin that writes periodic heartbeat messages to a file.

For more information about daemon plugins, see Section 21.2.4.5, “Writing Daemon Plugins”.

21.2.3.4. `INFORMATION_SCHEMA` Plugins

`INFORMATION_SCHEMA` plugins enable the creation of tables containing server metadata that are exposed to users through the `INFORMATION_SCHEMA` database. For example, `InnoDB` uses `INFORMATION_SCHEMA` plugins to provide tables that contain information about current transactions and locks.

For more information about `INFORMATION_SCHEMA` plugins, see Section 21.2.4.6, “Writing `INFORMATION_SCHEMA` Plugins”.

21.2.3.5. Semisynchronous Replication Plugins

MySQL replication is asynchronous by default. With semisynchronous replication, a commit performed on the master side blocks before returning to the session that performed the transaction until at least one slave acknowledges that it has received and logged the events for the transaction. Semisynchronous replication is implemented through complementary master and client plugins. See Section 15.3.8, “Semisynchronous Replication”.

For more information about semisynchronous replication plugins, see Section 21.2.4.7, “Writing Semisynchronous Replication Plugins”.

21.2.3.6. Audit Plugins

As of MySQL 5.5.3, the server provides a pluggable audit interface that enables information about server operations to be reported to interested parties. Currently, audit notification occurs for these operations (although the interface is general and the server could be modified to report others):

- Write a message to the general query log (if the log is enabled)
- Write a message to the error log
- Send a query result to a client

Audit plugins may register with the audit interface to receive notification about server operations. When an auditable event occurs within the server, the server determines whether notification is needed. For each registered audit plugin, the server checks the event against those event classes in which the plugin is interested and passes the event to the plugin if there is a match.

This interface enables audit plugins to receive notifications only about operations in event classes they consider significant and to ignore others. The interface provides for categorization of operations into event classes and further division into event subclasses within each class.

When an audit plugin is notified of an auditable event, it receives a pointer to the current THD structure and a pointer to a structure that contains information about the event. The plugin can examine the event and perform whatever auditing actions are appropriate. For example, the plugin can see what statement produced a result set or was logged, the number of rows in a result, who the current user was for an operation, or the error code for failed operations.

For more information about audit plugins, see Section 21.2.4.8, “Writing Audit Plugins”.

21.2.3.7. Authentication Plugins

MySQL 5.5.7 and up supports pluggable authentication. Authentication plugins exist on both the server and client sides. Plugins on the server side implement authentication methods for use by clients when they connect to the server. A plugin on the client side communicates with a server-side plugin to provide the authentication information that it requires. A client-side plugin may interact with the user, performing tasks such as soliciting a password or other authentication credentials to be sent to the server. See Section 5.5.6, “Pluggable Authentication”.

Pluggable authentication also enables proxy user capability, in which one user takes the identity of another user. A server-side authentication plugin can return to the server the name of the user whose identity the connecting user should have. See Section 5.5.7, “Proxy Users”.

For more information about authentication plugins, see Section 21.2.4.9, “Writing Authentication Plugins”.

21.2.4. Writing Plugins

To create a plugin library, you must provide the required descriptor information that indicates what plugins the library file contains, and write the interface functions for each plugin.

Every server plugin must have a general descriptor that provides information to the plugin API, and a type-specific descriptor that provides information about the plugin interface for a given type of plugin. The structure of the general descriptor is the same for all plugin types. The structure of the type-specific descriptor varies among plugin types and is determined by the requirements of what the plugin needs to do. The server plugin interface also enables plugins to expose status and system variables. These variables become visible through the `SHOW STATUS` and `SHOW VARIABLES` statements and the corresponding `INFORMATION_SCHEMA` tables.

For client-side plugins, the architecture is a bit different. Each plugin must have a descriptor, but there is no division into separate general and type-specific descriptors. Instead, the descriptor begins with a fixed set of members common to all client plugin types, and the common members are followed by any additional members required to implement the specific plugin type.

You can write plugins in C or C++ (or another language that can use C calling conventions). Plugins are loaded and unloaded dynamically, so your operating system must support dynamic loading and you must have compiled the calling application dynamically (not statically). For server plugins, this means that `mysqld` must be compiled dynamically.

A server plugin contains code that becomes part of the running server, so when you write the plugin, you are bound by any and all constraints that otherwise apply to writing server code. For example, you may have problems if you attempt to use functions from the `libstdc++` library. These constraints may change in future versions of the server, so it is possible that server upgrades will require revisions to plugins originally written for older servers. For information about these constraints, see Section 2.9.4, “MySQL Source-Configuration Options”, and Section 2.9.5, “Dealing with Problems Compiling MySQL”.

Client plugin writers should avoid dependencies on what symbols the calling application has because you cannot be sure what applications will use the plugin.

21.2.4.1. Overview of Plugin Writing

The following procedure provides an overview of the steps needed to create a plugin library. The next sections provide additional details on setting plugin data structures and writing specific types of plugins.

1. In the plugin source file, include the header files that the plugin library needs. The `plugin.h` file is required, and the library might require other files as well. For example:

   ```
   #include <stdlib.h>
   #include <ctype.h>
   #include <mysql/plugin.h>
   ```

2. Set up the descriptor information for the plugin library file. For server plugins, write the library descriptor, which must contain the general plugin descriptor for each server plugin in the file. For more information, see Section 21.2.4.2.1, “Server Plugin Library and Plugin Descriptors”. In addition, set up the type-specific descriptor for each server plugin in the library. Each plugin's general descriptor points to its type-specific descriptor.

   For client plugins, write the client descriptor. For more information, see Section 21.2.4.2.3, “Client Plugin Descriptors”.

3. Write the plugin interface functions for each plugin. For example, each plugin's general plugin descriptor points to the initialization and deinitialization functions that the server should invoke when it loads and unloads the plugin. The plugin's type-specific description may also point to interface functions.

4. For server plugins, set up the status and system variables, if there are any.

5. Compile the plugin library as a shared library and install it in the plugin directory. For more information, see Section 21.2.4.3, “Compiling and Installing Plugin Libraries”.

6. For server plugins, register the plugin with the server. For more information, see Section 5.1.7.1, “Installing and Uninstalling Plugins”.

7. Test the plugin to verify that it works properly.

21.2.4.2. Plugin Data Structures

A plugin library file includes descriptor information to indicate what plugins it contains.

If the plugin library contains any server plugins, it must include the following descriptor information:

- A library descriptor indicates the general server plugin API version number used by the library and contains a general plugin descriptor for each server plugin in the library. To provide the framework for this descriptor, invoke two macros from the `plugin.h` header file:

  ```
  mysql_declare_plugin(name)
   ... one or more server plugin descriptors here ...
  mysql_declare_plugin_end;
  ```

  The macros expand to provide a declaration for the API version automatically. You must provide the plugin descriptors.

- Within the library descriptor, each general server plugin is described by a `st_mysql_plugin` structure. This plugin descriptor structure contains information that is common to every type of server plugin: A value that indicates the plugin type; the plugin name, author, description, and license type; pointers to the initialization and deinitialization functions that the server invokes when it loads and unloads the plugin, and pointers to any status or system variables the plugin implements.

- Each general server plugin descriptor within the library descriptor also contains a pointer to a type-specific plugin descriptor.

The structure of the type-specific descriptors varies from one plugin type to another because each type of plugin can have its own API. A type-specific plugin descriptor contains a type-specific API version number and pointers to the functions that are needed to implement that plugin type. For example, a full-text parser plugin has initialization and deinitialization functions, and a main parsing function. The server invokes these functions when it uses the plugin to parse text.

The plugin library also contains the interface functions that are referenced by the general and type-specific descriptors for each plugin in the library.

If the plugin library contains a client plugin, it must include a descriptor for the plugin. The descriptor begins with a fixed set of members common to all client plugins, followed by any members specific to the plugin type. To provide the descriptor framework, invoke two macros from the `client_plugin.h` header file:

```
mysql_declare_client_plugin(plugin_type)
   ... members common to all client plugins ...
   ... type-specific extra members ...
mysql_end_client_plugin;
```

The plugin library also contains any interface functions referenced by the client descriptor.

The `mysql_declare_plugin()` and `mysql_declare_client_plugin()` macros differ somewhat in how they can be invoked, which has implications for the contents of plugin libraries. The following guidelines summarize the rules:

- `mysql_declare_plugin()` and `mysql_declare_client_plugin()` can both be used in the same source file, which means that a plugin library can contain both server and client plugins. However, each of `mysql_declare_plugin()` and `mysql_declare_client_plugin()` can be used at most once.
- `mysql_declare_plugin()` permits multiple server plugin declarations, so a plugin library can contain multiple server plugins.
- `mysql_declare_client_plugin()` permits only a single client plugin declaration. To create multiple client plugins, separate plugin libraries must be used.

When a client program looks for a client plugin that is in a plugin library and not built into `libmysql`, it looks for a file with a basename that is the same as the plugin name. For example, if a program needs to use a client authentication plugin named `auth_xxx` on a system that uses `.so` as the library extension, it looks in the file named `auth_xxx.so`. (On Mac OS X, the program looks first for `auth_xxx.dylib`, then for `auth_xxx.so`.) For this reason, if a plugin library contains a client plugin, the library must have the same basename as that plugin.

The same is not true for a library that contains server plugins. The `--plugin-load` option and the `INSTALL PLUGIN` statement provide the library file name explicitly, so there need be no explicit relationship between the library name and the name of any server plugins it contains.

21.2.4.2.1. Server Plugin Library and Plugin Descriptors

Every plugin library that contains server plugins must include a library descriptor that contains the general plugin descriptor for each server plugin in the file. This section discusses how to write the library and general descriptors for server plugins.

The library descriptor must define two symbols:

- `_mysql_plugin_interface_version_` specifies the version number of the general plugin framework. This is given by the `MYSQL_PLUGIN_INTERFACE_VERSION` symbol, which is defined in the `plugin.h` file.
- `_mysql_plugin_declarations_` defines an array of plugin declarations, terminated by a declaration with all members set to 0. Each declaration is an instance of the `st_mysql_plugin` structure (also defined in `plugin.h`). There must be one of these for each server plugin in the library.

If the server does not find those two symbols in a library, it does not accept it as a legal plugin library and rejects it with an error. This prevents use of a library for plugin purposes unless it was built specifically as a plugin library.

The conventional way to define the two required symbols is by using the `mysql_declare_plugin()` and `mysql_declare_plugin_end` macros from the `plugin.h` file:

```
mysql_declare_plugin(name)
 ... one or more server plugin descriptors here ...
mysql_declare_plugin_end;
```

Each server plugin must have a general descriptor that provides information to the server plugin API. The general descriptor has the same structure for all plugin types. The `st_mysql_plugin` structure in the `plugin.h` file defines this descriptor:

```
struct st_mysql_plugin
{
  int type;             /* the plugin type (a MYSQL_XXX_PLUGIN value)   */
  void *info;           /* pointer to type-specific plugin descriptor   */
  const char *name;     /* plugin name                                  */
  const char *author;   /* plugin author (for SHOW PLUGINS)             */
  const char *descr;    /* general descriptive text (for SHOW PLUGINS ) */
  int license;          /* the plugin license (PLUGIN_LICENSE_XXX)      */
  int (*init)(void *);  /* the function to invoke when plugin is loaded */
  int (*deinit)(void *);/* the function to invoke when plugin is unloaded */
  unsigned int version; /* plugin version (for SHOW PLUGINS)            */
  struct st_mysql_show_var *status_vars;
  struct st_mysql_sys_var **system_vars;
  void * __reserved1;   /* reserved for dependency checking             */
};
```

The `st_mysql_plugin` descriptor structure members are used as follows. `char *` members should be specified as null-terminated strings.

- `type`: The plugin type. This must be one of the plugin-type values from `plugin.h`:

  ```
  /*
    The allowable types of plugins
  */
  #define MYSQL_UDF_PLUGIN             0  /* User-defined function        */
  #define MYSQL_STORAGE_ENGINE_PLUGIN  1  /* Storage Engine               */
  #define MYSQL_FTPARSER_PLUGIN        2  /* Full-text parser plugin      */
  #define MYSQL_DAEMON_PLUGIN          3  /* The daemon/raw plugin type */
  #define MYSQL_INFORMATION_SCHEMA_PLUGIN  4  /* The I_S plugin type */
  #define MYSQL_AUDIT_PLUGIN           5  /* The Audit plugin type        */
  #define MYSQL_REPLICATION_PLUGIN     6 /* The replication plugin type */
  #define MYSQL_AUTHENTICATION_PLUGIN  7  /* The authentication plugin type */
  ...
  ```

  For example, for a full-text parser plugin, the `type` value is `MYSQL_FTPARSER_PLUGIN`.

- `info`: A pointer to the type-specific descriptor for the plugin. This descriptor's structure depends on the particular type of plugin, unlike that of the general plugin descriptor structure. For version-control purposes, the first member of the type-specific descriptor for every plugin type is expected to be the interface version for the type. This enables the server to check the type-specific version for every plugin no matter its type. Following the version number, the descriptor includes any other members needed, such as callback functions and other information needed by the server to invoke the plugin properly. Later sections on writing particular types of server plugins describe the structure of their type-specific descriptors.

- `name`: A string that gives the plugin name. This is the name that will be listed in the `mysql.plugin` table and by which you refer to the plugin in SQL statements such as `INSTALL PLUGIN` and `UNINSTALL PLUGIN`, or with the `--plugin-load` option. The name is also visible in the `INFORMATION_SCHEMA.PLUGINS` table or the output from `SHOW PLUGINS`.

- `author`: A string naming the plugin author. This can be whatever you like.

- `desc`: A string that provides a general description of the plugin. This can be whatever you like.

- `license`: The plugin license type. The value can be one of `PLUGIN_LICENSE_PROPRIETARY`, `PLUGIN_LICENSE_GPL`, or `PLUGIN_LICENSE_BSD`.

- `init`: A once-only initialization function, or `NULL` if there is no such function. The server executes this function when it loads the plugin, which happens for `INSTALL PLUGIN` or, for plugins listed in the `mysql.plugin` table, at server startup. The function takes one argument that points to the internal structure used to identify the plugin. It returns zero for success and nonzero for failure.

- `deinit`: A once-only deinitialization function, or `NULL` if there is no such function. The server executes this function when it unloads the plugin, which happens for `UNINSTALL PLUGIN` or, for plugins listed in the `mysql.plugin` table, at server shutdown. The function takes one argument that points to the internal structure used to identify the plugin It returns zero for success and nonzero for failure.

- `version`: The plugin version number. When the plugin is installed, this value can be retrieved from the `INFORMATION_SCHEMA.PLUGINS` table. The value includes major and minor numbers. If you write the value as a hex constant, the format is `0x`*`MMNN`*, where *`MM`* and `NN` are the major and minor numbers, respectively. For example, `0x0302` represents version 3.2.

- `status_vars`: A pointer to a structure for status variables associated with the plugin, or `NULL` if there are no such variables. When the plugin is installed, these variables are displayed in the output of the `SHOW STATUS` statement.

  The `status_vars` member, if not `NULL`, points to an array of `st_mysql_show_var` structures that describe status variables. See Section 21.2.4.2.2, “Server Plugin Status and System Variables”.

- `system_vars`: A pointer to a structure for system variables associated with the plugin, or `NULL` if there are no such variables. These options and system variables can be used to help initialize variables within the plugin.

  The `system_vars` member, if not `NULL`, points to an array of `st_mysql_sys_var` structures that describe system variables. See Section 21.2.4.2.2, “Server Plugin Status and System Variables”.

- `__reserved1`: A placeholder for the future. Currently, it should be set to `NULL`.

The server invokes the `init` and `deinit` functions in the general plugin descriptor only when loading and unloading the plugin. They have nothing to do with use of the plugin such as happens when an SQL statement causes the plugin to be invoked.

For example, the descriptor information for a library that contains a single full-text parser plugin named `simple_parser` looks like this:

```
mysql_declare_plugin(ftexample)
{
  MYSQL_FTPARSER_PLUGIN,      /* type                            */
  &simple_parser_descriptor,  /* descriptor                      */
  "simple_parser",            /* name                            */
  "Oracle Corporation",       /* author                          */
  "Simple Full-Text Parser",  /* description                     */
  PLUGIN_LICENSE_GPL,         /* plugin license                  */
  simple_parser_plugin_init,  /* init function (when loaded)     */
  simple_parser_plugin_deinit,/* deinit function (when unloaded) */
  0x0001,                     /* version                         */
  simple_status,              /* status variables                */
  simple_system_variables,    /* system variables                */
  NULL
}
mysql_declare_plugin_end;
```

For a full-text parser plugin, the type must be `MYSQL_FTPARSER_PLUGIN`. This is the value that identifies the plugin as being legal for use in a `WITH PARSER` clause when creating a `FULLTEXT` index. (No other plugin type is legal for this clause.)

`plugin.h` defines the `mysql_declare_plugin()` and `mysql_declare_plugin_end` macros like this:

```
#ifndef MYSQL_DYNAMIC_PLUGIN
#define __MYSQL_DECLARE_PLUGIN(NAME, VERSION, PSIZE, DECLS) \
MYSQL_PLUGIN_EXPORT int VERSION= MYSQL_PLUGIN_INTERFACE_VERSION; \
MYSQL_PLUGIN_EXPORT int PSIZE= sizeof(struct st_mysql_plugin); \
MYSQL_PLUGIN_EXPORT struct st_mysql_plugin DECLS[]= {
#else
#define __MYSQL_DECLARE_PLUGIN(NAME, VERSION, PSIZE, DECLS) \
MYSQL_PLUGIN_EXPORT int _mysql_plugin_interface_version_= MYSQL_PLUGIN_INTERFACE_VERSION; \
MYSQL_PLUGIN_EXPORT int _mysql_sizeof_struct_st_plugin_= sizeof(struct st_mysql_plugin); \
MYSQL_PLUGIN_EXPORT struct st_mysql_plugin _mysql_plugin_declarations_[]= {
#endif

#define mysql_declare_plugin(NAME) \
__MYSQL_DECLARE_PLUGIN(NAME, \
                 builtin_ ## NAME ## _plugin_interface_version, \
                 builtin_ ## NAME ## _sizeof_struct_st_plugin, \
                 builtin_ ## NAME ## _plugin)

#define mysql_declare_plugin_end ,{0,0,0,0,0,0,0,0,0,0,0,0}}
```

> **Note**
>
> Those declarations define the `_mysql_plugin_interface_version_` symbol only if the `MYSQL_DYNAMIC_PLUGIN` symbol is defined. This means that `-DMYSQL_DYNAMIC_PLUGIN` must be provided as part of the compilation command to build the plugin as a shared library.

When the macros are used as just shown, they expand to the following code, which defines both of the required symbols (`_mysql_plugin_interface_version_` and `_mysql_plugin_declarations_`):

```
int _mysql_plugin_interface_version_= MYSQL_PLUGIN_INTERFACE_VERSION;
int _mysql_sizeof_struct_st_plugin_= sizeof(struct st_mysql_plugin);
struct st_mysql_plugin _mysql_plugin_declarations_[]= {
{
  MYSQL_FTPARSER_PLUGIN,      /* type                            */
  &simple_parser_descriptor,  /* descriptor                      */
  "simple_parser",            /* name                            */
  "Oracle Corporation",       /* author                          */
  "Simple Full-Text Parser",  /* description                     */
  PLUGIN_LICENSE_GPL,         /* plugin license                  */
  simple_parser_plugin_init,  /* init function (when loaded)     */
  simple_parser_plugin_deinit,/* deinit function (when unloaded) */
  0x0001,                     /* version                         */
  simple_status,              /* status variables                */
  simple_system_variables,    /* system variables                */
  NULL
}
  ,{0,0,0,0,0,0,0,0,0,0,0,0,0}}
};
```

The preceding example declares a single plugin in the general descriptor, but it is possible to declare multiple plugins. List the declarations one after the other between `mysql_declare_plugin()` and `mysql_declare_plugin_end`, separated by commas.

MySQL server plugins can be written in C or C++ (or another language that can use C calling conventions). If you write a C++ plugin, one C++ feature that you should not use is nonconstant variables to initialize global structures. Members of structures such as the `st_mysql_plugin` structure should be initialized only with constant variables. The `simple_parser` descriptor shown earlier is permissible in a C++ plugin because it satisfies that requirement:

```
mysql_declare_plugin(ftexample)
{
  MYSQL_FTPARSER_PLUGIN,      /* type                            */
  &simple_parser_descriptor,  /* descriptor                      */
  "simple_parser",            /* name                            */
  "Oracle Corporation",       /* author                          */
  "Simple Full-Text Parser",  /* description                     */
  PLUGIN_LICENSE_GPL,         /* plugin license                  */
  simple_parser_plugin_init,  /* init function (when loaded)     */
  simple_parser_plugin_deinit,/* deinit function (when unloaded) */
  0x0001,                     /* version                         */
  simple_status,              /* status variables                */
  simple_system_variables,    /* system variables                */
  NULL
}
mysql_declare_plugin_end;
```

Here is another valid way to write the general descriptor. It uses constant variables to indicate the plugin name, author, and description:

```
const char *simple_parser_name = "simple_parser";
const char *simple_parser_author = "Oracle Corporation";
const char *simple_parser_description = "Simple Full-Text Parser";

mysql_declare_plugin(ftexample)
{
  MYSQL_FTPARSER_PLUGIN,      /* type                            */
  &simple_parser_descriptor,  /* descriptor                      */
  simple_parser_name,         /* name                            */
  simple_parser_author,       /* author                          */
  simple_parser_description,  /* description                     */
  PLUGIN_LICENSE_GPL,         /* plugin license                  */
  simple_parser_plugin_init,  /* init function (when loaded)     */
  simple_parser_plugin_deinit,/* deinit function (when unloaded) */
  0x0001,                     /* version                         */
  simple_status,              /* status variables                */
  simple_system_variables,    /* system variables                */
  NULL
}
mysql_declare_plugin_end;
```

However, the following general descriptor is invalid. It uses structure members to indicate the plugin name, author, and description, but structures are not considered constant initializers in C++:

```
typedef struct
{
  const char *name;
  const char *author;
  const char *description;
} plugin_info;

plugin_info parser_info = {
  "simple_parser",
  "Oracle Corporation",
  "Simple Full-Text Parser"
};

mysql_declare_plugin(ftexample)
{
  MYSQL_FTPARSER_PLUGIN,      /* type                            */
  &simple_parser_descriptor,  /* descriptor                      */
  parser_info.name,           /* name                            */
  parser_info.author,         /* author                          */
  parser_info.description,    /* description                     */
  PLUGIN_LICENSE_GPL,         /* plugin license                  */
  simple_parser_plugin_init,  /* init function (when loaded)     */
  simple_parser_plugin_deinit,/* deinit function (when unloaded) */
  0x0001,                     /* version                         */
  simple_status,              /* status variables                */
  simple_system_variables,    /* system variables                */
  NULL
}
mysql_declare_plugin_end;
```

21.2.4.2.2. Server Plugin Status and System Variables

The server plugin interface enables plugins to expose status and system variables using the `status_vars` and `system_vars` members of the general plugin descriptor.

The `status_vars` member of the general plugin descriptor, if not 0, points to an array of `st_mysql_show_var` structures, each of which describes one status variable, followed by a structure with all members set to 0. The `st_mysql_show_var` structure has this definition:

```
struct st_mysql_show_var {
  const char *name;
  char *value;
  enum enum_mysql_show_type type;
};
```

When the plugin is installed, the plugin name and the `name` value are joined with an underscore to form the name displayed by `SHOW STATUS`.

The following table shows the permissible status variable `type` values and what the corresponding variable should be.

Table 21.1. Server Plugin Status Variable Types

Variable Type	Meaning
`SHOW_BOOL`	Pointer to a boolean variable
`SHOW_INT`	Pointer to an integer variable
`SHOW_LONG`	Pointer to a long integer variable
`SHOW_LONGLONG`	Pointer to a longlong integer variable
`SHOW_CHAR`	A string
`SHOW_CHAR_PTR`	Pointer to a string
`SHOW_ARRAY`	Pointer to another `st_mysql_show_var` array
`SHOW_FUNC`	Pointer to a function
`SHOW_DOUBLE`	Pointer to a double

For the `SHOW_FUNC` type, the function is called and fills in its `out` parameter, which then provides information about the variable to be displayed. The function has this signature:

```
#define SHOW_VAR_FUNC_BUFF_SIZE 1024

typedef int (*mysql_show_var_func) (void *thd,
                                    struct st_mysql_show_var *out,
                                    char *buf);
```

The `system_vars` member, if not 0, points to an array of `st_mysql_sys_var` structures, each of which describes one system variable (which can also be set from the command-line or configuration file), followed by a structure with all members set to 0. The `st_mysql_sys_var` structure is defined as follows:

```
struct st_mysql_sys_var {
 int flags;
 const char *name, *comment;
 int (*check)(THD*, struct st_mysql_sys_var *, void*, st_mysql_value*);
 void (*update)(THD*, struct st_mysql_sys_var *, void*, const void*);
};
```

Additional fields are append as required depending upon the flags.

For convenience, a number of macros are defined that make creating new system variables within a plugin much simpler.

Throughout the macros, the following fields are available:

- `name`: An unquoted identifier for the system variable.
- `varname`: The identifier for the static variable. Where not available, it is the same as the `name` field.
- `opt`: Additional use flags for the system variable. The following table shows the permissible flags.

Table 21.2. Server Plugin System Variable Flags

Flag Value	Description
`PLUGIN_VAR_READONLY`	The system variable is read only
`PLUGIN_VAR_NOSYSVAR`	The system variable is not user visible at runtime
`PLUGIN_VAR_NOCMDOPT`	The system variable is not configurable from the command line
`PLUGIN_VAR_NOCMDARG`	No argument is required at the command line (typically used for boolean variables)
`PLUGIN_VAR_RQCMDARG`	An argument is required at the command line (this is the default)
`PLUGIN_VAR_OPCMDARG`	An argument is optional at the command line
`PLUGIN_VAR_MEMALLOC`	Used for string variables; indicates that memory is to be allocated for storage of the string

- `comment`: A descriptive comment to be displayed in the server help message. `NULL` if this variable is to be hidden.
- `check`: The check function, `NULL` for default.
- `update`: The update function, `NULL` for default.
- `default`: The variable default value.
- `minimum`: The variable minimum value.
- `maximum`: The variable maximum value.
- `blocksize`: The variable block size. When the value is set, it is rounded to the nearest multiple of `blocksize`.

A system variable may be accessed either by using the static variable directly or by using the `SYSVAR()`accessor macro. The `SYSVAR()` macro is provided for completeness. Usually it should be used only when the code cannot directly access the underlying variable.

For example:

```
static int my_foo;
static MYSQL_SYSVAR_INT(foo_var, my_foo,
                        PLUGIN_VAR_RQCMDARG, "foo comment",
                        NULL, NULL, 0, 0, INT_MAX, 0);
 ...
   SYSVAR(foo_var)= value;
   value= SYSVAR(foo_var);
   my_foo= value;
   value= my_foo;
```

Session variables may be accessed only through the `THDVAR()` accessor macro. For example:

```
static MYSQL_THDVAR_BOOL(some_flag,
                         PLUGIN_VAR_NOCMDARG, "flag comment",
                         NULL, NULL, FALSE);
 ...
   if (THDVAR(thd, some_flag))
   {
     do_something();
     THDVAR(thd, some_flag)= FALSE;
   }
```

All global and session system variables must be published to `mysqld` before use. This is done by constructing a `NULL`-terminated array of the variables and linking to it in the plugin public interface. For example:

```
static struct st_mysql_sys_var *my_plugin_vars[]= {
  MYSQL_SYSVAR(foo_var),
  MYSQL_SYSVAR(some_flag),
  NULL
};
mysql_declare_plugin(fooplug)
{
  MYSQL_..._PLUGIN,
  &plugin_data,
  "fooplug",
  "foo author",
  "This does foo!",
  PLUGIN_LICENSE_GPL,
  foo_init,
  foo_fini,
  0x0001,
  NULL,
  my_plugin_vars,
  NULL
}
mysql_declare_plugin_end;
```

The following convenience macros enable you to declare different types of system variables:

- Boolean system variables of type `my_bool`, which is a 1-byte boolean. (0 = FALSE, 1 = TRUE)

  ```
  MYSQL_THDVAR_BOOL(name, opt, comment, check, update, default)
  MYSQL_SYSVAR_BOOL(name, varname, opt, comment, check, update, default)
  ```

- String system variables of type `char*`, which is a pointer to a null-terminated string.

  ```
  MYSQL_THDVAR_STR(name, opt, comment, check, update, default)
  MYSQL_SYSVAR_STR(name, varname, opt, comment, check, update, default)
  ```

- Integer system variables, of which there are several varieties.

  - An `int` system variable, which is typically a 4-byte signed word.

    ```
    MYSQL_THDVAR_INT(name, opt, comment, check, update, default, min, max, blk)
    MYSQL_SYSVAR_INT(name, varname, opt, comment, check, update, default,
                   minimum, maximum, blocksize)
    ```

  - An `unsigned int` system variable, which is typically a 4-byte unsigned word.

    ```
    MYSQL_THDVAR_UINT(name, opt, comment, check, update, default, min, max, blk)
    MYSQL_SYSVAR_UINT(name, varname, opt, comment, check, update, default,
                    minimum, maximum, blocksize)
    ```

  - A `long` system variable, which is typically either a 4- or 8-byte signed word.

    ```
    MYSQL_THDVAR_LONG(name, opt, comment, check, update, default, min, max, blk)
    MYSQL_SYSVAR_LONG(name, varname, opt, comment, check, update, default,
                    minimum, maximum, blocksize)
    ```

  - An `unsigned long` system variable, which is typically either a 4- or 8-byte unsigned word.

    ```
    MYSQL_THDVAR_ULONG(name, opt, comment, check, update, default, min, max, blk)
    MYSQL_SYSVAR_ULONG(name, varname, opt, comment, check, update, default,
                     minimum, maximum, blocksize)
    ```

  - A `long long` system variable, which is typically an 8-byte signed word.

    ```
    MYSQL_THDVAR_LONGLONG(name, opt, comment, check, update,
                        default, minimum, maximum, blocksize)
    MYSQL_SYSVAR_LONGLONG(name, varname, opt, comment, check, update,
                        default, minimum, maximum, blocksize)
    ```

  - An `unsigned long long` system variable, which is typically an 8-byte unsigned word.

    ```
    MYSQL_THDVAR_ULONGLONG(name, opt, comment, check, update,
                         default, minimum, maximum, blocksize)
    MYSQL_SYSVAR_ULONGLONG(name, varname, opt, comment, check, update,
                         default, minimum, maximum, blocksize)
    ```

  - An `unsigned long` system variable, which is typically either a 4- or 8-byte unsigned word. The range of possible values is an ordinal of the number of elements in the `typelib`, starting from 0.

    ```
    MYSQL_THDVAR_ENUM(name, opt, comment, check, update, default, typelib)
    MYSQL_SYSVAR_ENUM(name, varname, opt, comment, check, update,
                    default, typelib)
    ```

  - An `unsigned long long` system variable, which is typically an 8-byte unsigned word. Each bit represents an element in the `typelib`.

    ```
    MYSQL_THDVAR_SET(name, opt, comment, check, update, default, typelib)
    MYSQL_SYSVAR_SET(name, varname, opt, comment, check, update,
                   default, typelib)
    ```

Internally, all mutable and plugin system variables are stored in a `HASH` structure.

Display of the server command-line help text is handled by compiling a `DYNAMIC_ARRAY` of all variables relevant to command-line options, sorting them, and then iterating through them to display each option.

When a command-line option has been handled, it is then removed from the `argv` by the `handle_option()` function (`my_getopt.c`); in effect, it is consumed.

The server processes command-line options during the plugin installation process, immediately after the plugin has been successfully loaded but before the plugin initialization function has been called

Plugins loaded at runtime do not benefit from any configuration options and must have usable defaults. Once they are installed, they are loaded at `mysqld` initialization time and configuration options can be set at the command line or within `my.cnf`.

Plugins should consider the `thd` parameter to be read only.

21.2.4.2.3. Client Plugin Descriptors

Each client plugin must have a descriptor that provides information to the client plugin API. The descriptor structure begins with a fixed set of members common to all client plugins, followed by any members specific to the plugin type.

The `st_mysql_client_plugin` structure in the `client_plugin.h` file defines a “generic” descriptor that contains the common members:

```
struct st_mysql_client_plugin
{
  int type;
  unsigned int interface_version;
  const char *name;
  const char *author;
  const char *desc;
  unsigned int version[3];
  const char *license;
  void *mysql_api;
  int (*init)(char *, size_t, int, va_list);
  int (*deinit)();
  int (*options)(const char *option, const void *);
};
```

The common `st_mysql_client_plugin` descriptor structure members are used as follows. `char *` members should be specified as null-terminated strings.

- `type`: The plugin type. This must be one of the plugin-type values from `client_plugin.h`, such as `MYSQL_CLIENT_AUTHENTICATION_PLUGIN`.
- `interface_version`: The plugin interface version. For example, this is `MYSQL_CLIENT_AUTHENTICATION_PLUGIN_INTERFACE_VERSION` for an authentication plugin.
- `name`: A string that gives the plugin name. This is the name by which you refer to the plugin when you call `mysql_options()` with the `MYSQL_DEFAULT_AUTH` option or specify the `--default-auth` option to a MySQL client program.
- `author`: A string naming the plugin author. This can be whatever you like.
- `desc`: A string that provides a general description of the plugin. This can be whatever you like.
- `version`: The plugin version as an array of three integers indicating the major, minor, and teeny versions. For example, `{1,2,3}` indicates version 1.2.3.
- `license`: A string that specifies the license type.
- `mysql_api`: For internal use. Specify it as `NULL` in the plugin descriptor.
- `init`: A once-only initialization function, or `NULL` if there is no such function. The client library executes this function when it loads the plugin. The function returns zero for success and nonzero for failure.

  The `init` function uses its first two arguments to return an error message if an error occurs. The first argument is a pointer to a `char` buffer, and the second argument indicates the buffer length. Any message returned by the `init` function must be null-terminated, so the maximum message length is the buffer length minus one. The next arguments are passed to `mysql_load_plugin()`. The first indicates how many more arguments there are (0 if none), followed by any remaining arguments.
- `deinit`: A once-only deinitialization function, or `NULL` if there is no such function. The client library executes this function

when it unloads the plugin. The function takes no arguments. It returns zero for success and nonzero for failure.

- `options`: A function for handling options passed to the plugin, or `NULL` if there is no such function. The function takes two arguments representing the option name and a pointer to its value.

For a given client plugin type, the common descriptor members may be followed by additional members necessary to implement plugins of that type. For example, the `st_mysql_client_plugin_AUTHENTICATION` structure for authentication plugins has a function at the end that the client library calls to perform authentication.

To declare a plugin, use the `mysql_declare_client_plugin()` and `mysql_end_client_plugin` macros:

```
mysql_declare_client_plugin(plugin_type)
   ... members common to all client plugins ...
   ... type-specific extra members ...
mysql_end_client_plugin;
```

Do not specify the `type` or `interface_version` member explicitly. The `mysql_declare_client_plugin()` macro uses the *`plugin_type`* argument to generate their values automatically. For example, declare an authentication client plugin like this:

```
mysql_declare_client_plugin(AUTHENTICATION)
  "my_auth_plugin",
  "Author Name",
  "My Client Authentication Plugin",
  {1,0,0},
  "GPL",
  NULL,
  my_auth_init,
  my_auth_deinit,
  my_auth_options,
  my_auth_main
mysql_end_client_plugin;
```

This declaration uses the `AUTHENTICATION` argument to set the `type` and `interface_version` members to `MYSQL_CLIENT_AUTHENTICATION_PLUGIN` and `MYSQL_CLIENT_AUTHENTICATION_PLUGIN_INTERFACE_VERSION`.

Depending on the plugin type, the descriptor may have other members following the common members. For example, for an authentication plugin, there is a function (`my_auth_main()` in the descriptor just shown) that handles communication with the server. See Section 21.2.4.9, “Writing Authentication Plugins”.

Normally, a client program that supports the use of authentication plugins causes a plugin to be loaded by calling `mysql_options()` to set the `MYSQL_DEFAULT_AUTH` and `MYSQL_PLUGIN_DIR` options:

```
char *plugin_dir = "path_to_plugin_dir";
char *default_auth = "plugin_name";

/* ... process command-line options ... */

mysql_options(&mysql, MYSQL_PLUGIN_DIR, plugin_dir);
mysql_options(&mysql, MYSQL_DEFAULT_AUTH, default_auth);
```

Typically, the program will also accept `--plugin-dir` and `--default-auth` options that enable users to override the default values.

Should a client program require lower-level plugin management, the client library contains functions that take an `st_mysql_client_plugin` argument. See Section 20.9.10, “C API Client Plugin Functions”.

21.2.4.3. Compiling and Installing Plugin Libraries

After your plugin is written, you must compile it and install it. The procedure for compiling shared objects varies from system to system. If you build your library using `CMake`, it should be able to generate the correct compilation commands for your system. If the library is named `somepluglib`, you should end up with a shared object file that has a name something like `somepluglib.so`. (The file name might have a different extension on your system.)

To use `CMake`, you'll need to set up the configuration files to enable the plugin to be compiled and installed. Use the plugin examples under the `plugin` directory of a MySQL source distribution as a guide.

Create `CMakeLists.txt`, which should look something like this:

```
MYSQL_ADD_PLUGIN(somepluglib somepluglib.c
  MODULE_ONLY MODULE_OUTPUT_NAME "somepluglib")
```

When `CMake` generates the `Makefile`, it should take care of passing to the compilation command the `-DMYSQL_DYNAMIC_PLUGIN` flag, and passing to the linker the `-lmysqlservices` flag, which is needed to link in any functions from services provided through the plugin services interface. See Section 21.2.5, “MySQL Services for Plugins”.

Run `CMake`, then run `make`:

```
shell> cmake .
shell> make
```

If you need to specify configuration options to `CMake`, see Section 2.9.4, “MySQL Source-Configuration Options”, for a list. For example, you might want to specify `CMAKE_INSTALL_PREFIX` to indicate the MySQL base directory under which the plugin should be installed. You can see what value to use for this option with `SHOW VARIABLES`:

```
mysql> SHOW VARIABLES LIKE 'basedir';
+---------------+------------------+
| Variable_name | Value            |
+---------------+------------------+
| base          | /usr/local/mysql |
+---------------+------------------+
```

The location of the plugin directory where you should install the library is given by the `plugin_dir` system variable. For example:

```
mysql> SHOW VARIABLES LIKE 'plugin_dir';
+---------------+-----------------------------------+
| Variable_name | Value                             |
+---------------+-----------------------------------+
| plugin_dir    | /usr/local/mysql/lib/mysql/plugin |
+---------------+-----------------------------------+
```

To install the plugin library, use `make`:

```
shell> make install
```

Verify that `make install` installed the plugin library in the proper directory. After installing it, make sure that the library permissions permit it to be executed by the server.

21.2.4.4. Writing Full-Text Parser Plugins

A full-text parser server plugin can be used to replace or modify the built-in full-text parser. This section describes how to write a full-text parser plugin named `simple_parser`. This plugin performs parsing based on simpler rules than those used by the MySQL built-in full-text parser: Words are nonempty runs of whitespace characters.

The instructions use the source code in the `plugin/fulltext` directory of MySQL source distributions, so change location into that directory. The following procedure describes how the plugin library is created:

1. To write a full-text parser plugin, include the following header file in the plugin source file. Other MySQL or general header files might also be needed.

   ```
   #include <mysql/plugin.h>
   ```

   `plugin.h` defines the `MYSQL_FTPARSER_PLUGIN` server plugin type and the data structures needed to declare the plugin.

2. Set up the library descriptor for the plugin library file.

   This descriptor contains the general plugin descriptor for the server plugin. For a full-text parser plugin, the type must be `MYSQL_FTPARSER_PLUGIN`. This is the value that identifies the plugin as being legal for use in a `WITH PARSER` clause when creating a `FULLTEXT` index. (No other plugin type is legal for this clause.)

   For example, the library descriptor for a library that contains a single full-text parser plugin named `simple_parser` looks like this:

   ```
   mysql_declare_plugin(ftexample)
   {
     MYSQL_FTPARSER_PLUGIN,      /* type                            */
     &simple_parser_descriptor,  /* descriptor                      */
     "simple_parser",            /* name                            */
     "Oracle Corporation",       /* author                          */
     "Simple Full-Text Parser",  /* description                     */
     PLUGIN_LICENSE_GPL,         /* plugin license                  */
     simple_parser_plugin_init,  /* init function (when loaded)     */
     simple_parser_plugin_deinit,/* deinit function (when unloaded) */
     0x0001,                     /* version                         */
     simple_status,              /* status variables                */
   ```

```
  simple_system_variables,    /* system variables                */
  NULL
}
mysql_declare_plugin_end;
```

The `name` member (`simple_parser`) indicates the name to use for references to the plugin in statements such as `INSTALL PLUGIN` or `UNINSTALL PLUGIN`. This is also the name displayed by `SHOW PLUGINS` or `INFORMATION_SCHEMA.PLUGINS`.

For more information, see Section 21.2.4.2.1, “Server Plugin Library and Plugin Descriptors”.

3. Set up the type-specific plugin descriptor.

   Each general plugin descriptor in the library descriptor points to a type-specific descriptor. For a full-text parser plugin, the type-specific descriptor is an instance of the `st_mysql_ftparser` structure in the `plugin.h` file:

```
struct st_mysql_ftparser
{
  int interface_version;
  int (*parse)(MYSQL_FTPARSER_PARAM *param);
  int (*init)(MYSQL_FTPARSER_PARAM *param);
  int (*deinit)(MYSQL_FTPARSER_PARAM *param);
};
```

As shown by the structure definition, the descriptor has an interface version number and contains pointers to three functions. The version is specified using a symbol of the form `MYSQL_xxx_INTERFACE_VERSION` (such as (`MYSQL_FTPARSER_INTERFACE_VERSION` for full-text parser plugins) The `init` and `deinit` members should point to a function or be set to 0 if the function is not needed. The `parse` member must point to the function that performs the parsing.

In the `simple_parser` declaration, that descriptor is indicated by `&simple_parser_descriptor`. The descriptor specifies the version number for the full-text plugin interface (as given by `MYSQL_FTPARSER_INTERFACE_VERSION`), and the plugin's parsing, initialization, and deinitialization functions:

```
static struct st_mysql_ftparser simple_parser_descriptor=
{
  MYSQL_FTPARSER_INTERFACE_VERSION, /* interface version      */
  simple_parser_parse,              /* parsing function       */
  simple_parser_init,               /* parser init function   */
  simple_parser_deinit              /* parser deinit function */
};
```

A full-text parser plugin is used in two different contexts, indexing and searching. In both contexts, the server calls the initialization and deinitialization functions at the beginning and end of processing each SQL statement that causes the plugin to be invoked. However, during statement processing, the server calls the main parsing function in context-specific fashion:

- For indexing, the server calls the parser for each column value to be indexed.
- For searching, the server calls the parser to parse the search string. The parser might also be called for rows processed by the statement. In natural language mode, there is no need for the server to call the parser. For boolean mode phrase searches or natural language searches with query expansion, the parser is used to parse column values for information that is not in the index. Also, if a boolean mode search is done for a column that has no `FULLTEXT` index, the built-in parser will be called. (Plugins are associated with specific indexes. If there is no index, no plugin is used.)

The plugin declaration in the general plugin descriptor has `init` and `deinit` members that point initialization and deinitialization functions, and so does the type-specific plugin descriptor to which it points. However, these pairs of functions have different purposes and are invoked for different reasons:

- For the plugin declaration in the general plugin descriptor, the initialization and deinitialization functions are invoked when the plugin is loaded and unloaded.
- For the type-specific plugin descriptor, the initialization and deinitialization functions are invoked per SQL statement for which the plugin is used.

Each interface function named in the plugin descriptor should return zero for success or nonzero for failure, and each of them receives an argument that points to a `MYSQL_FTPARSER_PARAM` structure containing the parsing context. The structure has this definition:

```
typedef struct st_mysql_ftparser_param
{
  int (*mysql_parse)(struct st_mysql_ftparser_param *,
                     char *doc, int doc_len);
  int (*mysql_add_word)(struct st_mysql_ftparser_param *,
                        char *word, int word_len,
                      MYSQL_FTPARSER_BOOLEAN_INFO *boolean_info);
  void *ftparser_state;
  void *mysql_ftparam;
  struct charset_info_st *cs;
  char *doc;
  int length;
  int flags;
  enum enum_ftparser_mode mode;
} MYSQL_FTPARSER_PARAM;
```

The structure members are used as follows:

- `mysql_parse`: A pointer to a callback function that invokes the server's built-in parser. Use this callback when the plugin acts as a front end to the built-in parser. That is, when the plugin parsing function is called, it should process the input to extract the text and pass the text to the `mysql_parse` callback.

  The first parameter for this callback function should be the `param` value itself:

  ```
  param->mysql_parse(param, ...);
  ```

  A front end plugin can extract text and pass it all at once to the built-in parser, or it can extract and pass text to the built-in parser a piece at a time. However, in this case, the built-in parser treats the pieces of text as though there are implicit word breaks between them.

- `mysql_add_word`: A pointer to a callback function that adds a word to a full-text index or to the list of search terms. Use this callback when the parser plugin replaces the built-in parser. That is, when the plugin parsing function is called, it should parse the input into words and invoke the `mysql_add_word` callback for each word.

  The first parameter for this callback function should be the `param` value itself:

  ```
  param->mysql_add_word(param, ...);
  ```

- `ftparser_state`: This is a generic pointer. The plugin can set it to point to information to be used internally for its own purposes.

- `mysql_ftparam`: This is set by the server. It is passed as the first argument to the `mysql_parse` or `mysql_add_word` callback.

- `cs`: A pointer to information about the character set of the text, or 0 if no information is available.

- `doc`: A pointer to the text to be parsed.

- `length`: The length of the text to be parsed, in bytes.

- `flags`: Parser flags. This is zero if there are no special flags. Currently, the only nonzero flag is `MYSQL_FTFLAGS_NEED_COPY`, which means that `mysql_add_word()` must save a copy of the word (that is, it cannot use a pointer to the word because the word is in a buffer that will be overwritten.) This member was added in MySQL 5.1.12.

  This flag might be set or reset by MySQL before calling the parser plugin, by the parser plugin itself, or by the `mysql_parse()` function.

- `mode`: The parsing mode. This value will be one of the following constants:

  - `MYSQL_FTPARSER_SIMPLE_MODE`: Parse in fast and simple mode, which is used for indexing and for natural language queries. The parser should pass to the server only those words that should be indexed. If the parser uses length limits or a stopword list to determine which words to ignore, it should not pass such words to the server.

  - `MYSQL_FTPARSER_WITH_STOPWORDS`: Parse in stopword mode. This is used in boolean searches for phrase matching. The parser should pass all words to the server, even stopwords or words that are outside any normal length limits.

  - `MYSQL_FTPARSER_FULL_BOOLEAN_INFO`: Parse in boolean mode. This is used for parsing boolean query strings. The parser should recognize not only words but also boolean-mode operators and pass them to the server as tokens using the `mysql_add_word` callback. To tell the server what kind of token is being passed, the plugin needs to fill in a `MYSQL_FTPARSER_BOOLEAN_INFO` structure and pass a pointer to it.

If the parser is called in boolean mode, the `param->mode` value will be `MYSQL_FTPARSER_FULL_BOOLEAN_INFO`. The `MYSQL_FTPARSER_BOOLEAN_INFO` structure that the parser uses for passing token information to the server looks like this:

```
typedef struct st_mysql_ftparser_boolean_info
{
  enum enum_ft_token_type type;
  int yesno;
  int weight_adjust;
  bool wasign;
  bool trunc;
  /* These are parser state and must be removed. */
  byte prev;
  byte *quot;
} MYSQL_FTPARSER_BOOLEAN_INFO;
```

The parser should fill in the structure members as follows:

- `type`: The token type. The following table shows the permissible types.

Table 21.3. Full-Text Parser Token Types

Token Value	Meaning
`FT_TOKEN_EOF`	End of data
`FT_TOKEN_WORD`	A regular word
`FT_TOKEN_LEFT_PAREN`	The beginning of a group or subexpression
`FT_TOKEN_RIGHT_PAREN`	The end of a group or subexpression
`FT_TOKEN_STOPWORD`	A stopword

- `yesno`: Whether the word must be present for a match to occur. 0 means that the word is optional but increases the match relevance if it is present. Values larger than 0 mean that the word must be present. Values smaller than 0 mean that the word must not be present.
- `weight_adjust`: A weighting factor that determines how much a match for the word counts. It can be used to increase or decrease the word's importance in relevance calculations. A value of zero indicates no weight adjustment. Values greater than or less than zero mean higher or lower weight, respectively. The examples at Section 11.9.2, “Boolean Full-Text Searches”, that use the `<` and `>` operators illustrate how weighting works.
- `wasign`: The sign of the weighting factor. A negative value acts like the `~` boolean-search operator, which causes the word's contribution to the relevance to be negative.
- `trunc`: Whether matching should be done as if the boolean-mode `*` truncation operator had been given.

Plugins should not use the `prev` and `quot` members of the `MYSQL_FTPARSER_BOOLEAN_INFO` structure.

4. Set up the plugin interface functions.

The general plugin descriptor in the library descriptor names the initialization and deinitialization functions that the server should invoke when it loads and unloads the plugin. For `simple_parser`, these functions do nothing but return zero to indicate that they succeeded:

```
static int simple_parser_plugin_init(void *arg __attribute__((unused)))
{
  return(0);
}

static int simple_parser_plugin_deinit(void *arg __attribute__((unused)))
{
  return(0);
}
```

Because those functions do not actually do anything, you could omit them and specify 0 for each of them in the plugin declaration.

The type-specific plugin descriptor for `simple_parser` names the initialization, deinitialization, and parsing functions that the server invokes when the plugin is used. For `simple_parser`, the initialization and deinitialization functions do nothing:

```
static int simple_parser_init(MYSQL_FTPARSER_PARAM *param
                              __attribute__((unused)))
{
  return(0);
}

static int simple_parser_deinit(MYSQL_FTPARSER_PARAM *param
                                __attribute__((unused)))
{
  return(0);
}
```

Here too, because those functions do nothing, you could omit them and specify 0 for each of them in the plugin descriptor.

The main parsing function, `simple_parser_parse()`, acts as a replacement for the built-in full-text parser, so it needs to split text into words and pass each word to the server. The parsing function's first argument is a pointer to a structure that contains the parsing context. This structure has a `doc` member that points to the text to be parsed, and a `length` member that indicates how long the text is. The simple parsing done by the plugin considers nonempty runs of whitespace characters to be words, so it identifies words like this:

```
static int simple_parser_parse(MYSQL_FTPARSER_PARAM *param)
{
  char *end, *start, *docend= param->doc + param->length;

  for (end= start= param->doc;; end++)
  {
    if (end == docend)
    {
      if (end > start)
        add_word(param, start, end - start);
      break;
    }
    else if (isspace(*end))
    {
      if (end > start)
        add_word(param, start, end - start);
      start= end + 1;
    }
  }
  return(0);
}
```

As the parser finds each word, it invokes a function `add_word()` to pass the word to the server. `add_word()` is a helper function only; it is not part of the plugin interface. The parser passes the parsing context pointer to `add_word()`, as well as a pointer to the word and a length value:

```
static void add_word(MYSQL_FTPARSER_PARAM *param, char *word, size_t len)
{
  MYSQL_FTPARSER_BOOLEAN_INFO bool_info=
    { FT_TOKEN_WORD, 0, 0, 0, 0, ' ', 0 };

  param->mysql_add_word(param, word, len, &bool_info);
}
```

For boolean-mode parsing, `add_word()` fills in the members of the `bool_info` structure as described earlier in the discussion of the `st_mysql_ftparser_boolean_info` structure.

5. Set up the status variables. For the `simple_parser` plugin, the following status variable array sets up one status variable with a value that is static text, and another with a value that is stored in a long integer variable:

```
long number_of_calls= 0;

struct st_mysql_show_var simple_status[]=
{
  {"static", (char *)"just a static text", SHOW_CHAR},
  {"called", (char *)&number_of_calls,     SHOW_LONG},
  {0,0,0}
};
```

When the plugin is installed, the plugin name and the `name` value are joined with an underscore to form the name displayed by `SHOW STATUS`. For the array just shown, the resulting status variable names are `simple_parser_static` and `simple_parser_called`. This convention means that you can easily display the variables for a plugin using its name:

```
mysql> SHOW STATUS LIKE 'simple_parser%';
+----------------------+--------------------+
| Variable_name        | Value              |
+----------------------+--------------------+
| simple_parser_static | just a static text |
| simple_parser_called | 0                  |
+----------------------+--------------------+
```

6. To compile and install a plugin library object file, use the instructions in Section 21.2.4.3, “Compiling and Installing Plugin Libraries”. To use the library file, it must be installed in the plugin directory (the directory named by the `plugin_dir` system variable). For the `simple_parser` plugin, it is compiled and installed when you build MySQL from source. It is also included in binary distributions. The build process produces a shared object library with a name of `mypluglib.so` (the extension might be different depending on your platform).

7. To use the plugin, register it with the server. For example, to register the plugin at runtime, use this statement (change the ex-

tension as necessary):

```
mysql> INSTALL PLUGIN simple_parser SONAME 'mypluglib.so';
```

For additional information about plugin loading, see Section 5.1.7.1, “Installing and Uninstalling Plugins”.

8. To verify plugin installation, examine the `INFORMATION_SCHEMA.PLUGINS` table or use the `SHOW PLUGINS` statement.

9. Test the plugin to verify that it works properly.

   Create a table that contains a string column and associate the parser plugin with a `FULLTEXT` index on the column:

```
mysql> CREATE TABLE t (c VARCHAR(255),
    ->   FULLTEXT (c) WITH PARSER simple_parser
    -> ) ENGINE=MyISAM;
Query OK, 0 rows affected (0.01 sec)
```

   Insert some text into the table and try some searches. These should verify that the parser plugin treats all nonwhitespace characters as word characters:

```
mysql> INSERT INTO t VALUES
    ->   ('latin1_general_cs is a case-sensitive collation'),
    ->   ('I\'d like a case of oranges'),
    ->   ('this is sensitive information'),
    ->   ('another row'),
    ->   ('yet another row');
Query OK, 5 rows affected (0.02 sec)
Records: 5  Duplicates: 0  Warnings: 0

mysql> SELECT c FROM t;
+--------------------------------------------------+
| c                                                |
+--------------------------------------------------+
| latin1_general_cs is a case-sensitive collation |
| I'd like a case of oranges                       |
| this is sensitive information                    |
| another row                                      |
| yet another row                                  |
+--------------------------------------------------+
5 rows in set (0.00 sec)

mysql> SELECT MATCH(c) AGAINST('case') FROM t;
+--------------------------+
| MATCH(c) AGAINST('case') |
+--------------------------+
|                        0 |
|          1.2968142032623 |
|                        0 |
|                        0 |
|                        0 |
+--------------------------+
5 rows in set (0.00 sec)

mysql> SELECT MATCH(c) AGAINST('sensitive') FROM t;
+-------------------------------+
| MATCH(c) AGAINST('sensitive') |
+-------------------------------+
|                             0 |
|                             0 |
|               1.3253291845322 |
|                             0 |
|                             0 |
+-------------------------------+
5 rows in set (0.01 sec)

mysql> SELECT MATCH(c) AGAINST('case-sensitive') FROM t;
+------------------------------------+
| MATCH(c) AGAINST('case-sensitive') |
+------------------------------------+
|                    1.3109166622162 |
|                                  0 |
|                                  0 |
|                                  0 |
|                                  0 |
+------------------------------------+
5 rows in set (0.01 sec)

mysql> SELECT MATCH(c) AGAINST('I\'d') FROM t;
+--------------------------+
| MATCH(c) AGAINST('I\'d') |
+--------------------------+
|                        0 |
|          1.2968142032623 |
|                        0 |
|                        0 |
|                        0 |
+--------------------------+
5 rows in set (0.01 sec)
```

Note how neither “case” nor “insensitive” match “case-insensitive” the way that they would for the built-in parser.

21.2.4.5. Writing Daemon Plugins

A daemon plugin is a simple type of plugin used for code that should be run by the server but that does not communicate with it. This section describes how to write a daemon server plugin, using the example plugin found in the `plugin/daemon_example` directory of MySQL source distributions. That directory contains the `daemon_example.cc` source file for a daemon plugin named `daemon_example` that writes a heartbeat string at regular intervals to a file named `mysql-heartbeat.log` in the data directory.

To write a daemon plugin, include the following header file in the plugin source file. Other MySQL or general header files might also be needed.

```
#include <mysql/plugin.h>
```

`plugin.h` defines the `MYSQL_DAEMON_PLUGIN` server plugin type and the data structures needed to declare the plugin.

The `daemon_example.cc` file sets up the library descriptor as follows. The library descriptor includes a single general server plugin descriptor.

```
mysql_declare_plugin(daemon_example)
{
  MYSQL_DAEMON_PLUGIN,
  &daemon_example_plugin,
  "daemon_example",
  "Brian Aker",
  "Daemon example, creates a heartbeat beat file in mysql-heartbeat.log",
  PLUGIN_LICENSE_GPL,
  daemon_example_plugin_init, /* Plugin Init */
  daemon_example_plugin_deinit, /* Plugin Deinit */
  0x0100 /* 1.0 */,
  NULL,                       /* status variables                */
  NULL,                       /* system variables                */
  NULL                        /* config options                  */
}
mysql_declare_plugin_end;
```

The `name` member (`daemon_example`) indicates the name to use for references to the plugin in statements such as `INSTALL PLUGIN` or `UNINSTALL PLUGIN`. This is also the name displayed by `SHOW PLUGINS` or `INFORMATION_SCHEMA.PLUGINS`.

The second member of the plugin descriptor, `daemon_example_plugin`, points to the type-specific daemon plugin descriptor. This structure consists only of the type-specific API version number:

```
struct st_mysql_daemon daemon_example_plugin=
{ MYSQL_DAEMON_INTERFACE_VERSION  };
```

The type-specific structure has no interface functions. There is no communication between the server and the plugin, except that the server calls the initialization and deinitialization functions from the general plugin descriptor to start and stop the plugin:

- `daemon_example_plugin_init()` opens the heartbeat file and spawns a thread that wakes up periodically and writes the next message to the file.
- `daemon_example_plugin_deinit()` closes the file and performs other cleanup.

To compile and install a plugin library object file, use the instructions in Section 21.2.4.3, “Compiling and Installing Plugin Libraries”. To use the library file, it must be installed in the plugin directory (the directory named by the `plugin_dir` system variable). For the `daemon_example` plugin, it is compiled and installed when you build MySQL from source. It is also included in binary distributions. The build process produces a shared object library with a name of `libdaemon_example.so` (the extension might be different depending on your platform).

To use the plugin, register it with the server. For example, to register the plugin at runtime, use this statement (change the extension as necessary):

```
mysql> INSTALL PLUGIN daemon_example SONAME 'libdaemon_example.so';
```

For additional information about plugin loading, see Section 5.1.7.1, “Installing and Uninstalling Plugins”.

To verify plugin installation, examine the `INFORMATION_SCHEMA.PLUGINS` table or use the `SHOW PLUGINS` statement.

While the plugin is loaded, it writes a heartbeat string at regular intervals to a file named `mysql-heartbeat.log` in the data directory. This file grows without limit, so after you have satistifed yourself that the plugin operates correctly, unload it:

```
mysql> UNINSTALL PLUGIN daemon_example;
```

21.2.4.6. Writing `INFORMATION_SCHEMA` Plugins

This section describes how to write an `INFORMATION_SCHEMA` table server plugin. For example code that implements such plugins, see the `sql/sql_show.cc` file of a MySQL source distribution. You can also look at the example plugins found in the `InnoDB` source. See the `handler/i_s.cc` and `handler/ha_innodb.cc` files within the `InnoDB` source tree (in the `storage/innobase` directory).

To write an `INFORMATION_SCHEMA` table plugin, include the following header files in the plugin source file. Other MySQL or general header files might also be needed.

```
#include <sql_class.h>
#include <table.h>
```

These header files are located in the `sql` directory of MySQL source distributions. They contain C++ structures, so the source file for an `INFORMATION_SCHEMA` plugin must be compled as C++ (not C) code.

The source file for the example plugin developed here is named `simple_i_s_table.cc`. It creates a simple `INFORMATION_SHEMA` table named `SIMPLE_I_S_TABLE` that has two columns named `NAME` and `VALUE`. The general descriptor for a plugin library that implements the table looks like this:

```
mysql_declare_plugin(simple_i_s_library)
{
  MYSQL_INFORMATION_SCHEMA_PLUGIN,
  &simple_table_info,                /* type-specific descriptor */
  "SIMPLE_I_S_TABLE",                /* table name */
  "Author Name",                     /* author */
  "Simple INFORMATION_SCHEMA table", /* description */
  PLUGIN_LICENSE_GPL,                /* license type */
  simple_table_init,                 /* init function */
  NULL,
  0x0100,                            /* version = 1.0 */
  NULL,                              /* no status variables */
  NULL,                              /* no system variables */
  NULL                               /* no reserved information */
}
mysql_declare_plugin_end;
```

The `name` member (`SIMPLE_I_S_TABLE`) indicates the name to use for references to the plugin in statements such as `INSTALL PLUGIN` or `UNINSTALL PLUGIN`. This is also the name displayed by `SHOW PLUGINS` or `INFORMATION_SCHEMA.PLUGINS`.

The `simple_table_info` member of the general descriptor points to the type-specific descriptor, which consists only of the type-specific API version number:

```
static struct st_mysql_information_schema simple_table_info =
{ MYSQL_INFORMATION_SCHEMA_INTERFACE_VERSION };
```

The general descriptor points to the initialization and deinitialization functions:

- The initialization function provides information about the table structure and a function that populates the table.
- The deinitialization function performs any required cleanup. If no cleanup is needed, this descriptor member can be `NULL` (as in the example shown).

The initialization function should return 0 for success, 1 if an error occurs. The function receives a generic pointer, which it should interpret as a pointer to the table structure:

```
static int table_init(void *ptr)
{
  ST_SCHEMA_TABLE *schema_table= (ST_SCHEMA_TABLE*)ptr;

  schema_table->fields_info= simple_table_fields;
  schema_table->fill_table= simple_fill_table;
  return 0;
}
```

The function should set these two members of the table structure:

- `fields_info`: An array of `ST_FIELD_INFO` structures that contain information about each column.
- `fill_table`: A function that populates the table.

The array pointed to by `fields_info` should contain one element per column of the `INFORMATION_SCHEMA` plus a terminating element. The following `simple_table_fields` array for the example plugin indicates that `SIMPLE_I_S_TABLE` has two columns. `NAME` is string-valued with a length of 10 and `VALUE` is integer-valued with a display width of 20. The last structure marks the end of the array.

```
static ST_FIELD_INFO simple_table_fields[]=
{
  {"NAME", 10, MYSQL_TYPE_STRING, 0, 0 0, 0},
  {"VALUE", 6, MYSQL_TYPE_LONG, 0, MY_I_S_UNSIGNED, 0, 0},
  {0, 0, MYSQL_TYPE_NULL, 0, 0, 0, 0}
};
```

For more information about the column information structure, see the definition of `ST_FIELD_INFO` in the `table.h` header file. The permissible `MYSQL_TYPE_xxx` type values are those used in the C API; see Section 20.9.1, “C API Data Structures”.

The `fill_table` member should be set to a function that populates the table and returns 0 for success, 1 if an error occurs. For the example plugin, the `simple_fill_table()` function looks like this:

```
static int simple_fill_table(THD *thd, TABLE_LIST *tables, COND *cond)
{
  TABLE *table= tables->table;

  table->field[0]->store("Name 1", 6, system_charset_info);
  table->field[1]->store(1);
  if (schema_table_store_record(thd, table))
    return 1;
  table->field[0]->store("Name 2", 6, system_charset_info);
  table->field[1]->store(2);
  if (schema_table_store_record(thd, table))
    return 1;
  return 0;
}
```

For each row of the `INFORMATION_SCHEMA` table, this function initializes each column, then calls `schema_table_store_record()` to install the row. The `store()` method arguments depend on the type of value to be stored. For column 0 (`NAME`, a string), `store()` takes a pointer to a string, its length, and information about the character set of the string:

```
store(const char *to, uint length, CHARSET_INFO *cs);
```

For column 1 (`VALUE`, an integer), `store()` takes the value and a flag indicating whether it is unsigned:

```
store(longlong nr, bool unsigned_value);
```

For other examples of how to populate `INFORMATION_SCHEMA` tables, search for instances of `schema_table_store_record()` in `sql_show.cc`.

To compile and install a plugin library object file, see the instructions in Section 21.2.4.3, “Compiling and Installing Plugin Libraries”. To use the library file, it must be installed in the plugin directory (the directory named by the `plugin_dir` system variable).

To test the plugin, install it:

```
mysql> INSTALL PLUGIN SIMPLE_I_S_TABLE SONAME 'simple_i_s_table.so';
```

Verify that the table is present:

```
mysql> SELECT TABLE_NAME FROM INFORMATION_SCHEMA.TABLES
    -> WHERE TABLE_NAME = 'SIMPLE_I_S_TABLE';
+------------------+
| TABLE_NAME       |
+------------------+
| SIMPLE_I_S_TABLE |
+------------------+
```

Try to select from it:

```
mysql> SELECT * FROM INFORMATION_SCHEMA.SIMPLE_I_S_TABLE;
+--------+-------+
| NAME   | VALUE |
+--------+-------+
| Name 1 |     1 |
| Name 2 |     2 |
+--------+-------+
```

Uninstall it:

```
mysql> UNINSTALL PLUGIN SIMPLE_I_S_TABLE;
```

21.2.4.7. Writing Semisynchronous Replication Plugins

This section describes how to write semisynchronous replication server plugins, using the example plugins found in the `plugin/semisync` directory of MySQL source distributions. That directory contains the source files for master and slave plugins named `rpl_semi_sync_master` and `rpl_semi_sync_slave`. The information here covers only how to set up the plugin framework. For details about how the plugins implement replication functions, see the source.

To write a semisynchronous replication plugin, include the following header file in the plugin source file. Other MySQL or general header files might also be needed.

```
#include <mysql/plugin.h>
```

`plugin.h` defines the `MYSQL_REPLICATION_PLUGIN` server plugin type and the data structures needed to declare the plugin.

For the master side, `semisync_master_plugin.cc` contains this general descriptor for a plugin named `rpl_semi_sync_master`:

```
mysql_declare_plugin(semi_sync_master)
{
  MYSQL_REPLICATION_PLUGIN,
  &semi_sync_master_plugin,
  "rpl_semi_sync_master",
  "He Zhenxing",
  "Semi-synchronous replication master",
  PLUGIN_LICENSE_GPL,
  semi_sync_master_plugin_init, /* Plugin Init */
  semi_sync_master_plugin_deinit, /* Plugin Deinit */
  0x0100 /* 1.0 */,
  semi_sync_master_status_vars, /* status variables */
  semi_sync_master_system_vars, /* system variables */
  NULL                        /* config options                  */
}
mysql_declare_plugin_end;
```

For the slave side, `semisync_slave_plugin.cc` contains this general descriptor for a plugin named `rpl_semi_sync_slave`:

```
mysql_declare_plugin(semi_sync_slave)
{
  MYSQL_REPLICATION_PLUGIN,
  &semi_sync_slave_plugin,
  "rpl_semi_sync_slave",
  "He Zhenxing",
  "Semi-synchronous replication slave",
  PLUGIN_LICENSE_GPL,
  semi_sync_slave_plugin_init, /* Plugin Init */
  semi_sync_slave_plugin_deinit, /* Plugin Deinit */
  0x0100 /* 1.0 */,
  semi_sync_slave_status_vars, /* status variables */
  semi_sync_slave_system_vars, /* system variables */
  NULL                        /* config options                  */
}
mysql_declare_plugin_end;
```

For both the master and slave plugins, the general descriptor has pointers to the type-specific descriptor, the initialization and deinitialization functions, and to the status and system variables implemented by the plugin. For information about variable setup, see Section 21.2.4.2.2, “Server Plugin Status and System Variables”. The following remarks discuss the type-specific descriptor and the initialization and deinitialization functions for the master plugin but apply similarly to the slave plugin.

The `semi_sync_master_plugin` member of the master general descriptor points to the type-specific descriptor, which consists only of the type-specific API version number:

```
struct Mysql_replication semi_sync_master_plugin= {
  MYSQL_REPLICATION_INTERFACE_VERSION
};
```

The initialization and deinitialization function declarations look like this:

```
static int semi_sync_master_plugin_init(void *p);
static int semi_sync_master_plugin_deinit(void *p);
```

The initialization function uses the pointer to register transaction and binary logging “observers” with the server. After successful initialization, the server takes care of invoking the observers at the appropriate times. (For details on the observers, see the source files.) The deinitialization function cleans up by deregistering the observers. Each function returns 0 for success or 1 if an error occurs.

To compile and install a plugin library object file, use the instructions in Section 21.2.4.3, “Compiling and Installing Plugin Libraries”. To use the library files, they must be installed in the plugin directory (the directory named by the `plugin_dir` system variable). For the `rpl_semi_sync_master` and `rpl_semi_sync_slave` plugins, they are compiled and installed when you build MySQL from source. They are also included in binary distributions. The build process produces shared object libraries with names of `semisync_master.so` and `semisync_slave.so` (the extension might be different depending on your platform).

21.2.4.8. Writing Audit Plugins

This section describes how to write an audit server plugin, using the example plugin found in the `plugin/audit_null` directory of MySQL source distributions. The `audit_null.c` source file in that directory implements a simple example audit plugin named `NULL_AUDIT`.

This description is current as of MySQL 5.5.14. For differences in the interface in earlier versions, see Audit Plugin Interface Changes.

Within the server, the pluggable audit interface is implemented in the `sql_audit.h` and `sql_audit.cc` files in the `sql` directory of MySQL source distributions. Additionally, several places in the server are modified to call the audit interface when an auditable event occurs, so that registered audit plugins can be notified about the event if necessary. To see where such calls occur, look for invocations of functions with names of the form `mysql_audit_xxx()`. Audit notification occurs for server operations such as these:

- Writing a message to the general query log (if the log is enabled)
- Writing a message to the error log
- Sending a query result to a client
- Client connect and disconnect events

To write an audit plugin, include the following header file in the plugin source file. Other MySQL or general header files might also be needed.

```
#include <mysql/plugin_audit.h>
```

`plugin_audit.h` includes `plugin.h`, so you need not include the latter file explicitly. `plugin.h` defines the `MYSQL_AUDIT_PLUGIN` server plugin type and the data structures needed to declare the plugin. `plugin_audit.h` defines data structures specific to audit plugins.

An audit plugin, like any MySQL server plugin, has a general plugin descriptor (see Section 21.2.4.2.1, “Server Plugin Library and Plugin Descriptors”). In `audit_null.c`, the general descriptor looks like this:

```
mysql_declare_plugin(audit_null)
{
  MYSQL_AUDIT_PLUGIN,         /* type                            */
  &audit_null_descriptor,     /* descriptor                      */
  "NULL_AUDIT",               /* name                            */
  "Oracle Corp",              /* author                          */
  "Simple NULL Audit",        /* description                     */
  PLUGIN_LICENSE_GPL,
  audit_null_plugin_init,     /* init function (when loaded)     */
  audit_null_plugin_deinit,   /* deinit function (when unloaded) */
  0x0002,                     /* version                         */
  simple_status,              /* status variables                */
  NULL,                       /* system variables                */
  NULL
}
mysql_declare_plugin_end;
```

The `name` member (`NULL_AUDIT`) indicates the name to use for references to the plugin in statements such as `INSTALL PLUGIN` or `UNINSTALL PLUGIN`. This is also the name displayed by `INFORMATION_SCHEMA.PLUGINS` or `SHOW PLUGINS`.

The general descriptor also refers to `simple_status`, a structure that exposes several status variables to the `SHOW STATUS` statement:

```
static struct st_mysql_show_var simple_status[]=
{
  { "Audit_null_called", (char *) &number_of_calls, SHOW_INT },
  { "Audit_null_general_log", (char *) &number_of_calls_general_log,
    SHOW_INT },
  { "Audit_null_general_error", (char *) &number_of_calls_general_error,
    SHOW_INT },
  { "Audit_null_general_result", (char *) &number_of_calls_general_result,
    SHOW_INT },
  { 0, 0, 0}
};
```

The `audit_null_plugin_init` initialization function sets the status variables to zero when the plugin is loaded. The `audit_null_plugin_deinit` function performs cleanup with the plugin is unloaded. During operation, the plugin increments the first status variable for each notification it receives. It also increments the others according to the event class and subclass. In effect, the first variable is the aggregate of the counts for the event subclasses.

The `audit_null_descriptor` value in the general descriptor points to the type-specific descriptor. For audit plugins, this descriptor has the following structure:

```
struct st_mysql_audit
{
  int interface_version;
  void (*release_thd)(MYSQL_THD);
  void (*event_notify)(MYSQL_THD, unsigned int, const void *);
  unsigned long class_mask[MYSQL_AUDIT_CLASS_MASK_SIZE];
};
```

The type-specific descriptor has these members:

- `interface_version`: By convention, type-specific plugin descriptors begin with the interface version for the given plugin type. The server checks `interface_version` when it loads the plugin to see whether the plugin is compatible with it. For audit plugins, the value of the `interface_version` member is `MYSQL_AUDIT_INTERFACE_VERSION` (defined in `plugin_audit.h`).
- `release_thd`: A function that the server calls to inform the plugin that it is being dissociated from its thread context. This should be `NULL` if there is no such function.
- `event_notify`: A function that the server calls to notify the plugin that an auditable event has occurred. This function should not be `NULL`; that would not make sense because no auditing would occur.
- `class_mask`: A bit mask that indicates the event classes for which the plugin wants to receive notification. If this value is 0, the server passes no events to the plugin.

The server uses the `event_notify` and `release_thd` functions together. They are called within the context of a specific thread, and a thread might perform an activity that produces several event notifications. The first time the server calls `event_notify` for a thread, it creates a binding of the plugin to the thread. The plugin cannot be uninstalled while this binding exists. When no more events for the thread will occur, the server informs the plugin of this by calling the `release_thd` function, and then destroys the binding. For example, when a client issues a statement, the thread processing the statement might notify audit plugins about the result set produced by the statement and about the statement being logged. After these notifications occur, the server releases the plugin before putting the thread to sleep until the client issues another statement.

This design enables the plugin to allocate resources needed for a given thread in the first call to the `event_notify` function and release them in the `release_thd` function:

```
event_notify function:
  if memory is needed to service the thread
    allocate memory
  ... rest of notification processing ...

release_thd function:
  if memory was allocated
    release memory
  ... rest of release processing ...
```

That is more efficient than allocating and releasing memory repeatedly in the notification function.

For the `NULL_AUDIT` example audit plugin, the type-specific descriptor looks like this:

```
static struct st_mysql_audit audit_null_descriptor=
{
  MYSQL_AUDIT_INTERFACE_VERSION,                    /* interface version    */
  NULL,                                             /* release_thd function */
  audit_null_notify,                                /* notify function      */
  { (unsigned long) MYSQL_AUDIT_GENERAL_CLASSMASK } /* class mask           */
};
```

The server calls `audit_null_notify` to pass audit event information to the plugin. There is no `release_thd` function.

The event class mask indicates an interest in all events of the “general” class. `plugin_audit.h` defines its symbol, `MYSQL_AUDIT_GENERAL_CLASS`, and a mask with a bit for this class:

```
#define MYSQL_AUDIT_GENERAL_CLASS 0
#define MYSQL_AUDIT_GENERAL_CLASSMASK (1 << MYSQL_AUDIT_GENERAL_CLASS)
```

`plugin_audit.h` also has defines for a “connection” event class, although the `NULL_AUDIT` plugin does nothing with such events:

```
#define MYSQL_AUDIT_CONNECTION_CLASS 1
#define MYSQL_AUDIT_CONNECTION_CLASSMASK (1 << MYSQL_AUDIT_CONNECTION_CLASS)
```

A plugin could be written to receive both general and connection events by setting its type-specific descriptor class mask like this:

```
  { (unsigned long) MYSQL_AUDIT_GENERAL_CLASSMASK |
                 MYSQL_AUDIT_CONNECTION_CLASSMASK } /* class mask        */
```

In the type-specific descriptor, the second and third parameters of the `event_notify` function prototype represent the event class and a generic pointer to an event structure:

```
void (*event_notify)(MYSQL_THD, unsigned int, const void *);
```

Events in different classes may have different structures, so the notification function should use the event class value to determine how to interpret the pointer to the event structure.

If the server calls the notification function with an event class of `MYSQL_AUDIT_GENERAL_CLASS`, it passes the event structure as a pointer to a `mysql_event_general` structure:

```
struct mysql_event_general
{
  unsigned int event_subclass;
  int general_error_code;
  unsigned long general_thread_id;
  const char *general_user;
  unsigned int general_user_length;
  const char *general_command;
  unsigned int general_command_length;
  const char *general_query;
  unsigned int general_query_length;
  struct charset_info_st *general_charset;
  unsigned long long general_time;
  unsigned long long general_rows;
};
```

Audit plugins can interpret `mysql_event_general` members as follows:

- `event_subclass`: The event subclass, one of the following values:

  ```
  #define MYSQL_AUDIT_GENERAL_LOG 0
  #define MYSQL_AUDIT_GENERAL_ERROR 1
  #define MYSQL_AUDIT_GENERAL_RESULT 2
  #define MYSQL_AUDIT_GENERAL_STATUS 3
  ```

- `general_error_code`: The error code. This is a value like that returned by the `mysql_errno()` C API function; 0 means “no error.”
- `general_thread_id`: The ID of the thread for which the event occurred.
- `general_user`: The current user for the event.
- `general_user_length`: The length of `general_user`, in bytes.
- `general_command`: For general query log events, the type of operation. Examples: `Connect`, `Query`, `Shutdown`. For error log events, the error message. This is a value like that returned by the `mysql_error()` C API function; an empty string means “no error.” For result events, this is empty.
- `general_command_length`: The length of `general_command`, in bytes.
- `general_query`: The SQL statement that was logged or produced a result.
- `general_query_length`: The length of `general_query`, in bytes.
- `general_charset`: Character set information for the event.

- `general_time`: A `TIMESTAMP` value indicating the time just before the notification function was called.
- `general_rows`: For general query log events, zero. For error log events, the row number at which an error occurred. For result events, the number of rows in the result plus one. For statements that produce no result set, the value is 0. This encoding enables statements that produce no result set to be distinguished from those that produce an empty result set. For example, for a `DELETE` statement, this value is 0. For a `SELECT`, the result is always 1 or more, where 1 represents an empty result set.

The `NULL_AUDIT` plugin notification function is quite simple. It increments a global event counter, verifies that the event is of the "general" class, then looks at the event subclass to determine which subclass counter to increment:

```
static void audit_null_notify(MYSQL_THD thd __attribute__((unused)),
                              unsigned int event_class,
                              const void *event)
{
  number_of_calls++;
  if (event_class == MYSQL_AUDIT_GENERAL_CLASS)
  {
    const struct mysql_event_general *event_general=
      (const struct mysql_event_general *) event;
    switch (event_general->event_subclass)
    {
    case MYSQL_AUDIT_GENERAL_LOG:
      number_of_calls_general_log++;
      break;
    case MYSQL_AUDIT_GENERAL_ERROR:
      number_of_calls_general_error++;
      break;
    case MYSQL_AUDIT_GENERAL_RESULT:
      number_of_calls_general_result++;
      break;
    default:
      break;
    }
  }
}
```

To compile and install a plugin library object file, use the instructions in Section 21.2.4.3, "Compiling and Installing Plugin Libraries". To use the library file, it must be installed in the plugin directory (the directory named by the `plugin_dir` system variable). For the `AUDIT_NULL` plugin, it is compiled and installed when you build MySQL from source. It is also included in binary distributions. The build process produces a shared object library with a name of `adt_null.so` (the extension might be be different depending on your platform).

To register the plugin at runtime, use this statement (change the extension as necessary):

```
mysql> INSTALL PLUGIN NULL_AUDIT SONAME 'adt_null.so';
```

For additional information about plugin loading, see Section 5.1.7.1, "Installing and Uninstalling Plugins".

To verify plugin installation, examine the `INFORMATION_SCHEMA.PLUGINS` table or use the `SHOW PLUGINS` statement.

While the audit plugin is installed, it exposes status variables that indicate the events for which the plugin has been called:

```
mysql> SHOW STATUS LIKE 'Audit_null%';
+--------------------------+-------+
| Variable_name            | Value |
+--------------------------+-------+
| Audit_null_called        | 1385  |
| Audit_null_general_error | 1     |
| Audit_null_general_log   | 741   |
| Audit_null_general_result | 643   |
+--------------------------+-------+
```

`Audit_null_called` counts all events, and the other variables count instances of event subclasses. For example, the preceding `SHOW STATUS` statement causes the server to send a result to the client and to write a message to the general query log if that log is enabled. Thus, a client that issues the statement repeatedly causes `Audit_null_called` and `Audit_null_general_result` to be incremented each time, and `Audit_null_general_log` to be incremented if the log is enabled.

To disable the plugin after testing it, use this statement to unload it:

```
mysql> UNINSTALL PLUGIN NULL_AUDIT;
```

Audit Plugin Interface Changes

The audit plugin interface has undergone the following changes:

- In MySQL 5.5.5, the `event_subclass` member was added to the `mysql_event_general` structure. Corresponding to this change, the type-specific interface version, `MYSQL_AUDIT_INTERFACE_VERSION`, was increased from `0x0100` to `0x0200` and
- In MySQL 5.5.9, the `MYSQL_AUDIT_CONNECTION_CLASS` event class was added, and the `MYSQL_AUDIT_GENERAL_STATUS` subclass was added to the `MYSQL_AUDIT_GENERAL_CLASS` event class.
- In MySQL 5.5.14, the `event_class` member was removed from the `mysql_event_general` structure and the calling sequence for the notification function changed. Originally, the second argument was a pointer to the event structure. The function now receives this information as two arguments: an event class number and a pointer to the event. Corresponding to these changes, `MYSQL_AUDIT_INTERFACE_VERSION` was increased to `0x0300`.

Each audit plugin must be compiled against MySQL source in which the value of `MYSQL_AUDIT_INTERFACE_VERSION` is appropriate for the interface version the plugin requires.

21.2.4.9. Writing Authentication Plugins

An authentication plugin can be written for the server side or the client side. Server-side plugins use the same plugin API that is used for the other server plugin types such as full-text parser or audit plugins (although with a different type-specific descriptor). Client-side plugins use the client plugin API.

Several header files contain information relevent to authentication plugins:

- `plugin.h`: Defines the `MYSQL_AUTHENTICATION_PLUGIN` server plugin type.
- `client_plugin.h`: Defines the API for client plugins. This includes the client plugin descriptor and function prototypes for client plugin C API calls (see Section 20.9.10, “C API Client Plugin Functions”).
- `plugin_auth.h`: Defines the part of the server plugin API specific to authentication plugins. This includes the type-specific descriptor for server-side authentication plugins and the `MYSQL_SERVER_AUTH_INFO` structure.
- `plugin_auth_common.h`: Contains common elements of client and server authentication plugins. This includes return value definitions and the `MYSQL_PLUGIN_VIO` structure.

To write an authentication plugin, include the following header files in the plugin source file. Other MySQL or general header files might also be needed.

- For a source file that implements a server authentication plugin, include this file:

  ```
  #include <mysql/plugin_auth.h>
  ```

- For a source file that implements a client authentication plugin, or both client and server plugins, include these files:

  ```
  #include <mysql/plugin_auth.h>
  #include <mysql/client_plugin.h>
  #include <mysql>
  ```

`plugin_auth.h` includes `plugin.h` and `plugin_auth_common.h`, so you need not include the latter files explicitly.

This section describes how to write a pair of simple server and client authentication plugins that work together. These plugins accept any non-empty password. This is insecure, so the plugins *should not be used in production environments.*

The server-side and client-side plugins developed here both are named `auth_simple`. As described in Section 21.2.4.2, “Plugin Data Structures”, the plugin library file must have the same basename as the client plugin, so the source file name is `auth_simple.c` and produces a library named `auth_simple.so` (assuming that your system uses `.so` as the extension for library files).

In MySQL source distributions, authentication plugin source is located in the `plugin/auth` directory and can be examined as a guide to writing other authentication plugins. Also, to see how the built-in authentication plugins are implemented, see `sql/sql_acl.cc` for plugins that are built in to the MySQL server and `sql-common/client.c` for plugins that are built in to the `libmysql` client library. (For the built-in client plugins, note that the `auth_plugin_t` structures used there differ from the structures used with the usual client plugin declaration macros. In particular, the first two members are provided explicitly, not by declaration macros.)

21.2.4.9.1. Writing the Server-Side Authentication Plugin

Declare the server-side plugin with the usual general descriptor format that is used for all server plugin types (see Section 21.2.4.2.1, “Server Plugin Library and Plugin Descriptors”). For the `auth_simple` plugin, the descriptor looks like this:

```
mysql_declare_plugin(auth_simple)
{
  MYSQL_AUTHENTICATION_PLUGIN,
  &auth_simple_handler,                 /* type-specific descriptor */
  "auth_simple",                        /* plugin name */
  "Author Name",                        /* author */
  "Any-password authentication plugin", /* description */
  PLUGIN_LICENSE_GPL,                   /* license type */
  NULL,                                 /* no init function */
  NULL,                                 /* no deinit function */
  0x0100,                               /* version = 1.0 */
  NULL,                                 /* no status variables */
  NULL,                                 /* no system variables */
  NULL                                  /* no reserved information */
}
mysql_declare_plugin_end;
```

The `name` member (`auth_simple`) indicates the name to use for references to the plugin in statements such as `INSTALL PLUGIN` or `UNINSTALL PLUGIN`. This is also the name displayed by `SHOW PLUGINS` or `INFORMATION_SCHEMA.PLUGINS`.

The `auth_simple_handler` member of the general descriptor points to the type-specific descriptor. This is an instance of the `st_mysql_auth` structure (defined in `plugin_auth.h`), which has three members: The type-specific API version number, the name of the required client plugin (or `NULL` for “any plugin”), and a pointer to the main plugin function that communicates with the client:

```
static struct st_mysql_auth auth_simple_handler =
{
  MYSQL_AUTHENTICATION_INTERFACE_VERSION,
  "auth_simple",           /* required client-side plugin name */
  auth_simple_server_main /* server-side plugin main function */
};
```

The main function takes two arguments representing an I/O structure and an authentication information structure. The function reads the password (a null-terminated string) from the client and succeeds if the password is nonempty (first byte not null):

```
static int auth_simple_server_main (MYSQL_PLUGIN_VIO *vio,
                                    MYSQL_SERVER_AUTH_INFO *info)
{
  unsigned char *pkt;
  int pkt_len;

  /* read the password as null-terminated string, fail on error */
  if ((pkt_len= vio->read_packet(vio, &pkt)) < 0)
    return CR_ERROR;
  /* fail on empty password */
  if (!pkt_len || *pkt == '\0')
  {
    info->password_used= PASSWORD_USED_NO;
    return CR_ERROR;
  }
  /* succeed on nonempty password */
  info->password_used= PASSWORD_USED_YES;
  return CR_OK;
}
```

The main function should return `CR_OK` for success, `CR_ERROR` for an error, or `CR_OK_HANDSHAKE_COMPLETE` to tell the server not to send a status packet back to the client. (For an example of how this handshake works, see the `plugin/auth/dialog.c` source file.)

`auth_simple_server_main()` is so basic that it does not use the authentication information structure except to set the member that indicates whether a password was received. For a description of this structure's members and how to use them, see the `plugin_auth.h` header file. For example, a plugin that supports proxy users must return to the server the name of the proxied user (the MySQL user whose privileges the client user should get). To do this, the plugin must set the `info->authenticated_as` member to the proxied user name. For information about proxying, see Section 5.5.7, “Proxy Users”.

21.2.4.9.2. Writing the Client-Side Authentication Plugin

Declare the client-side plugin with the `mysql_declare_client_plugin()` and `mysql_end_client_plugin` macros (see Section 21.2.4.2.3, “Client Plugin Descriptors”). For the `auth_simple` plugin, the descriptor looks like this:

```
mysql_declare_client_plugin(AUTHENTICATION)
  "auth_simple",                        /* plugin name */
  "Author Name",                        /* author */
  "Any-password authentication plugin", /* description */
  {1,0,0},                              /* version = 1.0.0 */
  "GPL",                                /* license type */
  NULL,                                 /* for internal use */
  NULL,                                 /* no init function */
  NULL,                                 /* no deinit function */
  NULL,                                  /* no option-handling function */
  auth_simple_client_main                /* main function */
mysql_end_client_plugin;
```

The descriptor members common to all client plugins are `auth_simple_client` (the plugin name) through the option-handling function. An authentication plugin also has one extra member following the common members. This is the “main” function, which handles communication with the server. The function takes two arguments representing an I/O structure and a connection handler. For our simple any-password plugin, the main function does nothing but write to the server the password provided by the user:

```
static int auth_simple_client_main (MYSQL_PLUGIN_VIO *vio, MYSQL *mysql)
{
  int res;

  /* send password as null-terminated string in clear text */
  res= vio->write_packet(vio, (const unsigned char *) mysql->passwd,
                                               strlen(mysql->passwd) + 1);

  return res ? CR_ERROR : CR_OK;
}
```

The main function should return `CR_OK` for success, `CR_ERROR` for an error, or `CR_OK_HANDSHAKE_COMPLETE` to indicate that the client has done its part successfully and has read the last packet. A plugin may return the latter status if the number of round trips in the authentication protocol is not known in advance and the client plugin must read another packet to determine whether authentication is finished.

21.2.4.9.3. Using the Authentication Plugins

To compile and install a plugin library object file, see the instructions in Section 21.2.4.3, “Compiling and Installing Plugin Libraries”. To use the library file, it must be installed in the plugin directory (the directory named by the `plugin_dir` system variable).

Register the server-side plugin with the server. For example, to load the plugin at server startup, use a `--plugin-load=auth_simple.so` option (change the library extension as necessary for your system).

Create a user for whom the server will use the `auth_simple` plugin for authentication:

```
mysql> CREATE USER 'x'@'localhost'
    -> IDENTIFIED WITH auth_simple;
```

Use a client program to connect to the server as user `x`. The server-side `auth_simple` plugin communicates with the client program that it should use the client-side `auth_simple` plugin, and the latter sends the password to the server. The server plugin should reject connections that send an empty password and accept connections that send a nonempty password. Invoke the client program each way to verify this:

```
shell> mysql --user=x --skip-password
ERROR 1045 (28000): Access denied for user 'x'@'localhost' (using password: NO)

shell> mysql --user=x --password=abc
mysql>
```

Because the server plugin accepts any nonempty password, it should be considered insecure. After testing the plugin to verify that it works, restart the server without the `--plugin-load` option so as not to indavertently leave the server running with an insecure authentication plugin loaded. Also, drop the user with `DROP USER 'x'@'localhost'`.

For additional information about loading and using authentication plugins, see Section 5.1.7.1, “Installing and Uninstalling Plugins”, and Section 5.5.6, “Pluggable Authentication”.

If you are writing a client program that supports the use of authentication plugins, normally such a program causes a plugin to be loaded by calling `mysql_options()` to set the `MYSQL_DEFAULT_AUTH` and `MYSQL_PLUGIN_DIR` options:

```
char *plugin_dir = "path_to_plugin_dir";
char *default_auth = "plugin_name";

/* ... process command-line options ... */

mysql_options(&mysql, MYSQL_PLUGIN_DIR, plugin_dir);
mysql_options(&mysql, MYSQL_DEFAULT_AUTH, default_auth);
```

Typically, the program will also accept `--plugin-dir` and `--default-auth` options that enable users to override the default values.

Should a client program require lower-level plugin management, the client library contains functions that take an `st_mysql_client_plugin` argument. See Section 20.9.10, “C API Client Plugin Functions”.

21.2.5. MySQL Services for Plugins

MySQL server plugins have access to server “services.” The services interface exposes server functionality that plugins can call. It complements the plugin API and has these characteristics:

- Services enable plugins to access code inside the server using ordinary function calls.
- Services are portable and work on multiple platforms.
- The interface includes a versioning mechanism so that service versions supported by the server can be checked at load time against plugin versions. Versioning protects against incompatibilities between the version of a service that the server provides and the version of the service expected or required by a plugin.

Current services include the following, and others can be implemented:

- `my_snprintf`: A string-formatting service that produces consistent results across platforms.
- `my_thd_scheduler`: A service for plugins to select a thread scheduler.
- `thd_alloc`: A memory-allocation service.
- `thd_wait`: A service for plugins to report when they are going to sleep or stall.

The plugin services interface differs from the plugin API as follows:

- The plugin API enables plugins to be used by the server. The calling initiative lies with the server to invoke plugins. This enables plugins to extend server functionality or register to receive notifications about server processing.
- The plugin services interface enables plugins to call code inside the server. The calling initiative lies with plugins to invoke service functions. This enables functionality already implemented in the server to be used by many plugins; they need not individually implement it themselves.

For developers who wish to modify the server to add a new service, see MySQL Services for Plugins in the MySQL Internals Manual.

The remainder of this section describes how a plugin uses server functionality that is available as a service. See also the source for the “daemon” example plugin, which uses the `my_snprintf` service. Within a MySQL source distribution, that plugin is located in the `plugin/daemon_example` directory.

To determine what services exist and what functions they provide, look in the `include/mysql` directory of a MySQL source distribution. The relevant files are:

- `plugin.h` includes `services.h`.
- `services.h` is the “umbrella” header that includes all available service-specific header files.
- Service-specific headers have names like `service_my_snprintf.h` or `service_thd_alloc.h`.

Each service-specific header should contain comments that provide full usage documentation for a given service, including what service functions are available, their calling sequences, and return values.

To use a service or services from within a plugin, the plugin source file must include the `plugin.h` header file to access service-related information:

```
#include <mysql/plugin.h>
```

This does not represent any additional setup cost. A plugin must include that file anyway because it contains definitions and structures that every plugin needs.

To access a service, a plugin calls service functions like any other function. For example, to format a string into a buffer for printing, call the `my_snprintf()` function provided by the service of the same name:

```
char buffer[BUFFER_SIZE];
my_snprintf(buffer, sizeof(buffer), format_string, argument_to_format, ...);
```

When you build your plugin, you must link in the `libmysqlservices` library. Use the `-lmysqlservices` flag at link time. For example, for `CMake`, put this in the top-level `CMakeLists.txt` file:

```
FIND_LIBRARY(MYSQLSERVICES_LIB mysqlservices
 PATHS "${MYSQL_SRCDIR}/libservices" NO_DEFAULT_PATH)
```

Put this in the `CMakeLists.txt` file in the directory containing the plugin source:

```
# the plugin needs the mysql services library for error logging
TARGET_LINK_LIBRARIES (your_plugin_library_name ${MYSQLSERVICES_LIB})
```

21.3. Adding New Functions to MySQL

There are three ways to add new functions to MySQL:

- You can add functions through the user-defined function (UDF) interface. User-defined functions are compiled as object files and then added to and removed from the server dynamically using the `CREATE FUNCTION` and `DROP FUNCTION` statements. See Section 12.4.3.1, "`CREATE FUNCTION` Syntax for User-Defined Functions".
- You can add functions as native (built-in) MySQL functions. Native functions are compiled into the `mysqld` server and become available on a permanent basis.
- Another way to add functions is by creating stored functions. These are written using SQL statements rather than by compiling object code. The syntax for writing stored functions is not covered here. See Section 17.2, "Using Stored Routines (Procedures and Functions)".

Each method of creating compiled functions has advantages and disadvantages:

- If you write user-defined functions, you must install object files in addition to the server itself. If you compile your function into the server, you don't need to do that.
- Native functions require you to modify a source distribution. UDFs do not. You can add UDFs to a binary MySQL distribution. No access to MySQL source is necessary.
- If you upgrade your MySQL distribution, you can continue to use your previously installed UDFs, unless you upgrade to a newer version for which the UDF interface changes. For native functions, you must repeat your modifications each time you upgrade.

Whichever method you use to add new functions, they can be invoked in SQL statements just like native functions such as `ABS()` or `SOUNDEX()`.

See Section 8.2.4, "Function Name Parsing and Resolution", for the rules describing how the server interprets references to different kinds of functions.

The following sections describe features of the UDF interface, provide instructions for writing UDFs, discuss security precautions that MySQL takes to prevent UDF misuse, and describe how to add native MySQL functions.

For example source code that illustrates how to write UDFs, take a look at the `sql/udf_example.c` file that is provided in MySQL source distributions.

21.3.1. Features of the User-Defined Function Interface

The MySQL interface for user-defined functions provides the following features and capabilities:

- Functions can return string, integer, or real values and can accept arguments of those same types.
- You can define simple functions that operate on a single row at a time, or aggregate functions that operate on groups of rows.
- Information is provided to functions that enables them to check the number, types, and names of the arguments passed to them.
- You can tell MySQL to coerce arguments to a given type before passing them to a function.
- You can indicate that a function returns `NULL` or that an error occurred.

21.3.2. Adding a New User-Defined Function

For the UDF mechanism to work, functions must be written in C or C++ and your operating system must support dynamic loading. MySQL source distributions include a file `sql/udf_example.c` that defines 5 new functions. Consult this file to see how UDF calling conventions work. The `include/mysql_com.h` header file defines UDF-related symbols and data structures. (You need not include this header file directly because it is included by `mysql.h`.)

A UDF contains code that becomes part of the running server, so when you write a UDF, you are bound by any and all constraints that otherwise apply to writing server code. For example, you may have problems if you attempt to use functions from the `libstdc++` library. These constraints may change in future versions of the server, so it is possible that server upgrades will require revisions to UDFs that were originally written for older servers. For information about these constraints, see Section 2.9.4, "MySQL Source-Configuration Options", and Section 2.9.5, "Dealing with Problems Compiling MySQL".

To be able to use UDFs, you need to link `mysqld` dynamically. If you want to use a UDF that needs to access symbols from `mysqld` (for example, the `metaphone` function in `sql/udf_example.c` that uses `default_charset_info`), you must link the program with `-rdynamic` (see `man dlopen`).

For each function that you want to use in SQL statements, you should define corresponding C (or C++) functions. In the following discussion, the name "xxx" is used for an example function name. To distinguish between SQL and C/C++ usage, `XXX()` (uppercase) indicates an SQL function call, and `xxx()` (lowercase) indicates a C/C++ function call.

> **Note**
>
> When using C++ you can encapsulate your C functions within:
>
> ```
> extern "C" { ... }
> ```
>
> This will ensure that your C++ function names remain readable in the completed UDF.

The C/C++ functions that you write to implement the interface for `XXX()` are:

- `xxx()` (required)

  The main function. This is where the function result is computed. The correspondence between the SQL function data type and the return type of your C/C++ function is shown here.

SQL Type	C/C++ Type
`STRING`	`char *`
`INTEGER`	`long long`
`REAL`	`double`

  It is also possible to declare a `DECIMAL` function, but currently the value is returned as a string, so you should write the UDF as though it were a `STRING` function. `ROW` functions are not implemented.

- `xxx_init()` (optional)

  The initialization function for `xxx()`. It can be used for the following purposes:

  - To check the number of arguments to `XXX()`.
  - To check that the arguments are of a required type or, alternatively, to tell MySQL to coerce arguments to the types you want when the main function is called.
  - To allocate any memory required by the main function.
  - To specify the maximum length of the result.
  - To specify (for `REAL` functions) the maximum number of decimal places in the result.
  - To specify whether the result can be `NULL`.

- `xxx_deinit()` (optional)

  The deinitialization function for `xxx()`. It should deallocate any memory allocated by the initialization function.

When an SQL statement invokes `XXX()`, MySQL calls the initialization function `xxx_init()` to let it perform any required setup, such as argument checking or memory allocation. If `xxx_init()` returns an error, MySQL aborts the SQL statement with an error message and does not call the main or deinitialization functions. Otherwise, MySQL calls the main function `xxx()` once for each row. After all rows have been processed, MySQL calls the deinitialization function `xxx_deinit()` so that it can perform any required cleanup.

For aggregate functions that work like `SUM()`, you must also provide the following functions:

- `xxx_clear()`

  Reset the current aggregate value but do not insert the argument as the initial aggregate value for a new group.

- `xxx_add()`

  Add the argument to the current aggregate value.

MySQL handles aggregate UDFs as follows:

1. Call `xxx_init()` to let the aggregate function allocate any memory it needs for storing results.
2. Sort the table according to the `GROUP BY` expression.
3. Call `xxx_clear()` for the first row in each new group.
4. Call `xxx_add()` for each row that belongs in the same group.
5. Call `xxx()` to get the result for the aggregate when the group changes or after the last row has been processed.
6. Repeat steps 3 to 5 until all rows has been processed
7. Call `xxx_deinit()` to let the UDF free any memory it has allocated.

All functions must be thread-safe. This includes not just the main function, but the initialization and deinitialization functions as well, and also the additional functions required by aggregate functions. A consequence of this requirement is that you are not permitted to allocate any global or static variables that change! If you need memory, you should allocate it in `xxx_init()` and free it in `xxx_deinit()`.

21.3.2.1. UDF Calling Sequences for Simple Functions

This section describes the different functions that you need to define when you create a simple UDF. Section 21.3.2, “Adding a New User-Defined Function”, describes the order in which MySQL calls these functions.

The main `xxx()` function should be declared as shown in this section. Note that the return type and parameters differ, depending on whether you declare the SQL function `XXX()` to return `STRING`, `INTEGER`, or `REAL` in the `CREATE FUNCTION` statement:

For `STRING` functions:

```
char *xxx(UDF_INIT *initid, UDF_ARGS *args,
          char *result, unsigned long *length,
          char *is_null, char *error);
```

For `INTEGER` functions:

```
long long xxx(UDF_INIT *initid, UDF_ARGS *args,
              char *is_null, char *error);
```

For `REAL` functions:

```
double xxx(UDF_INIT *initid, UDF_ARGS *args,
              char *is_null, char *error);
```

`DECIMAL` functions return string values and should be declared the same way as `STRING` functions. `ROW` functions are not implemented.

The initialization and deinitialization functions are declared like this:

```
my_bool xxx_init(UDF_INIT *initid, UDF_ARGS *args, char *message);

void xxx_deinit(UDF_INIT *initid);
```

The `initid` parameter is passed to all three functions. It points to a `UDF_INIT` structure that is used to communicate information between functions. The `UDF_INIT` structure members follow. The initialization function should fill in any members that it wishes to change. (To use the default for a member, leave it unchanged.)

- `my_bool maybe_null`

  `xxx_init()` should set `maybe_null` to `1` if `xxx()` can return `NULL`. The default value is `1` if any of the arguments are declared `maybe_null`.

- `unsigned int decimals`

  The number of decimal digits to the right of the decimal point. The default value is the maximum number of decimal digits in the arguments passed to the main function. For example, if the function is passed `1.34`, `1.345`, and `1.3`, the default would be 3, because `1.345` has 3 decimal digits.

  For arguments that have no fixed number of decimals, the `decimals` value is set to 31, which is 1 more than the maximum number of decimals permitted for the `DECIMAL`, `FLOAT`, and `DOUBLE` data types. As of MySQL 5.5.3, this value is available as the constant `NOT_FIXED_DEC` in the `mysql_com.h` header file.

  A `decimals` value of 31 is used for arguments in cases such as a `FLOAT` or `DOUBLE` column declared without an explicit number of decimals (for example, `FLOAT` rather than `FLOAT(10,3)`) and for floating-point constants such as `1345E-3`. It is also used for string and other nonnumber arguments that might be converted within the function to numeric form.

  The value to which the `decimals` member is initialized is only a default. It can be changed within the function to reflect the actual calculation performed. The default is determined such that the largest number of decimals of the arguments is used. If the number of decimals is `NOT_FIXED_DEC` for even one of the arguments, that is the value used for `decimals`.

- `unsigned int max_length`

  The maximum length of the result. The default `max_length` value differs depending on the result type of the function. For string functions, the default is the length of the longest argument. For integer functions, the default is 21 digits. For real functions, the default is 13 plus the number of decimal digits indicated by `initid->decimals`. (For numeric functions, the length includes any sign or decimal point characters.)

  If you want to return a blob value, you can set `max_length` to 65KB or 16MB. This memory is not allocated, but the value is used to decide which data type to use if there is a need to temporarily store the data.

- `char *ptr`

  A pointer that the function can use for its own purposes. For example, functions can use `initid->ptr` to communicate allocated memory among themselves. `xxx_init()` should allocate the memory and assign it to this pointer:

  ```
  initid->ptr = allocated_memory;
  ```

  In `xxx()` and `xxx_deinit()`, refer to `initid->ptr` to use or deallocate the memory.

- `my_bool const_item`

  `xxx_init()` should set `const_item` to `1` if `xxx()` always returns the same value and to `0` otherwise.

21.3.2.2. UDF Calling Sequences for Aggregate Functions

This section describes the different functions that you need to define when you create an aggregate UDF. Section 21.3.2, “Adding a New User-Defined Function”, describes the order in which MySQL calls these functions.

- `xxx_reset()`

  This function is called when MySQL finds the first row in a new group. It should reset any internal summary variables and then use the given `UDF_ARGS` argument as the first value in your internal summary value for the group. Declare `xxx_reset()` as follows:

  ```
  void xxx_reset(UDF_INIT *initid, UDF_ARGS *args,
                 char *is_null, char *error);
  ```

  `xxx_reset()` is not needed or used in MySQL 5.5, in which the UDF interface uses `xxx_clear()` instead. However, you can define both `xxx_reset()` and `xxx_clear()` if you want to have your UDF work with older versions of the server. (If you do include both functions, the `xxx_reset()` function in many cases can be implemented internally by calling `xxx_clear()` to reset all variables, and then calling `xxx_add()` to add the `UDF_ARGS` argument as the first value in the group.)

- `xxx_clear()`

  This function is called when MySQL needs to reset the summary results. It is called at the beginning for each new group but can also be called to reset the values for a query where there were no matching rows. Declare `xxx_clear()` as follows:

  ```
  void xxx_clear(UDF_INIT *initid, char *is_null, char *error);
  ```

  `is_null` is set to point to `CHAR(0)` before calling `xxx_clear()`.

  If something went wrong, you can store a value in the variable to which the `error` argument points. `error` points to a single-byte variable, not to a string buffer.

  `xxx_clear()` is required by MySQL 5.5.

- `xxx_add()`

  This function is called for all rows that belong to the same group. You should use it to add the value in the `UDF_ARGS` argument to your internal summary variable.

  ```
  void xxx_add(UDF_INIT *initid, UDF_ARGS *args,
               char *is_null, char *error);
  ```

The `xxx()` function for an aggregate UDF should be declared the same way as for a nonaggregate UDF. See Section 21.3.2.1, “UDF Calling Sequences for Simple Functions”.

For an aggregate UDF, MySQL calls the `xxx()` function after all rows in the group have been processed. You should normally never access its `UDF_ARGS` argument here but instead return a value based on your internal summary variables.

Return value handling in `xxx()` should be done the same way as for a nonaggregate UDF. See Section 21.3.2.4, “UDF Return Values and Error Handling”.

The `xxx_reset()` and `xxx_add()` functions handle their `UDF_ARGS` argument the same way as functions for nonaggregate UDFs. See Section 21.3.2.3, “UDF Argument Processing”.

The pointer arguments to `is_null` and `error` are the same for all calls to `xxx_reset()`, `xxx_clear()`, `xxx_add()` and `xxx()`. You can use this to remember that you got an error or whether the `xxx()` function should return `NULL`. You should not store a string into `*error`! `error` points to a single-byte variable, not to a string buffer.

`*is_null` is reset for each group (before calling `xxx_clear()`). `*error` is never reset.

If `*is_null` or `*error` are set when `xxx()` returns, MySQL returns `NULL` as the result for the group function.

21.3.2.3. UDF Argument Processing

The `args` parameter points to a `UDF_ARGS` structure that has the members listed here:

- `unsigned int arg_count`

  The number of arguments. Check this value in the initialization function if you require your function to be called with a particular number of arguments. For example:

  ```
  if (args->arg_count != 2)
  {
      strcpy(message,"XXX() requires two arguments");
      return 1;
  }
  ```

  For other `UDF_ARGS` member values that are arrays, array references are zero-based. That is, refer to array members using index values from 0 to `args->arg_count` – 1.

- `enum Item_result *arg_type`

  A pointer to an array containing the types for each argument. The possible type values are `STRING_RESULT`, `INT_RESULT`, `REAL_RESULT`, and `DECIMAL_RESULT`.

  To make sure that arguments are of a given type and return an error if they are not, check the `arg_type` array in the initialization function. For example:

```
if (args->arg_type[0] != STRING_RESULT ||
    args->arg_type[1] != INT_RESULT)
{
    strcpy(message,"XXX() requires a string and an integer");
    return 1;
}
```

Arguments of type `DECIMAL_RESULT` are passed as strings, so you should handle them the same way as `STRING_RESULT` values.

As an alternative to requiring your function's arguments to be of particular types, you can use the initialization function to set the `arg_type` elements to the types you want. This causes MySQL to coerce arguments to those types for each call to `xxx()`. For example, to specify that the first two arguments should be coerced to string and integer, respectively, do this in `xxx_init()`:

```
args->arg_type[0] = STRING_RESULT;
args->arg_type[1] = INT_RESULT;
```

Exact-value decimal arguments such as `1.3` or `DECIMAL` column values are passed with a type of `DECIMAL_RESULT`. However, the values are passed as strings. If you want to receive a number, use the initialization function to specify that the argument should be coerced to a `REAL_RESULT` value:

```
args->arg_type[2] = REAL_RESULT;
```

- `char **args`

  `args->args` communicates information to the initialization function about the general nature of the arguments passed to your function. For a constant argument `i`, `args->args[i]` points to the argument value. (See later for instructions on how to access the value properly.) For a nonconstant argument, `args->args[i]` is `0`. A constant argument is an expression that uses only constants, such as `3` or `4*7-2` or `SIN(3.14)`. A nonconstant argument is an expression that refers to values that may change from row to row, such as column names or functions that are called with nonconstant arguments.

  For each invocation of the main function, `args->args` contains the actual arguments that are passed for the row currently being processed.

  If argument `i` represents `NULL`, `args->args[i]` is a null pointer (0). If the argument is not `NULL`, functions can refer to it as follows:

  - An argument of type `STRING_RESULT` is given as a string pointer plus a length, to enable handling of binary data or data of arbitrary length. The string contents are available as `args->args[i]` and the string length is `args->lengths[i]`. Do not assume that the string is null-terminated.

  - For an argument of type `INT_RESULT`, you must cast `args->args[i]` to a `long long` value:

    ```
    long long int_val;
    int_val = *((long long*) args->args[i]);
    ```

  - For an argument of type `REAL_RESULT`, you must cast `args->args[i]` to a `double` value:

    ```
    double    real_val;
    real_val = *((double*) args->args[i]);
    ```

  - For an argument of type `DECIMAL_RESULT`, the value is passed as a string and should be handled like a `STRING_RESULT` value.

  - `ROW_RESULT` arguments are not implemented.

- `unsigned long *lengths`

  For the initialization function, the `lengths` array indicates the maximum string length for each argument. You should not change these. For each invocation of the main function, `lengths` contains the actual lengths of any string arguments that are passed for the row currently being processed. For arguments of types `INT_RESULT` or `REAL_RESULT`, `lengths` still contains the maximum length of the argument (as for the initialization function).

- `char *maybe_null`

  For the initialization function, the `maybe_null` array indicates for each argument whether the argument value might be null (0 if no, 1 if yes).

- `char **attributes`

  `args->attributes` communicates information about the names of the UDF arguments. For argument `i`, the attribute name is available as a string in `args->attributes[i]` and the attribute length is `args->attribute_lengths[i]`. Do not assume that the string is null-terminated.

  By default, the name of a UDF argument is the text of the expression used to specify the argument. For UDFs, an argument may also have an optional `[AS] alias_name` clause, in which case the argument name is *`alias_name`*. The `attributes` value for each argument thus depends on whether an alias was given.

  Suppose that a UDF `my_udf()` is invoked as follows:

  ```
  SELECT my_udf(expr1, expr2 AS alias1, expr3 alias2);
  ```

  In this case, the `attributes` and `attribute_lengths` arrays will have these values:

  ```
  args->attributes[0] = "expr1"
  args->attribute_lengths[0] = 5

  args->attributes[1] = "alias1"
  args->attribute_lengths[1] = 6

  args->attributes[2] = "alias2"
  args->attribute_lengths[2] = 6
  ```

- `unsigned long *attribute_lengths`

  The `attribute_lengths` array indicates the length of each argument name.

21.3.2.4. UDF Return Values and Error Handling

The initialization function should return `0` if no error occurred and `1` otherwise. If an error occurs, `xxx_init()` should store a null-terminated error message in the `message` parameter. The message is returned to the client. The message buffer is `MYSQL_ERRMSG_SIZE` characters long, but you should try to keep the message to less than 80 characters so that it fits the width of a standard terminal screen.

The return value of the main function `xxx()` is the function value, for `long long` and `double` functions. A string function should return a pointer to the result and set `*length` to the length (in bytes) of the return value. For example:

```
memcpy(result, "result string", 13);
*length = 13;
```

MySQL passes a buffer to the `xxx()` function using the `result` parameter. This buffer is sufficiently long to hold 255 characters, which can be multi-byte characters. The `xxx()` function can store the result in this buffer if it fits, in which case the return value should be a pointer to the buffer. If the function stores the result in a different buffer, it should return a pointer to that buffer.

If your string function does not use the supplied buffer (for example, if it needs to return a string longer than 255 characters), you must allocate the space for your own buffer with `malloc()` in your `xxx_init()` function or your `xxx()` function and free it in your `xxx_deinit()` function. You can store the allocated memory in the `ptr` slot in the `UDF_INIT` structure for reuse by future `xxx()` calls. See Section 21.3.2.1, “UDF Calling Sequences for Simple Functions”.

To indicate a return value of `NULL` in the main function, set `*is_null` to `1`:

```
*is_null = 1;
```

To indicate an error return in the main function, set `*error` to `1`:

```
*error = 1;
```

If `xxx()` sets `*error` to `1` for any row, the function value is `NULL` for the current row and for any subsequent rows processed by the statement in which `XXX()` was invoked. (`xxx()` is not even called for subsequent rows.)

21.3.2.5. Compiling and Installing User-Defined Functions

Files implementing UDFs must be compiled and installed on the host where the server runs. This process is described below for the example UDF file `sql/udf_example.c` that is included in MySQL source distributions.

If a UDF will be referred to in statements that will be replicated to slave servers, you must ensure that every slave also has the function available. Otherwise, replication will fail on the slaves when they attempt to invoke the function.

The immediately following instructions are for Unix. Instructions for Windows are given later in this section.

The `udf_example.c` file contains the following functions:

- `metaphon()` returns a metaphon string of the string argument. This is something like a soundex string, but it is more tuned for English.
- `myfunc_double()` returns the sum of the ASCII values of the characters in its arguments, divided by the sum of the length of its arguments.
- `myfunc_int()` returns the sum of the length of its arguments.
- `sequence([const int])` returns a sequence starting from the given number or 1 if no number has been given.
- `lookup()` returns the IP address for a host name.
- `reverse_lookup()` returns the host name for an IP address. The function may be called either with a single string argument of the form `'xxx.xxx.xxx.xxx'` or with four numbers.
- `avgcost()` returns an average cost. This is an aggregate function.

A dynamically loadable file should be compiled as a sharable object file, using a command something like this:

```
shell> gcc -shared -o udf_example.so udf_example.c
```

If you are using `gcc` with `CMake` (which is how MySQL is configured), you should be able to create `udf_example.so` with a simpler command:

```
shell> make udf_example
```

After you compile a shared object containing UDFs, you must install it and tell MySQL about it. Compiling a shared object from `udf_example.c` using `gcc` directly produces a file named `udf_example.so`. Copy the shared object to the server's plugin directory and name it `udf_example.so`. This directory is given by the value of the `plugin_dir` system variable.

On some systems, the `ldconfig` program that configures the dynamic linker does not recognize a shared object unless its name begins with `lib`. In this case you should rename a file such as `udf_example.so` to `libudf_example.so`.

On Windows, you can compile user-defined functions by using the following procedure:

1. Obtain a MySQL source distribution. See Section 2.1.3, “How to Get MySQL”.
2. Obtain the `CMake` build utility, if necessary, from http://www.cmake.org. (Version 2.6 or later is required).
3. In the source tree, look in the `sql` directory. There are files named `udf_example.def` `udf_example.c` there. Copy both files from this directory to your working directory.
4. Create a `CMake` `makefile` (`CMakeLists.txt`) with these contents:

```
PROJECT(udf_example)

# Path for MySQL include directory
INCLUDE_DIRECTORIES("c:/mysql/include")

ADD_DEFINITIONS("-DHAVE_DLOPEN")
ADD_LIBRARY(udf_example MODULE udf_example.c udf_example.def)
TARGET_LINK_LIBRARIES(udf_example wsock32)
```

5. Create the VC project and solution files:

```
cmake -G "<Generator>"
```

   Invoking `cmake --help` shows you a list of valid Generators.

6. Create `udf_example.dll`:

```
devenv udf_example.sln /build Release
```

After the shared object file has been installed, notify `mysqld` about the new functions with the following statements. If object files have a suffix different from `.so` on your system, substitute the correct suffix throughout (for example, `.dll` on Windows).

```
mysql> CREATE FUNCTION metaphon RETURNS STRING SONAME 'udf_example.so';
mysql> CREATE FUNCTION myfunc_double RETURNS REAL SONAME 'udf_example.so';
mysql> CREATE FUNCTION myfunc_int RETURNS INTEGER SONAME 'udf_example.so';
mysql> CREATE FUNCTION sequence RETURNS INTEGER SONAME 'udf_example.so';
mysql> CREATE FUNCTION lookup RETURNS STRING SONAME 'udf_example.so';
mysql> CREATE FUNCTION reverse_lookup
    ->        RETURNS STRING SONAME 'udf_example.so';
mysql> CREATE AGGREGATE FUNCTION avgcost
    ->        RETURNS REAL SONAME 'udf_example.so';
```

To delete functions, use `DROP FUNCTION`:

```
mysql> DROP FUNCTION metaphon;
mysql> DROP FUNCTION myfunc_double;
mysql> DROP FUNCTION myfunc_int;
mysql> DROP FUNCTION sequence;
mysql> DROP FUNCTION lookup;
mysql> DROP FUNCTION reverse_lookup;
mysql> DROP FUNCTION avgcost;
```

The `CREATE FUNCTION` and `DROP FUNCTION` statements update the `func` system table in the `mysql` database. The function's name, type and shared library name are saved in the table. You must have the `INSERT` or `DELETE` privilege for the `mysql` database to create or drop functions, respectively.

You should not use `CREATE FUNCTION` to add a function that has previously been created. If you need to reinstall a function, you should remove it with `DROP FUNCTION` and then reinstall it with `CREATE FUNCTION`. You would need to do this, for example, if you recompile a new version of your function, so that `mysqld` gets the new version. Otherwise, the server continues to use the old version.

An active function is one that has been loaded with `CREATE FUNCTION` and not removed with `DROP FUNCTION`. All active functions are reloaded each time the server starts, unless you start `mysqld` with the `--skip-grant-tables` option. In this case, UDF initialization is skipped and UDFs are unavailable.

21.3.2.6. User-Defined Function Security Precautions

MySQL takes the following measures to prevent misuse of user-defined functions.

You must have the `INSERT` privilege to be able to use `CREATE FUNCTION` and the `DELETE` privilege to be able to use `DROP FUNCTION`. This is necessary because these statements add and delete rows from the `mysql.func` table.

UDFs should have at least one symbol defined in addition to the `xxx` symbol that corresponds to the main `xxx()` function. These auxiliary symbols correspond to the `xxx_init()`, `xxx_deinit()`, `xxx_reset()`, `xxx_clear()`, and `xxx_add()` functions. `mysqld` also supports an `--allow-suspicious-udfs` option that controls whether UDFs that have only an `xxx` symbol can be loaded. By default, the option is off, to prevent attempts at loading functions from shared object files other than those containing legitimate UDFs. If you have older UDFs that contain only the `xxx` symbol and that cannot be recompiled to include an auxiliary symbol, it may be necessary to specify the `--allow-suspicious-udfs` option. Otherwise, you should avoid enabling this capability.

UDF object files cannot be placed in arbitrary directories. They must be located in the server's plugin directory. This directory is given by the value of the `plugin_dir` system variable.

21.3.3. Adding a New Native Function

To add a new native MySQL function, use the procedure described here, which requires that you use a source distribution. You cannot add native functions to a binary distribution because it is necessary to modify MySQL source code and compile MySQL from the modified source. If you migrate to another version of MySQL (for example, when a new version is released), you must repeat the procedure with the new version.

If the new native function will be referred to in statements that will be replicated to slave servers, you must ensure that every slave server also has the function available. Otherwise, replication will fail on the slaves when they attempt to invoke the function.

To add a new native function, follow these steps to modify source files in the `sql` directory:

1. Create a subclass for the function in `item_create.cc`:

   - If the function takes a fixed number of arguments, create a subclass of `Create_func_arg0`, `Create_func_arg1`, `Create_func_arg2`, or `Create_func_arg3`, respectively, depending on whether the function takes zero, one, two, or three arguments. For examples, see the `Create_func_uuid`, `Create_func_abs`, `Create_func_pow`, and `Create_func_lpad` classes.

- If the function takes a variable number of arguments, create a subclass of `Create_native_func`. For an example, see `Create_func_concat`.

2. To provide a name by which the function can be referred to in SQL statements, register the name in `item_create.cc` by adding a line to this array:

   ```
   static Native_func_registry func_array[]
   ```

   You can register several names for the same function. For example, see the lines for `"LCASE"` and `"LOWER"`, which are aliases for `Create_func_lcase`.

3. In `item_func.h`, declare a class inheriting from `Item_num_func` or `Item_str_func`, depending on whether your function returns a number or a string.

4. In `item_func.cc`, add one of the following declarations, depending on whether you are defining a numeric or string function:

   ```
   double   Item_func_newname::val()
   longlong Item_func_newname::val_int()
   String  *Item_func_newname::Str(String *str)
   ```

   If you inherit your object from any of the standard items (like `Item_num_func`), you probably only have to define one of these functions and let the parent object take care of the other functions. For example, the `Item_str_func` class defines a `val()` function that executes `atof()` on the value returned by `::str()`.

5. If the function is nondeterministic, include the following statement in the item constructor to indicate that function results should not be cached:

   ```
   current_thd->lex->safe_to_cache_query=0;
   ```

   A function is nondeterministic if, given fixed values for its arguments, it can return different results for different invocations.

6. You should probably also define the following object function:

   ```
   void Item_func_newname::fix_length_and_dec()
   ```

   This function should at least calculate `max_length` based on the given arguments. `max_length` is the maximum number of characters the function may return. This function should also set `maybe_null = 0` if the main function can't return a `NULL` value. The function can check whether any of the function arguments can return `NULL` by checking the arguments' `maybe_null` variable. Look at `Item_func_mod::fix_length_and_dec` for a typical example of how to do this.

All functions must be thread-safe. In other words, do not use any global or static variables in the functions without protecting them with mutexes.

If you want to return `NULL` from `::val()`, `::val_int()`, or `::str()`, you should set `null_value` to 1 and return 0.

For `::str()` object functions, there are additional considerations to be aware of:

- The `String *str` argument provides a string buffer that may be used to hold the result. (For more information about the `String` type, take a look at the `sql_string.h` file.)
- The `::str()` function should return the string that holds the result, or `(char*) 0` if the result is `NULL`.
- All current string functions try to avoid allocating any memory unless absolutely necessary!

21.4. Adding New Procedures to MySQL

In MySQL, you can define a procedure in C++ that can access and modify the data in a query before it is sent to the client. The modification can be done on a row-by-row or `GROUP BY` level.

We have created an example procedure to show you what can be done.

21.4.1. `PROCEDURE ANALYSE`

`ANALYSE([max_elements[,max_memory]])`

`ANALYSE()` is defined in the `sql/sql_analyse.cc` source file, which serves as an example of how to create a procedure for use with the `PROCEDURE` clause of `SELECT` statements. `ANALYSE()` is built in and is available by default; other procedures can be created using the format demonstrated in the source file.

`ANALYSE()` examines the result from a query and returns an analysis of the results that suggests optimal data types for each column that may help reduce table sizes. To obtain this analysis, append `PROCEDURE ANALYSE` to the end of a `SELECT` statement:

```
SELECT ... FROM ... WHERE ... PROCEDURE ANALYSE([max_elements,[max_memory]])
```

For example:

```
SELECT col1, col2 FROM table1 PROCEDURE ANALYSE(10, 2000);
```

The results show some statistics for the values returned by the query, and propose an optimal data type for the columns. This can be helpful for checking your existing tables, or after importing new data. You may need to try different settings for the arguments so that `PROCEDURE ANALYSE()` does not suggest the `ENUM` data type when it is not appropriate.

The arguments are optional and are used as follows:

- *`max_elements`* (default 256) is the maximum number of distinct values that `ANALYSE()` notices per column. This is used by `ANALYSE()` to check whether the optimal data type should be of type `ENUM`; if there are more than *`max_elements`* distinct values, then `ENUM` is not a suggested type.
- *`max_memory`* (default 8192) is the maximum amount of memory that `ANALYSE()` should allocate per column while trying to find all distinct values.

21.4.2. Writing a Procedure

You can find information about procedures by examining the following source files:

- `sql/sql_analyse.cc`
- `sql/procedure.h`
- `sql/procedure.cc`
- `sql/sql_select.cc`

See also Writing a Procedure at MySQL Forge.

21.5. Debugging and Porting MySQL

This appendix helps you port MySQL to other operating systems. Do check the list of currently supported operating systems first. See Section 2.1.1, “Operating Systems Supported by MySQL Community Server”. If you have created a new port of MySQL, please let us know so that we can list it here and on our Web site (http://www.mysql.com/), recommending it to other users.

> **Note**
>
> If you create a new port of MySQL, you are free to copy and distribute it under the GPL license, but it does not make you a copyright holder of MySQL.

A working POSIX thread library is needed for the server.

To build MySQL from source, your system must satisfy the tool requirements listed at Section 2.9, “Installing MySQL from Source”.

> **Important**
>
> If you are trying to build MySQL 5.5 with `icc` on the IA64 platform, and need support for MySQL Cluster, you should first ensure that you are using `icc` version 9.1.043 or later. (For details, see Bug #21875.)

If you run into problems with a new port, you may have to do some debugging of MySQL! See Section 21.5.1, “Debugging a MySQL Server”.

Note

Before you start debugging `mysqld`, first get the test programs `mysys/thr_alarm` and `mysys/thr_lock` to work. This ensures that your thread installation has even a remote chance to work!

21.5.1. Debugging a MySQL Server

If you are using some functionality that is very new in MySQL, you can try to run `mysqld` with the `--skip-new` (which disables all new, potentially unsafe functionality) or with `--safe-mode` which disables a lot of optimization that may cause problems. See Section C.5.4.2, “What to Do If MySQL Keeps Crashing”.

If `mysqld` doesn't want to start, you should verify that you don't have any `my.cnf` files that interfere with your setup! You can check your `my.cnf` arguments with `mysqld --print-defaults` and avoid using them by starting with `mysqld --no-defaults ...`.

If `mysqld` starts to eat up CPU or memory or if it “hangs,” you can use `mysqladmin processlist status` to find out if someone is executing a query that takes a long time. It may be a good idea to run `mysqladmin -i10 processlist status` in some window if you are experiencing performance problems or problems when new clients can't connect.

The command `mysqladmin debug` dumps some information about locks in use, used memory and query usage to the MySQL log file. This may help solve some problems. This command also provides some useful information even if you haven't compiled MySQL for debugging!

If the problem is that some tables are getting slower and slower you should try to optimize the table with `OPTIMIZE TABLE` or `myisamchk`. See Chapter 5, *MySQL Server Administration*. You should also check the slow queries with `EXPLAIN`.

You should also read the OS-specific section in this manual for problems that may be unique to your environment. See Section 2.1, “General Installation Guidance”.

21.5.1.1. Compiling MySQL for Debugging

If you have some very specific problem, you can always try to debug MySQL. To do this you must configure MySQL with the `-DWITH_DEBUG=1` option. You can check whether MySQL was compiled with debugging by doing: `mysqld --help`. If the `--debug` flag is listed with the options then you have debugging enabled. `mysqladmin ver` also lists the `mysqld` version as `mysql ... --debug` in this case.

If `mysqld` stops crashing when you compile it with `-DWITH_DEBUG=1`, you probably have found a compiler bug or a timing bug within MySQL. In this case, you can try to add `-g` to the `CFLAGS` and `CXXFLAGS` environment variables and not use `-DWITH_DEBUG=1`. If `mysqld` dies, you can at least attach to it with `gdb` or use `gdb` on the core file to find out what happened.

When you configure MySQL for debugging you automatically enable a lot of extra safety check functions that monitor the health of `mysqld`. If they find something “unexpected,” an entry is written to `stderr`, which `mysqld_safe` directs to the error log! This also means that if you are having some unexpected problems with MySQL and are using a source distribution, the first thing you should do is to configure MySQL for debugging! (The second thing is to send mail to a MySQL mailing list and ask for help. See Section 1.6.1, “MySQL Mailing Lists”. If you believe that you have found a bug, please use the instructions at Section 1.7, “How to Report Bugs or Problems”.

In the Windows MySQL distribution, `mysqld.exe` is by default compiled with support for trace files.

21.5.1.2. Creating Trace Files

If the `mysqld` server doesn't start or if you can cause it to crash quickly, you can try to create a trace file to find the problem.

To do this, you must have a `mysqld` that has been compiled with debugging support. You can check this by executing `mysqld -V`. If the version number ends with `-debug`, it is compiled with support for trace files. (On Windows, the debugging server is named `mysqld-debug` rather than `mysqld` as of MySQL 4.1.)

Start the `mysqld` server with a trace log in `/tmp/mysqld.trace` on Unix or `C:\mysqld.trace` on Windows:

```
shell> mysqld --debug
```

On Windows, you should also use the `--standalone` flag to not start `mysqld` as a service. In a console window, use this command:

```
C:\> mysqld-debug --debug --standalone
```

After this, you can use the `mysql.exe` command-line tool in a second console window to reproduce the problem. You can stop the `mysqld` server with `mysqladmin shutdown`.

The trace file can become **very large**! To generate a smaller trace file, you can use debugging options something like this:

```
mysqld --debug=d,info,error,query,general,where:O,/tmp/mysqld.trace
```

This only prints information with the most interesting tags to the trace file.

If you make a bug report about this, please only send the lines from the trace file to the appropriate mailing list where something seems to go wrong! If you can't locate the wrong place, you can ftp the trace file, together with a full bug report, to ftp://ftp.mysql.com/pub/mysql/upload/ so that a MySQL developer can take a look at it.

The trace file is made with the **DBUG** package by Fred Fish. See Section 21.5.3, “The DBUG Package”.

21.5.1.3. Using `pdb` to create a Windows crashdump

Program Database files (extension `pdb`) are included in the Noinstall distribution of MySQL. These files provide information for debugging your MySQL installation in the event of a problem.

The PDB file contains more detailed information about `mysqld` and other tools that enables more detailed trace and dump files to be created. You can use these with Dr Watson, `WinDbg` and Visual Studio to debug `mysqld`.

For more information on PDB files, see Microsoft Knowledge Base Article 121366. For more information on the debugging options available, see Debugging Tools for Windows.

Dr Watson is installed with all Windows distributions, but if you have installed Windows development tools, Dr Watson may have been replaced with WinDbg, the debugger included with Visual Studio, or the debugging tools provided with Borland or Delphi.

To generate a crash file using Dr Watson, follow these steps:

1. Start Dr Watson by running `drwtsn32.exe` interactively using the `-i` option:

   ```
   C:\> drwtsn32 -i
   ```

2. Set the **Log File Path** to the directory where you want to store trace files.
3. Make sure **Dump All Thread Contexts** and **Append To Existing Log File**.
4. Uncheck **Dump Symbol Table**, **Visual Notification**, **Sound Notification** and **Create Crash Dump File**.
5. Set the **Number of Instructions** to a suitable value to capture enough calls in the stacktrace. A value of at 25 should be enough.

Note that the file generated can become very large.

21.5.1.4. Debugging `mysqld` under `gdb`

On most systems you can also start `mysqld` from `gdb` to get more information if `mysqld` crashes.

With some older `gdb` versions on Linux you must use `run --one-thread` if you want to be able to debug `mysqld` threads. In this case, you can only have one thread active at a time. It is best to upgrade to `gdb` 5.1 because thread debugging works much better with this version!

NPTL threads (the new thread library on Linux) may cause problems while running `mysqld` under `gdb`. Some symptoms are:

- `mysqld` hangs during startup (before it writes `ready for connections`).
- `mysqld` crashes during a `pthread_mutex_lock()` or `pthread_mutex_unlock()` call.

In this case, you should set the following environment variable in the shell before starting `gdb`:

```
LD_ASSUME_KERNEL=2.4.1
export LD_ASSUME_KERNEL
```

When running `mysqld` under `gdb`, you should disable the stack trace with `--skip-stack-trace` to be able to catch segfaults within `gdb`.

In MySQL 4.0.14 and above you should use the `--gdb` option to `mysqld`. This installs an interrupt handler for `SIGINT` (needed to stop `mysqld` with `^C` to set breakpoints) and disable stack tracing and core file handling.

It is very hard to debug MySQL under `gdb` if you do a lot of new connections the whole time as `gdb` doesn't free the memory for old threads. You can avoid this problem by starting `mysqld` with `thread_cache_size` set to a value equal to `max_connections` + 1. In most cases just using `--thread_cache_size=5'` helps a lot!

If you want to get a core dump on Linux if `mysqld` dies with a SIGSEGV signal, you can start `mysqld` with the `--core-file` option. This core file can be used to make a backtrace that may help you find out why `mysqld` died:

```
shell> gdb mysqld core
gdb>   backtrace full
gdb>   quit
```

See Section C.5.4.2, “What to Do If MySQL Keeps Crashing”.

If you are using `gdb` 4.17.x or above on Linux, you should install a `.gdb` file, with the following information, in your current directory:

```
set print sevenbit off
handle SIGUSR1 nostop noprint
handle SIGUSR2 nostop noprint
handle SIGWAITING nostop noprint
handle SIGLWP nostop noprint
handle SIGPIPE nostop
handle SIGALRM nostop
handle SIGHUP nostop
handle SIGTERM nostop noprint
```

If you have problems debugging threads with `gdb`, you should download gdb 5.x and try this instead. The new `gdb` version has very improved thread handling!

Here is an example how to debug `mysqld`:

```
shell> gdb /usr/local/libexec/mysqld
gdb> run
...
backtrace full # Do this when mysqld crashes
```

Include the preceding output in a bug report, which you can file using the instructions in Section 1.7, “How to Report Bugs or Problems”.

If `mysqld` hangs, you can try to use some system tools like `strace` or `/usr/proc/bin/pstack` to examine where `mysqld` has hung.

```
strace /tmp/log libexec/mysqld
```

If you are using the Perl `DBI` interface, you can turn on debugging information by using the `trace` method or by setting the `DBI_TRACE` environment variable.

21.5.1.5. Using a Stack Trace

On some operating systems, the error log contains a stack trace if `mysqld` dies unexpectedly. You can use this to find out where (and maybe why) `mysqld` died. See Section 5.2.2, “The Error Log”. To get a stack trace, you must not compile `mysqld` with the `-fomit-frame-pointer` option to gcc. See Section 21.5.1.1, “Compiling MySQL for Debugging”.

A stack trace in the error log looks something like this:

```
mysqld got signal 11;
Attempting backtrace. You can use the following information
to find out where mysqld died. If you see no messages after
this, something went terribly wrong...

stack_bottom = 0x41fd0110 thread_stack 0x40000
mysqld(my_print_stacktrace+0x32)[0x9da402]
mysqld(handle_segfault+0x28a)[0x6648e9]
/lib/libpthread.so.0[0x7f1a5af000f0]
/lib/libc.so.6(strcmp+0x2)[0x7f1a5a10f0f2]
mysqld(_Z21check_change_passwordP3THDPKcS2_Pcj+0x7c)[0x7412cb]
mysqld(_ZN16set_var_password5checkEP3THD+0xd0)[0x688354]
mysqld(_Z17sql_set_variablesP3THDP4ListI12set_var_baseE+0x68)[0x688494]
mysqld(_Z21mysql_execute_commandP3THD+0x41a0)[0x67a170]
mysqld(_Z11mysql_parseP3THDPKcjPS2_+0x282)[0x67f0ad]
mysqld(_Z16dispatch_command19enum_server_commandP3THDPcj+0xbb7[0x67fdf8]
mysqld(_Z10do_commandP3THD+0x24d)[0x6811b6]
mysqld(handle_one_connection+0x11c)[0x66e05e]
```

If resolution of function names for the trace fails, the trace contains less information:

```
mysqld got signal 11;
Attempting backtrace. You can use the following information
to find out where mysqld died. If you see no messages after
this, something went terribly wrong...

stack_bottom = 0x41fd0110 thread_stack 0x40000
[0x9da402]
[0x6648e9]
[0x7f1a5af000f0]
[0x7f1a5a10f0f2]
[0x7412cb]
[0x688354]
[0x688494]
[0x67a170]
[0x67f0ad]
[0x67fdf8]
[0x6811b6]
[0x66e05e]
```

In the latter case, you can use the `resolve_stack_dump` utility to determine where `mysqld` died by using the following procedure:

1. Copy the numbers from the stack trace to a file, for example `mysqld.stack`. The numbers should not include the surrounding square brackets:

   ```
   0x9da402
   0x6648e9
   0x7f1a5af000f0
   0x7f1a5a10f0f2
   0x7412cb
   0x688354
   0x688494
   0x67a170
   0x67f0ad
   0x67fdf8
   0x6811b6
   0x66e05e
   ```

2. Make a symbol file for the `mysqld` server:

   ```
   shell> nm -n libexec/mysqld > /tmp/mysqld.sym
   ```

   If `mysqld` is not linked statically, use the following command instead:

   ```
   shell> nm -D -n libexec/mysqld > /tmp/mysqld.sym
   ```

   If you want to decode C++ symbols, use the `--demangle`, if available, to `nm`. If your version of `nm` does not have this option, you will need to use the `c++filt` command after the stack dump has been produced to demangle the C++ names.

3. Execute the following command:

   ```
   shell> resolve_stack_dump -s /tmp/mysqld.sym -n mysqld.stack
   ```

   If you were not able to include demangled C++ names in your symbol file, process the `resolve_stack_dump` output using `c++filt`:

   ```
   shell> resolve_stack_dump -s /tmp/mysqld.sym -n mysqld.stack | c++filt
   ```

   This prints out where `mysqld` died. If that does not help you find out why `mysqld` died, you should create a bug report and include the output from the preceding command with the bug report.

   However, in most cases it does not help us to have just a stack trace to find the reason for the problem. To be able to locate the bug or provide a workaround, in most cases we need to know the statement that killed `mysqld` and preferably a test case so that we can repeat the problem! See Section 1.7, “How to Report Bugs or Problems”.

Newer versions of `glibc` stack trace functions also print the address as relative to the object. On `glibc`-based systems (Linux), the trace for a crash within a plugin looks something like:

```
plugin/auth/auth_test_plugin.so(+0x9a6)[0x7ff4d11c29a6]
```

To translate the relative address (`+0x9a6`) into a file name and line number, use this command:

```
shell> addr2line -fie auth_test_plugin.so 0x9a6
auth_test_plugin
```

```
mysql-trunk/plugin/auth/test_plugin.c:65
```

The `addr2line` utility is part of the `binutils` package on Linux.

On Solaris, the procedure is similar. The Solaris `printstack()` already prints relative addresses:

```
plugin/auth/auth_test_plugin.so:0x1510
```

To translate, use this command:

```
shell> gaddr2line -fie auth_test_plugin.so 0x1510
mysql-trunk/plugin/auth/test_plugin.c:88
```

Windows already prints the address, function name and line:

```
000007FEF07E10A4 auth_test_plugin.dll!auth_test_plugin()[test_plugin.c:72]
```

21.5.1.6. Using Server Logs to Find Causes of Errors in `mysqld`

Note that before starting `mysqld` with the general query log enabled, you should check all your tables with `myisamchk`. See Chapter 5, *MySQL Server Administration*.

If `mysqld` dies or hangs, you should start `mysqld` with the general query log enabled. See Section 5.2.3, "The General Query Log". When `mysqld` dies again, you can examine the end of the log file for the query that killed `mysqld`.

If you use the default general query log file, the log is stored in the database directory as `*host_name*.log` In most cases it is the last query in the log file that killed `mysqld`, but if possible you should verify this by restarting `mysqld` and executing the found query from the `mysql` command-line tools. If this works, you should also test all complicated queries that didn't complete.

You can also try the command `EXPLAIN` on all `SELECT` statements that takes a long time to ensure that `mysqld` is using indexes properly. See Section 12.8.2, "`EXPLAIN` Syntax".

You can find the queries that take a long time to execute by starting `mysqld` with the slow query log enabled. See Section 5.2.5, "The Slow Query Log".

If you find the text `mysqld restarted` in the error log file (normally named `hostname.err`) you probably have found a query that causes `mysqld` to fail. If this happens, you should check all your tables with `myisamchk` (see Chapter 5, *MySQL Server Administration*), and test the queries in the MySQL log files to see whether one fails. If you find such a query, try first upgrading to the newest MySQL version. If this doesn't help and you can't find anything in the `mysql` mail archive, you should report the bug to a MySQL mailing list. The mailing lists are described at http://lists.mysql.com/, which also has links to online list archives.

If you have started `mysqld` with `--myisam-recover-options`, MySQL automatically checks and tries to repair `MyISAM` tables if they are marked as 'not closed properly' or 'crashed'. If this happens, MySQL writes an entry in the `hostname.err` file `'Warning: Checking table ...'` which is followed by `Warning: Repairing table` if the table needs to be repaired. If you get a lot of these errors, without `mysqld` having died unexpectedly just before, then something is wrong and needs to be investigated further. See Section 5.1.2, "Server Command Options".

As of MySQL 5.5.3, when the server detects `MyISAM` table corruption, it writes additional information to the error log, such as the name and line number of the source file, and the list of threads accessing the table. Example: `Got an error from thread_id=1, mi_dynrec.c:368`. This is useful information to include in bug reports.

It is not a good sign if `mysqld` did die unexpectedly, but in this case, you should not investigate the `Checking table...` messages, but instead try to find out why `mysqld` died.

21.5.1.7. Making a Test Case If You Experience Table Corruption

If you get corrupted tables or if `mysqld` always fails after some update commands, you can test whether this bug is reproducible by doing the following:

- Take down the MySQL daemon (with `mysqladmin shutdown`).
- Make a backup of the tables (to guard against the very unlikely case that the repair does something bad).
- Check all tables with `myisamchk -s database/*.MYI`. Repair any wrong tables with `myisamchk -r database/*table*.MYI`.
- Make a second backup of the tables.
- Remove (or move away) any old log files from the MySQL data directory if you need more space.

- Start `mysqld` with the binary log enabled. If you want to find a query that crashes `mysqld`, you should start the server with both the general query log enabled as well. See Section 5.2.3, “The General Query Log”, and Section 5.2.4, “The Binary Log”.
- When you have gotten a crashed table, stop the `mysqld server`.
- Restore the backup.
- Restart the `mysqld` server **without** the binary log enabled.
- Re-execute the commands with `mysqlbinlog binary-log-file | mysql`. The binary log is saved in the MySQL database directory with the name `hostname-bin.NNNNNN`.
- If the tables are corrupted again or you can get `mysqld` to die with the above command, you have found reproducible bug that should be easy to fix! FTP the tables and the binary log to ftp://ftp.mysql.com/pub/mysql/upload/ and report it in our bugs database using the instructions given in Section 1.7, “How to Report Bugs or Problems”. (Please note that the `/pub/mysql/upload/` FTP directory is not listable, so you'll not see what you've uploaded in your FTP client.) If you are a support customer, you can use the MySQL Customer Support Center https://support.mysql.com/ to alert the MySQL team about the problem and have it fixed as soon as possible.

You can also use the script `mysql_find_rows` to just execute some of the update statements if you want to narrow down the problem.

21.5.2. Debugging a MySQL Client

To be able to debug a MySQL client with the integrated debug package, you should configure MySQL with `-DWITH_DEBUG=1`. See Section 2.9.4, “MySQL Source-Configuration Options”.

Before running a client, you should set the `MYSQL_DEBUG` environment variable:

```
shell> MYSQL_DEBUG=d:t:O,/tmp/client.trace
shell> export MYSQL_DEBUG
```

This causes clients to generate a trace file in `/tmp/client.trace`.

If you have problems with your own client code, you should attempt to connect to the server and run your query using a client that is known to work. Do this by running `mysql` in debugging mode (assuming that you have compiled MySQL with debugging on):

```
shell> mysql --debug=d:t:O,/tmp/client.trace
```

This provides useful information in case you mail a bug report. See Section 1.7, “How to Report Bugs or Problems”.

If your client crashes at some 'legal' looking code, you should check that your `mysql.h` include file matches your MySQL library file. A very common mistake is to use an old `mysql.h` file from an old MySQL installation with new MySQL library.

21.5.3. The DBUG Package

The MySQL server and most MySQL clients are compiled with the DBUG package originally created by Fred Fish. When you have configured MySQL for debugging, this package makes it possible to get a trace file of what the program is debugging. See Section 21.5.1.2, “Creating Trace Files”.

This section summaries the argument values that you can specify in debug options on the command line for MySQL programs that have been built with debugging support. For more information about programming with the DBUG package, see the DBUG manual in the `dbug` directory of MySQL source distributions. It is best to use a recent distribution to get the most updated DBUG manual.

You use the debug package by invoking a program with the `--debug="..."` or the `-#...` option.

Most MySQL programs have a default debug string that is used if you don't specify an option to `--debug`. The default trace file is usually `/tmp/program_name.trace` on Unix and `\program_name.trace` on Windows.

The debug control string is a sequence of colon-separated fields as follows:

```
<field_1>:<field_2>:...:<field_N>
```

Each field consists of a mandatory flag character followed by an optional “`,`” and comma-separated list of modifiers:

```
flag[,modifier,modifier,...,modifier]
```

The following table shows the currently recognized flag characters.

Flag	Description
`d`	Enable output from DBUG_<N> macros for the current state. May be followed by a list of keywords which selects output only for the DBUG macros with that keyword. An empty list of keywords implies output for all macros.
`D`	Delay after each debugger output line. The argument is the number of tenths of seconds to delay, subject to machine capabilities. For example, `-#D,20` specifies a delay of two seconds.
`f`	Limit debugging, tracing, and profiling to the list of named functions. Note that a null list disables all functions. The appropriate `d` or `t` flags must still be given; this flag only limits their actions if they are enabled.
`F`	Identify the source file name for each line of debug or trace output.
`i`	Identify the process with the PID or thread ID for each line of debug or trace output.
`g`	Enable profiling. Create a file called `dbugmon.out` containing information that can be used to profile the program. May be followed by a list of keywords that select profiling only for the functions in that list. A null list implies that all functions are considered.
`L`	Identify the source file line number for each line of debug or trace output.
`n`	Print the current function nesting depth for each line of debug or trace output.
`N`	Number each line of debug output.
`o`	Redirect the debugger output stream to the specified file. The default output is `stderr`.
`O`	Like `o`, but the file is really flushed between each write. When needed, the file is closed and reopened between each write.
`p`	Limit debugger actions to specified processes. A process must be identified with the `DBUG_PROCESS` macro and match one in the list for debugger actions to occur.
`P`	Print the current process name for each line of debug or trace output.
`r`	When pushing a new state, do not inherit the previous state's function nesting level. Useful when the output is to start at the left margin.
`S`	Do function `_sanity(_file_,_line_)` at each debugged function until `_sanity()` returns something that differs from 0.
`t`	Enable function call/exit trace lines. May be followed by a list (containing only one modifier) giving a numeric maximum trace level, beyond which no output occurs for either debugging or tracing macros. The default is a compile time option.

Some examples of debug control strings that might appear on a shell command line (the `-#` is typically used to introduce a control string to an application program) are:

```
-#d:t
-#d:f,main,subr1:F:L:t,20
-#d,input,output,files:n
-#d:t:i:O,\\mysqld.trace
```

In MySQL, common tags to print (with the `d` option) are `enter`, `exit`, `error`, `warning`, `info`, and `loop`.

Chapter 22. MySQL Enterprise Monitor

MySQL Enterprise Monitor is an enterprise monitoring system for MySQL that keeps an eye on your MySQL servers, notifies you of potential issues and problems, and advises you how to fix the issues. MySQL Enterprise Monitor can monitor all kinds of configurations, from a single MySQL server that is important to your business, all the way up to a huge farm of MySQL servers powering a busy web site.

The following discussion briefly describes the basic components that make up the MySQL Enterprise Monitor product. For more information, see the MySQL Enterprise Monitor manual, available at http://dev.mysql.com/doc/mysql-monitor/en/.

MySQL Enterprise Monitor components can be installed in various configurations depending on your own database and network topology, to give you the best combination of reliable and responsive monitoring data, with minimal overhead on the database server machines. A typical MySQL Enterprise Monitor installation consists of:

- One or more MySQL servers that you want to monitor. MySQL Enterprise Monitor can monitor both Community and Enterprise MySQL server releases.
- A MySQL Enterprise Agent for each monitored MySQL server.
- A single MySQL Enterprise Service Manager, which collates information from the agents, and provides the user interface to the collected data.

MySQL Enterprise Monitor is designed to monitor one or more MySQL servers. The monitoring information is collected by using an agent, *MySQL Enterprise Agent*. The agent communicates with the MySQL server that it monitors, collecting variables, status and health information, and sending this information to the MySQL Enterprise Service Manager. If you have multiple MySQL servers, then you have multiple MySQL Enterprise Agent processes monitoring each MySQL server.

The information collected by the agent about each MySQL server you are monitoring is sent to the *MySQL Enterprise Service Manager*. This server collates all of the information from the agents. As it collates the information sent by the agents, the MySQL Enterprise Service Manager continually tests the collected data, comparing the status of the server to reasonable values. When thresholds are reached, the server can trigger an event (including an alarm and notification) to highlight a potential issue, such as low memory, high CPU usage, or more complex conditions such insufficient buffer sizes and status information. We call each test, with its associated threshold value, a *rule*.

These rules, and the alarms and notifications, are each known as a *MySQL Enterprise Advisor*. Advisors form a critical part of the MySQL Enterprise Service Manager, as they provide warning information and troubleshooting advice about potential problems.

The MySQL Enterprise Service Manager includes a web server, and you interact with it through any web browser. This interface, the MySQL Enterprise Dashboard, displays all of the information collected by the agents, and lets you view all of your servers and their current status as a group or individually. You control and configure all aspects of the service using the MySQL Enterprise Dashboard.

The information supplied by the MySQL Enterprise Agent processes also includes statistical and query information, which you can view in the form of graphs. For example, you can view aspects such as server load, query numbers, or index usage information as a graph over time. The graph lets you pinpoint problems or potential issues on your server, and can help diagnose the impact from database or external problems (such as external system or network failure) by examining the data from a specific time interval.

The MySQL Enterprise Agent can also be configured to collect detailed information about the queries executed on your server, including the row counts and performance times for executing each query. You can correlate the detailed query data with the graphical information to identify which queries were executing when you experienced a particularly high load, index or other issue. The query data is supported by a system called Query Analyzer, and the data can be presented in different ways depending on your needs.

Chapter 23. MySQL Enterprise Backup

The MySQL Enterprise Backup product performs hot backup operations for MySQL databases. The product is architected for efficient and reliable backups of tables created by the InnoDB storage engine. For completeness, it can also back up tables from MyISAM and other storage engines.

Hot backups are performed while the database is running. This type of backup does not block normal database operations, and it captures even changes that occur while the backup is happening. For these reasons, hot backups are desirable when your database "grows up" -- when the data is large enough that the backup takes significant time, and when your data is important enough to your business so that you must capture every last change, without taking your application, web site, or web service offline.

MySQL Enterprise Backup does a hot backup of all tables that use the InnoDB storage engine. For tables using MyISAM or other non-InnoDB storage engines, it does a "warm" backup, where the database continues to run, but those tables cannot be modified while being backed up. For efficient backup operations, you can designate InnoDB as the default storage engine for new tables, or convert existing tables to use the InnoDB storage engine.

For more information, see the MySQL Enterprise Backup manual, available at http://dev.mysql.com/doc/mysql-enterprise-backup/en/.

Chapter 24. MySQL Workbench

MySQL Workbench provides a graphical tool for working with MySQL Servers and databases. MySQL Workbench fully supports MySQL Server versions 5.1 and above. It is also compatible with MySQL Server 5.0, but not every feature of 5.0 may be supported. It does not support MySQL Server versions 4.x.

The following discussion briefly describes MySQL Workbench capabilities. For more information, see the MySQL Workbench manual, available at http://dev.mysql.com/doc/workbench/en/.

MySQL Workbench provides three main areas of functionality:

- **SQL Development**: Enables you to create and manage connections to database servers. As well as enabling you to configure connection parameters, MySQL Workbench provides the capability to execute SQL queries on the database connections using the built-in SQL Editor. This functionality replaces that previously provided by the Query Browser standalone application.
- **Data Modeling**: Enables you to create models of your database schema graphically, reverse and forward engineer between a schema and a live database, and edit all aspects of your database using the comprehensive Table Editor. The Table Editor provides easy-to-use facilities for editing Tables, Columns, Indexes, Triggers, Partitioning, Options, Inserts and Privileges, Routines and Views.
- **Server Administration**: Enables you to create and administer server instances. This functionality replaces that previously provided by the MySQL Administrator standalone application.

MySQL Workbench is available in two editions, the Community Edition and the Standard Edition. The Community Edition is available free of charge. The Standard Edition provides additional Enterprise features, such as database documentation generation, at low cost.

Appendix A. Licenses for Third-Party Components

The following is a list of the libraries we have included with the MySQL Server source and components used to test MySQL. We are thankful to all individuals that have created these. Some of the components require that their licensing terms be included in the documentation of products that include them. Cross references to these licensing terms are given with the applicable items in the list.

- GroupLens Research Project

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MySQL 5.5

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  ...

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tar -xvfX mysql-proxy-0.8.1-solaris10-x86-64bit.tar.gz Exclude

Exclude File:
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mysql-proxy-0.8.1-solaris10-x86-64bit/lib/libglib-2.0.so.0
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ZLIB.NET

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Appendix B. MySQL 5.5 Frequently Asked Questions

B.1. MySQL 5.5 FAQ: General

Questions

- B.1.1: Which version of MySQL is production-ready (GA)?
- B.1.2: What is the state of development (non-GA) versions?
- B.1.3: Can MySQL 5.5 do subqueries?
- B.1.4: Can MySQL 5.5 perform multiple-table inserts, updates, and deletes?
- B.1.5: Does MySQL 5.5 have a Query Cache? Does it work on Server, Instance or Database?
- B.1.6: Does MySQL 5.5 have Sequences?
- B.1.7: Does MySQL 5.5 have a `NOW()` function with fractions of seconds?
- B.1.8: Does MySQL 5.5 work with multi-core processors?
- B.1.9: Why do I see multiple processes for `mysqld`?
- B.1.10: Have there been there any improvements in error reporting when foreign keys fail? Does MySQL now report which column and reference failed?
- B.1.11: Can MySQL 5.5 perform ACID transactions?

Questions and Answers

B.1.1: Which version of MySQL is production-ready (GA)?

Currently, both MySQL 5.0 and MySQL 5.1 are supported for production use.

MySQL 5.0 achieved General Availability (GA) status with MySQL 5.0.15, which was released for production use on 19 October 2005.

MySQL 5.1 achieved General Availability (GA) status with MySQL 5.1.30, which was released for production use on 14 November 2008.

B.1.2: What is the state of development (non-GA) versions?

MySQL follows a milestone release model that introduces pre-production-quality features and stabilizes them to release quality (see http://forge.mysql.com/wiki/Development_Cycle). This process then repeats, so releases cycle between pre-production and release quality status. Please check the change logs to identify the status of a given release.

MySQL 5.4 was a development series. Work on this series has ceased.

MySQL 5.5 is being actively developed using the milestone release methodology described above.

MySQL 5.6 is being actively developed using the milestone release methodology described above.

MySQL 6.0 was a development series. Work on this series has ceased.

B.1.3: Can MySQL 5.5 do subqueries?

Yes. See Section 12.2.10, “Subquery Syntax”.

B.1.4: Can MySQL 5.5 perform multiple-table inserts, updates, and deletes?

Yes. For the syntax required to perform multiple-table updates, see Section 12.2.11, “`UPDATE` Syntax”; for that required to perform multiple-table deletes, see Section 12.2.2, “`DELETE` Syntax”.

A multiple-table insert can be accomplished using a trigger whose `FOR EACH ROW` clause contains multiple `INSERT` statements within a `BEGIN ... END` block. See Section 17.3, “Using Triggers”.

B.1.5: Does MySQL 5.5 have a Query Cache? Does it work on Server, Instance or Database?

Yes. The query cache operates on the server level, caching complete result sets matched with the original query string. If an exactly identical query is made (which often happens, particularly in web applications), no parsing or execution is necessary; the result is sent directly from the cache. Various tuning options are available. See Section 7.9.3, "The MySQL Query Cache".

B.1.6: Does MySQL 5.5 have Sequences?

No. However, MySQL has an `AUTO_INCREMENT` system, which in MySQL 5.5 can also handle inserts in a multi-master replication setup. With the `auto_increment_increment` and `auto_increment_offset` system variables, you can set each server to generate auto-increment values that don't conflict with other servers. The `auto_increment_increment` value should be greater than the number of servers, and each server should have a unique offset.

B.1.7: Does MySQL 5.5 have a `NOW()` function with fractions of seconds?

No. This is on the MySQL roadmap as a "rolling feature". This means that it is not a flagship feature, but will be implemented, development time permitting. Specific customer demand may change this scheduling.

However, MySQL does parse time strings with a fractional component. See Section 10.3.2, "The `TIME` Type".

B.1.8: Does MySQL 5.5 work with multi-core processors?

Yes. MySQL is fully multi-threaded, and will make use of multiple CPUs, provided that the operating system supports them.

B.1.9: Why do I see multiple processes for `mysqld`?

When using LinuxThreads, you should see a minimum of three `mysqld` processes running. These are in fact threads. There is one thread for the LinuxThreads manager, one thread to handle connections, and one thread to handle alarms and signals.

B.1.10: Have there been there any improvements in error reporting when foreign keys fail? Does MySQL now report which column and reference failed?

The foreign key support in `InnoDB` has seen improvements in each major version of MySQL. Foreign key support generic to all storage engines is scheduled for MySQL 6.x; this should resolve any inadequacies in the current storage engine specific implementation.

B.1.11: Can MySQL 5.5 perform ACID transactions?

Yes. All current MySQL versions support transactions. The `InnoDB` storage engine offers full ACID transactions with row-level locking, multi-versioning, nonlocking repeatable reads, and all four SQL standard isolation levels.

The `NDB` storage engine supports the `READ COMMITTED` transaction isolation level only.

B.2. MySQL 5.5 FAQ: Storage Engines

Questions

- B.2.1: Where can I obtain complete documentation for MySQL storage engines?
- B.2.2: Are there any new storage engines in MySQL 5.5?
- B.2.3: Have any storage engines been removed in MySQL 5.5?
- B.2.4: What are the unique benefits of the `ARCHIVE` storage engine?
- B.2.5: Do the new features in MySQL 5.5 apply to all storage engines?

Questions and Answers

B.2.1: Where can I obtain complete documentation for MySQL storage engines?

See Chapter 13, *Storage Engines*. That chapter contains information about all MySQL storage engines except for the `NDB` storage engine used for MySQL Cluster; `NDB` is covered in MySQL Cluster NDB 6.X/7.X.

B.2.2: Are there any new storage engines in MySQL 5.5?

No, but the `InnoDB Plugin` is the built-in version of the `InnoDB` storage engine.

B.2.3: Have any storage engines been removed in MySQL 5.5?

No.

B.2.4: What are the unique benefits of the `ARCHIVE` storage engine?

The `ARCHIVE` storage engine is ideally suited for storing large amounts of data without indexes; it has a very small footprint, and performs selects using table scans. See Section 13.8, “The `ARCHIVE` Storage Engine”, for details.

B.2.5: Do the new features in MySQL 5.5 apply to all storage engines?

The general new features such as views, stored procedures, triggers, `INFORMATION_SCHEMA`, precision math (`DECIMAL` column type), and the `BIT` column type, apply to all storage engines. There are also additions and changes for specific storage engines.

B.3. MySQL 5.5 FAQ: Server SQL Mode

Questions

- B.3.1: What are server SQL modes?
- B.3.2: How many server SQL modes are there?
- B.3.3: How do you determine the server SQL mode?
- B.3.4: Is the mode dependent on the database or connection?
- B.3.5: Can the rules for strict mode be extended?
- B.3.6: Does strict mode impact performance?
- B.3.7: What is the default server SQL mode when My SQL 5.5 is installed?

Questions and Answers

B.3.1: What are server SQL modes?

Server SQL modes define what SQL syntax MySQL should support and what kind of data validation checks it should perform. This makes it easier to use MySQL in different environments and to use MySQL together with other database servers. The MySQL Server apply these modes individually to different clients. For more information, see Section 5.1.6, “Server SQL Modes”.

B.3.2: How many server SQL modes are there?

Each mode can be independently switched on and off. See Section 5.1.6, “Server SQL Modes”, for a complete list of available modes.

B.3.3: How do you determine the server SQL mode?

You can set the default SQL mode (for `mysqld` startup) with the `--sql-mode` option. Using the statement `SET [GLOBAL|SESSION] sql_mode='modes'`, you can change the settings from within a connection, either locally to the connection, or to take effect globally. You can retrieve the current mode by issuing a `SELECT @@sql_mode` statement.

B.3.4: Is the mode dependent on the database or connection?

A mode is not linked to a particular database. Modes can be set locally to the session (connection), or globally for the server. you can change these settings using `SET [GLOBAL|SESSION] sql_mode='modes'`.

B.3.5: Can the rules for strict mode be extended?

When we refer to *strict mode*, we mean a mode where at least one of the modes `TRADITIONAL`, `STRICT_TRANS_TABLES`, or `STRICT_ALL_TABLES` is enabled. Options can be combined, so you can add restrictions to a mode. See Section 5.1.6, “Server SQL Modes”, for more information.

B.3.6: Does strict mode impact performance?

The intensive validation of input data that some settings requires more time than if the validation is not done. While the performance impact is not that great, if you do not require such validation (perhaps your application already handles all of this), then MySQL gives you the option of leaving strict mode disabled. However—if you do require it—strict mode can provide such validation.

B.3.7: What is the default server SQL mode when My SQL 5.5 is installed?

By default, no special modes are enabled. See Section 5.1.6, “Server SQL Modes”, for information about all available modes and MySQL's default behavior.

B.4. MySQL 5.5 FAQ: Stored Procedures and Functions

Questions

- B.4.1: Does MySQL 5.5 support stored procedures and functions?
- B.4.2: Where can I find documentation for MySQL stored procedures and stored functions?
- B.4.3: Is there a discussion forum for MySQL stored procedures?
- B.4.4: Where can I find the ANSI SQL 2003 specification for stored procedures?
- B.4.5: How do you manage stored routines?
- B.4.6: Is there a way to view all stored procedures and stored functions in a given database?
- B.4.7: Where are stored procedures stored?
- B.4.8: Is it possible to group stored procedures or stored functions into packages?
- B.4.9: Can a stored procedure call another stored procedure?
- B.4.10: Can a stored procedure call a trigger?
- B.4.11: Can a stored procedure access tables?
- B.4.12: Do stored procedures have a statement for raising application errors?
- B.4.13: Do stored procedures provide exception handling?
- B.4.14: Can MySQL 5.5 stored routines return result sets?
- B.4.15: Is `WITH RECOMPILE` supported for stored procedures?
- B.4.16: Is there a MySQL equivalent to using `mod_plsql` as a gateway on Apache to talk directly to a stored procedure in the database?
- B.4.17: Can I pass an array as input to a stored procedure?
- B.4.18: Can I pass a cursor as an `IN` parameter to a stored procedure?
- B.4.19: Can I return a cursor as an `OUT` parameter from a stored procedure?
- B.4.20: Can I print out a variable's value within a stored routine for debugging purposes?
- B.4.21: Can I commit or roll back transactions inside a stored procedure?
- B.4.22: Do MySQL 5.5 stored procedures and functions work with replication?
- B.4.23: Are stored procedures and functions created on a master server replicated to a slave?
- B.4.24: How are actions that take place inside stored procedures and functions replicated?
- B.4.25: Are there special security requirements for using stored procedures and functions together with replication?
- B.4.26: What limitations exist for replicating stored procedure and function actions?
- B.4.27: Do the preceding limitations affect MySQL's ability to do point-in-time recovery?
- B.4.28: What is being done to correct the aforementioned limitations?

Questions and Answers

B.4.1: Does MySQL 5.5 support stored procedures and functions?

Yes. MySQL 5.5 supports two types of stored routines—stored procedures and stored functions.

B.4.2: Where can I find documentation for MySQL stored procedures and stored functions?

See Section 17.2, “Using Stored Routines (Procedures and Functions)”.

B.4.3: Is there a discussion forum for MySQL stored procedures?

Yes. See http://forums.mysql.com/list.php?98.

B.4.4: Where can I find the ANSI SQL 2003 specification for stored procedures?

Unfortunately, the official specifications are not freely available (ANSI makes them available for purchase). However, there are books—such as *SQL-99 Complete, Really* by Peter Gulutzan and Trudy Pelzer—which give a comprehensive overview of the standard, including coverage of stored procedures.

B.4.5: How do you manage stored routines?

It is always good practice to use a clear naming scheme for your stored routines. You can manage stored procedures with `CREATE [FUNCTION|PROCEDURE]`, `ALTER [FUNCTION|PROCEDURE]`, `DROP [FUNCTION|PROCEDURE]`, and `SHOW CREATE [FUNCTION|PROCEDURE]`. You can obtain information about existing stored procedures using the `ROUTINES` table in the `INFORMATION_SCHEMA` database (see Section 18.14, “The `INFORMATION_SCHEMA ROUTINES` Table”).

B.4.6: Is there a way to view all stored procedures and stored functions in a given database?

Yes. For a database named *`dbname`*, use this query on the `INFORMATION_SCHEMA.ROUTINES` table:

```
SELECT ROUTINE_TYPE, ROUTINE_NAME
    FROM INFORMATION_SCHEMA.ROUTINES
    WHERE ROUTINE_SCHEMA='dbname';
```

For more information, see Section 18.14, “The `INFORMATION_SCHEMA ROUTINES` Table”.

The body of a stored routine can be viewed using `SHOW CREATE FUNCTION` (for a stored function) or `SHOW CREATE PROCEDURE` (for a stored procedure). See Section 12.4.5.11, “`SHOW CREATE PROCEDURE` Syntax”, for more information.

B.4.7: Where are stored procedures stored?

In the `proc` table of the `mysql` system database. However, you should not access the tables in the system database directly. Instead, use `SHOW CREATE FUNCTION` to obtain information about stored functions, and `SHOW CREATE PROCEDURE` to obtain information about stored procedures. See Section 12.4.5.11, “`SHOW CREATE PROCEDURE` Syntax”, for more information about these statements.

You can also query the `ROUTINES` table in the `INFORMATION_SCHEMA` database—see Section 18.14, “The `INFORMATION_SCHEMA ROUTINES` Table”, for information about this table.

B.4.8: Is it possible to group stored procedures or stored functions into packages?

No. This is not supported in MySQL 5.5.

B.4.9: Can a stored procedure call another stored procedure?

Yes.

B.4.10: Can a stored procedure call a trigger?

A stored procedure can execute an SQL statement, such as an `UPDATE`, that causes a trigger to activate.

B.4.11: Can a stored procedure access tables?

Yes. A stored procedure can access one or more tables as required.

B.4.12: Do stored procedures have a statement for raising application errors?

Yes. MySQL 5.5 implements the SQL standard `SIGNAL` and `RESIGNAL` statements. See Section 12.7.8, “`SIGNAL` and `RESIGNAL`”.

B.4.13: Do stored procedures provide exception handling?

MySQL implements `HANDLER` definitions according to the SQL standard. See Section 12.7.4.2, “`DECLARE` for Handlers”, for details.

B.4.14: Can MySQL 5.5 stored routines return result sets?

Stored procedures can, but stored functions cannot. If you perform an ordinary `SELECT` inside a stored procedure, the result set is returned directly to the client. You need to use the MySQL 4.1 (or above) client/server protocol for this to work. This means that—for instance—in PHP, you need to use the `mysqli` extension rather than the old `mysql` extension.

B.4.15: Is `WITH RECOMPILE` supported for stored procedures?

Not in MySQL 5.5.

B.4.16: Is there a MySQL equivalent to using `mod_plsql` as a gateway on Apache to talk directly to a stored procedure in the database?

There is no equivalent in MySQL 5.5.

B.4.17: Can I pass an array as input to a stored procedure?

Not in MySQL 5.5.

B.4.18: Can I pass a cursor as an `IN` parameter to a stored procedure?

In MySQL 5.5, cursors are available inside stored procedures only.

B.4.19: Can I return a cursor as an `OUT` parameter from a stored procedure?

In MySQL 5.5, cursors are available inside stored procedures only. However, if you do not open a cursor on a `SELECT`, the result will be sent directly to the client. You can also `SELECT INTO` variables. See Section 12.2.9, "`SELECT` Syntax".

B.4.20: Can I print out a variable's value within a stored routine for debugging purposes?

Yes, you can do this in a *stored procedure*, but not in a stored function. If you perform an ordinary `SELECT` inside a stored procedure, the result set is returned directly to the client. You will need to use the MySQL 4.1 (or above) client/server protocol for this to work. This means that—for instance—in PHP, you need to use the `mysqli` extension rather than the old `mysql` extension.

B.4.21: Can I commit or roll back transactions inside a stored procedure?

Yes. However, you cannot perform transactional operations within a stored function.

B.4.22: Do MySQL 5.5 stored procedures and functions work with replication?

Yes, standard actions carried out in stored procedures and functions are replicated from a master MySQL server to a slave server. There are a few limitations that are described in detail in Section 17.7, "Binary Logging of Stored Programs".

B.4.23: Are stored procedures and functions created on a master server replicated to a slave?

Yes, creation of stored procedures and functions carried out through normal DDL statements on a master server are replicated to a slave, so the objects will exist on both servers. `ALTER` and `DROP` statements for stored procedures and functions are also replicated.

B.4.24: How are actions that take place inside stored procedures and functions replicated?

MySQL records each DML event that occurs in a stored procedure and replicates those individual actions to a slave server. The actual calls made to execute stored procedures are not replicated.

Stored functions that change data are logged as function invocations, not as the DML events that occur inside each function.

B.4.25: Are there special security requirements for using stored procedures and functions together with replication?

Yes. Because a slave server has authority to execute any statement read from a master's binary log, special security constraints exist for using stored functions with replication. If replication or binary logging in general (for the purpose of point-in-time recovery) is active, then MySQL DBAs have two security options open to them:

1. Any user wishing to create stored functions must be granted the `SUPER` privilege.
2. Alternatively, a DBA can set the `log_bin_trust_function_creators` system variable to 1, which enables anyone with the standard `CREATE ROUTINE` privilege to create stored functions.

B.4.26: What limitations exist for replicating stored procedure and function actions?

Nondeterministic (random) or time-based actions embedded in stored procedures may not replicate properly. By their very nature, randomly produced results are not predictable and cannot be exactly reproduced, and therefore, random actions replicated to a slave will not mirror those performed on a master. Note that declaring stored functions to be `DETERMINISTIC` or setting the `log_bin_trust_function_creators` system variable to 0 will not allow random-valued operations to be invoked.

In addition, time-based actions cannot be reproduced on a slave because the timing of such actions in a stored procedure is not reproducible through the binary log used for replication. It records only DML events and does not factor in timing constraints.

Finally, nontransactional tables for which errors occur during large DML actions (such as bulk inserts) may experience replication issues in that a master may be partially updated from DML activity, but no updates are done to the slave because of the errors that occurred. A workaround is for a function's DML actions to be carried out with the `IGNORE` keyword so that updates on the master that cause errors are ignored and updates that do not cause errors are replicated to the slave.

B.4.27: Do the preceding limitations affect MySQL's ability to do point-in-time recovery?

The same limitations that affect replication do affect point-in-time recovery.

B.4.28: What is being done to correct the aforementioned limitations?

You can choose either statement-based replication or row-based replication. The original replication implementation is based on statement-based binary logging. Row-based binary logging resolves the limitations mentioned earlier.

Mixed replication is also available (by starting the server with `--binlog-format=mixed`). This hybrid, “smart” form of replication “knows” whether statement-level replication can safely be used, or row-level replication is required.

For additional information, see Section 15.1.2, “Replication Formats”.

B.5. MySQL 5.5 FAQ: Triggers

Questions

- B.5.1: Where can I find the documentation for MySQL 5.5 triggers?
- B.5.2: Is there a discussion forum for MySQL Triggers?
- B.5.3: Does MySQL 5.5 have statement-level or row-level triggers?
- B.5.4: Are there any default triggers?
- B.5.5: How are triggers managed in MySQL?
- B.5.6: Is there a way to view all triggers in a given database?
- B.5.7: Where are triggers stored?
- B.5.8: Can a trigger call a stored procedure?
- B.5.9: Can triggers access tables?
- B.5.10: Can triggers call an external application through a UDF?
- B.5.11: Is it possible for a trigger to update tables on a remote server?
- B.5.12: Do triggers work with replication?
- B.5.13: How are actions carried out through triggers on a master replicated to a slave?

Questions and Answers

B.5.1: Where can I find the documentation for MySQL 5.5 triggers?

See Section 17.3, “Using Triggers”.

B.5.2: Is there a discussion forum for MySQL Triggers?

Yes. It is available at http://forums.mysql.com/list.php?99.

B.5.3: Does MySQL 5.5 have statement-level or row-level triggers?

In MySQL 5.5, all triggers are `FOR EACH ROW`—that is, the trigger is activated for each row that is inserted, updated, or deleted. MySQL 5.5 does not support triggers using `FOR EACH STATEMENT`.

B.5.4: Are there any default triggers?

Not explicitly. MySQL does have specific special behavior for some `TIMESTAMP` columns, as well as for columns which are defined using `AUTO_INCREMENT`.

B.5.5: How are triggers managed in MySQL?

In MySQL 5.5, triggers can be created using the `CREATE TRIGGER` statement, and dropped using `DROP TRIGGER`. See Section 12.1.15, “`CREATE TRIGGER` Syntax”, and Section 12.1.24, “`DROP TRIGGER` Syntax”, for more about these statements.

Information about triggers can be obtained by querying the `INFORMATION_SCHEMA.TRIGGERS` table. See Section 18.16, “The `INFORMATION_SCHEMA TRIGGERS` Table”.

B.5.6: Is there a way to view all triggers in a given database?

Yes. You can obtain a listing of all triggers defined on database `dbname` using a query on the `INFORMATION_SCHEMA.TRIGGERS` table such as the one shown here:

```
SELECT TRIGGER_NAME, EVENT_MANIPULATION, EVENT_OBJECT_TABLE, ACTION_STATEMENT
    FROM INFORMATION_SCHEMA.TRIGGERS
    WHERE TRIGGER_SCHEMA='dbname';
```

For more information about this table, see Section 18.16, “The `INFORMATION_SCHEMA TRIGGERS` Table”.

You can also use the `SHOW TRIGGERS` statement, which is specific to MySQL. See Section 12.4.5.39, “`SHOW TRIGGERS` Syntax”.

B.5.7: Where are triggers stored?

Triggers for a table are currently stored in `.TRG` files, with one such file one per table.

B.5.8: Can a trigger call a stored procedure?

Yes.

B.5.9: Can triggers access tables?

A trigger can access both old and new data in its own table. A trigger can also affect other tables, but it is not permitted to modify a table that is already being used (for reading or writing) by the statement that invoked the function or trigger.

B.5.10: Can triggers call an external application through a UDF?

Yes. For example, a trigger could invoke the `sys_exec()` UDF available at MySQL Forge here: http://forge.mysql.com/projects/project.php?id=211

B.5.11: Is it possible for a trigger to update tables on a remote server?

Yes. A table on a remote server could be updated using the `FEDERATED` storage engine. (See Section 13.11, “The `FEDERATED` Storage Engine”).

B.5.12: Do triggers work with replication?

Yes. However, the way in which they work depends whether you are using MySQL's “classic” statement-based replication available in all versions of MySQL, or the row-based replication format introduced in MySQL 5.1.

When using statement-based replication, triggers on the slave are executed by statements that are executed on the master (and replicated to the slave).

When using row-based replication, triggers are not executed on the slave due to statements that were run on the master and then replicated to the slave. Instead, when using row-based replication, the changes caused by executing the trigger on the master are applied on the slave.

For more information, see Section 15.4.1.30, “Replication and Triggers”.

B.5.13: How are actions carried out through triggers on a master replicated to a slave?

Again, this depends on whether you are using statement-based or row-based replication.

Statement-based replication. First, the triggers that exist on a master must be re-created on the slave server. Once this is done, the replication flow works as any other standard DML statement that participates in replication. For example, consider a table `EMP` that has an `AFTER` insert trigger, which exists on a master MySQL server. The same `EMP` table and `AFTER` insert trigger exist on the slave server as well. The replication flow would be:

1. An `INSERT` statement is made to `EMP`.
2. The `AFTER` trigger on `EMP` activates.

3. The `INSERT` statement is written to the binary log.
4. The replication slave picks up the `INSERT` statement to `EMP` and executes it.
5. The `AFTER` trigger on `EMP` that exists on the slave activates.

Row-based replication. When you use row-based replication, the changes caused by executing the trigger on the master are applied on the slave. However, the triggers themselves are not actually executed on the slave under row-based replication. This is because, if both the master and the slave applied the changes from the master and—in addition—the trigger causing these changes were applied on the slave, the changes would in effect be applied twice on the slave, leading to different data on the master and the slave.

In most cases, the outcome is the same for both row-based and statement-based replication. However, if you use different triggers on the master and slave, you cannot use row-based replication. (This is because the row-based format replicates the changes made by triggers executing on the master to the slaves, rather than the statements that caused the triggers to execute, and the corresponding triggers on the slave are not executed.) Instead, any statements causing such triggers to be executed must be replicated using statement-based replication.

For more information, see Section 15.4.1.30, “Replication and Triggers”.

B.6. MySQL 5.5 FAQ: Views

Questions

- B.6.1: Where can I find documentation covering MySQL Views?
- B.6.2: Is there a discussion forum for MySQL Views?
- B.6.3: What happens to a view if an underlying table is dropped or renamed?
- B.6.4: Does MySQL 5.5 have table snapshots?
- B.6.5: Does MySQL 5.5 have materialized views?
- B.6.6: Can you insert into views that are based on joins?

Questions and Answers

B.6.1: Where can I find documentation covering MySQL Views?

See Section 17.5, “Using Views”.

B.6.2: Is there a discussion forum for MySQL Views?

Yes. See http://forums.mysql.com/list.php?100

B.6.3: What happens to a view if an underlying table is dropped or renamed?

After a view has been created, it is possible to drop or alter a table or view to which the definition refers. To check a view definition for problems of this kind, use the `CHECK TABLE` statement. (See Section 12.4.2.2, “`CHECK TABLE` Syntax”.)

B.6.4: Does MySQL 5.5 have table snapshots?

No.

B.6.5: Does MySQL 5.5 have materialized views?

No.

B.6.6: Can you insert into views that are based on joins?

It is possible, provided that your `INSERT` statement has a column list that makes it clear there is only one table involved.

You *cannot* insert into multiple tables with a single insert on a view.

B.7. MySQL 5.5 FAQ: `INFORMATION_SCHEMA`

Questions

- B.7.1: Where can I find documentation for the MySQL `INFORMATION_SCHEMA` database?
- B.7.2: Is there a discussion forum for `INFORMATION_SCHEMA`?
- B.7.3: Where can I find the ANSI SQL 2003 specification for `INFORMATION_SCHEMA`?
- B.7.4: What is the difference between the Oracle Data Dictionary and MySQL's `INFORMATION_SCHEMA`?
- B.7.5: Can I add to or otherwise modify the tables found in the `INFORMATION_SCHEMA` database?

Questions and Answers

B.7.1: Where can I find documentation for the MySQL `INFORMATION_SCHEMA` database?

See Chapter 18, *`INFORMATION_SCHEMA` Tables*

B.7.2: Is there a discussion forum for `INFORMATION_SCHEMA`?

See http://forums.mysql.com/list.php?101.

B.7.3: Where can I find the ANSI SQL 2003 specification for `INFORMATION_SCHEMA`?

Unfortunately, the official specifications are not freely available. (ANSI makes them available for purchase.) However, there are books available—such as *SQL-99 Complete, Really* by Peter Gulutzan and Trudy Pelzer—which give a comprehensive overview of the standard, including `INFORMATION_SCHEMA`.

B.7.4: What is the difference between the Oracle Data Dictionary and MySQL's `INFORMATION_SCHEMA`?

Both Oracle and MySQL provide metadata in tables. However, Oracle and MySQL use different table names and column names. MySQL's implementation is more similar to those found in DB2 and SQL Server, which also support `INFORMATION_SCHEMA` as defined in the SQL standard.

B.7.5: Can I add to or otherwise modify the tables found in the `INFORMATION_SCHEMA` database?

No. Since applications may rely on a certain standard structure, this should not be modified. For this reason, *we cannot support bugs or other issues which result from modifying `INFORMATION_SCHEMA` tables or data*.

B.8. MySQL 5.5 FAQ: Migration

Questions

- B.8.1: Where can I find information on how to migrate from MySQL 5.1 to MySQL 5.5?
- B.8.2: How has storage engine (table type) support changed in MySQL 5.5 from previous versions?

Questions and Answers

B.8.1: Where can I find information on how to migrate from MySQL 5.1 to MySQL 5.5?

For detailed upgrade information, see Section 2.11.1, “Upgrading MySQL”. Do not skip a major version when upgrading, but rather complete the process in steps, upgrading from one major version to the next in each step. This may seem more complicated, but it will you save time and trouble—if you encounter problems during the upgrade, their origin will be easier to identify, either by you or—if you have a MySQL Enterprise subscription—by MySQL support.

B.8.2: How has storage engine (table type) support changed in MySQL 5.5 from previous versions?

Storage engine support has changed as follows:

- Support for `ISAM` tables was removed in MySQL 5.0 and you should now use the `MyISAM` storage engine in place of `ISAM`. To convert a table *`tblname`* from `ISAM` to `MyISAM`, simply issue a statement such as this one:

  ```
  ALTER TABLE tblname ENGINE=MYISAM;
  ```

- Internal `RAID` for `MyISAM` tables was also removed in MySQL 5.0. This was formerly used to allow large tables in file systems that did not support file sizes greater than 2GB. All modern file systems allow for larger tables; in addition, there are now other solutions such as `MERGE` tables and views.

- The `VARCHAR` column type now retains trailing spaces in all storage engines.
- `MEMORY` tables (formerly known as `HEAP` tables) can also contain `VARCHAR` columns.

B.9. MySQL 5.5 FAQ: Security

Questions

- B.9.1: Where can I find documentation that addresses security issues for MySQL?
- B.9.2: Does MySQL 5.5 have native support for SSL?
- B.9.3: Is SSL support be built into MySQL binaries, or must I recompile the binary myself to enable it?
- B.9.4: Does MySQL 5.5 have built-in authentication against LDAP directories?
- B.9.5: Does MySQL 5.5 include support for Roles Based Access Control (RBAC)?

Questions and Answers

B.9.1: Where can I find documentation that addresses security issues for MySQL?

The best place to start is Section 5.3, "General Security Issues".

Other portions of the MySQL Documentation which you may find useful with regard to specific security concerns include the following:

- Section 5.3.1, "General Security Guidelines".
- Section 5.3.3, "Making MySQL Secure Against Attackers".
- Section C.5.4.1, "How to Reset the Root Password".
- Section 5.3.6, "How to Run MySQL as a Normal User".
- Section 21.3.2.6, "User-Defined Function Security Precautions".
- Section 5.3.4, "Security-Related `mysqld` Options".
- Section 5.3.5, "Security Issues with `LOAD DATA LOCAL`".
- Section 2.10, "Postinstallation Setup and Testing".
- Section 5.5.8.1, "Basic SSL Concepts".

B.9.2: Does MySQL 5.5 have native support for SSL?

Most 5.5 binaries have support for SSL connections between the client and server. We can't currently build with the new YaSSL library everywhere, as it is still quite new and does not compile on all platforms yet. See Section 5.5.8, "Using SSL for Secure Connections".

You can also tunnel a connection using SSH, if (for example) the client application doesn't support SSL connections. For an example, see Section 5.5.9, "Connecting to MySQL Remotely from Windows with SSH".

B.9.3: Is SSL support be built into MySQL binaries, or must I recompile the binary myself to enable it?

Most 5.5 binaries have SSL enabled for client/server connections that are secured, authenticated, or both. However, the YaSSL library currently does not compile on all platforms. See Section 5.5.8, "Using SSL for Secure Connections", for a complete listing of supported and unsupported platforms.

B.9.4: Does MySQL 5.5 have built-in authentication against LDAP directories?

Not at this time.

B.9.5: Does MySQL 5.5 include support for Roles Based Access Control (RBAC)?

Not at this time.

B.10. MySQL 5.5 FAQ: MySQL Cluster

In the following section, we answer questions that are frequently asked about MySQL Cluster and the `NDBCLUSTER` storage engine.

Questions

- B.10.1: Which versions of the MySQL software support Cluster? Do I have to compile from source?

Questions and Answers

B.10.1: Which versions of the MySQL software support Cluster? Do I have to compile from source?

MySQL Cluster is not supported in MySQL Server 5.5 releases. Instead, MySQL Cluster is released as a separate product, available as MySQL Cluster NDB 6.3 and MySQL Cluster NDB 7.0. You should use one of these for new deployments, and plan to upgrade to one of them if you are using a previous version of MySQL with clustering support. For an overview of improvements in MySQL Cluster NDB 6.2 and 6.3, see MySQL Cluster Development in MySQL Cluster NDB 6.3, and MySQL Cluster Development in MySQL Cluster NDB 7.0.

For answers to frequently asked questions about MySQL Cluster, see MySQL 5.1 FAQ: MySQL Cluster. For detailed information about deploying and using MySQL Cluster, see MySQL Cluster NDB 6.X/7.X.

B.11. MySQL 5.5 FAQ: MySQL Chinese, Japanese, and Korean Character Sets

This set of Frequently Asked Questions derives from the experience of MySQL's Support and Development groups in handling many inquiries about CJK (Chinese-Japanese-Korean) issues.

Questions

- B.11.1: What CJK character sets are available in MySQL?
- B.11.2: I have inserted CJK characters into my table. Why does `SELECT` display them as “?” characters?
- B.11.3: What problems should I be aware of when working with the Big5 Chinese character set?
- B.11.4: Why do Japanese character set conversions fail?
- B.11.5: What should I do if I want to convert SJIS `81CA` to `cp932`?
- B.11.6: How does MySQL represent the Yen (`¥`) sign?
- B.11.7: Does MySQL plan to make a separate character set where `5C` is the Yen sign, as at least one other major DBMS does?
- B.11.8: Of what issues should I be aware when working with Korean character sets in MySQL?
- B.11.9: Why do I get `INCORRECT STRING VALUE` error messages?
- B.11.10: Why does my GUI front end or browser not display CJK characters correctly in my application using Access, PHP, or another API?
- B.11.11: I've upgraded to MySQL 5.5. How can I revert to behavior like that in MySQL 4.0 with regard to character sets?
- B.11.12: Why do some `LIKE` and `FULLTEXT` searches with CJK characters fail?
- B.11.13: How do I know whether character *`X`* is available in all character sets?
- B.11.14: Why do CJK strings sort incorrectly in Unicode? (I)
- B.11.15: Why do CJK strings sort incorrectly in Unicode? (II)
- B.11.16: Why are my supplementary characters rejected by MySQL?

- B.11.17: Shouldn't it be “CJKV”?
- B.11.18: Does MySQL allow CJK characters to be used in database and table names?
- B.11.19: Where can I find translations of the MySQL Manual into Chinese, Japanese, and Korean?
- B.11.20: Where can I get help with CJK and related issues in MySQL?

Questions and Answers

B.11.1: What CJK character sets are available in MySQL?

The list of CJK character sets may vary depending on your MySQL version. For example, the `eucjpms` character set was not supported prior to MySQL 5.0.3 (see Changes in MySQL 5.0.3). However, since the name of the applicable language appears in the `DESCRIPTION` column for every entry in the `INFORMATION_SCHEMA.CHARACTER_SETS` table, you can obtain a current list of all the non-Unicode CJK character sets using this query:

```
mysql> SELECT CHARACTER_SET_NAME, DESCRIPTION
    -> FROM INFORMATION_SCHEMA.CHARACTER_SETS
    -> WHERE DESCRIPTION LIKE '%Chinese%'
    -> OR DESCRIPTION LIKE '%Japanese%'
    -> OR DESCRIPTION LIKE '%Korean%'
    -> ORDER BY CHARACTER_SET_NAME;
+--------------------+---------------------------+
| CHARACTER_SET_NAME | DESCRIPTION               |
+--------------------+---------------------------+
| big5               | Big5 Traditional Chinese  |
| cp932              | SJIS for Windows Japanese |
| eucjpms            | UJIS for Windows Japanese |
| euckr              | EUC-KR Korean             |
| gb2312             | GB2312 Simplified Chinese |
| gbk                | GBK Simplified Chinese    |
| sjis               | Shift-JIS Japanese        |
| ujis               | EUC-JP Japanese           |
+--------------------+---------------------------+
8 rows in set (0.01 sec)
```

(See Section 18.9, “The `INFORMATION_SCHEMA CHARACTER_SETS` Table”, for more information.)

MySQL supports the two common variants of the *GB* (*Guojia Biaozhun*, or *National Standard*, or *Simplified Chinese*) character sets which are official in the People's Republic of China: `gb2312` and `gbk`. Sometimes people try to insert `gbk` characters into `gb2312`, and it works most of the time because `gbk` is a superset of `gb2312`—but eventually they try to insert a rarer Chinese character and it doesn't work. (See Bug #16072 for an example).

Here, we try to clarify exactly what characters are legitimate in `gb2312` or `gbk`, with reference to the official documents. Please check these references before reporting `gb2312` or `gbk` bugs.

- For a complete listing of the `gb2312` characters, ordered according to the `gb2312_chinese_ci` collation: gb2312
- MySQL's `gbk` is in reality “Microsoft code page 936”. This differs from the official `gbk` for characters `A1A4` (middle dot), `A1AA` (em dash), `A6E0-A6F5`, and `A8BB-A8C0`.
- For a listing of `gbk`/Unicode mappings, see http://www.unicode.org/Public/MAPPINGS/VENDORS/MICSFT/WINDOWS/CP936.TXT.
- For MySQL's listing of `gbk` characters, see gbk.

B.11.2: I have inserted CJK characters into my table. Why does `SELECT` display them as “?” characters?

This problem is usually due to a setting in MySQL that doesn't match the settings for the application program or the operating system. Here are some common steps for correcting these types of issues:

- *Be certain of what MySQL version you are using.*

  Use the statement `SELECT VERSION();` to determine this.

- *Make sure that the database is actually using the desired character set.*

  People often think that the client character set is always the same as either the server character set or the character set used for display purposes. However, both of these are false assumptions. You can make sure by checking the result of `SHOW CREATE TABLE tablename` or—better yet—by using this statement:

```
SELECT character_set_name, collation_name
    FROM information_schema.columns
    WHERE table_schema = your_database_name
        AND table_name = your_table_name
        AND column_name = your_column_name;
```

- *Determine the hexadecimal value of the character or characters that are not being displayed correctly.*

  You can obtain this information for a column `column_name` in the table `table_name` using the following query:

  ```
  SELECT HEX(column_name)
  FROM table_name;
  ```

  `3F` is the encoding for the `?` character; this means that `?` is the character actually stored in the column. This most often happens because of a problem converting a particular character from your client character set to the target character set.

- *Make sure that a round trip possible—that is, when you select* `literal` *(or* `_introducer hexadecimal-value`*), you obtain* `literal` *as a result.*

  For example, the Japanese *Katakana* character *Pe* (`ペ'`) exists in all CJK character sets, and has the code point value (hexadecimal coding) `0x30da`. To test a round trip for this character, use this query:

  ```
  SELECT 'ペ' AS `ペ`;         /* or SELECT _ucs2 0x30da; */
  ```

  If the result is not also `ペ`, then the round trip has failed.

  For bug reports regarding such failures, we might ask you to follow up with `SELECT HEX('ペ');`. Then we can determine whether the client encoding is correct.

- *Make sure that the problem is not with the browser or other application, rather than with MySQL.*

  Use the `mysql` client program (on Windows: `mysql.exe`) to accomplish this task. If `mysql` displays correctly but your application doesn't, then your problem is probably due to system settings.

  To find out what your settings are, use the `SHOW VARIABLES` statement, whose output should resemble what is shown here:

  ```
  mysql> SHOW VARIABLES LIKE 'char%';
  +--------------------------+----------------------------------------+
  | Variable_name            | Value                                  |
  +--------------------------+----------------------------------------+
  | character_set_client     | utf8                                   |
  | character_set_connection | utf8                                   |
  | character_set_database   | latin1                                 |
  | character_set_filesystem | binary                                 |
  | character_set_results    | utf8                                   |
  | character_set_server     | latin1                                 |
  | character_set_system     | utf8                                   |
  | character_sets_dir       | /usr/local/mysql/share/mysql/charsets/ |
  +--------------------------+----------------------------------------+
  8 rows in set (0.03 sec)
  ```

  These are typical character-set settings for an international-oriented client (notice the use of `utf8` Unicode) connected to a server in the West (`latin1` is a West Europe character set and a default for MySQL).

  Although Unicode (usually the `utf8` variant on Unix, and the `ucs2` variant on Windows) is preferable to Latin, it is often not what your operating system utilities support best. Many Windows users find that a Microsoft character set, such as `cp932` for Japanese Windows, is suitable.

  If you cannot control the server settings, and you have no idea what your underlying computer is, then try changing to a common character set for the country that you're in (`euckr` = Korea; `gb2312` or `gbk` = People's Republic of China; `big5` = Taiwan; `sjis`, `ujis`, `cp932`, or `eucjpms` = Japan; `ucs2` or `utf8` = anywhere). Usually it is necessary to change only the client and connection and results settings. There is a simple statement which changes all three at once: `SET NAMES`. For example:

  ```
  SET NAMES 'big5';
  ```

  Once the setting is correct, you can make it permanent by editing `my.cnf` or `my.ini`. For example you might add lines looking like these:

  ```
  [mysqld]
  character-set-server=big5
  [client]
  default-character-set=big5
  ```

It is also possible that there are issues with the API configuration setting being used in your application; see *Why does my GUI front end or browser not display CJK characters correctly...?* for more information.

B.11.3: What problems should I be aware of when working with the Big5 Chinese character set?

MySQL supports the Big5 character set which is common in Hong Kong and Taiwan (Republic of China). MySQL's `big5` is in reality Microsoft code page 950, which is very similar to the original `big5` character set. We changed to this character set starting with MySQL version 4.1.16 / 5.0.16 (as a result of Bug #12476). For example, the following statements work in current versions of MySQL, but not in old versions:

```
mysql> CREATE TABLE big5 (BIG5 CHAR(1) CHARACTER SET BIG5);
Query OK, 0 rows affected (0.13 sec)

mysql> INSERT INTO big5 VALUES (0xf9dc);
Query OK, 1 row affected (0.00 sec)

mysql> SELECT * FROM big5;
+------+
| big5 |
+------+
| 嫺  |
+------+
1 row in set (0.02 sec)
```

A feature request for adding `HKSCS` extensions has been filed. People who need this extension may find the suggested patch for Bug #13577 to be of interest.

B.11.4: Why do Japanese character set conversions fail?

MySQL supports the `sjis`, `ujis`, `cp932`, and `eucjpms` character sets, as well as Unicode. A common need is to convert between character sets. For example, there might be a Unix server (typically with `sjis` or `ujis`) and a Windows client (typically with `cp932`).

In the following conversion table, the `ucs2` column represents the source, and the `sjis`, `cp932`, `ujis`, and `eucjpms` columns represent the destinations—that is, the last 4 columns provide the hexadecimal result when we use `CONVERT(ucs2)` or we assign a `ucs2` column containing the value to an `sjis`, `cp932`, `ujis`, or `eucjpms` column.

Character Name	ucs2	sjis	cp932	ujis	eucjpms
BROKEN BAR	00A6	3F	3F	8FA2C3	3F
FULLWIDTH BROKEN BAR	FFE4	3F	FA55	3F	8FA2
YEN SIGN	00A5	3F	3F	20	3F
FULLWIDTH YEN SIGN	FFE5	818F	818F	A1EF	3F
TILDE	007E	7E	7E	7E	7E
OVERLINE	203E	3F	3F	20	3F
HORIZONTAL BAR	2015	815C	815C	A1BD	A1BD
EM DASH	2014	3F	3F	3F	3F
REVERSE SOLIDUS	005C	815F	5C	5C	5C
FULLWIDTH ""	FF3C	3F	815F	3F	A1C0
WAVE DASH	301C	8160	3F	A1C1	3F
FULLWIDTH TILDE	FF5E	3F	8160	3F	A1C1
DOUBLE VERTICAL LINE	2016	8161	3F	A1C2	3F
PARALLEL TO	2225	3F	8161	3F	A1C2
MINUS SIGN	2212	817C	3F	A1DD	3F
FULLWIDTH HYPHEN-MINUS	FF0D	3F	817C	3F	A1DD
CENT SIGN	00A2	8191	3F	A1F1	3F
FULLWIDTH CENT SIGN	FFE0	3F	8191	3F	A1F1
POUND SIGN	00A3	8192	3F	A1F2	3F
FULLWIDTH POUND SIGN	FFE1	3F	8192	3F	A1F2
NOT SIGN	00AC	81CA	3F	A2CC	3F
FULLWIDTH NOT SIGN	FFE2	3F	81CA	3F	A2CC

Now consider the following portion of the table.

	ucs2	**sjis**	**cp932**
NOT SIGN	00AC	81CA	3F
FULLWIDTH NOT SIGN	FFE2	3F	81CA

This means that MySQL converts the `NOT SIGN` (Unicode `U+00AC`) to `sjis` code point `0x81CA` and to `cp932` code point `3F`. (`3F` is the question mark ("?")—this is what is always used when the conversion cannot be performed.

B.11.5: What should I do if I want to convert SJIS `81CA` to `cp932`?

Our answer is: "?". There are serious complaints about this: many people would prefer a "loose" conversion, so that `81CA (NOT SIGN)` in `sjis` becomes `81CA (FULLWIDTH NOT SIGN)` in `cp932`. We are considering a change to this behavior.

B.11.6: How does MySQL represent the Yen (`¥`) sign?

A problem arises because some versions of Japanese character sets (both `sjis` and `euc`) treat `5C` as a *reverse solidus* (`\`—also known as a backslash), and others treat it as a yen sign (`¥`).

MySQL follows only one version of the JIS (Japanese Industrial Standards) standard description. In MySQL, *`5C` is always the reverse solidus (`\`).*

B.11.7: Does MySQL plan to make a separate character set where `5C` is the Yen sign, as at least one other major DBMS does?

This is one possible solution to the Yen sign issue; however, this will not happen in MySQL 5.1 or 6.0.

B.11.8: Of what issues should I be aware when working with Korean character sets in MySQL?

In theory, while there have been several versions of the `euckr` (*Extended Unix Code Korea*) character set, only one problem has been noted.

We use the "ASCII" variant of EUC-KR, in which the code point `0x5c` is REVERSE SOLIDUS, that is `\`, instead of the "KS-Roman" variant of EUC-KR, in which the code point `0x5c` is `WON SIGN`(`₩`). This means that you cannot convert Unicode `U+20A9` to `euckr`:

```
mysql> SELECT
    ->     CONVERT('₩' USING euckr) AS euckr,
    ->     HEX(CONVERT('₩' USING euckr)) AS hexeuckr;
+-------+----------+
| euckr | hexeuckr |
+-------+----------+
| ?     | 3F       |
+-------+----------+
1 row in set (0.00 sec)
```

MySQL's graphic Korean chart is here: euckr.

B.11.9: Why do I get `Incorrect string value` error messages?

For illustration, we'll create a table with one Unicode (`ucs2`) column and one Chinese (`gb2312`) column.

```
mysql> CREATE TABLE ch
    -> (ucs2 CHAR(3) CHARACTER SET ucs2,
    -> gb2312 CHAR(3) CHARACTER SET gb2312);
Query OK, 0 rows affected (0.05 sec)
```

We'll try to place the rare character 汌 in both columns.

```
mysql> INSERT INTO ch VALUES ('A汌B','A汌B');
Query OK, 1 row affected, 1 warning (0.00 sec)
```

Ah, there is a warning. Use the following statement to see what it is:

```
mysql> SHOW WARNINGS\G
*************************** 1. row ***************************
  Level: Warning
   Code: 1366
Message: Incorrect string value: '\xE6\xB1\x8CB' for column 'gb2312' at row 1
1 row in set (0.00 sec)
```

So it is a warning about the `gb2312` column only.

```
mysql> SELECT ucs2,HEX(ucs2),gb2312,HEX(gb2312) FROM ch;
+-------+--------------+--------+-------------+
| ucs2  | HEX(ucs2)    | gb2312 | HEX(gb2312) |
+-------+--------------+--------+-------------+
| A汌B | 00416C4C0042 | A?B    | 413F42      |
+-------+--------------+--------+-------------+
1 row in set (0.00 sec)
```

Several things need explanation here:

1. The fact that it is a “warning” rather than an “error” is characteristic of MySQL. We like to try to do what we can, to get the best fit, rather than give up.
2. The 汌 character is not in the `gb2312` character set. We described that problem earlier.
3. If you are using an old version of MySQL, you will probably see a different message.
4. With `sql_mode=TRADITIONAL`, there would be an error message, rather than a warning.

B.11.10: Why does my GUI front end or browser not display CJK characters correctly in my application using Access, PHP, or another API?

Obtain a direct connection to the server using the `mysql` client (Windows: `mysql.exe`), and try the same query there. If `mysql` responds correctly, then the trouble may be that your application interface requires initialization. Use `mysql` to tell you what character set or sets it uses with the statement `SHOW VARIABLES LIKE 'char%';`. If you are using Access, then you are most likely connecting with MyODBC. In this case, you should check Section 20.1.4, “Connector/ODBC Configuration”. If, for instance, you use `big5`, you would enter `SET NAMES 'big5'`. (Note that no `;` is required in this case). If you are using ASP, you might need to add `SET NAMES` in the code. Here is an example that has worked in the past:

```
<%
Session.CodePage=0
Dim strConnection
Dim Conn
strConnection="driver={MySQL ODBC 3.51 Driver};server=server;uid=username;" \
               & "pwd=password;database=database;stmt=SET NAMES 'big5';"
Set Conn = Server.CreateObject("ADODB.Connection")
Conn.Open strConnection
%>
```

In much the same way, if you are using any character set other than `latin1` with Connector/Net, then you must specify the character set in the connection string. See Section 20.2.5.1, “Connecting to MySQL Using Connector/Net”, for more information.

If you are using PHP, try this:

```
<?php
  $link = mysql_connect($host, $usr, $pwd);

  mysql_select_db($db);

  if( mysql_error() ) { print "Database ERROR: " . mysql_error(); }
  mysql_query("SET NAMES 'utf8'", $link);
?>
```

In this case, we used `SET NAMES` to change `character_set_client` and `character_set_connection` and `character_set_results`.

We encourage the use of the newer `mysqli` extension, rather than `mysql`. Using `mysqli`, the previous example could be rewritten as shown here:

```
<?php
  $link = new mysqli($host, $usr, $pwd, $db);

  if( mysqli_connect_errno() )
  {
    printf("Connect failed: %s\n", mysqli_connect_error());
    exit();
  }

  $link->query("SET NAMES 'utf8'");
?>
```

Another issue often encountered in PHP applications has to do with assumptions made by the browser. Sometimes adding or changing a `<meta>` tag suffices to correct the problem: for example, to insure that the user agent interprets page content as `UTF-8`, you should include `<meta http-equiv="Content-Type" content="text/html; charset=utf-8">` in the `<head>` of the HTML page.

If you are using Connector/J, see Section 20.3.4.4, “Using Character Sets and Unicode”.

B.11.11: I've upgraded to MySQL 5.5. How can I revert to behavior like that in MySQL 4.0 with regard to character sets?

In MySQL Version 4.0, there was a single “global” character set for both server and client, and the decision as to which character to use was made by the server administrator. This changed starting with MySQL Version 4.1. What happens now is a “handshake”, as described in Section 9.1.4, “Connection Character Sets and Collations”:

> When a client connects, it sends to the server the name of the character set that it wants to use. The server uses the name to set the `character_set_client`, `character_set_results`, and `character_set_connection` system variables. In effect, the server performs a `SET NAMES` operation using the character set name.

The effect of this is that you cannot control the client character set by starting `mysqld` with `--character-set-server=utf8`. However, some of our Asian customers have said that they prefer the MySQL 4.0 behavior. To make it possible to retain this behavior, we added a `mysqld` switch, `--character-set-client-handshake`, which can be turned off with `--skip-character-set-client-handshake`. If you start `mysqld` with `--skip-character-set-client-handshake`, then, when a client connects, it sends to the server the name of the character set that it wants to use—however, *the server ignores this request from the client*.

By way of example, suppose that your favorite server character set is `latin1` (unlikely in a CJK area, but this is the default value). Suppose further that the client uses `utf8` because this is what the client's operating system supports. Now, start the server with `latin1` as its default character set:

```
mysqld --character-set-server=latin1
```

And then start the client with the default character set `utf8`:

```
mysql --default-character-set=utf8
```

The current settings can be seen by viewing the output of `SHOW VARIABLES`:

```
mysql> SHOW VARIABLES LIKE 'char%';
+--------------------------+----------------------------------------+
| Variable_name            | Value                                  |
+--------------------------+----------------------------------------+
| character_set_client     | utf8                                   |
| character_set_connection | utf8                                   |
| character_set_database   | latin1                                 |
| character_set_filesystem | binary                                 |
| character_set_results    | utf8                                   |
| character_set_server     | latin1                                 |
| character_set_system     | utf8                                   |
| character_sets_dir       | /usr/local/mysql/share/mysql/charsets/ |
+--------------------------+----------------------------------------+
8 rows in set (0.01 sec)
```

Now stop the client, and then stop the server using `mysqladmin`. Then start the server again, but this time tell it to skip the handshake like so:

```
mysqld --character-set-server=utf8 --skip-character-set-client-handshake
```

Start the client with `utf8` once again as the default character set, then display the current settings:

```
mysql> SHOW VARIABLES LIKE 'char%';
+--------------------------+----------------------------------------+
| Variable_name            | Value                                  |
+--------------------------+----------------------------------------+
| character_set_client     | latin1                                 |
| character_set_connection | latin1                                 |
| character_set_database   | latin1                                 |
| character_set_filesystem | binary                                 |
| character_set_results    | latin1                                 |
| character_set_server     | latin1                                 |
| character_set_system     | utf8                                   |
| character_sets_dir       | /usr/local/mysql/share/mysql/charsets/ |
+--------------------------+----------------------------------------+
8 rows in set (0.01 sec)
```

As you can see by comparing the differing results from `SHOW VARIABLES`, the server ignores the client's initial settings if the `--skip-character-set-client-handshake` is used.

B.11.12: Why do some `LIKE` and `FULLTEXT` searches with CJK characters fail?

There is a very simple problem with `LIKE` searches on `BINARY` and `BLOB` columns: we need to know the end of a character. With multi-byte character sets, different characters might have different octet lengths. For example, in `utf8`, `A` requires one byte but `ペ`

requires three bytes, as shown here:

```
+-------------------------+---------------------------+
| OCTET_LENGTH(_utf8 'A') | OCTET_LENGTH(_utf8 'ペ') |
+-------------------------+---------------------------+
|                       1 |                         3 |
+-------------------------+---------------------------+
1 row in set (0.00 sec)
```

If we don't know where the first character ends, then we don't know where the second character begins, in which case even very simple searches such as `LIKE '_A%'` fail. The solution is to use a regular CJK character set in the first place, or to convert to a CJK character set before comparing.

This is one reason why MySQL cannot allow encodings of nonexistent characters. If it is not strict about rejecting bad input, then it has no way of knowing where characters end.

For `FULLTEXT` searches, we need to know where words begin and end. With Western languages, this is rarely a problem because most (if not all) of these use an easy-to-identify word boundary—the space character. However, this is not usually the case with Asian writing. We could use arbitrary halfway measures, like assuming that all Han characters represent words, or (for Japanese) depending on changes from Katakana to Hiragana due to grammatical endings. However, the only sure solution requires a comprehensive word list, which means that we would have to include a dictionary in the server for each Asian language supported. This is simply not feasible.

B.11.13: How do I know whether character *`X`* is available in all character sets?

The majority of simplified Chinese and basic nonhalfwidth Japanese *Kana* characters appear in all CJK character sets. This stored procedure accepts a `UCS-2` Unicode character, converts it to all other character sets, and displays the results in hexadecimal.

```
DELIMITER //

CREATE PROCEDURE p_convert(ucs2_char CHAR(1) CHARACTER SET ucs2)
BEGIN

CREATE TABLE tj
             (ucs2 CHAR(1) character set ucs2,
              utf8 CHAR(1) character set utf8,
              big5 CHAR(1) character set big5,
              cp932 CHAR(1) character set cp932,
              eucjpms CHAR(1) character set eucjpms,
              euckr CHAR(1) character set euckr,
              gb2312 CHAR(1) character set gb2312,
              gbk CHAR(1) character set gbk,
              sjis CHAR(1) character set sjis,
              ujis CHAR(1) character set ujis);

INSERT INTO tj (ucs2) VALUES (ucs2_char);

UPDATE tj SET utf8=ucs2,
              big5=ucs2,
              cp932=ucs2,
              eucjpms=ucs2,
              euckr=ucs2,
              gb2312=ucs2,
              gbk=ucs2,
              sjis=ucs2,
              ujis=ucs2;

/* If there is a conversion problem, UPDATE will produce a warning. */

SELECT hex(ucs2) AS ucs2,
       hex(utf8) AS utf8,
       hex(big5) AS big5,
       hex(cp932) AS cp932,
       hex(eucjpms) AS eucjpms,
       hex(euckr) AS euckr,
       hex(gb2312) AS gb2312,
       hex(gbk) AS gbk,
       hex(sjis) AS sjis,
       hex(ujis) AS ujis
FROM tj;

DROP TABLE tj;

END//
```

The input can be any single `ucs2` character, or it can be the code point value (hexadecimal representation) of that character. For example, from Unicode's list of `ucs2` encodings and names (http://www.unicode.org/Public/UNIDATA/UnicodeData.txt), we know that the *Katakana* character *Pe* appears in all CJK character sets, and that its code point value is `0x30da`. If we use this value as the argument to `p_convert()`, the result is as shown here:

```
mysql> CALL p_convert(0x30da)//
+------+--------+------+-------+---------+-------+--------+------+------+------+
| ucs2 | utf8   | big5 | cp932 | eucjpms | euckr | gb2312 | gbk  | sjis | ujis |
+------+--------+------+-------+---------+-------+--------+------+------+------+
| 30DA | E3839A | C772 | 8379  | A5DA    | ABDA  | A5DA   | A5DA | 8379 | A5DA |
+------+--------+------+-------+---------+-------+--------+------+------+------+
1 row in set (0.04 sec)
```

Since none of the column values is `3F`—that is, the question mark character (`?`)—we know that every conversion worked.

B.11.14: Why do CJK strings sort incorrectly in Unicode? (I)

Sometimes people observe that the result of a `utf8_unicode_ci` or `ucs2_unicode_ci` search, or of an `ORDER BY` sort is not what they think a native would expect. Although we never rule out the possibility that there is a bug, we have found in the past that many people do not read correctly the standard table of weights for the Unicode Collation Algorithm. MySQL uses the table found at http://www.unicode.org/Public/UCA/4.0.0/allkeys-4.0.0.txt. This is not the first table you will find by navigating from the `unicode.org` home page, because MySQL uses the older 4.0.0 “allkeys” table, rather than the more recent 4.1.0 table. (The newer `'520'` collations in MySQL 5.6 use the 5.2 “allkeys” table.) This is because we are very wary about changing ordering which affects indexes, lest we bring about situations such as that reported in Bug #16526, illustrated as follows:

```
mysql< CREATE TABLE tj (s1 CHAR(1) CHARACTER SET utf8 COLLATE utf8_unicode_ci);
Query OK, 0 rows affected (0.05 sec)

mysql> INSERT INTO tj VALUES ('が'),('か');
Query OK, 2 rows affected (0.00 sec)
Records: 2  Duplicates: 0  Warnings: 0

mysql> SELECT * FROM tj WHERE s1 = 'か';
+------+
| s1   |
+------+
| が  |
| か  |
+------+
2 rows in set (0.00 sec)
```

The character in the first result row is not the one that we searched for. Why did MySQL retrieve it? First we look for the Unicode code point value, which is possible by reading the hexadecimal number for the `ucs2` version of the characters:

```
mysql> SELECT s1, HEX(CONVERT(s1 USING ucs2)) FROM tj;
+------+-----------------------------+
| s1   | HEX(CONVERT(s1 USING ucs2)) |
+------+-----------------------------+
| が  | 304C                        |
| か  | 304B                        |
+------+-----------------------------+
2 rows in set (0.03 sec)
```

Now we search for `304B` and `304C` in the `4.0.0 allkeys` table, and find these lines:

```
304B  ; [.1E57.0020.000E.304B] # HIRAGANA LETTER KA
304C  ; [.1E57.0020.000E.304B][.0000.0140.0002.3099] # HIRAGANA LETTER GA; QQCM
```

The official Unicode names (following the “#” mark) tell us the Japanese syllabary (Hiragana), the informal classification (letter, digit, or punctuation mark), and the Western identifier (`KA` or `GA`, which happen to be voiced and unvoiced components of the same letter pair). More importantly, the *primary weight* (the first hexadecimal number inside the square brackets) is `1E57` on both lines. For comparisons in both searching and sorting, MySQL pays attention to the primary weight only, ignoring all the other numbers. This means that we are sorting が and か correctly according to the Unicode specification. If we wanted to distinguish them, we'd have to use a non-UCA (Unicode Collation Algorithm) collation (`utf8_bin` or `utf8_general_ci`), or to compare the `HEX()` values, or use `ORDER BY CONVERT(s1 USING sjis)`. Being correct “according to Unicode” isn't enough, of course: the person who submitted the bug was equally correct. We plan to add another collation for Japanese according to the JIS X 4061 standard, in which voiced/unvoiced letter pairs like `KA`/`GA` are distinguishable for ordering purposes.

B.11.15: Why do CJK strings sort incorrectly in Unicode? (II)

If you are using Unicode (`ucs2` or `utf8`), and you know what the Unicode sort order is (see Section B.11, “MySQL 5.5 FAQ: MySQL Chinese, Japanese, and Korean Character Sets”), but MySQL still seems to sort your table incorrectly, then you should first verify the table character set:

```
mysql> SHOW CREATE TABLE t\G
******************** 1. row ******************
Table: t
Create Table: CREATE TABLE `t` (
`s1` char(1) CHARACTER SET ucs2 DEFAULT NULL
) ENGINE=MyISAM DEFAULT CHARSET=latin1
1 row in set (0.00 sec)
```

Since the character set appears to be correct, let's see what information the `INFORMATION_SCHEMA.COLUMNS` table can provide about this column:

```
mysql> SELECT COLUMN_NAME, CHARACTER_SET_NAME, COLLATION_NAME
    -> FROM INFORMATION_SCHEMA.COLUMNS
    -> WHERE COLUMN_NAME = 's1'
    -> AND TABLE_NAME = 't';
```

```
+-------------+--------------------+-----------------+
| COLUMN_NAME | CHARACTER_SET_NAME | COLLATION_NAME  |
+-------------+--------------------+-----------------+
| s1          | ucs2               | ucs2_general_ci |
+-------------+--------------------+-----------------+
1 row in set (0.01 sec)
```

(See Section 18.3, “The `INFORMATION_SCHEMA COLUMNS` Table”, for more information.)

You can see that the collation is `ucs2_general_ci` instead of `ucs2_unicode_ci`. The reason why this is so can be found using `SHOW CHARSET`, as shown here:

```
mysql> SHOW CHARSET LIKE 'ucs2%';
+---------+---------------+-------------------+--------+
| Charset | Description   | Default collation | Maxlen |
+---------+---------------+-------------------+--------+
| ucs2    | UCS-2 Unicode | ucs2_general_ci   |      2 |
+---------+---------------+-------------------+--------+
1 row in set (0.00 sec)
```

For `ucs2` and `utf8`, the default collation is “general”. To specify a Unicode collation, use `COLLATE ucs2_unicode_ci`.

B.11.16: Why are my supplementary characters rejected by MySQL?

Before MySQL 5.5.3, MySQL does not support supplementary characters—that is, characters which need more than 3 bytes—for `UTF-8`. We support only what Unicode calls the *Basic Multilingual Plane / Plane 0*. Only a few very rare Han characters are supplementary; support for them is uncommon. This has led to reports such as that found in Bug #12600, which we rejected as “not a bug”. With `utf8`, we must truncate an input string when we encounter bytes that we don't understand. Otherwise, we wouldn't know how long the bad multi-byte character is.

One possible workaround is to use `ucs2` instead of `utf8`, in which case the “bad” characters are changed to question marks; however, no truncation takes place. You can also change the data type to `BLOB` or `BINARY`, which perform no validity checking.

As of MySQL 5.5.3, Unicode support is extended to include supplementary characters by means of additional Unicode character sets: `utf16`, `utf32`, and 4-byte `utf8mb4`. These character sets support supplementary Unicode characters outside the Basic Multilingual Plane (BMP).

B.11.17: Shouldn't it be “CJKV”?

No. The term “CJKV” (*Chinese Japanese Korean Vietnamese*) refers to Vietnamese character sets which contain Han (originally Chinese) characters. MySQL has no plan to support the old Vietnamese script using Han characters. MySQL does of course support the modern Vietnamese script with Western characters.

As of MySQL 5.6, there are Vietnamese collations for Unicode character sets, as described in Section 9.1.14.1, “Unicode Character Sets”.

B.11.18: Does MySQL allow CJK characters to be used in database and table names?

This issue is fixed in MySQL 5.1, by automatically rewriting the names of the corresponding directories and files.

For example, if you create a database named `楮` on a server whose operating system does not support CJK in directory names, MySQL creates a directory named `@0w@00a5@00ae`. which is just a fancy way of encoding `E6A5AE`—that is, the Unicode hexadecimal representation for the `楮` character. However, if you run a `SHOW DATABASES` statement, you can see that the database is listed as `楮`.

B.11.19: Where can I find translations of the MySQL Manual into Chinese, Japanese, and Korean?

A Simplified Chinese version of the Manual, current for MySQL 5.1.12, can be found at http://dev.mysql.com/doc/. The Japanese translation of the MySQL 4.1 manual can be downloaded from http://dev.mysql.com/doc/.

B.11.20: Where can I get help with CJK and related issues in MySQL?

The following resources are available:

- A listing of MySQL user groups can be found at http://dev.mysql.com/user-groups/.
- View feature requests relating to character set issues at http://tinyurl.com/y6xcuf.
- Visit the MySQL Character Sets, Collation, Unicode Forum. We are also in the process of adding foreign-language forums at http://forums.mysql.com/.

B.12. MySQL 5.5 FAQ: Connectors & APIs

For common questions, issues, and answers relating to the MySQL Connectors and other APIs, see the following areas of the Manual:

- Section 20.9.11, “Common Questions and Problems When Using the C API”
- Section 20.10.6, “Common Problems with MySQL and PHP”
- Section 20.1.7, “Connector/ODBC Notes and Tips”
- Section 20.2.5, “Connector/Net Programming”
- Section 20.3.5, “Connector/J Notes and Tips”
- Section 20.4.6, “Connector/MXJ Notes and Tips”

B.13. MySQL 5.5 FAQ: Replication

For answers to common queries and question regarding Replication within MySQL, see Section 15.4.4, “Replication FAQ”.

B.14. MySQL 5.5 FAQ: MySQL, DRBD, and Heartbeat

B.14.1. Distributed Replicated Block Device (DRBD)

In the following section, we provide answers to questions that are most frequently asked about Distributed Replicated Block Device (DRBD).

Questions

- B.14.1.1: What is DRBD?
- B.14.1.2: What are “Block Devices”?
- B.14.1.3: How is DRBD licensed?
- B.14.1.4: Where can I download DRBD?
- B.14.1.5: If I find a bug in DRBD, to whom do I submit the issue?
- B.14.1.6: Where can I get more technical and business information concerning MySQL and DRBD?

Questions and Answers

B.14.1.1: What is DRBD?

DRBD is an acronym for Distributed Replicated Block Device. DRBD is an open source Linux kernel block device which leverages synchronous replication to achieve a consistent view of data between two systems, typically an Active and Passive system. DRBD currently supports all the major flavors of Linux and comes bundled in several major Linux distributions. The DRBD project is maintained by LINBIT.

B.14.1.2: What are “Block Devices”?

A *block device* is the type of device used to represent storage in the Linux Kernel. All physical disk devices present a block device interface. Additionally, virtual disk systems like LVM or DRBD present a block device interface. In this way, the file system or other software that might want to access a disk device can be used with any number of real or virtual devices without having to know anything about their underlying implementation details.

B.14.1.3: How is DRBD licensed?

DRBD is licensed under the GPL.

B.14.1.4: Where can I download DRBD?

Please see http://www.drbd.org/download/packages/.

B.14.1.5: If I find a bug in DRBD, to whom do I submit the issue?

Bug reports should be submitted to the DRBD mailing list. Please see http://lists.linbit.com/.

B.14.1.6: Where can I get more technical and business information concerning MySQL and DRBD?

Please visit http://mysql.com/drbd/.

B.14.2. Linux Heartbeat

In the following section, we provide answers to questions that are most frequently asked about Linux Heartbeat.

Questions

- B.14.2.1: How is Linux Heartbeat licensed?
- B.14.2.2: Where can I download Linux Heartbeat?
- B.14.2.3: If I find a bug with Linux Heartbeat, to whom do I submit the issue?

Questions and Answers

B.14.2.1: How is Linux Heartbeat licensed?

Linux Heartbeat is licensed under the GPL.

B.14.2.2: Where can I download Linux Heartbeat?

Please see http://linux-ha.org/download/index.html.

B.14.2.3: If I find a bug with Linux Heartbeat, to whom do I submit the issue?

Bug reports should be submitted to http://www.linux-ha.org/ClusterResourceManager/BugReports.

B.14.3. DRBD Architecture

In the following section, we provide answers to questions that are most frequently asked about DRBD Architecture.

Questions

- B.14.3.1: Is an Active/Active option available for MySQL with DRBD?
- B.14.3.2: What MySQL storage engines are supported with DRBD?
- B.14.3.3: How long does a failover take?
- B.14.3.4: How long does it take to resynchronize data after a failure?
- B.14.3.5: Are there any situations where you shouldn't use DRBD?
- B.14.3.6: Are there any limitations to DRBD?
- B.14.3.7: Where can I find more information on sample architectures?

Questions and Answers

B.14.3.1: Is an Active/Active option available for MySQL with DRBD?

Currently, MySQL does not support Active/Active configurations using DRBD “out of the box”.

B.14.3.2: What MySQL storage engines are supported with DRBD?

All of the MySQL transactional storage engines are supported by DRBD, including InnoDB and Falcon. For archived or read-only data, MyISAM or Archive can also be used.

B.14.3.3: How long does a failover take?

Failover time is dependent on many things, some of which are configurable. After activating the passive host, MySQL will have to start and run a normal recovery process. If the InnoDB log files have been configured to a large size and there was heavy write traffic, this may take a reasonably long period of time. However, under normal circumstances, failover tends to take less than a minute.

B.14.3.4: How long does it take to resynchronize data after a failure?

Resynchronization time depends on how long the two machines are out of communication and how much data was written during that period of time. Resynchronization time is a function of data to be synced, network speed and disk speed. DRBD maintains a bitmap of changed blocks on the primary machine, so only those blocks that have changed will need to be transferred.

B.14.3.5: Are there any situations where you shouldn't use DRBD?

See When Not To Use DRBD.

B.14.3.6: Are there any limitations to DRBD?

See DRBD limitations (or are they?).

B.14.3.7: Where can I find more information on sample architectures?

For an example of a Heartbeat R1-compatible resource configuration involving a MySQL database backed by DRBD, see DRBD User's Guide.

For an example of the same DRBD-backed configuration for a MySQL database in a Heartbeat CRM cluster, see DRBD User's Guide.

B.14.4. DRBD and MySQL Replication

In the following section, we provide answers to questions that are most frequently asked about MySQL Replication Scale-out.

Questions

- B.14.4.1: What is the difference between MySQL Cluster and DRBD?
- B.14.4.2: What is the difference between MySQL Replication and DRBD?
- B.14.4.3: How can I combine MySQL Replication scale-out with DRBD?

Questions and Answers

B.14.4.1: What is the difference between MySQL Cluster and DRBD?

Both MySQL Cluster and DRBD replicate data synchronously. MySQL Cluster leverages a shared-nothing storage architecture in which the cluster can be architected beyond an Active/Passive configuration. DRBD operates at a much lower level within the "stack", at the disk I/O level. For a comparison of various high availability features between these two options, please refer to Chapter 14, *High Availability and Scalability*.

B.14.4.2: What is the difference between MySQL Replication and DRBD?

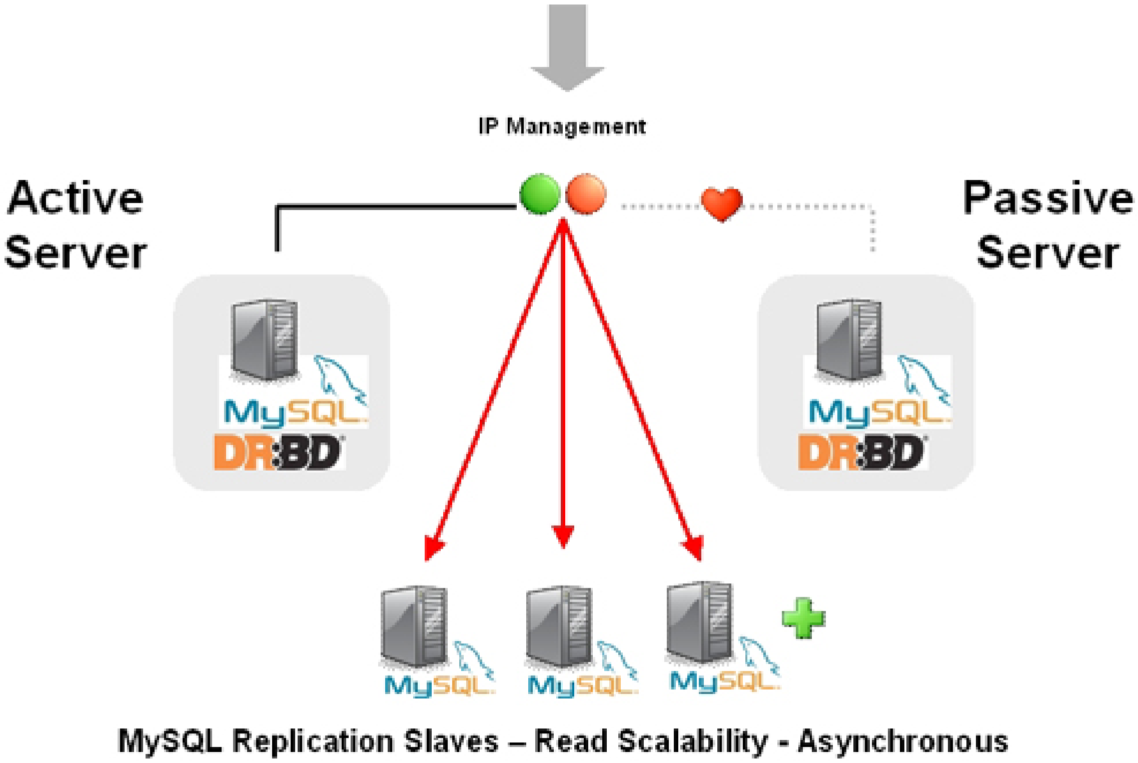
MySQL Replication replicates data asynchronously while DRBD replicates data synchronously. Also, MySQL Replication replicates MySQL statements, while DRBD replicates the underlying block device that stores the MySQL data files. For a comparison of various high availability features between these two options, please refer to the high availability comparison grid, Chapter 14, *High Availability and Scalability*.

B.14.4.3: How can I combine MySQL Replication scale-out with DRBD?

MySQL Replication is typically deployed in a Master to many Slaves configuration. In this configuration, having many Slaves provides read scalability. DRBD is used to provide high-availability for the Master MySQL Server in an Active/Passive configuration. This provides for automatic failover, safeguards against data loss, and automatically synchronizes the failed MySQL Master after a failover.

The most likely scenario in which MySQL Replication scale-out can be leveraged with DRBD is in the form of attaching replicated MySQL "read-slaves" off of the Active-Master MySQL Server. Since DRBD replicates an entire block device, master information such as the binary logs are also replicated. In this way, all of the slaves can attach to the Virtual IP Address managed by Linux Heartbeat. In the event of a failure, the asynchronous nature of MySQL Replication allows the slaves to continue with the new Active machine as their master with no intervention needed.

Figure B.1. Active-Master MySQL Server


IP Management
Active Server
Passive Server
MySQL
DRBD
MySQL
DRBD
MySQL
MySQL
MySQL
MySQL Replication Slaves – Read Scalability - Asynchronous

B.14.5. DRBD and File Systems

In the following section, we provide answers to questions that are most frequently asked about DRBD and file systems.

Questions

- B.14.5.1: Can XFS be used with DRBD?

Questions and Answers

B.14.5.1: Can XFS be used with DRBD?

Yes. XFS uses dynamic block size, thus DRBD 0.7 or later is needed.

B.14.6. DRBD and LVM

In the following section, we provide answers to questions that are most frequently asked about DRBD and LVM.

Questions

- B.14.6.1: Can I use DRBD on top of LVM?
- B.14.6.2: Can I use LVM on top of DRBD?
- B.14.6.3: Can I use DRBD on top of LVM while at the same time running LVM on top of that DRBD?

Questions and Answers

B.14.6.1: Can I use DRBD on top of LVM?

Yes, DRBD supports on-line resizing. If you enlarge your logical volume that acts as a backing device for DRBD, you can enlarge DRBD itself too, and of course your file system if it supports resizing.

B.14.6.2: Can I use LVM on top of DRBD?

Yes, you can use DRBD as a Physical Volume (PV) for LVM. Depending on the default LVM configuration shipped with your distribution, you may need to add the `/dev/drbd*` device files to the `filter` option in your `lvm.conf` so LVM scans your DRBDs for PV signatures.

B.14.6.3: Can I use DRBD on top of LVM while at the same time running LVM on top of that DRBD?

This requires careful tuning of your LVM configuration to avoid duplicate PV scans, but yes, it is possible.

B.14.7. DRBD and Virtualization

In the following section, we provide answers to questions that are most frequently asked about DRBD and virtualization.

Questions

- B.14.7.1: Can I use DRBD with OpenVZ?
- B.14.7.2: Can I use DRBD with Xen or KVM?

Questions and Answers

B.14.7.1: Can I use DRBD with OpenVZ?

See http://wiki.openvz.org/HA_cluster_with_DRBD_and_Heartbeat.

B.14.7.2: Can I use DRBD with Xen or KVM?

Yes. If you are looking for professional consultancy or expert commercial support for Xen- or KVM-based virtualization clusters with DRBD, contact LINBIT (http://www.linbit.com).

B.14.8. DRBD and Security

In the following section, we provide answers to questions that are most frequently asked about DRBD and security.

Questions

- B.14.8.1: Can I encrypt/compress the exchanged data?
- B.14.8.2: Does DRBD do mutual node authentication?

Questions and Answers

B.14.8.1: Can I encrypt/compress the exchanged data?

Yes. But there is no option within DRBD to allow for this. You’ll need to leverage a VPN and the network layer should do the rest.

B.14.8.2: Does DRBD do mutual node authentication?

Yes, starting with DRBD 8 shared-secret mutual node authentication is supported.

B.14.9. DRBD and System Requirements

In the following section, we provide answers to questions that are most frequently asked about DRBD and System Requirements.

Questions

- B.14.9.1: What other packages besides DRBD are required?
- B.14.9.2: How many machines are required to set up DRBD?
- B.14.9.3: Does DRBD only run on Linux?

Questions and Answers

B.14.9.1: What other packages besides DRBD are required?

When using pre-built binary packages, none except a matching kernel, plus packages for `glibc` and your favorite shell. When compiling DRBD from source additional prerequisite packages may be required. They include but are not limited to:

- glib-devel
- openssl
- devel
- libgcrypt-devel
- glib2-devel
- pkgconfig
- ncurses-devel
- rpm-build
- rpm-devel
- redhat-rpm-config
- gcc
- gcc-c++
- bison
- flex
- gnutls-devel
- lm_sensors-devel
- net-snmp-devel
- python-devel
- bzip2-devel
- libselinux-devel
- perl-DBI
- libnet

Pre-built x86 and x86_64 packages for specific kernel versions are available with a support subscription from LINBIT. Please note that if the kernel is upgraded, DRBD must be as well.

B.14.9.2: How many machines are required to set up DRBD?

Two machines are required to achieve the minimum degree of high availability. Although at any one given point in time one will be primary and one will be secondary, it is better to consider the machines as part of a mirrored pair without a “natural” primary machine.

B.14.9.3: Does DRBD only run on Linux?

DRBD is a Linux Kernel Module, and can work with many popular Linux distributions. DRBD is currently not available for non-Linux operating systems.

B.14.10. DRBD and Support and Consulting

In the following section, we provide answers to questions that are most frequently asked about DRBD and resources.

Questions

- B.14.10.1: Does MySQL offer professional consulting to help with designing a DRBD system?
- B.14.10.2: Does MySQL offer support for DRBD and Linux Heartbeat from MySQL?
- B.14.10.3: Are pre-built binaries or RPMs available?
- B.14.10.4: Does MySQL have documentation to help me with the installation and configuration of DRBD and Linux Heartbeat?
- B.14.10.5: Is there a dedicated discussion forum for MySQL High-Availability?
- B.14.10.6: Where can I get more information about MySQL for DRBD?

Questions and Answers

B.14.10.1: Does MySQL offer professional consulting to help with designing a DRBD system?

Yes. MySQL offers consulting for the design, installation, configuration, and monitoring of high availability DRBD. For more information concerning a High Availability Jumpstart, please see: http://www.mysql.com/consulting/packaged/scaleout.html.

B.14.10.2: Does MySQL offer support for DRBD and Linux Heartbeat from MySQL?

Yes. Support for DRBD is available with an add-on subscription to MySQL Enterprise called “DRBD for MySQL”. For more information about support options for DRBD see: http://mysql.com/products/enterprise/features.html.

For the list of supported Linux distributions, please see: http://www.mysql.com/support/supportedplatforms/enterprise.html.

> **Note**
>
> DRBD is only available on Linux. DRBD is not available on Windows, MacOS, Solaris, HPUX, AIX, FreeBSD, or other non-Linux platforms.

B.14.10.3: Are pre-built binaries or RPMs available?

Yes. “DRBD for MySQL” is an add-on subscription to MySQL Enterprise, which provides pre-built binaries for DRBD. For more information, see: http://mysql.com/products/enterprise/features.html.

B.14.10.4: Does MySQL have documentation to help me with the installation and configuration of DRBD and Linux Heartbeat?

For MySQL-specific DRBD documentation, see Section 14.2, “Using MySQL with DRBD”.

For general DRBD documentation, see DRBD User's Guide.

B.14.10.5: Is there a dedicated discussion forum for MySQL High-Availability?

Yes, http://forums.mysql.com/list.php?144.

B.14.10.6: Where can I get more information about MySQL for DRBD?

For more information about MySQL for DRBD, including a technical white paper please see: http://www.mysql.com/products/enterprise/drbd.html.

Appendix C. Errors, Error Codes, and Common Problems

This appendix lists common problems and errors that may occur and potential resolutions, in addition to listing the errors that may appear when you call MySQL from any host language. The first section covers problems and resolutions. Detailed information on errors is provided; The first list displays server error messages. The second list displays client program messages.

C.1. Sources of Error Information

There are several sources of error information in MySQL:

- Each SQL statement executed results in an error code, an SQLSTATE value, and an error message, as described in Section C.2, “Types of Error Values”. These errors are returned from the server side; see Section C.3, “Server Error Codes and Messages”.
- Errors can occur on the client side, usually involving problems communicating with the server; see Section C.4, “Client Error Codes and Messages”.
- SQL statement warning and error information is available through the `SHOW WARNINGS` and `SHOW ERRORS` statements. The `warning_count` and `error_count` system variables provide counts of the number of warnings and errors.
- `SHOW SLAVE STATUS` statement output includes information about replication errors occurring on the slave side.
- `SHOW ENGINE INNODB STATUS` statement output includes information about the most recent foreign key error if a `CREATE TABLE` statement for an `InnoDB` table fails.
- The `perror` program provides information from the command line about error numbers. See Section 4.8.1, “`perror` — Explain Error Codes”.

Descriptions of server and client errors are provided later in this Appendix. For information about errors related to `InnoDB`, see Section 13.3.13, “`InnoDB` Error Handling”.

C.2. Types of Error Values

When an error occurs in MySQL, the server returns two types of error values:

- A MySQL-specific error code. This value is numeric. It is not portable to other database systems.
- An SQLSTATE value. The value is a five-character string (for example, `'42S02'`). The values are specified by ANSI SQL and ODBC and are more standardized.

A message string that provides a textual description of the error is also available.

When an error occurs, you can access the MySQL error code, the SQLSTATE value, and the message string using C API functions:

- MySQL error code: Call `mysql_errno()`
- SQLSTATE value: Call `mysql_sqlstate()`
- Error message: Call `mysql_error()`

For prepared statements, the corresponding error functions are `mysql_stmt_errno()`, `mysql_stmt_sqlstate()`, and `mysql_stmt_error()`. All error functions are described in Section 20.9, “MySQL C API”.

The first two characters of an SQLSTATE value indicate the error class:

- `'00'` indicates success.
- `'01'` indicates a warning.
- `'02'` indicates “not found.” These values are relevant only within the context of cursors and are used to control what happens when a cursor reaches the end of a data set.

- Other values indicate an exception.

C.3. Server Error Codes and Messages

MySQL programs have access to several types of error information when the server returns an error. For example, the `mysql` client program displays errors using the following format:

```
shell> SELECT * FROM no_such_table;
ERROR 1146 (42S02): Table 'test.no_such_table' doesn't exist
```

The message displayed contains three types of information:

- A numeric error code (`1146`). This number is MySQL-specific and is not portable to other database systems.
- A five-character SQLSTATE value (`'42S02'`). The values are specified by ANSI SQL and ODBC and are more standardized. Not all MySQL error numbers are mapped to SQLSTATE error codes. The value `'HY000'` (general error) is used for unmapped errors.
- A message string that provides a textual description of the error.

For error checking, use error codes, not error messages. Error messages do not change often, but it is possible. Also if the database administrator changes the language setting, that affects the language of error messages.

Error codes are stable across GA releases of a given MySQL series. Before a series reaches GA status, new codes may still be under development and subject to change.

Server error information comes from the following source files. For details about the way that error information is defined, see the MySQL Internals manual, available at http://forge.mysql.com/wiki/MySQL_Internals.

- Error message information is listed in the `share/errmsg.txt` file. `%d` and `%s` represent numbers and strings, respectively, that are substituted into the Message values when they are displayed.
- The Error values listed in `share/errmsg.txt` are used to generate the definitions in the `include/mysqld_error.h` and `include/mysqld_ername.h` MySQL source files.
- The SQLSTATE values listed in `share/errmsg.txt` are used to generate the definitions in the `include/sql_state.h` MySQL source file.

Because updates are frequent, it is possible that those files will contain additional error information not listed here.

- Error: `1000` SQLSTATE: `HY000` (`ER_HASHCHK`)

  Message: hashchk
- Error: `1001` SQLSTATE: `HY000` (`ER_NISAMCHK`)

  Message: isamchk
- Error: `1002` SQLSTATE: `HY000` (`ER_NO`)

  Message: NO
- Error: `1003` SQLSTATE: `HY000` (`ER_YES`)

  Message: YES
- Error: `1004` SQLSTATE: `HY000` (`ER_CANT_CREATE_FILE`)

  Message: Can't create file '%s' (errno: %d)
- Error: `1005` SQLSTATE: `HY000` (`ER_CANT_CREATE_TABLE`)

  Message: Can't create table '%s' (errno: %d)
- Error: `1006` SQLSTATE: `HY000` (`ER_CANT_CREATE_DB`)

Message: Can't create database '%s' (errno: %d)

- Error: `1007` SQLSTATE: `HY000` (`ER_DB_CREATE_EXISTS`)

  Message: Can't create database '%s'; database exists

- Error: `1008` SQLSTATE: `HY000` (`ER_DB_DROP_EXISTS`)

  Message: Can't drop database '%s'; database doesn't exist

- Error: `1009` SQLSTATE: `HY000` (`ER_DB_DROP_DELETE`)

  Message: Error dropping database (can't delete '%s', errno: %d)

- Error: `1010` SQLSTATE: `HY000` (`ER_DB_DROP_RMDIR`)

  Message: Error dropping database (can't rmdir '%s', errno: %d)

- Error: `1011` SQLSTATE: `HY000` (`ER_CANT_DELETE_FILE`)

  Message: Error on delete of '%s' (errno: %d)

- Error: `1012` SQLSTATE: `HY000` (`ER_CANT_FIND_SYSTEM_REC`)

  Message: Can't read record in system table

- Error: `1013` SQLSTATE: `HY000` (`ER_CANT_GET_STAT`)

  Message: Can't get status of '%s' (errno: %d)

- Error: `1014` SQLSTATE: `HY000` (`ER_CANT_GET_WD`)

  Message: Can't get working directory (errno: %d)

- Error: `1015` SQLSTATE: `HY000` (`ER_CANT_LOCK`)

  Message: Can't lock file (errno: %d)

- Error: `1016` SQLSTATE: `HY000` (`ER_CANT_OPEN_FILE`)

  Message: Can't open file: '%s' (errno: %d)

- Error: `1017` SQLSTATE: `HY000` (`ER_FILE_NOT_FOUND`)

  Message: Can't find file: '%s' (errno: %d)

- Error: `1018` SQLSTATE: `HY000` (`ER_CANT_READ_DIR`)

  Message: Can't read dir of '%s' (errno: %d)

- Error: `1019` SQLSTATE: `HY000` (`ER_CANT_SET_WD`)

  Message: Can't change dir to '%s' (errno: %d)

- Error: `1020` SQLSTATE: `HY000` (`ER_CHECKREAD`)

  Message: Record has changed since last read in table '%s'

- Error: `1021` SQLSTATE: `HY000` (`ER_DISK_FULL`)

  Message: Disk full (%s); waiting for someone to free some space...

- Error: `1022` SQLSTATE: `23000` (`ER_DUP_KEY`)

  Message: Can't write; duplicate key in table '%s'

- Error: `1023` SQLSTATE: `HY000` (`ER_ERROR_ON_CLOSE`)

  Message: Error on close of '%s' (errno: %d)

- Error: `1024` SQLSTATE: `HY000` (`ER_ERROR_ON_READ`)

Message: Error reading file '%s' (errno: %d)

- Error: `1025` SQLSTATE: `HY000` (`ER_ERROR_ON_RENAME`)

  Message: Error on rename of '%s' to '%s' (errno: %d)

- Error: `1026` SQLSTATE: `HY000` (`ER_ERROR_ON_WRITE`)

  Message: Error writing file '%s' (errno: %d)

- Error: `1027` SQLSTATE: `HY000` (`ER_FILE_USED`)

  Message: '%s' is locked against change

- Error: `1028` SQLSTATE: `HY000` (`ER_FILSORT_ABORT`)

  Message: Sort aborted

- Error: `1029` SQLSTATE: `HY000` (`ER_FORM_NOT_FOUND`)

  Message: View '%s' doesn't exist for '%s'

- Error: `1030` SQLSTATE: `HY000` (`ER_GET_ERRNO`)

  Message: Got error %d from storage engine

- Error: `1031` SQLSTATE: `HY000` (`ER_ILLEGAL_HA`)

  Message: Table storage engine for '%s' doesn't have this option

- Error: `1032` SQLSTATE: `HY000` (`ER_KEY_NOT_FOUND`)

  Message: Can't find record in '%s'

- Error: `1033` SQLSTATE: `HY000` (`ER_NOT_FORM_FILE`)

  Message: Incorrect information in file: '%s'

- Error: `1034` SQLSTATE: `HY000` (`ER_NOT_KEYFILE`)

  Message: Incorrect key file for table '%s'; try to repair it

- Error: `1035` SQLSTATE: `HY000` (`ER_OLD_KEYFILE`)

  Message: Old key file for table '%s'; repair it!

- Error: `1036` SQLSTATE: `HY000` (`ER_OPEN_AS_READONLY`)

  Message: Table '%s' is read only

- Error: `1037` SQLSTATE: `HY001` (`ER_OUTOFMEMORY`)

  Message: Out of memory; restart server and try again (needed %d bytes)

- Error: `1038` SQLSTATE: `HY001` (`ER_OUT_OF_SORTMEMORY`)

  Message: Out of sort memory, consider increasing server sort buffer size

- Error: `1039` SQLSTATE: `HY000` (`ER_UNEXPECTED_EOF`)

  Message: Unexpected EOF found when reading file '%s' (errno: %d)

- Error: `1040` SQLSTATE: `08004` (`ER_CON_COUNT_ERROR`)

  Message: Too many connections

- Error: `1041` SQLSTATE: `HY000` (`ER_OUT_OF_RESOURCES`)

  Message: Out of memory; check if mysqld or some other process uses all available memory; if not, you may have to use 'ulimit' to allow mysqld to use more memory or you can add more swap space

- Error: `1042` SQLSTATE: `08S01` (`ER_BAD_HOST_ERROR`)

  Message: Can't get hostname for your address
- Error: `1043` SQLSTATE: `08S01` (`ER_HANDSHAKE_ERROR`)

  Message: Bad handshake
- Error: `1044` SQLSTATE: `42000` (`ER_DBACCESS_DENIED_ERROR`)

  Message: Access denied for user '%s'@'%s' to database '%s'
- Error: `1045` SQLSTATE: `28000` (`ER_ACCESS_DENIED_ERROR`)

  Message: Access denied for user '%s'@'%s' (using password: %s)
- Error: `1046` SQLSTATE: `3D000` (`ER_NO_DB_ERROR`)

  Message: No database selected
- Error: `1047` SQLSTATE: `08S01` (`ER_UNKNOWN_COM_ERROR`)

  Message: Unknown command
- Error: `1048` SQLSTATE: `23000` (`ER_BAD_NULL_ERROR`)

  Message: Column '%s' cannot be null
- Error: `1049` SQLSTATE: `42000` (`ER_BAD_DB_ERROR`)

  Message: Unknown database '%s'
- Error: `1050` SQLSTATE: `42S01` (`ER_TABLE_EXISTS_ERROR`)

  Message: Table '%s' already exists
- Error: `1051` SQLSTATE: `42S02` (`ER_BAD_TABLE_ERROR`)

  Message: Unknown table '%s'
- Error: `1052` SQLSTATE: `23000` (`ER_NON_UNIQ_ERROR`)

  Message: Column '%s' in %s is ambiguous
- Error: `1053` SQLSTATE: `08S01` (`ER_SERVER_SHUTDOWN`)

  Message: Server shutdown in progress
- Error: `1054` SQLSTATE: `42S22` (`ER_BAD_FIELD_ERROR`)

  Message: Unknown column '%s' in '%s'
- Error: `1055` SQLSTATE: `42000` (`ER_WRONG_FIELD_WITH_GROUP`)

  Message: '%s' isn't in GROUP BY
- Error: `1056` SQLSTATE: `42000` (`ER_WRONG_GROUP_FIELD`)

  Message: Can't group on '%s'
- Error: `1057` SQLSTATE: `42000` (`ER_WRONG_SUM_SELECT`)

  Message: Statement has sum functions and columns in same statement
- Error: `1058` SQLSTATE: `21S01` (`ER_WRONG_VALUE_COUNT`)

  Message: Column count doesn't match value count
- Error: `1059` SQLSTATE: `42000` (`ER_TOO_LONG_IDENT`)

  Message: Identifier name '%s' is too long

- Error: `1060` SQLSTATE: `42S21` (`ER_DUP_FIELDNAME`)

  Message: Duplicate column name '%s'

- Error: `1061` SQLSTATE: `42000` (`ER_DUP_KEYNAME`)

  Message: Duplicate key name '%s'

- Error: `1062` SQLSTATE: `23000` (`ER_DUP_ENTRY`)

  Message: Duplicate entry '%s' for key %d

- Error: `1063` SQLSTATE: `42000` (`ER_WRONG_FIELD_SPEC`)

  Message: Incorrect column specifier for column '%s'

- Error: `1064` SQLSTATE: `42000` (`ER_PARSE_ERROR`)

  Message: %s near '%s' at line %d

- Error: `1065` SQLSTATE: `42000` (`ER_EMPTY_QUERY`)

  Message: Query was empty

- Error: `1066` SQLSTATE: `42000` (`ER_NONUNIQ_TABLE`)

  Message: Not unique table/alias: '%s'

- Error: `1067` SQLSTATE: `42000` (`ER_INVALID_DEFAULT`)

  Message: Invalid default value for '%s'

- Error: `1068` SQLSTATE: `42000` (`ER_MULTIPLE_PRI_KEY`)

  Message: Multiple primary key defined

- Error: `1069` SQLSTATE: `42000` (`ER_TOO_MANY_KEYS`)

  Message: Too many keys specified; max %d keys allowed

- Error: `1070` SQLSTATE: `42000` (`ER_TOO_MANY_KEY_PARTS`)

  Message: Too many key parts specified; max %d parts allowed

- Error: `1071` SQLSTATE: `42000` (`ER_TOO_LONG_KEY`)

  Message: Specified key was too long; max key length is %d bytes

- Error: `1072` SQLSTATE: `42000` (`ER_KEY_COLUMN_DOES_NOT_EXITS`)

  Message: Key column '%s' doesn't exist in table

- Error: `1073` SQLSTATE: `42000` (`ER_BLOB_USED_AS_KEY`)

  Message: BLOB column '%s' can't be used in key specification with the used table type

- Error: `1074` SQLSTATE: `42000` (`ER_TOO_BIG_FIELDLENGTH`)

  Message: Column length too big for column '%s' (max = %lu); use BLOB or TEXT instead

- Error: `1075` SQLSTATE: `42000` (`ER_WRONG_AUTO_KEY`)

  Message: Incorrect table definition; there can be only one auto column and it must be defined as a key

- Error: `1076` SQLSTATE: `HY000` (`ER_READY`)

  Message: %s: ready for connections. Version: '%s' socket: '%s' port: %d

- Error: `1077` SQLSTATE: `HY000` (`ER_NORMAL_SHUTDOWN`)

  Message: %s: Normal shutdown

- Error: `1078` SQLSTATE: `HY000` (`ER_GOT_SIGNAL`)

  Message: %s: Got signal %d. Aborting!

- Error: `1079` SQLSTATE: `HY000` (`ER_SHUTDOWN_COMPLETE`)

  Message: %s: Shutdown complete

- Error: `1080` SQLSTATE: `08S01` (`ER_FORCING_CLOSE`)

  Message: %s: Forcing close of thread %ld user: '%s'

- Error: `1081` SQLSTATE: `08S01` (`ER_IPSOCK_ERROR`)

  Message: Can't create IP socket

- Error: `1082` SQLSTATE: `42S12` (`ER_NO_SUCH_INDEX`)

  Message: Table '%s' has no index like the one used in CREATE INDEX; recreate the table

- Error: `1083` SQLSTATE: `42000` (`ER_WRONG_FIELD_TERMINATORS`)

  Message: Field separator argument is not what is expected; check the manual

- Error: `1084` SQLSTATE: `42000` (`ER_BLOBS_AND_NO_TERMINATED`)

  Message: You can't use fixed rowlength with BLOBs; please use 'fields terminated by'

- Error: `1085` SQLSTATE: `HY000` (`ER_TEXTFILE_NOT_READABLE`)

  Message: The file '%s' must be in the database directory or be readable by all

- Error: `1086` SQLSTATE: `HY000` (`ER_FILE_EXISTS_ERROR`)

  Message: File '%s' already exists

- Error: `1087` SQLSTATE: `HY000` (`ER_LOAD_INFO`)

  Message: Records: %ld Deleted: %ld Skipped: %ld Warnings: %ld

- Error: `1088` SQLSTATE: `HY000` (`ER_ALTER_INFO`)

  Message: Records: %ld Duplicates: %ld

- Error: `1089` SQLSTATE: `HY000` (`ER_WRONG_SUB_KEY`)

  Message: Incorrect prefix key; the used key part isn't a string, the used length is longer than the key part, or the storage engine doesn't support unique prefix keys

- Error: `1090` SQLSTATE: `42000` (`ER_CANT_REMOVE_ALL_FIELDS`)

  Message: You can't delete all columns with ALTER TABLE; use DROP TABLE instead

- Error: `1091` SQLSTATE: `42000` (`ER_CANT_DROP_FIELD_OR_KEY`)

  Message: Can't DROP '%s'; check that column/key exists

- Error: `1092` SQLSTATE: `HY000` (`ER_INSERT_INFO`)

  Message: Records: %ld Duplicates: %ld Warnings: %ld

- Error: `1093` SQLSTATE: `HY000` (`ER_UPDATE_TABLE_USED`)

  Message: You can't specify target table '%s' for update in FROM clause

- Error: `1094` SQLSTATE: `HY000` (`ER_NO_SUCH_THREAD`)

  Message: Unknown thread id: %lu

- Error: `1095` SQLSTATE: `HY000` (`ER_KILL_DENIED_ERROR`)

  Message: You are not owner of thread %lu

- Error: `1096` SQLSTATE: `HY000` (`ER_NO_TABLES_USED`)

  Message: No tables used

- Error: `1097` SQLSTATE: `HY000` (`ER_TOO_BIG_SET`)

  Message: Too many strings for column %s and SET

- Error: `1098` SQLSTATE: `HY000` (`ER_NO_UNIQUE_LOGFILE`)

  Message: Can't generate a unique log-filename %s.(1-999)

- Error: `1099` SQLSTATE: `HY000` (`ER_TABLE_NOT_LOCKED_FOR_WRITE`)

  Message: Table '%s' was locked with a READ lock and can't be updated

- Error: `1100` SQLSTATE: `HY000` (`ER_TABLE_NOT_LOCKED`)

  Message: Table '%s' was not locked with LOCK TABLES

- Error: `1101` SQLSTATE: `42000` (`ER_BLOB_CANT_HAVE_DEFAULT`)

  Message: BLOB/TEXT column '%s' can't have a default value

- Error: `1102` SQLSTATE: `42000` (`ER_WRONG_DB_NAME`)

  Message: Incorrect database name '%s'

- Error: `1103` SQLSTATE: `42000` (`ER_WRONG_TABLE_NAME`)

  Message: Incorrect table name '%s'

- Error: `1104` SQLSTATE: `42000` (`ER_TOO_BIG_SELECT`)

  Message: The SELECT would examine more than MAX_JOIN_SIZE rows; check your WHERE and use SET SQL_BIG_SELECTS=1 or SET SQL_MAX_JOIN_SIZE=# if the SELECT is okay

- Error: `1105` SQLSTATE: `HY000` (`ER_UNKNOWN_ERROR`)

  Message: Unknown error

- Error: `1106` SQLSTATE: `42000` (`ER_UNKNOWN_PROCEDURE`)

  Message: Unknown procedure '%s'

- Error: `1107` SQLSTATE: `42000` (`ER_WRONG_PARAMCOUNT_TO_PROCEDURE`)

  Message: Incorrect parameter count to procedure '%s'

- Error: `1108` SQLSTATE: `HY000` (`ER_WRONG_PARAMETERS_TO_PROCEDURE`)

  Message: Incorrect parameters to procedure '%s'

- Error: `1109` SQLSTATE: `42S02` (`ER_UNKNOWN_TABLE`)

  Message: Unknown table '%s' in %s

- Error: `1110` SQLSTATE: `42000` (`ER_FIELD_SPECIFIED_TWICE`)

  Message: Column '%s' specified twice

- Error: `1111` SQLSTATE: `HY000` (`ER_INVALID_GROUP_FUNC_USE`)

  Message: Invalid use of group function

- Error: `1112` SQLSTATE: `42000` (`ER_UNSUPPORTED_EXTENSION`)

  Message: Table '%s' uses an extension that doesn't exist in this MySQL version

- Error: `1113` SQLSTATE: `42000` (`ER_TABLE_MUST_HAVE_COLUMNS`)

  Message: A table must have at least 1 column

- Error: `1114` SQLSTATE: `HY000` (`ER_RECORD_FILE_FULL`)

  Message: The table '%s' is full

- Error: `1115` SQLSTATE: `42000` (`ER_UNKNOWN_CHARACTER_SET`)

  Message: Unknown character set: '%s'

- Error: `1116` SQLSTATE: `HY000` (`ER_TOO_MANY_TABLES`)

  Message: Too many tables; MySQL can only use %d tables in a join

- Error: `1117` SQLSTATE: `HY000` (`ER_TOO_MANY_FIELDS`)

  Message: Too many columns

- Error: `1118` SQLSTATE: `42000` (`ER_TOO_BIG_ROWSIZE`)

  Message: Row size too large. The maximum row size for the used table type, not counting BLOBs, is %ld. You have to change some columns to TEXT or BLOBs

- Error: `1119` SQLSTATE: `HY000` (`ER_STACK_OVERRUN`)

  Message: Thread stack overrun: Used: %ld of a %ld stack. Use 'mysqld --thread_stack=#' to specify a bigger stack if needed

- Error: `1120` SQLSTATE: `42000` (`ER_WRONG_OUTER_JOIN`)

  Message: Cross dependency found in OUTER JOIN; examine your ON conditions

- Error: `1121` SQLSTATE: `42000` (`ER_NULL_COLUMN_IN_INDEX`)

  Message: Table handler doesn't support NULL in given index. Please change column '%s' to be NOT NULL or use another handler

- Error: `1122` SQLSTATE: `HY000` (`ER_CANT_FIND_UDF`)

  Message: Can't load function '%s'

- Error: `1123` SQLSTATE: `HY000` (`ER_CANT_INITIALIZE_UDF`)

  Message: Can't initialize function '%s'; %s

- Error: `1124` SQLSTATE: `HY000` (`ER_UDF_NO_PATHS`)

  Message: No paths allowed for shared library

- Error: `1125` SQLSTATE: `HY000` (`ER_UDF_EXISTS`)

  Message: Function '%s' already exists

- Error: `1126` SQLSTATE: `HY000` (`ER_CANT_OPEN_LIBRARY`)

  Message: Can't open shared library '%s' (errno: %d %s)

- Error: `1127` SQLSTATE: `HY000` (`ER_CANT_FIND_DL_ENTRY`)

  Message: Can't find symbol '%s' in library

- Error: `1128` SQLSTATE: `HY000` (`ER_FUNCTION_NOT_DEFINED`)

  Message: Function '%s' is not defined

- Error: `1129` SQLSTATE: `HY000` (`ER_HOST_IS_BLOCKED`)

  Message: Host '%s' is blocked because of many connection errors; unblock with 'mysqladmin flush-hosts'

- Error: `1130` SQLSTATE: `HY000` (`ER_HOST_NOT_PRIVILEGED`)

  Message: Host '%s' is not allowed to connect to this MySQL server

- Error: `1131` SQLSTATE: `42000` (`ER_PASSWORD_ANONYMOUS_USER`)

Message: You are using MySQL as an anonymous user and anonymous users are not allowed to change passwords

- Error: `1132` SQLSTATE: `42000` (`ER_PASSWORD_NOT_ALLOWED`)

  Message: You must have privileges to update tables in the mysql database to be able to change passwords for others

- Error: `1133` SQLSTATE: `42000` (`ER_PASSWORD_NO_MATCH`)

  Message: Can't find any matching row in the user table

- Error: `1134` SQLSTATE: `HY000` (`ER_UPDATE_INFO`)

  Message: Rows matched: %ld Changed: %ld Warnings: %ld

- Error: `1135` SQLSTATE: `HY000` (`ER_CANT_CREATE_THREAD`)

  Message: Can't create a new thread (errno %d); if you are not out of available memory, you can consult the manual for a possible OS-dependent bug

- Error: `1136` SQLSTATE: `21S01` (`ER_WRONG_VALUE_COUNT_ON_ROW`)

  Message: Column count doesn't match value count at row %ld

- Error: `1137` SQLSTATE: `HY000` (`ER_CANT_REOPEN_TABLE`)

  Message: Can't reopen table: '%s'

- Error: `1138` SQLSTATE: `22004` (`ER_INVALID_USE_OF_NULL`)

  Message: Invalid use of NULL value

- Error: `1139` SQLSTATE: `42000` (`ER_REGEXP_ERROR`)

  Message: Got error '%s' from regexp

- Error: `1140` SQLSTATE: `42000` (`ER_MIX_OF_GROUP_FUNC_AND_FIELDS`)

  Message: Mixing of GROUP columns (MIN(),MAX(),COUNT(),...) with no GROUP columns is illegal if there is no GROUP BY clause

- Error: `1141` SQLSTATE: `42000` (`ER_NONEXISTING_GRANT`)

  Message: There is no such grant defined for user '%s' on host '%s'

- Error: `1142` SQLSTATE: `42000` (`ER_TABLEACCESS_DENIED_ERROR`)

  Message: %s command denied to user '%s'@'%s' for table '%s'

- Error: `1143` SQLSTATE: `42000` (`ER_COLUMNACCESS_DENIED_ERROR`)

  Message: %s command denied to user '%s'@'%s' for column '%s' in table '%s'

- Error: `1144` SQLSTATE: `42000` (`ER_ILLEGAL_GRANT_FOR_TABLE`)

  Message: Illegal GRANT/REVOKE command; please consult the manual to see which privileges can be used

- Error: `1145` SQLSTATE: `42000` (`ER_GRANT_WRONG_HOST_OR_USER`)

  Message: The host or user argument to GRANT is too long

- Error: `1146` SQLSTATE: `42S02` (`ER_NO_SUCH_TABLE`)

  Message: Table '%s.%s' doesn't exist

- Error: `1147` SQLSTATE: `42000` (`ER_NONEXISTING_TABLE_GRANT`)

  Message: There is no such grant defined for user '%s' on host '%s' on table '%s'

- Error: `1148` SQLSTATE: `42000` (`ER_NOT_ALLOWED_COMMAND`)

  Message: The used command is not allowed with this MySQL version

- Error: `1149` SQLSTATE: `42000` (`ER_SYNTAX_ERROR`)

  Message: You have an error in your SQL syntax; check the manual that corresponds to your MySQL server version for the right syntax to use

- Error: `1150` SQLSTATE: `HY000` (`ER_DELAYED_CANT_CHANGE_LOCK`)

  Message: Delayed insert thread couldn't get requested lock for table %s

- Error: `1151` SQLSTATE: `HY000` (`ER_TOO_MANY_DELAYED_THREADS`)

  Message: Too many delayed threads in use

- Error: `1152` SQLSTATE: `08S01` (`ER_ABORTING_CONNECTION`)

  Message: Aborted connection %ld to db: '%s' user: '%s' (%s)

- Error: `1153` SQLSTATE: `08S01` (`ER_NET_PACKET_TOO_LARGE`)

  Message: Got a packet bigger than 'max_allowed_packet' bytes

- Error: `1154` SQLSTATE: `08S01` (`ER_NET_READ_ERROR_FROM_PIPE`)

  Message: Got a read error from the connection pipe

- Error: `1155` SQLSTATE: `08S01` (`ER_NET_FCNTL_ERROR`)

  Message: Got an error from fcntl()

- Error: `1156` SQLSTATE: `08S01` (`ER_NET_PACKETS_OUT_OF_ORDER`)

  Message: Got packets out of order

- Error: `1157` SQLSTATE: `08S01` (`ER_NET_UNCOMPRESS_ERROR`)

  Message: Couldn't uncompress communication packet

- Error: `1158` SQLSTATE: `08S01` (`ER_NET_READ_ERROR`)

  Message: Got an error reading communication packets

- Error: `1159` SQLSTATE: `08S01` (`ER_NET_READ_INTERRUPTED`)

  Message: Got timeout reading communication packets

- Error: `1160` SQLSTATE: `08S01` (`ER_NET_ERROR_ON_WRITE`)

  Message: Got an error writing communication packets

- Error: `1161` SQLSTATE: `08S01` (`ER_NET_WRITE_INTERRUPTED`)

  Message: Got timeout writing communication packets

- Error: `1162` SQLSTATE: `42000` (`ER_TOO_LONG_STRING`)

  Message: Result string is longer than 'max_allowed_packet' bytes

- Error: `1163` SQLSTATE: `42000` (`ER_TABLE_CANT_HANDLE_BLOB`)

  Message: The used table type doesn't support BLOB/TEXT columns

- Error: `1164` SQLSTATE: `42000` (`ER_TABLE_CANT_HANDLE_AUTO_INCREMENT`)

  Message: The used table type doesn't support AUTO_INCREMENT columns

- Error: `1165` SQLSTATE: `HY000` (`ER_DELAYED_INSERT_TABLE_LOCKED`)

  Message: INSERT DELAYED can't be used with table '%s' because it is locked with LOCK TABLES

- Error: `1166` SQLSTATE: `42000` (`ER_WRONG_COLUMN_NAME`)

  Message: Incorrect column name '%s'

- Error: `1167` SQLSTATE: `42000` (`ER_WRONG_KEY_COLUMN`)

  Message: The used storage engine can't index column '%s'

- Error: `1168` SQLSTATE: `HY000` (`ER_WRONG_MRG_TABLE`)

  Message: Unable to open underlying table which is differently defined or of non-MyISAM type or doesn't exist

- Error: `1169` SQLSTATE: `23000` (`ER_DUP_UNIQUE`)

  Message: Can't write, because of unique constraint, to table '%s'

- Error: `1170` SQLSTATE: `42000` (`ER_BLOB_KEY_WITHOUT_LENGTH`)

  Message: BLOB/TEXT column '%s' used in key specification without a key length

- Error: `1171` SQLSTATE: `42000` (`ER_PRIMARY_CANT_HAVE_NULL`)

  Message: All parts of a PRIMARY KEY must be NOT NULL; if you need NULL in a key, use UNIQUE instead

- Error: `1172` SQLSTATE: `42000` (`ER_TOO_MANY_ROWS`)

  Message: Result consisted of more than one row

- Error: `1173` SQLSTATE: `42000` (`ER_REQUIRES_PRIMARY_KEY`)

  Message: This table type requires a primary key

- Error: `1174` SQLSTATE: `HY000` (`ER_NO_RAID_COMPILED`)

  Message: This version of MySQL is not compiled with RAID support

- Error: `1175` SQLSTATE: `HY000` (`ER_UPDATE_WITHOUT_KEY_IN_SAFE_MODE`)

  Message: You are using safe update mode and you tried to update a table without a WHERE that uses a KEY column

- Error: `1176` SQLSTATE: `42000` (`ER_KEY_DOES_NOT_EXITS`)

  Message: Key '%s' doesn't exist in table '%s'

- Error: `1177` SQLSTATE: `42000` (`ER_CHECK_NO_SUCH_TABLE`)

  Message: Can't open table

- Error: `1178` SQLSTATE: `42000` (`ER_CHECK_NOT_IMPLEMENTED`)

  Message: The storage engine for the table doesn't support %s

- Error: `1179` SQLSTATE: `25000` (`ER_CANT_DO_THIS_DURING_AN_TRANSACTION`)

  Message: You are not allowed to execute this command in a transaction

- Error: `1180` SQLSTATE: `HY000` (`ER_ERROR_DURING_COMMIT`)

  Message: Got error %d during COMMIT

- Error: `1181` SQLSTATE: `HY000` (`ER_ERROR_DURING_ROLLBACK`)

  Message: Got error %d during ROLLBACK

- Error: `1182` SQLSTATE: `HY000` (`ER_ERROR_DURING_FLUSH_LOGS`)

  Message: Got error %d during FLUSH_LOGS

- Error: `1183` SQLSTATE: `HY000` (`ER_ERROR_DURING_CHECKPOINT`)

  Message: Got error %d during CHECKPOINT

- Error: `1184` SQLSTATE: `08S01` (`ER_NEW_ABORTING_CONNECTION`)

  Message: Aborted connection %ld to db: '%s' user: '%s' host: '%s' (%s)

- Error: `1185` SQLSTATE: `HY000` (`ER_DUMP_NOT_IMPLEMENTED`)

  Message: The storage engine for the table does not support binary table dump

- Error: `1186` SQLSTATE: `HY000` (`ER_FLUSH_MASTER_BINLOG_CLOSED`)

  Message: Binlog closed, cannot RESET MASTER

- Error: `1187` SQLSTATE: `HY000` (`ER_INDEX_REBUILD`)

  Message: Failed rebuilding the index of dumped table '%s'

- Error: `1188` SQLSTATE: `HY000` (`ER_MASTER`)

  Message: Error from master: '%s'

- Error: `1189` SQLSTATE: `08S01` (`ER_MASTER_NET_READ`)

  Message: Net error reading from master

- Error: `1190` SQLSTATE: `08S01` (`ER_MASTER_NET_WRITE`)

  Message: Net error writing to master

- Error: `1191` SQLSTATE: `HY000` (`ER_FT_MATCHING_KEY_NOT_FOUND`)

  Message: Can't find FULLTEXT index matching the column list

- Error: `1192` SQLSTATE: `HY000` (`ER_LOCK_OR_ACTIVE_TRANSACTION`)

  Message: Can't execute the given command because you have active locked tables or an active transaction

- Error: `1193` SQLSTATE: `HY000` (`ER_UNKNOWN_SYSTEM_VARIABLE`)

  Message: Unknown system variable '%s'

- Error: `1194` SQLSTATE: `HY000` (`ER_CRASHED_ON_USAGE`)

  Message: Table '%s' is marked as crashed and should be repaired

- Error: `1195` SQLSTATE: `HY000` (`ER_CRASHED_ON_REPAIR`)

  Message: Table '%s' is marked as crashed and last (automatic?) repair failed

- Error: `1196` SQLSTATE: `HY000` (`ER_WARNING_NOT_COMPLETE_ROLLBACK`)

  Message: Some non-transactional changed tables couldn't be rolled back

- Error: `1197` SQLSTATE: `HY000` (`ER_TRANS_CACHE_FULL`)

  Message: Multi-statement transaction required more than 'max_binlog_cache_size' bytes of storage; increase this mysqld variable and try again

- Error: `1198` SQLSTATE: `HY000` (`ER_SLAVE_MUST_STOP`)

  Message: This operation cannot be performed with a running slave; run STOP SLAVE first

- Error: `1199` SQLSTATE: `HY000` (`ER_SLAVE_NOT_RUNNING`)

  Message: This operation requires a running slave; configure slave and do START SLAVE

- Error: `1200` SQLSTATE: `HY000` (`ER_BAD_SLAVE`)

  Message: The server is not configured as slave; fix in config file or with CHANGE MASTER TO

- Error: `1201` SQLSTATE: `HY000` (`ER_MASTER_INFO`)

  Message: Could not initialize master info structure; more error messages can be found in the MySQL error log

- Error: `1202` SQLSTATE: `HY000` (`ER_SLAVE_THREAD`)

  Message: Could not create slave thread; check system resources

- Error: `1203` SQLSTATE: `42000` (`ER_TOO_MANY_USER_CONNECTIONS`)

  Message: User %s already has more than 'max_user_connections' active connections
- Error: `1204` SQLSTATE: `HY000` (`ER_SET_CONSTANTS_ONLY`)

  Message: You may only use constant expressions with SET
- Error: `1205` SQLSTATE: `HY000` (`ER_LOCK_WAIT_TIMEOUT`)

  Message: Lock wait timeout exceeded; try restarting transaction
- Error: `1206` SQLSTATE: `HY000` (`ER_LOCK_TABLE_FULL`)

  Message: The total number of locks exceeds the lock table size
- Error: `1207` SQLSTATE: `25000` (`ER_READ_ONLY_TRANSACTION`)

  Message: Update locks cannot be acquired during a READ UNCOMMITTED transaction
- Error: `1208` SQLSTATE: `HY000` (`ER_DROP_DB_WITH_READ_LOCK`)

  Message: DROP DATABASE not allowed while thread is holding global read lock
- Error: `1209` SQLSTATE: `HY000` (`ER_CREATE_DB_WITH_READ_LOCK`)

  Message: CREATE DATABASE not allowed while thread is holding global read lock
- Error: `1210` SQLSTATE: `HY000` (`ER_WRONG_ARGUMENTS`)

  Message: Incorrect arguments to %s
- Error: `1211` SQLSTATE: `42000` (`ER_NO_PERMISSION_TO_CREATE_USER`)

  Message: '%s'@'%s' is not allowed to create new users
- Error: `1212` SQLSTATE: `HY000` (`ER_UNION_TABLES_IN_DIFFERENT_DIR`)

  Message: Incorrect table definition; all MERGE tables must be in the same database
- Error: `1213` SQLSTATE: `40001` (`ER_LOCK_DEADLOCK`)

  Message: Deadlock found when trying to get lock; try restarting transaction
- Error: `1214` SQLSTATE: `HY000` (`ER_TABLE_CANT_HANDLE_FT`)

  Message: The used table type doesn't support FULLTEXT indexes
- Error: `1215` SQLSTATE: `HY000` (`ER_CANNOT_ADD_FOREIGN`)

  Message: Cannot add foreign key constraint
- Error: `1216` SQLSTATE: `23000` (`ER_NO_REFERENCED_ROW`)

  Message: Cannot add or update a child row: a foreign key constraint fails
- Error: `1217` SQLSTATE: `23000` (`ER_ROW_IS_REFERENCED`)

  Message: Cannot delete or update a parent row: a foreign key constraint fails
- Error: `1218` SQLSTATE: `08S01` (`ER_CONNECT_TO_MASTER`)

  Message: Error connecting to master: %s
- Error: `1219` SQLSTATE: `HY000` (`ER_QUERY_ON_MASTER`)

  Message: Error running query on master: %s
- Error: `1220` SQLSTATE: `HY000` (`ER_ERROR_WHEN_EXECUTING_COMMAND`)

  Message: Error when executing command %s: %s

- Error: `1221` SQLSTATE: `HY000` (`ER_WRONG_USAGE`)

  Message: Incorrect usage of %s and %s

- Error: `1222` SQLSTATE: `21000` (`ER_WRONG_NUMBER_OF_COLUMNS_IN_SELECT`)

  Message: The used SELECT statements have a different number of columns

- Error: `1223` SQLSTATE: `HY000` (`ER_CANT_UPDATE_WITH_READLOCK`)

  Message: Can't execute the query because you have a conflicting read lock

- Error: `1224` SQLSTATE: `HY000` (`ER_MIXING_NOT_ALLOWED`)

  Message: Mixing of transactional and non-transactional tables is disabled

- Error: `1225` SQLSTATE: `HY000` (`ER_DUP_ARGUMENT`)

  Message: Option '%s' used twice in statement

- Error: `1226` SQLSTATE: `42000` (`ER_USER_LIMIT_REACHED`)

  Message: User '%s' has exceeded the '%s' resource (current value: %ld)

- Error: `1227` SQLSTATE: `42000` (`ER_SPECIFIC_ACCESS_DENIED_ERROR`)

  Message: Access denied; you need (at least one of) the %s privilege(s) for this operation

- Error: `1228` SQLSTATE: `HY000` (`ER_LOCAL_VARIABLE`)

  Message: Variable '%s' is a SESSION variable and can't be used with SET GLOBAL

- Error: `1229` SQLSTATE: `HY000` (`ER_GLOBAL_VARIABLE`)

  Message: Variable '%s' is a GLOBAL variable and should be set with SET GLOBAL

- Error: `1230` SQLSTATE: `42000` (`ER_NO_DEFAULT`)

  Message: Variable '%s' doesn't have a default value

- Error: `1231` SQLSTATE: `42000` (`ER_WRONG_VALUE_FOR_VAR`)

  Message: Variable '%s' can't be set to the value of '%s'

- Error: `1232` SQLSTATE: `42000` (`ER_WRONG_TYPE_FOR_VAR`)

  Message: Incorrect argument type to variable '%s'

- Error: `1233` SQLSTATE: `HY000` (`ER_VAR_CANT_BE_READ`)

  Message: Variable '%s' can only be set, not read

- Error: `1234` SQLSTATE: `42000` (`ER_CANT_USE_OPTION_HERE`)

  Message: Incorrect usage/placement of '%s'

- Error: `1235` SQLSTATE: `42000` (`ER_NOT_SUPPORTED_YET`)

  Message: This version of MySQL doesn't yet support '%s'

- Error: `1236` SQLSTATE: `HY000` (`ER_MASTER_FATAL_ERROR_READING_BINLOG`)

  Message: Got fatal error %d from master when reading data from binary log: '%s'

- Error: `1237` SQLSTATE: `HY000` (`ER_SLAVE_IGNORED_TABLE`)

  Message: Slave SQL thread ignored the query because of replicate-*-table rules

- Error: `1238` SQLSTATE: `HY000` (`ER_INCORRECT_GLOBAL_LOCAL_VAR`)

  Message: Variable '%s' is a %s variable

- Error: `1239` SQLSTATE: `42000` (`ER_WRONG_FK_DEF`)

  Message: Incorrect foreign key definition for '%s': %s

- Error: `1240` SQLSTATE: `HY000` (`ER_KEY_REF_DO_NOT_MATCH_TABLE_REF`)

  Message: Key reference and table reference don't match

- Error: `1241` SQLSTATE: `21000` (`ER_OPERAND_COLUMNS`)

  Message: Operand should contain %d column(s)

- Error: `1242` SQLSTATE: `21000` (`ER_SUBQUERY_NO_1_ROW`)

  Message: Subquery returns more than 1 row

- Error: `1243` SQLSTATE: `HY000` (`ER_UNKNOWN_STMT_HANDLER`)

  Message: Unknown prepared statement handler (%.*s) given to %s

- Error: `1244` SQLSTATE: `HY000` (`ER_CORRUPT_HELP_DB`)

  Message: Help database is corrupt or does not exist

- Error: `1245` SQLSTATE: `HY000` (`ER_CYCLIC_REFERENCE`)

  Message: Cyclic reference on subqueries

- Error: `1246` SQLSTATE: `HY000` (`ER_AUTO_CONVERT`)

  Message: Converting column '%s' from %s to %s

- Error: `1247` SQLSTATE: `42S22` (`ER_ILLEGAL_REFERENCE`)

  Message: Reference '%s' not supported (%s)

- Error: `1248` SQLSTATE: `42000` (`ER_DERIVED_MUST_HAVE_ALIAS`)

  Message: Every derived table must have its own alias

- Error: `1249` SQLSTATE: `01000` (`ER_SELECT_REDUCED`)

  Message: Select %u was reduced during optimization

- Error: `1250` SQLSTATE: `42000` (`ER_TABLENAME_NOT_ALLOWED_HERE`)

  Message: Table '%s' from one of the SELECTs cannot be used in %s

- Error: `1251` SQLSTATE: `08004` (`ER_NOT_SUPPORTED_AUTH_MODE`)

  Message: Client does not support authentication protocol requested by server; consider upgrading MySQL client

- Error: `1252` SQLSTATE: `42000` (`ER_SPATIAL_CANT_HAVE_NULL`)

  Message: All parts of a SPATIAL index must be NOT NULL

- Error: `1253` SQLSTATE: `42000` (`ER_COLLATION_CHARSET_MISMATCH`)

  Message: COLLATION '%s' is not valid for CHARACTER SET '%s'

- Error: `1254` SQLSTATE: `HY000` (`ER_SLAVE_WAS_RUNNING`)

  Message: Slave is already running

- Error: `1255` SQLSTATE: `HY000` (`ER_SLAVE_WAS_NOT_RUNNING`)

  Message: Slave already has been stopped

- Error: `1256` SQLSTATE: `HY000` (`ER_TOO_BIG_FOR_UNCOMPRESS`)

  Message: Uncompressed data size too large; the maximum size is %d (probably, length of uncompressed data was corrupted)

- Error: `1257` SQLSTATE: `HY000` (`ER_ZLIB_Z_MEM_ERROR`)

  Message: ZLIB: Not enough memory

- Error: `1258` SQLSTATE: `HY000` (`ER_ZLIB_Z_BUF_ERROR`)

  Message: ZLIB: Not enough room in the output buffer (probably, length of uncompressed data was corrupted)

- Error: `1259` SQLSTATE: `HY000` (`ER_ZLIB_Z_DATA_ERROR`)

  Message: ZLIB: Input data corrupted

- Error: `1260` SQLSTATE: `HY000` (`ER_CUT_VALUE_GROUP_CONCAT`)

  Message: Row %u was cut by GROUP_CONCAT()

- Error: `1261` SQLSTATE: `01000` (`ER_WARN_TOO_FEW_RECORDS`)

  Message: Row %ld doesn't contain data for all columns

- Error: `1262` SQLSTATE: `01000` (`ER_WARN_TOO_MANY_RECORDS`)

  Message: Row %ld was truncated; it contained more data than there were input columns

- Error: `1263` SQLSTATE: `22004` (`ER_WARN_NULL_TO_NOTNULL`)

  Message: Column set to default value; NULL supplied to NOT NULL column '%s' at row %ld

- Error: `1264` SQLSTATE: `22003` (`ER_WARN_DATA_OUT_OF_RANGE`)

  Message: Out of range value for column '%s' at row %ld

- Error: `1265` SQLSTATE: `01000` (`WARN_DATA_TRUNCATED`)

  Message: Data truncated for column '%s' at row %ld

- Error: `1266` SQLSTATE: `HY000` (`ER_WARN_USING_OTHER_HANDLER`)

  Message: Using storage engine %s for table '%s'

- Error: `1267` SQLSTATE: `HY000` (`ER_CANT_AGGREGATE_2COLLATIONS`)

  Message: Illegal mix of collations (%s,%s) and (%s,%s) for operation '%s'

- Error: `1268` SQLSTATE: `HY000` (`ER_DROP_USER`)

  Message: Cannot drop one or more of the requested users

- Error: `1269` SQLSTATE: `HY000` (`ER_REVOKE_GRANTS`)

  Message: Can't revoke all privileges for one or more of the requested users

- Error: `1270` SQLSTATE: `HY000` (`ER_CANT_AGGREGATE_3COLLATIONS`)

  Message: Illegal mix of collations (%s,%s), (%s,%s), (%s,%s) for operation '%s'

- Error: `1271` SQLSTATE: `HY000` (`ER_CANT_AGGREGATE_NCOLLATIONS`)

  Message: Illegal mix of collations for operation '%s'

- Error: `1272` SQLSTATE: `HY000` (`ER_VARIABLE_IS_NOT_STRUCT`)

  Message: Variable '%s' is not a variable component (can't be used as XXXX.variable_name)

- Error: `1273` SQLSTATE: `HY000` (`ER_UNKNOWN_COLLATION`)

  Message: Unknown collation: '%s'

- Error: `1274` SQLSTATE: `HY000` (`ER_SLAVE_IGNORED_SSL_PARAMS`)

  Message: SSL parameters in CHANGE MASTER are ignored because this MySQL slave was compiled without SSL support; they can be used later if MySQL slave with SSL is started

- Error: `1275` SQLSTATE: `HY000` (`ER_SERVER_IS_IN_SECURE_AUTH_MODE`)

  Message: Server is running in --secure-auth mode, but '%s'@'%s' has a password in the old format; please change the password to the new format

- Error: `1276` SQLSTATE: `HY000` (`ER_WARN_FIELD_RESOLVED`)

  Message: Field or reference '%s%s%s%s%s' of SELECT #%d was resolved in SELECT #%d

- Error: `1277` SQLSTATE: `HY000` (`ER_BAD_SLAVE_UNTIL_COND`)

  Message: Incorrect parameter or combination of parameters for START SLAVE UNTIL

- Error: `1278` SQLSTATE: `HY000` (`ER_MISSING_SKIP_SLAVE`)

  Message: It is recommended to use --skip-slave-start when doing step-by-step replication with START SLAVE UNTIL; otherwise, you will get problems if you get an unexpected slave's mysqld restart

- Error: `1279` SQLSTATE: `HY000` (`ER_UNTIL_COND_IGNORED`)

  Message: SQL thread is not to be started so UNTIL options are ignored

- Error: `1280` SQLSTATE: `42000` (`ER_WRONG_NAME_FOR_INDEX`)

  Message: Incorrect index name '%s'

- Error: `1281` SQLSTATE: `42000` (`ER_WRONG_NAME_FOR_CATALOG`)

  Message: Incorrect catalog name '%s'

- Error: `1282` SQLSTATE: `HY000` (`ER_WARN_QC_RESIZE`)

  Message: Query cache failed to set size %lu; new query cache size is %lu

- Error: `1283` SQLSTATE: `HY000` (`ER_BAD_FT_COLUMN`)

  Message: Column '%s' cannot be part of FULLTEXT index

- Error: `1284` SQLSTATE: `HY000` (`ER_UNKNOWN_KEY_CACHE`)

  Message: Unknown key cache '%s'

- Error: `1285` SQLSTATE: `HY000` (`ER_WARN_HOSTNAME_WONT_WORK`)

  Message: MySQL is started in --skip-name-resolve mode; you must restart it without this switch for this grant to work

- Error: `1286` SQLSTATE: `42000` (`ER_UNKNOWN_STORAGE_ENGINE`)

  Message: Unknown storage engine '%s'

- Error: `1287` SQLSTATE: `HY000` (`ER_WARN_DEPRECATED_SYNTAX`)

  Message: '%s' is deprecated and will be removed in a future release. Please use %s instead

- Error: `1288` SQLSTATE: `HY000` (`ER_NON_UPDATABLE_TABLE`)

  Message: The target table %s of the %s is not updatable

- Error: `1289` SQLSTATE: `HY000` (`ER_FEATURE_DISABLED`)

  Message: The '%s' feature is disabled; you need MySQL built with '%s' to have it working

- Error: `1290` SQLSTATE: `HY000` (`ER_OPTION_PREVENTS_STATEMENT`)

  Message: The MySQL server is running with the %s option so it cannot execute this statement

- Error: `1291` SQLSTATE: `HY000` (`ER_DUPLICATED_VALUE_IN_TYPE`)

  Message: Column '%s' has duplicated value '%s' in %s

- Error: `1292` SQLSTATE: `22007` (`ER_TRUNCATED_WRONG_VALUE`)

Message: Truncated incorrect %s value: '%s'

- Error: `1293` SQLSTATE: `HY000` (`ER_TOO_MUCH_AUTO_TIMESTAMP_COLS`)

  Message: Incorrect table definition; there can be only one TIMESTAMP column with CURRENT_TIMESTAMP in DEFAULT or ON UPDATE clause

- Error: `1294` SQLSTATE: `HY000` (`ER_INVALID_ON_UPDATE`)

  Message: Invalid ON UPDATE clause for '%s' column

- Error: `1295` SQLSTATE: `HY000` (`ER_UNSUPPORTED_PS`)

  Message: This command is not supported in the prepared statement protocol yet

- Error: `1296` SQLSTATE: `HY000` (`ER_GET_ERRMSG`)

  Message: Got error %d '%s' from %s

- Error: `1297` SQLSTATE: `HY000` (`ER_GET_TEMPORARY_ERRMSG`)

  Message: Got temporary error %d '%s' from %s

- Error: `1298` SQLSTATE: `HY000` (`ER_UNKNOWN_TIME_ZONE`)

  Message: Unknown or incorrect time zone: '%s'

- Error: `1299` SQLSTATE: `HY000` (`ER_WARN_INVALID_TIMESTAMP`)

  Message: Invalid TIMESTAMP value in column '%s' at row %ld

- Error: `1300` SQLSTATE: `HY000` (`ER_INVALID_CHARACTER_STRING`)

  Message: Invalid %s character string: '%s'

- Error: `1301` SQLSTATE: `HY000` (`ER_WARN_ALLOWED_PACKET_OVERFLOWED`)

  Message: Result of %s() was larger than max_allowed_packet (%ld) - truncated

- Error: `1302` SQLSTATE: `HY000` (`ER_CONFLICTING_DECLARATIONS`)

  Message: Conflicting declarations: '%s%s' and '%s%s'

- Error: `1303` SQLSTATE: `2F003` (`ER_SP_NO_RECURSIVE_CREATE`)

  Message: Can't create a %s from within another stored routine

- Error: `1304` SQLSTATE: `42000` (`ER_SP_ALREADY_EXISTS`)

  Message: %s %s already exists

- Error: `1305` SQLSTATE: `42000` (`ER_SP_DOES_NOT_EXIST`)

  Message: %s %s does not exist

- Error: `1306` SQLSTATE: `HY000` (`ER_SP_DROP_FAILED`)

  Message: Failed to DROP %s %s

- Error: `1307` SQLSTATE: `HY000` (`ER_SP_STORE_FAILED`)

  Message: Failed to CREATE %s %s

- Error: `1308` SQLSTATE: `42000` (`ER_SP_LILABEL_MISMATCH`)

  Message: %s with no matching label: %s

- Error: `1309` SQLSTATE: `42000` (`ER_SP_LABEL_REDEFINE`)

  Message: Redefining label %s

- Error: `1310` SQLSTATE: `42000` (`ER_SP_LABEL_MISMATCH`)

  Message: End-label %s without match

- Error: `1311` SQLSTATE: `01000` (`ER_SP_UNINIT_VAR`)

  Message: Referring to uninitialized variable %s

- Error: `1312` SQLSTATE: `0A000` (`ER_SP_BADSELECT`)

  Message: PROCEDURE %s can't return a result set in the given context

- Error: `1313` SQLSTATE: `42000` (`ER_SP_BADRETURN`)

  Message: RETURN is only allowed in a FUNCTION

- Error: `1314` SQLSTATE: `0A000` (`ER_SP_BADSTATEMENT`)

  Message: %s is not allowed in stored procedures

- Error: `1315` SQLSTATE: `42000` (`ER_UPDATE_LOG_DEPRECATED_IGNORED`)

  Message: The update log is deprecated and replaced by the binary log; SET SQL_LOG_UPDATE has been ignored. This option will be removed in MySQL 5.6.

- Error: `1316` SQLSTATE: `42000` (`ER_UPDATE_LOG_DEPRECATED_TRANSLATED`)

  Message: The update log is deprecated and replaced by the binary log; SET SQL_LOG_UPDATE has been translated to SET SQL_LOG_BIN. This option will be removed in MySQL 5.6.

- Error: `1317` SQLSTATE: `70100` (`ER_QUERY_INTERRUPTED`)

  Message: Query execution was interrupted

- Error: `1318` SQLSTATE: `42000` (`ER_SP_WRONG_NO_OF_ARGS`)

  Message: Incorrect number of arguments for %s %s; expected %u, got %u

- Error: `1319` SQLSTATE: `42000` (`ER_SP_COND_MISMATCH`)

  Message: Undefined CONDITION: %s

- Error: `1320` SQLSTATE: `42000` (`ER_SP_NORETURN`)

  Message: No RETURN found in FUNCTION %s

- Error: `1321` SQLSTATE: `2F005` (`ER_SP_NORETURNEND`)

  Message: FUNCTION %s ended without RETURN

- Error: `1322` SQLSTATE: `42000` (`ER_SP_BAD_CURSOR_QUERY`)

  Message: Cursor statement must be a SELECT

- Error: `1323` SQLSTATE: `42000` (`ER_SP_BAD_CURSOR_SELECT`)

  Message: Cursor SELECT must not have INTO

- Error: `1324` SQLSTATE: `42000` (`ER_SP_CURSOR_MISMATCH`)

  Message: Undefined CURSOR: %s

- Error: `1325` SQLSTATE: `24000` (`ER_SP_CURSOR_ALREADY_OPEN`)

  Message: Cursor is already open

- Error: `1326` SQLSTATE: `24000` (`ER_SP_CURSOR_NOT_OPEN`)

  Message: Cursor is not open

- Error: `1327` SQLSTATE: `42000` (`ER_SP_UNDECLARED_VAR`)

Message: Undeclared variable: %s

- Error: `1328` SQLSTATE: `HY000` (`ER_SP_WRONG_NO_OF_FETCH_ARGS`)

  Message: Incorrect number of FETCH variables
- Error: `1329` SQLSTATE: `02000` (`ER_SP_FETCH_NO_DATA`)

  Message: No data - zero rows fetched, selected, or processed
- Error: `1330` SQLSTATE: `42000` (`ER_SP_DUP_PARAM`)

  Message: Duplicate parameter: %s
- Error: `1331` SQLSTATE: `42000` (`ER_SP_DUP_VAR`)

  Message: Duplicate variable: %s
- Error: `1332` SQLSTATE: `42000` (`ER_SP_DUP_COND`)

  Message: Duplicate condition: %s
- Error: `1333` SQLSTATE: `42000` (`ER_SP_DUP_CURS`)

  Message: Duplicate cursor: %s
- Error: `1334` SQLSTATE: `HY000` (`ER_SP_CANT_ALTER`)

  Message: Failed to ALTER %s %s
- Error: `1335` SQLSTATE: `0A000` (`ER_SP_SUBSELECT_NYI`)

  Message: Subquery value not supported
- Error: `1336` SQLSTATE: `0A000` (`ER_STMT_NOT_ALLOWED_IN_SF_OR_TRG`)

  Message: %s is not allowed in stored function or trigger
- Error: `1337` SQLSTATE: `42000` (`ER_SP_VARCOND_AFTER_CURSHNDLR`)

  Message: Variable or condition declaration after cursor or handler declaration
- Error: `1338` SQLSTATE: `42000` (`ER_SP_CURSOR_AFTER_HANDLER`)

  Message: Cursor declaration after handler declaration
- Error: `1339` SQLSTATE: `20000` (`ER_SP_CASE_NOT_FOUND`)

  Message: Case not found for CASE statement
- Error: `1340` SQLSTATE: `HY000` (`ER_FPARSER_TOO_BIG_FILE`)

  Message: Configuration file '%s' is too big
- Error: `1341` SQLSTATE: `HY000` (`ER_FPARSER_BAD_HEADER`)

  Message: Malformed file type header in file '%s'
- Error: `1342` SQLSTATE: `HY000` (`ER_FPARSER_EOF_IN_COMMENT`)

  Message: Unexpected end of file while parsing comment '%s'
- Error: `1343` SQLSTATE: `HY000` (`ER_FPARSER_ERROR_IN_PARAMETER`)

  Message: Error while parsing parameter '%s' (line: '%s')
- Error: `1344` SQLSTATE: `HY000` (`ER_FPARSER_EOF_IN_UNKNOWN_PARAMETER`)

  Message: Unexpected end of file while skipping unknown parameter '%s'
- Error: `1345` SQLSTATE: `HY000` (`ER_VIEW_NO_EXPLAIN`)

Message: EXPLAIN/SHOW can not be issued; lacking privileges for underlying table

- Error: `1346` SQLSTATE: `HY000` (`ER_FRM_UNKNOWN_TYPE`)

  Message: File '%s' has unknown type '%s' in its header

- Error: `1347` SQLSTATE: `HY000` (`ER_WRONG_OBJECT`)

  Message: '%s.%s' is not %s

- Error: `1348` SQLSTATE: `HY000` (`ER_NONUPDATEABLE_COLUMN`)

  Message: Column '%s' is not updatable

- Error: `1349` SQLSTATE: `HY000` (`ER_VIEW_SELECT_DERIVED`)

  Message: View's SELECT contains a subquery in the FROM clause

- Error: `1350` SQLSTATE: `HY000` (`ER_VIEW_SELECT_CLAUSE`)

  Message: View's SELECT contains a '%s' clause

- Error: `1351` SQLSTATE: `HY000` (`ER_VIEW_SELECT_VARIABLE`)

  Message: View's SELECT contains a variable or parameter

- Error: `1352` SQLSTATE: `HY000` (`ER_VIEW_SELECT_TMPTABLE`)

  Message: View's SELECT refers to a temporary table '%s'

- Error: `1353` SQLSTATE: `HY000` (`ER_VIEW_WRONG_LIST`)

  Message: View's SELECT and view's field list have different column counts

- Error: `1354` SQLSTATE: `HY000` (`ER_WARN_VIEW_MERGE`)

  Message: View merge algorithm can't be used here for now (assumed undefined algorithm)

- Error: `1355` SQLSTATE: `HY000` (`ER_WARN_VIEW_WITHOUT_KEY`)

  Message: View being updated does not have complete key of underlying table in it

- Error: `1356` SQLSTATE: `HY000` (`ER_VIEW_INVALID`)

  Message: View '%s.%s' references invalid table(s) or column(s) or function(s) or definer/invoker of view lack rights to use them

- Error: `1357` SQLSTATE: `HY000` (`ER_SP_NO_DROP_SP`)

  Message: Can't drop or alter a %s from within another stored routine

- Error: `1358` SQLSTATE: `HY000` (`ER_SP_GOTO_IN_HNDLR`)

  Message: GOTO is not allowed in a stored procedure handler

- Error: `1359` SQLSTATE: `HY000` (`ER_TRG_ALREADY_EXISTS`)

  Message: Trigger already exists

- Error: `1360` SQLSTATE: `HY000` (`ER_TRG_DOES_NOT_EXIST`)

  Message: Trigger does not exist

- Error: `1361` SQLSTATE: `HY000` (`ER_TRG_ON_VIEW_OR_TEMP_TABLE`)

  Message: Trigger's '%s' is view or temporary table

- Error: `1362` SQLSTATE: `HY000` (`ER_TRG_CANT_CHANGE_ROW`)

  Message: Updating of %s row is not allowed in %strigger

- Error: `1363` SQLSTATE: `HY000` (`ER_TRG_NO_SUCH_ROW_IN_TRG`)

  Message: There is no %s row in %s trigger
- Error: `1364` SQLSTATE: `HY000` (`ER_NO_DEFAULT_FOR_FIELD`)

  Message: Field '%s' doesn't have a default value
- Error: `1365` SQLSTATE: `22012` (`ER_DIVISION_BY_ZERO`)

  Message: Division by 0
- Error: `1366` SQLSTATE: `HY000` (`ER_TRUNCATED_WRONG_VALUE_FOR_FIELD`)

  Message: Incorrect %s value: '%s' for column '%s' at row %ld
- Error: `1367` SQLSTATE: `22007` (`ER_ILLEGAL_VALUE_FOR_TYPE`)

  Message: Illegal %s '%s' value found during parsing
- Error: `1368` SQLSTATE: `HY000` (`ER_VIEW_NONUPD_CHECK`)

  Message: CHECK OPTION on non-updatable view '%s.%s'
- Error: `1369` SQLSTATE: `HY000` (`ER_VIEW_CHECK_FAILED`)

  Message: CHECK OPTION failed '%s.%s'
- Error: `1370` SQLSTATE: `42000` (`ER_PROCACCESS_DENIED_ERROR`)

  Message: %s command denied to user '%s'@'%s' for routine '%s'
- Error: `1371` SQLSTATE: `HY000` (`ER_RELAY_LOG_FAIL`)

  Message: Failed purging old relay logs: %s
- Error: `1372` SQLSTATE: `HY000` (`ER_PASSWD_LENGTH`)

  Message: Password hash should be a %d-digit hexadecimal number
- Error: `1373` SQLSTATE: `HY000` (`ER_UNKNOWN_TARGET_BINLOG`)

  Message: Target log not found in binlog index
- Error: `1374` SQLSTATE: `HY000` (`ER_IO_ERR_LOG_INDEX_READ`)

  Message: I/O error reading log index file
- Error: `1375` SQLSTATE: `HY000` (`ER_BINLOG_PURGE_PROHIBITED`)

  Message: Server configuration does not permit binlog purge
- Error: `1376` SQLSTATE: `HY000` (`ER_FSEEK_FAIL`)

  Message: Failed on fseek()
- Error: `1377` SQLSTATE: `HY000` (`ER_BINLOG_PURGE_FATAL_ERR`)

  Message: Fatal error during log purge
- Error: `1378` SQLSTATE: `HY000` (`ER_LOG_IN_USE`)

  Message: A purgeable log is in use, will not purge
- Error: `1379` SQLSTATE: `HY000` (`ER_LOG_PURGE_UNKNOWN_ERR`)

  Message: Unknown error during log purge
- Error: `1380` SQLSTATE: `HY000` (`ER_RELAY_LOG_INIT`)

  Message: Failed initializing relay log position: %s

- Error: `1381` SQLSTATE: `HY000` (`ER_NO_BINARY_LOGGING`)

  Message: You are not using binary logging
- Error: `1382` SQLSTATE: `HY000` (`ER_RESERVED_SYNTAX`)

  Message: The '%s' syntax is reserved for purposes internal to the MySQL server
- Error: `1383` SQLSTATE: `HY000` (`ER_WSAS_FAILED`)

  Message: WSAStartup Failed
- Error: `1384` SQLSTATE: `HY000` (`ER_DIFF_GROUPS_PROC`)

  Message: Can't handle procedures with different groups yet
- Error: `1385` SQLSTATE: `HY000` (`ER_NO_GROUP_FOR_PROC`)

  Message: Select must have a group with this procedure
- Error: `1386` SQLSTATE: `HY000` (`ER_ORDER_WITH_PROC`)

  Message: Can't use ORDER clause with this procedure
- Error: `1387` SQLSTATE: `HY000` (`ER_LOGGING_PROHIBIT_CHANGING_OF`)

  Message: Binary logging and replication forbid changing the global server %s
- Error: `1388` SQLSTATE: `HY000` (`ER_NO_FILE_MAPPING`)

  Message: Can't map file: %s, errno: %d
- Error: `1389` SQLSTATE: `HY000` (`ER_WRONG_MAGIC`)

  Message: Wrong magic in %s
- Error: `1390` SQLSTATE: `HY000` (`ER_PS_MANY_PARAM`)

  Message: Prepared statement contains too many placeholders
- Error: `1391` SQLSTATE: `HY000` (`ER_KEY_PART_0`)

  Message: Key part '%s' length cannot be 0
- Error: `1392` SQLSTATE: `HY000` (`ER_VIEW_CHECKSUM`)

  Message: View text checksum failed
- Error: `1393` SQLSTATE: `HY000` (`ER_VIEW_MULTIUPDATE`)

  Message: Can not modify more than one base table through a join view '%s.%s'
- Error: `1394` SQLSTATE: `HY000` (`ER_VIEW_NO_INSERT_FIELD_LIST`)

  Message: Can not insert into join view '%s.%s' without fields list
- Error: `1395` SQLSTATE: `HY000` (`ER_VIEW_DELETE_MERGE_VIEW`)

  Message: Can not delete from join view '%s.%s'
- Error: `1396` SQLSTATE: `HY000` (`ER_CANNOT_USER`)

  Message: Operation %s failed for %s
- Error: `1397` SQLSTATE: `XAE04` (`ER_XAER_NOTA`)

  Message: XAER_NOTA: Unknown XID
- Error: `1398` SQLSTATE: `XAE05` (`ER_XAER_INVAL`)

  Message: XAER_INVAL: Invalid arguments (or unsupported command)

- Error: `1399` SQLSTATE: `XAE07` (`ER_XAER_RMFAIL`)

  Message: XAER_RMFAIL: The command cannot be executed when global transaction is in the %s state
- Error: `1400` SQLSTATE: `XAE09` (`ER_XAER_OUTSIDE`)

  Message: XAER_OUTSIDE: Some work is done outside global transaction
- Error: `1401` SQLSTATE: `XAE03` (`ER_XAER_RMERR`)

  Message: XAER_RMERR: Fatal error occurred in the transaction branch - check your data for consistency
- Error: `1402` SQLSTATE: `XA100` (`ER_XA_RBROLLBACK`)

  Message: XA_RBROLLBACK: Transaction branch was rolled back
- Error: `1403` SQLSTATE: `42000` (`ER_NONEXISTING_PROC_GRANT`)

  Message: There is no such grant defined for user '%s' on host '%s' on routine '%s'
- Error: `1404` SQLSTATE: `HY000` (`ER_PROC_AUTO_GRANT_FAIL`)

  Message: Failed to grant EXECUTE and ALTER ROUTINE privileges
- Error: `1405` SQLSTATE: `HY000` (`ER_PROC_AUTO_REVOKE_FAIL`)

  Message: Failed to revoke all privileges to dropped routine
- Error: `1406` SQLSTATE: `22001` (`ER_DATA_TOO_LONG`)

  Message: Data too long for column '%s' at row %ld
- Error: `1407` SQLSTATE: `42000` (`ER_SP_BAD_SQLSTATE`)

  Message: Bad SQLSTATE: '%s'
- Error: `1408` SQLSTATE: `HY000` (`ER_STARTUP`)

  Message: %s: ready for connections. Version: '%s' socket: '%s' port: %d %s
- Error: `1409` SQLSTATE: `HY000` (`ER_LOAD_FROM_FIXED_SIZE_ROWS_TO_VAR`)

  Message: Can't load value from file with fixed size rows to variable
- Error: `1410` SQLSTATE: `42000` (`ER_CANT_CREATE_USER_WITH_GRANT`)

  Message: You are not allowed to create a user with GRANT
- Error: `1411` SQLSTATE: `HY000` (`ER_WRONG_VALUE_FOR_TYPE`)

  Message: Incorrect %s value: '%s' for function %s
- Error: `1412` SQLSTATE: `HY000` (`ER_TABLE_DEF_CHANGED`)

  Message: Table definition has changed, please retry transaction
- Error: `1413` SQLSTATE: `42000` (`ER_SP_DUP_HANDLER`)

  Message: Duplicate handler declared in the same block
- Error: `1414` SQLSTATE: `42000` (`ER_SP_NOT_VAR_ARG`)

  Message: OUT or INOUT argument %d for routine %s is not a variable or NEW pseudo-variable in BEFORE trigger
- Error: `1415` SQLSTATE: `0A000` (`ER_SP_NO_RETSET`)

  Message: Not allowed to return a result set from a %s
- Error: `1416` SQLSTATE: `22003` (`ER_CANT_CREATE_GEOMETRY_OBJECT`)

  Message: Cannot get geometry object from data you send to the GEOMETRY field

- Error: `1417` SQLSTATE: `HY000` (`ER_FAILED_ROUTINE_BREAK_BINLOG`)

  Message: A routine failed and has neither NO SQL nor READS SQL DATA in its declaration and binary logging is enabled; if non-transactional tables were updated, the binary log will miss their changes

- Error: `1418` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_ROUTINE`)

  Message: This function has none of DETERMINISTIC, NO SQL, or READS SQL DATA in its declaration and binary logging is enabled (you *might* want to use the less safe log_bin_trust_function_creators variable)

- Error: `1419` SQLSTATE: `HY000` (`ER_BINLOG_CREATE_ROUTINE_NEED_SUPER`)

  Message: You do not have the SUPER privilege and binary logging is enabled (you *might* want to use the less safe log_bin_trust_function_creators variable)

- Error: `1420` SQLSTATE: `HY000` (`ER_EXEC_STMT_WITH_OPEN_CURSOR`)

  Message: You can't execute a prepared statement which has an open cursor associated with it. Reset the statement to re-execute it.

- Error: `1421` SQLSTATE: `HY000` (`ER_STMT_HAS_NO_OPEN_CURSOR`)

  Message: The statement (%lu) has no open cursor.

- Error: `1422` SQLSTATE: `HY000` (`ER_COMMIT_NOT_ALLOWED_IN_SF_OR_TRG`)

  Message: Explicit or implicit commit is not allowed in stored function or trigger.

- Error: `1423` SQLSTATE: `HY000` (`ER_NO_DEFAULT_FOR_VIEW_FIELD`)

  Message: Field of view '%s.%s' underlying table doesn't have a default value

- Error: `1424` SQLSTATE: `HY000` (`ER_SP_NO_RECURSION`)

  Message: Recursive stored functions and triggers are not allowed.

- Error: `1425` SQLSTATE: `42000` (`ER_TOO_BIG_SCALE`)

  Message: Too big scale %d specified for column '%s'. Maximum is %lu.

- Error: `1426` SQLSTATE: `42000` (`ER_TOO_BIG_PRECISION`)

  Message: Too big precision %d specified for column '%s'. Maximum is %lu.

- Error: `1427` SQLSTATE: `42000` (`ER_M_BIGGER_THAN_D`)

  Message: For float(M,D), double(M,D) or decimal(M,D), M must be >= D (column '%s').

- Error: `1428` SQLSTATE: `HY000` (`ER_WRONG_LOCK_OF_SYSTEM_TABLE`)

  Message: You can't combine write-locking of system tables with other tables or lock types

- Error: `1429` SQLSTATE: `HY000` (`ER_CONNECT_TO_FOREIGN_DATA_SOURCE`)

  Message: Unable to connect to foreign data source: %s

- Error: `1430` SQLSTATE: `HY000` (`ER_QUERY_ON_FOREIGN_DATA_SOURCE`)

  Message: There was a problem processing the query on the foreign data source. Data source error: %s

- Error: `1431` SQLSTATE: `HY000` (`ER_FOREIGN_DATA_SOURCE_DOESNT_EXIST`)

  Message: The foreign data source you are trying to reference does not exist. Data source error: %s

- Error: `1432` SQLSTATE: `HY000` (`ER_FOREIGN_DATA_STRING_INVALID_CANT_CREATE`)

  Message: Can't create federated table. The data source connection string '%s' is not in the correct format

- Error: `1433` SQLSTATE: `HY000` (`ER_FOREIGN_DATA_STRING_INVALID`)

  Message: The data source connection string '%s' is not in the correct format

- Error: `1434` SQLSTATE: `HY000` (`ER_CANT_CREATE_FEDERATED_TABLE`)

  Message: Can't create federated table. Foreign data src error: %s

- Error: `1435` SQLSTATE: `HY000` (`ER_TRG_IN_WRONG_SCHEMA`)

  Message: Trigger in wrong schema

- Error: `1436` SQLSTATE: `HY000` (`ER_STACK_OVERRUN_NEED_MORE`)

  Message: Thread stack overrun: %ld bytes used of a %ld byte stack, and %ld bytes needed. Use 'mysqld --thread_stack=#' to specify a bigger stack.

- Error: `1437` SQLSTATE: `42000` (`ER_TOO_LONG_BODY`)

  Message: Routine body for '%s' is too long

- Error: `1438` SQLSTATE: `HY000` (`ER_WARN_CANT_DROP_DEFAULT_KEYCACHE`)

  Message: Cannot drop default keycache

- Error: `1439` SQLSTATE: `42000` (`ER_TOO_BIG_DISPLAYWIDTH`)

  Message: Display width out of range for column '%s' (max = %lu)

- Error: `1440` SQLSTATE: `XAE08` (`ER_XAER_DUPID`)

  Message: XAER_DUPID: The XID already exists

- Error: `1441` SQLSTATE: `22008` (`ER_DATETIME_FUNCTION_OVERFLOW`)

  Message: Datetime function: %s field overflow

- Error: `1442` SQLSTATE: `HY000` (`ER_CANT_UPDATE_USED_TABLE_IN_SF_OR_TRG`)

  Message: Can't update table '%s' in stored function/trigger because it is already used by statement which invoked this stored function/trigger.

- Error: `1443` SQLSTATE: `HY000` (`ER_VIEW_PREVENT_UPDATE`)

  Message: The definition of table '%s' prevents operation %s on table '%s'.

- Error: `1444` SQLSTATE: `HY000` (`ER_PS_NO_RECURSION`)

  Message: The prepared statement contains a stored routine call that refers to that same statement. It's not allowed to execute a prepared statement in such a recursive manner

- Error: `1445` SQLSTATE: `HY000` (`ER_SP_CANT_SET_AUTOCOMMIT`)

  Message: Not allowed to set autocommit from a stored function or trigger

- Error: `1446` SQLSTATE: `HY000` (`ER_MALFORMED_DEFINER`)

  Message: Definer is not fully qualified

- Error: `1447` SQLSTATE: `HY000` (`ER_VIEW_FRM_NO_USER`)

  Message: View '%s'.'%s' has no definer information (old table format). Current user is used as definer. Please recreate the view!

- Error: `1448` SQLSTATE: `HY000` (`ER_VIEW_OTHER_USER`)

  Message: You need the SUPER privilege for creation view with '%s'@'%s' definer

- Error: `1449` SQLSTATE: `HY000` (`ER_NO_SUCH_USER`)

  Message: The user specified as a definer ('%s'@'%s') does not exist

- Error: `1450` SQLSTATE: `HY000` (`ER_FORBID_SCHEMA_CHANGE`)

  Message: Changing schema from '%s' to '%s' is not allowed.

- Error: `1451` SQLSTATE: `23000` (`ER_ROW_IS_REFERENCED_2`)

Message: Cannot delete or update a parent row: a foreign key constraint fails (%s)

- Error: `1452` SQLSTATE: `23000` (`ER_NO_REFERENCED_ROW_2`)

  Message: Cannot add or update a child row: a foreign key constraint fails (%s)

- Error: `1453` SQLSTATE: `42000` (`ER_SP_BAD_VAR_SHADOW`)

  Message: Variable '%s' must be quoted with \`...\`, or renamed

- Error: `1454` SQLSTATE: `HY000` (`ER_TRG_NO_DEFINER`)

  Message: No definer attribute for trigger '%s'.'%s'. The trigger will be activated under the authorization of the invoker, which may have insufficient privileges. Please recreate the trigger.

- Error: `1455` SQLSTATE: `HY000` (`ER_OLD_FILE_FORMAT`)

  Message: '%s' has an old format, you should re-create the '%s' object(s)

- Error: `1456` SQLSTATE: `HY000` (`ER_SP_RECURSION_LIMIT`)

  Message: Recursive limit %d (as set by the max_sp_recursion_depth variable) was exceeded for routine %s

- Error: `1457` SQLSTATE: `HY000` (`ER_SP_PROC_TABLE_CORRUPT`)

  Message: Failed to load routine %s. The table mysql.proc is missing, corrupt, or contains bad data (internal code %d)

- Error: `1458` SQLSTATE: `42000` (`ER_SP_WRONG_NAME`)

  Message: Incorrect routine name '%s'

- Error: `1459` SQLSTATE: `HY000` (`ER_TABLE_NEEDS_UPGRADE`)

  Message: Table upgrade required. Please do "REPAIR TABLE \`%s\`" or dump/reload to fix it!

- Error: `1460` SQLSTATE: `42000` (`ER_SP_NO_AGGREGATE`)

  Message: AGGREGATE is not supported for stored functions

- Error: `1461` SQLSTATE: `42000` (`ER_MAX_PREPARED_STMT_COUNT_REACHED`)

  Message: Can't create more than max_prepared_stmt_count statements (current value: %lu)

- Error: `1462` SQLSTATE: `HY000` (`ER_VIEW_RECURSIVE`)

  Message: \`%s\`.\`%s\` contains view recursion

- Error: `1463` SQLSTATE: `42000` (`ER_NON_GROUPING_FIELD_USED`)

  Message: non-grouping field '%s' is used in %s clause

- Error: `1464` SQLSTATE: `HY000` (`ER_TABLE_CANT_HANDLE_SPKEYS`)

  Message: The used table type doesn't support SPATIAL indexes

- Error: `1465` SQLSTATE: `HY000` (`ER_NO_TRIGGERS_ON_SYSTEM_SCHEMA`)

  Message: Triggers can not be created on system tables

- Error: `1466` SQLSTATE: `HY000` (`ER_REMOVED_SPACES`)

  Message: Leading spaces are removed from name '%s'

- Error: `1467` SQLSTATE: `HY000` (`ER_AUTOINC_READ_FAILED`)

  Message: Failed to read auto-increment value from storage engine

- Error: `1468` SQLSTATE: `HY000` (`ER_USERNAME`)

  Message: user name

- Error: `1469` SQLSTATE: `HY000` (`ER_HOSTNAME`)

  Message: host name

- Error: `1470` SQLSTATE: `HY000` (`ER_WRONG_STRING_LENGTH`)

  Message: String '%s' is too long for %s (should be no longer than %d)

- Error: `1471` SQLSTATE: `HY000` (`ER_NON_INSERTABLE_TABLE`)

  Message: The target table %s of the %s is not insertable-into

- Error: `1472` SQLSTATE: `HY000` (`ER_ADMIN_WRONG_MRG_TABLE`)

  Message: Table '%s' is differently defined or of non-MyISAM type or doesn't exist

- Error: `1473` SQLSTATE: `HY000` (`ER_TOO_HIGH_LEVEL_OF_NESTING_FOR_SELECT`)

  Message: Too high level of nesting for select

- Error: `1474` SQLSTATE: `HY000` (`ER_NAME_BECOMES_EMPTY`)

  Message: Name '%s' has become ''

- Error: `1475` SQLSTATE: `HY000` (`ER_AMBIGUOUS_FIELD_TERM`)

  Message: First character of the FIELDS TERMINATED string is ambiguous; please use non-optional and non-empty FIELDS ENCLOSED BY

- Error: `1476` SQLSTATE: `HY000` (`ER_FOREIGN_SERVER_EXISTS`)

  Message: The foreign server, %s, you are trying to create already exists.

- Error: `1477` SQLSTATE: `HY000` (`ER_FOREIGN_SERVER_DOESNT_EXIST`)

  Message: The foreign server name you are trying to reference does not exist. Data source error: %s

- Error: `1478` SQLSTATE: `HY000` (`ER_ILLEGAL_HA_CREATE_OPTION`)

  Message: Table storage engine '%s' does not support the create option '%s'

- Error: `1479` SQLSTATE: `HY000` (`ER_PARTITION_REQUIRES_VALUES_ERROR`)

  Message: Syntax error: %s PARTITIONING requires definition of VALUES %s for each partition

- Error: `1480` SQLSTATE: `HY000` (`ER_PARTITION_WRONG_VALUES_ERROR`)

  Message: Only %s PARTITIONING can use VALUES %s in partition definition

- Error: `1481` SQLSTATE: `HY000` (`ER_PARTITION_MAXVALUE_ERROR`)

  Message: MAXVALUE can only be used in last partition definition

- Error: `1482` SQLSTATE: `HY000` (`ER_PARTITION_SUBPARTITION_ERROR`)

  Message: Subpartitions can only be hash partitions and by key

- Error: `1483` SQLSTATE: `HY000` (`ER_PARTITION_SUBPART_MIX_ERROR`)

  Message: Must define subpartitions on all partitions if on one partition

- Error: `1484` SQLSTATE: `HY000` (`ER_PARTITION_WRONG_NO_PART_ERROR`)

  Message: Wrong number of partitions defined, mismatch with previous setting

- Error: `1485` SQLSTATE: `HY000` (`ER_PARTITION_WRONG_NO_SUBPART_ERROR`)

  Message: Wrong number of subpartitions defined, mismatch with previous setting

- Error: `1486` SQLSTATE: `HY000` (`ER_WRONG_EXPR_IN_PARTITION_FUNC_ERROR`)

  Message: Constant, random or timezone-dependent expressions in (sub)partitioning function are not allowed

- Error: `1487` SQLSTATE: `HY000` (`ER_NO_CONST_EXPR_IN_RANGE_OR_LIST_ERROR`)

  Message: Expression in RANGE/LIST VALUES must be constant

- Error: `1488` SQLSTATE: `HY000` (`ER_FIELD_NOT_FOUND_PART_ERROR`)

  Message: Field in list of fields for partition function not found in table

- Error: `1489` SQLSTATE: `HY000` (`ER_LIST_OF_FIELDS_ONLY_IN_HASH_ERROR`)

  Message: List of fields is only allowed in KEY partitions

- Error: `1490` SQLSTATE: `HY000` (`ER_INCONSISTENT_PARTITION_INFO_ERROR`)

  Message: The partition info in the frm file is not consistent with what can be written into the frm file

- Error: `1491` SQLSTATE: `HY000` (`ER_PARTITION_FUNC_NOT_ALLOWED_ERROR`)

  Message: The %s function returns the wrong type

- Error: `1492` SQLSTATE: `HY000` (`ER_PARTITIONS_MUST_BE_DEFINED_ERROR`)

  Message: For %s partitions each partition must be defined

- Error: `1493` SQLSTATE: `HY000` (`ER_RANGE_NOT_INCREASING_ERROR`)

  Message: VALUES LESS THAN value must be strictly increasing for each partition

- Error: `1494` SQLSTATE: `HY000` (`ER_INCONSISTENT_TYPE_OF_FUNCTIONS_ERROR`)

  Message: VALUES value must be of same type as partition function

- Error: `1495` SQLSTATE: `HY000` (`ER_MULTIPLE_DEF_CONST_IN_LIST_PART_ERROR`)

  Message: Multiple definition of same constant in list partitioning

- Error: `1496` SQLSTATE: `HY000` (`ER_PARTITION_ENTRY_ERROR`)

  Message: Partitioning can not be used stand-alone in query

- Error: `1497` SQLSTATE: `HY000` (`ER_MIX_HANDLER_ERROR`)

  Message: The mix of handlers in the partitions is not allowed in this version of MySQL

- Error: `1498` SQLSTATE: `HY000` (`ER_PARTITION_NOT_DEFINED_ERROR`)

  Message: For the partitioned engine it is necessary to define all %s

- Error: `1499` SQLSTATE: `HY000` (`ER_TOO_MANY_PARTITIONS_ERROR`)

  Message: Too many partitions (including subpartitions) were defined

- Error: `1500` SQLSTATE: `HY000` (`ER_SUBPARTITION_ERROR`)

  Message: It is only possible to mix RANGE/LIST partitioning with HASH/KEY partitioning for subpartitioning

- Error: `1501` SQLSTATE: `HY000` (`ER_CANT_CREATE_HANDLER_FILE`)

  Message: Failed to create specific handler file

- Error: `1502` SQLSTATE: `HY000` (`ER_BLOB_FIELD_IN_PART_FUNC_ERROR`)

  Message: A BLOB field is not allowed in partition function

- Error: `1503` SQLSTATE: `HY000` (`ER_UNIQUE_KEY_NEED_ALL_FIELDS_IN_PF`)

  Message: A %s must include all columns in the table's partitioning function

- Error: `1504` SQLSTATE: `HY000` (`ER_NO_PARTS_ERROR`)

  Message: Number of %s = 0 is not an allowed value

- Error: `1505` SQLSTATE: `HY000` (`ER_PARTITION_MGMT_ON_NONPARTITIONED`)

  Message: Partition management on a not partitioned table is not possible

- Error: `1506` SQLSTATE: `HY000` (`ER_FOREIGN_KEY_ON_PARTITIONED`)

  Message: Foreign key clause is not yet supported in conjunction with partitioning

- Error: `1507` SQLSTATE: `HY000` (`ER_DROP_PARTITION_NON_EXISTENT`)

  Message: Error in list of partitions to %s

- Error: `1508` SQLSTATE: `HY000` (`ER_DROP_LAST_PARTITION`)

  Message: Cannot remove all partitions, use DROP TABLE instead

- Error: `1509` SQLSTATE: `HY000` (`ER_COALESCE_ONLY_ON_HASH_PARTITION`)

  Message: COALESCE PARTITION can only be used on HASH/KEY partitions

- Error: `1510` SQLSTATE: `HY000` (`ER_REORG_HASH_ONLY_ON_SAME_NO`)

  Message: REORGANIZE PARTITION can only be used to reorganize partitions not to change their numbers

- Error: `1511` SQLSTATE: `HY000` (`ER_REORG_NO_PARAM_ERROR`)

  Message: REORGANIZE PARTITION without parameters can only be used on auto-partitioned tables using HASH PARTITIONs

- Error: `1512` SQLSTATE: `HY000` (`ER_ONLY_ON_RANGE_LIST_PARTITION`)

  Message: %s PARTITION can only be used on RANGE/LIST partitions

- Error: `1513` SQLSTATE: `HY000` (`ER_ADD_PARTITION_SUBPART_ERROR`)

  Message: Trying to Add partition(s) with wrong number of subpartitions

- Error: `1514` SQLSTATE: `HY000` (`ER_ADD_PARTITION_NO_NEW_PARTITION`)

  Message: At least one partition must be added

- Error: `1515` SQLSTATE: `HY000` (`ER_COALESCE_PARTITION_NO_PARTITION`)

  Message: At least one partition must be coalesced

- Error: `1516` SQLSTATE: `HY000` (`ER_REORG_PARTITION_NOT_EXIST`)

  Message: More partitions to reorganize than there are partitions

- Error: `1517` SQLSTATE: `HY000` (`ER_SAME_NAME_PARTITION`)

  Message: Duplicate partition name %s

- Error: `1518` SQLSTATE: `HY000` (`ER_NO_BINLOG_ERROR`)

  Message: It is not allowed to shut off binlog on this command

- Error: `1519` SQLSTATE: `HY000` (`ER_CONSECUTIVE_REORG_PARTITIONS`)

  Message: When reorganizing a set of partitions they must be in consecutive order

- Error: `1520` SQLSTATE: `HY000` (`ER_REORG_OUTSIDE_RANGE`)

  Message: Reorganize of range partitions cannot change total ranges except for last partition where it can extend the range

- Error: `1521` SQLSTATE: `HY000` (`ER_PARTITION_FUNCTION_FAILURE`)

  Message: Partition function not supported in this version for this handler

- Error: `1522` SQLSTATE: `HY000` (`ER_PART_STATE_ERROR`)

  Message: Partition state cannot be defined from CREATE/ALTER TABLE

- Error: `1523` SQLSTATE: `HY000` (`ER_LIMITED_PART_RANGE`)

  Message: The %s handler only supports 32 bit integers in VALUES
- Error: `1524` SQLSTATE: `HY000` (`ER_PLUGIN_IS_NOT_LOADED`)

  Message: Plugin '%s' is not loaded
- Error: `1525` SQLSTATE: `HY000` (`ER_WRONG_VALUE`)

  Message: Incorrect %s value: '%s'
- Error: `1526` SQLSTATE: `HY000` (`ER_NO_PARTITION_FOR_GIVEN_VALUE`)

  Message: Table has no partition for value %s
- Error: `1527` SQLSTATE: `HY000` (`ER_FILEGROUP_OPTION_ONLY_ONCE`)

  Message: It is not allowed to specify %s more than once
- Error: `1528` SQLSTATE: `HY000` (`ER_CREATE_FILEGROUP_FAILED`)

  Message: Failed to create %s
- Error: `1529` SQLSTATE: `HY000` (`ER_DROP_FILEGROUP_FAILED`)

  Message: Failed to drop %s
- Error: `1530` SQLSTATE: `HY000` (`ER_TABLESPACE_AUTO_EXTEND_ERROR`)

  Message: The handler doesn't support autoextend of tablespaces
- Error: `1531` SQLSTATE: `HY000` (`ER_WRONG_SIZE_NUMBER`)

  Message: A size parameter was incorrectly specified, either number or on the form 10M
- Error: `1532` SQLSTATE: `HY000` (`ER_SIZE_OVERFLOW_ERROR`)

  Message: The size number was correct but we don't allow the digit part to be more than 2 billion
- Error: `1533` SQLSTATE: `HY000` (`ER_ALTER_FILEGROUP_FAILED`)

  Message: Failed to alter: %s
- Error: `1534` SQLSTATE: `HY000` (`ER_BINLOG_ROW_LOGGING_FAILED`)

  Message: Writing one row to the row-based binary log failed
- Error: `1535` SQLSTATE: `HY000` (`ER_BINLOG_ROW_WRONG_TABLE_DEF`)

  Message: Table definition on master and slave does not match: %s
- Error: `1536` SQLSTATE: `HY000` (`ER_BINLOG_ROW_RBR_TO_SBR`)

  Message: Slave running with --log-slave-updates must use row-based binary logging to be able to replicate row-based binary log events
- Error: `1537` SQLSTATE: `HY000` (`ER_EVENT_ALREADY_EXISTS`)

  Message: Event '%s' already exists
- Error: `1538` SQLSTATE: `HY000` (`ER_EVENT_STORE_FAILED`)

  Message: Failed to store event %s. Error code %d from storage engine.
- Error: `1539` SQLSTATE: `HY000` (`ER_EVENT_DOES_NOT_EXIST`)

  Message: Unknown event '%s'
- Error: `1540` SQLSTATE: `HY000` (`ER_EVENT_CANT_ALTER`)

  Message: Failed to alter event '%s'

- Error: `1541` SQLSTATE: `HY000` (`ER_EVENT_DROP_FAILED`)

  Message: Failed to drop %s
- Error: `1542` SQLSTATE: `HY000` (`ER_EVENT_INTERVAL_NOT_POSITIVE_OR_TOO_BIG`)

  Message: INTERVAL is either not positive or too big
- Error: `1543` SQLSTATE: `HY000` (`ER_EVENT_ENDS_BEFORE_STARTS`)

  Message: ENDS is either invalid or before STARTS
- Error: `1544` SQLSTATE: `HY000` (`ER_EVENT_EXEC_TIME_IN_THE_PAST`)

  Message: Event execution time is in the past. Event has been disabled
- Error: `1545` SQLSTATE: `HY000` (`ER_EVENT_OPEN_TABLE_FAILED`)

  Message: Failed to open mysql.event
- Error: `1546` SQLSTATE: `HY000` (`ER_EVENT_NEITHER_M_EXPR_NOR_M_AT`)

  Message: No datetime expression provided
- Error: `1547` SQLSTATE: `HY000` (`ER_COL_COUNT_DOESNT_MATCH_CORRUPTED`)

  Message: Column count of mysql.%s is wrong. Expected %d, found %d. The table is probably corrupted
- Error: `1548` SQLSTATE: `HY000` (`ER_CANNOT_LOAD_FROM_TABLE`)

  Message: Cannot load from mysql.%s. The table is probably corrupted
- Error: `1549` SQLSTATE: `HY000` (`ER_EVENT_CANNOT_DELETE`)

  Message: Failed to delete the event from mysql.event
- Error: `1550` SQLSTATE: `HY000` (`ER_EVENT_COMPILE_ERROR`)

  Message: Error during compilation of event's body
- Error: `1551` SQLSTATE: `HY000` (`ER_EVENT_SAME_NAME`)

  Message: Same old and new event name
- Error: `1552` SQLSTATE: `HY000` (`ER_EVENT_DATA_TOO_LONG`)

  Message: Data for column '%s' too long
- Error: `1553` SQLSTATE: `HY000` (`ER_DROP_INDEX_FK`)

  Message: Cannot drop index '%s': needed in a foreign key constraint
- Error: `1554` SQLSTATE: `HY000` (`ER_WARN_DEPRECATED_SYNTAX_WITH_VER`)

  Message: The syntax '%s' is deprecated and will be removed in MySQL %s. Please use %s instead
- Error: `1555` SQLSTATE: `HY000` (`ER_CANT_WRITE_LOCK_LOG_TABLE`)

  Message: You can't write-lock a log table. Only read access is possible
- Error: `1556` SQLSTATE: `HY000` (`ER_CANT_LOCK_LOG_TABLE`)

  Message: You can't use locks with log tables.
- Error: `1557` SQLSTATE: `23000` (`ER_FOREIGN_DUPLICATE_KEY`)

  Message: Upholding foreign key constraints for table '%s', entry '%s', key %d would lead to a duplicate entry
- Error: `1558` SQLSTATE: `HY000` (`ER_COL_COUNT_DOESNT_MATCH_PLEASE_UPDATE`)

  Message: Column count of mysql.%s is wrong. Expected %d, found %d. Created with MySQL %d, now running %d. Please use mysql_upgrade to fix this error.

- Error: `1559` SQLSTATE: `HY000` (`ER_TEMP_TABLE_PREVENTS_SWITCH_OUT_OF_RBR`)

  Message: Cannot switch out of the row-based binary log format when the session has open temporary tables
- Error: `1560` SQLSTATE: `HY000` (`ER_STORED_FUNCTION_PREVENTS_SWITCH_BINLOG_FORMAT`)

  Message: Cannot change the binary logging format inside a stored function or trigger
- Error: `1561` SQLSTATE: `HY000` (`ER_NDB_CANT_SWITCH_BINLOG_FORMAT`)

  Message: The NDB cluster engine does not support changing the binlog format on the fly yet
- Error: `1562` SQLSTATE: `HY000` (`ER_PARTITION_NO_TEMPORARY`)

  Message: Cannot create temporary table with partitions
- Error: `1563` SQLSTATE: `HY000` (`ER_PARTITION_CONST_DOMAIN_ERROR`)

  Message: Partition constant is out of partition function domain
- Error: `1564` SQLSTATE: `HY000` (`ER_PARTITION_FUNCTION_IS_NOT_ALLOWED`)

  Message: This partition function is not allowed
- Error: `1565` SQLSTATE: `HY000` (`ER_DDL_LOG_ERROR`)

  Message: Error in DDL log
- Error: `1566` SQLSTATE: `HY000` (`ER_NULL_IN_VALUES_LESS_THAN`)

  Message: Not allowed to use NULL value in VALUES LESS THAN
- Error: `1567` SQLSTATE: `HY000` (`ER_WRONG_PARTITION_NAME`)

  Message: Incorrect partition name
- Error: `1568` SQLSTATE: `25001` (`ER_CANT_CHANGE_TX_ISOLATION`)

  Message: Transaction isolation level can't be changed while a transaction is in progress
- Error: `1569` SQLSTATE: `HY000` (`ER_DUP_ENTRY_AUTOINCREMENT_CASE`)

  Message: ALTER TABLE causes auto_increment resequencing, resulting in duplicate entry '%s' for key '%s'
- Error: `1570` SQLSTATE: `HY000` (`ER_EVENT_MODIFY_QUEUE_ERROR`)

  Message: Internal scheduler error %d
- Error: `1571` SQLSTATE: `HY000` (`ER_EVENT_SET_VAR_ERROR`)

  Message: Error during starting/stopping of the scheduler. Error code %u
- Error: `1572` SQLSTATE: `HY000` (`ER_PARTITION_MERGE_ERROR`)

  Message: Engine cannot be used in partitioned tables
- Error: `1573` SQLSTATE: `HY000` (`ER_CANT_ACTIVATE_LOG`)

  Message: Cannot activate '%s' log
- Error: `1574` SQLSTATE: `HY000` (`ER_RBR_NOT_AVAILABLE`)

  Message: The server was not built with row-based replication
- Error: `1575` SQLSTATE: `HY000` (`ER_BASE64_DECODE_ERROR`)

  Message: Decoding of base64 string failed
- Error: `1576` SQLSTATE: `HY000` (`ER_EVENT_RECURSION_FORBIDDEN`)

  Message: Recursion of EVENT DDL statements is forbidden when body is present

- Error: `1577` SQLSTATE: `HY000` (`ER_EVENTS_DB_ERROR`)

  Message: Cannot proceed because system tables used by Event Scheduler were found damaged at server start
- Error: `1578` SQLSTATE: `HY000` (`ER_ONLY_INTEGERS_ALLOWED`)

  Message: Only integers allowed as number here
- Error: `1579` SQLSTATE: `HY000` (`ER_UNSUPORTED_LOG_ENGINE`)

  Message: This storage engine cannot be used for log tables"
- Error: `1580` SQLSTATE: `HY000` (`ER_BAD_LOG_STATEMENT`)

  Message: You cannot '%s' a log table if logging is enabled
- Error: `1581` SQLSTATE: `HY000` (`ER_CANT_RENAME_LOG_TABLE`)

  Message: Cannot rename '%s'. When logging enabled, rename to/from log table must rename two tables: the log table to an archive table and another table back to '%s'
- Error: `1582` SQLSTATE: `42000` (`ER_WRONG_PARAMCOUNT_TO_NATIVE_FCT`)

  Message: Incorrect parameter count in the call to native function '%s'
- Error: `1583` SQLSTATE: `42000` (`ER_WRONG_PARAMETERS_TO_NATIVE_FCT`)

  Message: Incorrect parameters in the call to native function '%s'
- Error: `1584` SQLSTATE: `42000` (`ER_WRONG_PARAMETERS_TO_STORED_FCT`)

  Message: Incorrect parameters in the call to stored function '%s'
- Error: `1585` SQLSTATE: `HY000` (`ER_NATIVE_FCT_NAME_COLLISION`)

  Message: This function '%s' has the same name as a native function
- Error: `1586` SQLSTATE: `23000` (`ER_DUP_ENTRY_WITH_KEY_NAME`)

  Message: Duplicate entry '%s' for key '%s'
- Error: `1587` SQLSTATE: `HY000` (`ER_BINLOG_PURGE_EMFILE`)

  Message: Too many files opened, please execute the command again
- Error: `1588` SQLSTATE: `HY000` (`ER_EVENT_CANNOT_CREATE_IN_THE_PAST`)

  Message: Event execution time is in the past and ON COMPLETION NOT PRESERVE is set. The event was dropped immediately after creation.
- Error: `1589` SQLSTATE: `HY000` (`ER_EVENT_CANNOT_ALTER_IN_THE_PAST`)

  Message: Event execution time is in the past and ON COMPLETION NOT PRESERVE is set. The event was dropped immediately after creation.
- Error: `1590` SQLSTATE: `HY000` (`ER_SLAVE_INCIDENT`)

  Message: The incident %s occured on the master. Message: %s
- Error: `1591` SQLSTATE: `HY000` (`ER_NO_PARTITION_FOR_GIVEN_VALUE_SILENT`)

  Message: Table has no partition for some existing values
- Error: `1592` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_STATEMENT`)

  Message: Unsafe statement written to the binary log using statement format since BINLOG_FORMAT = STATEMENT. %s
- Error: `1593` SQLSTATE: `HY000` (`ER_SLAVE_FATAL_ERROR`)

  Message: Fatal error: %s
- Error: `1594` SQLSTATE: `HY000` (`ER_SLAVE_RELAY_LOG_READ_FAILURE`)

Message: Relay log read failure: %s

- Error: `1595` SQLSTATE: `HY000` (`ER_SLAVE_RELAY_LOG_WRITE_FAILURE`)

  Message: Relay log write failure: %s

- Error: `1596` SQLSTATE: `HY000` (`ER_SLAVE_CREATE_EVENT_FAILURE`)

  Message: Failed to create %s

- Error: `1597` SQLSTATE: `HY000` (`ER_SLAVE_MASTER_COM_FAILURE`)

  Message: Master command %s failed: %s

- Error: `1598` SQLSTATE: `HY000` (`ER_BINLOG_LOGGING_IMPOSSIBLE`)

  Message: Binary logging not possible. Message: %s

- Error: `1599` SQLSTATE: `HY000` (`ER_VIEW_NO_CREATION_CTX`)

  Message: View \`%s\`.\`%s\` has no creation context

- Error: `1600` SQLSTATE: `HY000` (`ER_VIEW_INVALID_CREATION_CTX`)

  Message: Creation context of view \`%s\`.\`%s' is invalid

- Error: `1601` SQLSTATE: `HY000` (`ER_SR_INVALID_CREATION_CTX`)

  Message: Creation context of stored routine \`%s\`.\`%s\` is invalid

- Error: `1602` SQLSTATE: `HY000` (`ER_TRG_CORRUPTED_FILE`)

  Message: Corrupted TRG file for table \`%s\`.\`%s\`

- Error: `1603` SQLSTATE: `HY000` (`ER_TRG_NO_CREATION_CTX`)

  Message: Triggers for table \`%s\`.\`%s\` have no creation context

- Error: `1604` SQLSTATE: `HY000` (`ER_TRG_INVALID_CREATION_CTX`)

  Message: Trigger creation context of table \`%s\`.\`%s\` is invalid

- Error: `1605` SQLSTATE: `HY000` (`ER_EVENT_INVALID_CREATION_CTX`)

  Message: Creation context of event \`%s\`.\`%s\` is invalid

- Error: `1606` SQLSTATE: `HY000` (`ER_TRG_CANT_OPEN_TABLE`)

  Message: Cannot open table for trigger \`%s\`.\`%s\`

- Error: `1607` SQLSTATE: `HY000` (`ER_CANT_CREATE_SROUTINE`)

  Message: Cannot create stored routine \`%s\`. Check warnings

- Error: `1608` SQLSTATE: `HY000` (`ER_NEVER_USED`)

  Message: Ambiguous slave modes combination. %s

- Error: `1609` SQLSTATE: `HY000` (`ER_NO_FORMAT_DESCRIPTION_EVENT_BEFORE_BINLOG_STATEMENT`)

  Message: The BINLOG statement of type \`%s\` was not preceded by a format description BINLOG statement.

- Error: `1610` SQLSTATE: `HY000` (`ER_SLAVE_CORRUPT_EVENT`)

  Message: Corrupted replication event was detected

- Error: `1611` SQLSTATE: `HY000` (`ER_LOAD_DATA_INVALID_COLUMN`)

  Message: Invalid column reference (%s) in LOAD DATA

- Error: `1612` SQLSTATE: `HY000` (`ER_LOG_PURGE_NO_FILE`)

Message: Being purged log %s was not found

- Error: `1613` SQLSTATE: `XA106` (`ER_XA_RBTIMEOUT`)

  Message: XA_RBTIMEOUT: Transaction branch was rolled back: took too long

- Error: `1614` SQLSTATE: `XA102` (`ER_XA_RBDEADLOCK`)

  Message: XA_RBDEADLOCK: Transaction branch was rolled back: deadlock was detected

- Error: `1615` SQLSTATE: `HY000` (`ER_NEED_REPREPARE`)

  Message: Prepared statement needs to be re-prepared

- Error: `1616` SQLSTATE: `HY000` (`ER_DELAYED_NOT_SUPPORTED`)

  Message: DELAYED option not supported for table '%s'

- Error: `1617` SQLSTATE: `HY000` (`WARN_NO_MASTER_INFO`)

  Message: The master info structure does not exist

- Error: `1618` SQLSTATE: `HY000` (`WARN_OPTION_IGNORED`)

  Message: <%s> option ignored

- Error: `1619` SQLSTATE: `HY000` (`WARN_PLUGIN_DELETE_BUILTIN`)

  Message: Built-in plugins cannot be deleted

- Error: `1620` SQLSTATE: `HY000` (`WARN_PLUGIN_BUSY`)

  Message: Plugin is busy and will be uninstalled on shutdown

- Error: `1621` SQLSTATE: `HY000` (`ER_VARIABLE_IS_READONLY`)

  Message: %s variable '%s' is read-only. Use SET %s to assign the value

- Error: `1622` SQLSTATE: `HY000` (`ER_WARN_ENGINE_TRANSACTION_ROLLBACK`)

  Message: Storage engine %s does not support rollback for this statement. Transaction rolled back and must be restarted

- Error: `1623` SQLSTATE: `HY000` (`ER_SLAVE_HEARTBEAT_FAILURE`)

  Message: Unexpected master's heartbeat data: %s

- Error: `1624` SQLSTATE: `HY000` (`ER_SLAVE_HEARTBEAT_VALUE_OUT_OF_RANGE`)

  Message: The requested value for the heartbeat period is either negative or exceeds the maximum allowed (%s seconds).

- Error: `1625` SQLSTATE: `HY000` (`ER_NDB_REPLICATION_SCHEMA_ERROR`)

  Message: Bad schema for mysql.ndb_replication table. Message: %s

- Error: `1626` SQLSTATE: `HY000` (`ER_CONFLICT_FN_PARSE_ERROR`)

  Message: Error in parsing conflict function. Message: %s

- Error: `1627` SQLSTATE: `HY000` (`ER_EXCEPTIONS_WRITE_ERROR`)

  Message: Write to exceptions table failed. Message: %s"

- Error: `1628` SQLSTATE: `HY000` (`ER_TOO_LONG_TABLE_COMMENT`)

  Message: Comment for table '%s' is too long (max = %lu)

- Error: `1629` SQLSTATE: `HY000` (`ER_TOO_LONG_FIELD_COMMENT`)

  Message: Comment for field '%s' is too long (max = %lu)

- Error: `1630` SQLSTATE: `42000` (`ER_FUNC_INEXISTENT_NAME_COLLISION`)

Message: FUNCTION %s does not exist. Check the 'Function Name Parsing and Resolution' section in the Reference Manual

- Error: `1631` SQLSTATE: `HY000` (`ER_DATABASE_NAME`)

  Message: Database

- Error: `1632` SQLSTATE: `HY000` (`ER_TABLE_NAME`)

  Message: Table

- Error: `1633` SQLSTATE: `HY000` (`ER_PARTITION_NAME`)

  Message: Partition

- Error: `1634` SQLSTATE: `HY000` (`ER_SUBPARTITION_NAME`)

  Message: Subpartition

- Error: `1635` SQLSTATE: `HY000` (`ER_TEMPORARY_NAME`)

  Message: Temporary

- Error: `1636` SQLSTATE: `HY000` (`ER_RENAMED_NAME`)

  Message: Renamed

- Error: `1637` SQLSTATE: `HY000` (`ER_TOO_MANY_CONCURRENT_TRXS`)

  Message: Too many active concurrent transactions

- Error: `1638` SQLSTATE: `HY000` (`WARN_NON_ASCII_SEPARATOR_NOT_IMPLEMENTED`)

  Message: Non-ASCII separator arguments are not fully supported

- Error: `1639` SQLSTATE: `HY000` (`ER_DEBUG_SYNC_TIMEOUT`)

  Message: debug sync point wait timed out

- Error: `1640` SQLSTATE: `HY000` (`ER_DEBUG_SYNC_HIT_LIMIT`)

  Message: debug sync point hit limit reached

- Error: `1641` SQLSTATE: `42000` (`ER_DUP_SIGNAL_SET`)

  Message: Duplicate condition information item '%s'

- Error: `1642` SQLSTATE: `01000` (`ER_SIGNAL_WARN`)

  Message: Unhandled user-defined warning condition

- Error: `1643` SQLSTATE: `02000` (`ER_SIGNAL_NOT_FOUND`)

  Message: Unhandled user-defined not found condition

- Error: `1644` SQLSTATE: `HY000` (`ER_SIGNAL_EXCEPTION`)

  Message: Unhandled user-defined exception condition

- Error: `1645` SQLSTATE: `0K000` (`ER_RESIGNAL_WITHOUT_ACTIVE_HANDLER`)

  Message: RESIGNAL when handler not active

- Error: `1646` SQLSTATE: `HY000` (`ER_SIGNAL_BAD_CONDITION_TYPE`)

  Message: SIGNAL/RESIGNAL can only use a CONDITION defined with SQLSTATE

- Error: `1647` SQLSTATE: `HY000` (`WARN_COND_ITEM_TRUNCATED`)

  Message: Data truncated for condition item '%s'

- Error: `1648` SQLSTATE: `HY000` (`ER_COND_ITEM_TOO_LONG`)

Message: Data too long for condition item '%s'

- Error: `1649` SQLSTATE: `HY000` (`ER_UNKNOWN_LOCALE`)

  Message: Unknown locale: '%s'

- Error: `1650` SQLSTATE: `HY000` (`ER_SLAVE_IGNORE_SERVER_IDS`)

  Message: The requested server id %d clashes with the slave startup option --replicate-same-server-id

- Error: `1651` SQLSTATE: `HY000` (`ER_QUERY_CACHE_DISABLED`)

  Message: Query cache is disabled; restart the server with query_cache_type=1 to enable it

- Error: `1652` SQLSTATE: `HY000` (`ER_SAME_NAME_PARTITION_FIELD`)

  Message: Duplicate partition field name '%s'

- Error: `1653` SQLSTATE: `HY000` (`ER_PARTITION_COLUMN_LIST_ERROR`)

  Message: Inconsistency in usage of column lists for partitioning

- Error: `1654` SQLSTATE: `HY000` (`ER_WRONG_TYPE_COLUMN_VALUE_ERROR`)

  Message: Partition column values of incorrect type

- Error: `1655` SQLSTATE: `HY000` (`ER_TOO_MANY_PARTITION_FUNC_FIELDS_ERROR`)

  Message: Too many fields in '%s'

- Error: `1656` SQLSTATE: `HY000` (`ER_MAXVALUE_IN_VALUES_IN`)

  Message: Cannot use MAXVALUE as value in VALUES IN

- Error: `1657` SQLSTATE: `HY000` (`ER_TOO_MANY_VALUES_ERROR`)

  Message: Cannot have more than one value for this type of %s partitioning

- Error: `1658` SQLSTATE: `HY000` (`ER_ROW_SINGLE_PARTITION_FIELD_ERROR`)

  Message: Row expressions in VALUES IN only allowed for multi-field column partitioning

- Error: `1659` SQLSTATE: `HY000` (`ER_FIELD_TYPE_NOT_ALLOWED_AS_PARTITION_FIELD`)

  Message: Field '%s' is of a not allowed type for this type of partitioning

- Error: `1660` SQLSTATE: `HY000` (`ER_PARTITION_FIELDS_TOO_LONG`)

  Message: The total length of the partitioning fields is too large

- Error: `1661` SQLSTATE: `HY000` (`ER_BINLOG_ROW_ENGINE_AND_STMT_ENGINE`)

  Message: Cannot execute statement: impossible to write to binary log since both row-incapable engines and statement-incapable engines are involved.

- Error: `1662` SQLSTATE: `HY000` (`ER_BINLOG_ROW_MODE_AND_STMT_ENGINE`)

  Message: Cannot execute statement: impossible to write to binary log since BINLOG_FORMAT = ROW and at least one table uses a storage engine limited to statement-based logging.

- Error: `1663` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_AND_STMT_ENGINE`)

  Message: Cannot execute statement: impossible to write to binary log since statement is unsafe, storage engine is limited to statement-based logging, and BINLOG_FORMAT = MIXED. %s

- Error: `1664` SQLSTATE: `HY000` (`ER_BINLOG_ROW_INJECTION_AND_STMT_ENGINE`)

  Message: Cannot execute statement: impossible to write to binary log since statement is in row format and at least one table uses a storage engine limited to statement-based logging.

- Error: `1665` SQLSTATE: `HY000` (`ER_BINLOG_STMT_MODE_AND_ROW_ENGINE`)

Message: Cannot execute statement: impossible to write to binary log since BINLOG_FORMAT = STATEMENT and at least one table uses a storage engine limited to row-based logging.%s

- Error: `1666` SQLSTATE: `HY000` (`ER_BINLOG_ROW_INJECTION_AND_STMT_MODE`)

  Message: Cannot execute statement: impossible to write to binary log since statement is in row format and BINLOG_FORMAT = STATEMENT.

- Error: `1667` SQLSTATE: `HY000` (`ER_BINLOG_MULTIPLE_ENGINES_AND_SELF_LOGGING_ENGINE`)

  Message: Cannot execute statement: impossible to write to binary log since more than one engine is involved and at least one engine is self-logging.

- Error: `1668` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_LIMIT`)

  Message: The statement is unsafe because it uses a LIMIT clause. This is unsafe because the set of rows included cannot be predicted.

- Error: `1669` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_INSERT_DELAYED`)

  Message: The statement is unsafe because it uses INSERT DELAYED. This is unsafe because the times when rows are inserted cannot be predicted.

- Error: `1670` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_SYSTEM_TABLE`)

  Message: The statement is unsafe because it uses the general log, slow query log, or performance_schema table(s). This is unsafe because system tables may differ on slaves.

- Error: `1671` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_AUTOINC_COLUMNS`)

  Message: Statement is unsafe because it invokes a trigger or a stored function that inserts into an AUTO_INCREMENT column. Inserted values cannot be logged correctly.

- Error: `1672` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_UDF`)

  Message: Statement is unsafe because it uses a UDF which may not return the same value on the slave.

- Error: `1673` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_SYSTEM_VARIABLE`)

  Message: Statement is unsafe because it uses a system variable that may have a different value on the slave.

- Error: `1674` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_SYSTEM_FUNCTION`)

  Message: Statement is unsafe because it uses a system function that may return a different value on the slave.

- Error: `1675` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_NONTRANS_AFTER_TRANS`)

  Message: Statement is unsafe because it accesses a non-transactional table after accessing a transactional table within the same transaction.

- Error: `1676` SQLSTATE: `HY000` (`ER_MESSAGE_AND_STATEMENT`)

  Message: %s Statement: %s

- Error: `1677` SQLSTATE: `HY000` (`ER_SLAVE_CONVERSION_FAILED`)

  Message: Column %d of table '%s.%s' cannot be converted from type '%s' to type '%s'

- Error: `1678` SQLSTATE: `HY000` (`ER_SLAVE_CANT_CREATE_CONVERSION`)

  Message: Can't create conversion table for table '%s.%s'

- Error: `1679` SQLSTATE: `HY000` (`ER_INSIDE_TRANSACTION_PREVENTS_SWITCH_BINLOG_FORMAT`)

  Message: Cannot modify @@session.binlog_format inside a transaction

- Error: `1680` SQLSTATE: `HY000` (`ER_PATH_LENGTH`)

  Message: The path specified for %s is too long.

- Error: `1681` SQLSTATE: `HY000` (`ER_WARN_DEPRECATED_SYNTAX_NO_REPLACEMENT`)

Message: The syntax '%s' is deprecated and will be removed in MySQL %s.

- Error: `1682` SQLSTATE: `HY000` (`ER_WRONG_NATIVE_TABLE_STRUCTURE`)

  Message: Native table '%s'.'%s' has the wrong structure

- Error: `1683` SQLSTATE: `HY000` (`ER_WRONG_PERFSCHEMA_USAGE`)

  Message: Invalid performance_schema usage.

- Error: `1684` SQLSTATE: `HY000` (`ER_WARN_I_S_SKIPPED_TABLE`)

  Message: Table '%s'.'%s' was skipped since its definition is being modified by concurrent DDL statement

- Error: `1685` SQLSTATE: `HY000` (`ER_INSIDE_TRANSACTION_PREVENTS_SWITCH_BINLOG_DIRECT`)

  Message: Cannot modify @@session.binlog_direct_non_transactional_updates inside a transaction

- Error: `1686` SQLSTATE: `HY000` (`ER_STORED_FUNCTION_PREVENTS_SWITCH_BINLOG_DIRECT`)

  Message: Cannot change the binlog direct flag inside a stored function or trigger

- Error: `1687` SQLSTATE: `42000` (`ER_SPATIAL_MUST_HAVE_GEOM_COL`)

  Message: A SPATIAL index may only contain a geometrical type column

- Error: `1688` SQLSTATE: `HY000` (`ER_TOO_LONG_INDEX_COMMENT`)

  Message: Comment for index '%s' is too long (max = %lu)

- Error: `1689` SQLSTATE: `HY000` (`ER_LOCK_ABORTED`)

  Message: Wait on a lock was aborted due to a pending exclusive lock

- Error: `1690` SQLSTATE: `22003` (`ER_DATA_OUT_OF_RANGE`)

  Message: %s value is out of range in '%s'

- Error: `1691` SQLSTATE: `HY000` (`ER_WRONG_SPVAR_TYPE_IN_LIMIT`)

  Message: A variable of a non-integer type in LIMIT clause

- Error: `1692` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_MULTIPLE_ENGINES_AND_SELF_LOGGING_ENGINE`)

  Message: Mixing self-logging and non-self-logging engines in a statement is unsafe.

- Error: `1693` SQLSTATE: `HY000` (`ER_BINLOG_UNSAFE_MIXED_STATEMENT`)

  Message: Statement accesses nontransactional table as well as transactional or temporary table, and writes to any of them.

- Error: `1694` SQLSTATE: `HY000` (`ER_INSIDE_TRANSACTION_PREVENTS_SWITCH_SQL_LOG_BIN`)

  Message: Cannot modify @@session.sql_log_bin inside a transaction

- Error: `1695` SQLSTATE: `HY000` (`ER_STORED_FUNCTION_PREVENTS_SWITCH_SQL_LOG_BIN`)

  Message: Cannot change the sql_log_bin inside a stored function or trigger

- Error: `1696` SQLSTATE: `HY000` (`ER_FAILED_READ_FROM_PAR_FILE`)

  Message: Failed to read from the .par file

- Error: `1697` SQLSTATE: `HY000` (`ER_VALUES_IS_NOT_INT_TYPE_ERROR`)

  Message: VALUES value for partition '%s' must have type INT

- Error: `1698` SQLSTATE: `28000` (`ER_ACCESS_DENIED_NO_PASSWORD_ERROR`)

  Message: Access denied for user '%s'@'%s'

- Error: `1699` SQLSTATE: `HY000` (`ER_SET_PASSWORD_AUTH_PLUGIN`)

  Message: SET PASSWORD has no significance for users authenticating via plugins

- Error: `1700` SQLSTATE: `HY000` (`ER_GRANT_PLUGIN_USER_EXISTS`)

  Message: GRANT with IDENTIFIED WITH is illegal because the user %-.*s already exists

- Error: `1701` SQLSTATE: `42000` (`ER_TRUNCATE_ILLEGAL_FK`)

  Message: Cannot truncate a table referenced in a foreign key constraint (%s)

- Error: `1702` SQLSTATE: `HY000` (`ER_PLUGIN_IS_PERMANENT`)

  Message: Plugin '%s' is force_plus_permanent and can not be unloaded

- Error: `1703` SQLSTATE: `HY000` (`ER_SLAVE_HEARTBEAT_VALUE_OUT_OF_RANGE_MIN`)

  Message: The requested value for the heartbeat period is less than 1 millisecond. The value is reset to 0, meaning that heartbeating will effectively be disabled.

- Error: `1704` SQLSTATE: `HY000` (`ER_SLAVE_HEARTBEAT_VALUE_OUT_OF_RANGE_MAX`)

  Message: The requested value for the heartbeat period exceeds the value of `slave_net_timeout' seconds. A sensible value for the period should be less than the timeout.

- Error: `1705` SQLSTATE: `HY000` (`ER_STMT_CACHE_FULL`)

  Message: Multi-row statements required more than 'max_binlog_stmt_cache_size' bytes of storage; increase this mysqld variable and try again

- Error: `1706` SQLSTATE: `HY000` (`ER_MULTI_UPDATE_KEY_CONFLICT`)

  Message: Primary key/partition key update is not allowed since the table is updated both as '%s' and '%s'.

- Error: `1707` SQLSTATE: `HY000` (`ER_TABLE_NEEDS_REBUILD`)

  Message: Table rebuild required. Please do "ALTER TABLE `%s` FORCE" or dump/reload to fix it!

- Error: `1708` SQLSTATE: `HY000` (`WARN_OPTION_BELOW_LIMIT`)

  Message: The value of '%s' should be no less than the value of '%s'

- Error: `1709` SQLSTATE: `HY000` (`ER_INDEX_COLUMN_TOO_LONG`)

  Message: Index column size too large. The maximum column size is %lu bytes.

- Error: `1710` SQLSTATE: `HY000` (`ER_ERROR_IN_TRIGGER_BODY`)

  Message: Trigger '%s' has an error in its body: '%s'

- Error: `1711` SQLSTATE: `HY000` (`ER_ERROR_IN_UNKNOWN_TRIGGER_BODY`)

  Message: Unknown trigger has an error in its body: '%s'

C.4. Client Error Codes and Messages

Client error information comes from the following source files:

- The Error values and the symbols in parentheses correspond to definitions in the `include/errmsg.h` MySQL source file.
- The Message values correspond to the error messages that are listed in the `libmysql/errmsg.c` file. `%d` and `%s` represent numbers and strings, respectively, that are substituted into the messages when they are displayed.

Because updates are frequent, it is possible that those files will contain additional error information not listed here.

- Error: `2000` (`CR_UNKNOWN_ERROR`)

Message: Unknown MySQL error

- Error: `2001` (`CR_SOCKET_CREATE_ERROR`)

  Message: Can't create UNIX socket (%d)

- Error: `2002` (`CR_CONNECTION_ERROR`)

  Message: Can't connect to local MySQL server through socket '%s' (%d)

- Error: `2003` (`CR_CONN_HOST_ERROR`)

  Message: Can't connect to MySQL server on '%s' (%d)

- Error: `2004` (`CR_IPSOCK_ERROR`)

  Message: Can't create TCP/IP socket (%d)

- Error: `2005` (`CR_UNKNOWN_HOST`)

  Message: Unknown MySQL server host '%s' (%d)

- Error: `2006` (`CR_SERVER_GONE_ERROR`)

  Message: MySQL server has gone away

- Error: `2007` (`CR_VERSION_ERROR`)

  Message: Protocol mismatch; server version = %d, client version = %d

- Error: `2008` (`CR_OUT_OF_MEMORY`)

  Message: MySQL client ran out of memory

- Error: `2009` (`CR_WRONG_HOST_INFO`)

  Message: Wrong host info

- Error: `2010` (`CR_LOCALHOST_CONNECTION`)

  Message: Localhost via UNIX socket

- Error: `2011` (`CR_TCP_CONNECTION`)

  Message: %s via TCP/IP

- Error: `2012` (`CR_SERVER_HANDSHAKE_ERR`)

  Message: Error in server handshake

- Error: `2013` (`CR_SERVER_LOST`)

  Message: Lost connection to MySQL server during query

- Error: `2014` (`CR_COMMANDS_OUT_OF_SYNC`)

  Message: Commands out of sync; you can't run this command now

- Error: `2015` (`CR_NAMEDPIPE_CONNECTION`)

  Message: Named pipe: %s

- Error: `2016` (`CR_NAMEDPIPEWAIT_ERROR`)

  Message: Can't wait for named pipe to host: %s pipe: %s (%lu)

- Error: `2017` (`CR_NAMEDPIPEOPEN_ERROR`)

  Message: Can't open named pipe to host: %s pipe: %s (%lu)

- Error: `2018` (`CR_NAMEDPIPESETSTATE_ERROR`)

Message: Can't set state of named pipe to host: %s pipe: %s (%lu)

- Error: `2019` (`CR_CANT_READ_CHARSET`)

  Message: Can't initialize character set %s (path: %s)

- Error: `2020` (`CR_NET_PACKET_TOO_LARGE`)

  Message: Got packet bigger than 'max_allowed_packet' bytes

- Error: `2021` (`CR_EMBEDDED_CONNECTION`)

  Message: Embedded server

- Error: `2022` (`CR_PROBE_SLAVE_STATUS`)

  Message: Error on SHOW SLAVE STATUS:

- Error: `2023` (`CR_PROBE_SLAVE_HOSTS`)

  Message: Error on SHOW SLAVE HOSTS:

- Error: `2024` (`CR_PROBE_SLAVE_CONNECT`)

  Message: Error connecting to slave:

- Error: `2025` (`CR_PROBE_MASTER_CONNECT`)

  Message: Error connecting to master:

- Error: `2026` (`CR_SSL_CONNECTION_ERROR`)

  Message: SSL connection error: %s

- Error: `2027` (`CR_MALFORMED_PACKET`)

  Message: Malformed packet

- Error: `2028` (`CR_WRONG_LICENSE`)

  Message: This client library is licensed only for use with MySQL servers having '%s' license

- Error: `2029` (`CR_NULL_POINTER`)

  Message: Invalid use of null pointer

- Error: `2030` (`CR_NO_PREPARE_STMT`)

  Message: Statement not prepared

- Error: `2031` (`CR_PARAMS_NOT_BOUND`)

  Message: No data supplied for parameters in prepared statement

- Error: `2032` (`CR_DATA_TRUNCATED`)

  Message: Data truncated

- Error: `2033` (`CR_NO_PARAMETERS_EXISTS`)

  Message: No parameters exist in the statement

- Error: `2034` (`CR_INVALID_PARAMETER_NO`)

  Message: Invalid parameter number

- Error: `2035` (`CR_INVALID_BUFFER_USE`)

  Message: Can't send long data for non-string/non-binary data types (parameter: %d)

- Error: `2036` (`CR_UNSUPPORTED_PARAM_TYPE`)

Message: Using unsupported buffer type: %d (parameter: %d)

- Error: `2037` (`CR_SHARED_MEMORY_CONNECTION`)

  Message: Shared memory: %s

- Error: `2038` (`CR_SHARED_MEMORY_CONNECT_REQUEST_ERROR`)

  Message: Can't open shared memory; client could not create request event (%lu)

- Error: `2039` (`CR_SHARED_MEMORY_CONNECT_ANSWER_ERROR`)

  Message: Can't open shared memory; no answer event received from server (%lu)

- Error: `2040` (`CR_SHARED_MEMORY_CONNECT_FILE_MAP_ERROR`)

  Message: Can't open shared memory; server could not allocate file mapping (%lu)

- Error: `2041` (`CR_SHARED_MEMORY_CONNECT_MAP_ERROR`)

  Message: Can't open shared memory; server could not get pointer to file mapping (%lu)

- Error: `2042` (`CR_SHARED_MEMORY_FILE_MAP_ERROR`)

  Message: Can't open shared memory; client could not allocate file mapping (%lu)

- Error: `2043` (`CR_SHARED_MEMORY_MAP_ERROR`)

  Message: Can't open shared memory; client could not get pointer to file mapping (%lu)

- Error: `2044` (`CR_SHARED_MEMORY_EVENT_ERROR`)

  Message: Can't open shared memory; client could not create %s event (%lu)

- Error: `2045` (`CR_SHARED_MEMORY_CONNECT_ABANDONED_ERROR`)

  Message: Can't open shared memory; no answer from server (%lu)

- Error: `2046` (`CR_SHARED_MEMORY_CONNECT_SET_ERROR`)

  Message: Can't open shared memory; cannot send request event to server (%lu)

- Error: `2047` (`CR_CONN_UNKNOW_PROTOCOL`)

  Message: Wrong or unknown protocol

- Error: `2048` (`CR_INVALID_CONN_HANDLE`)

  Message: Invalid connection handle

- Error: `2049` (`CR_SECURE_AUTH`)

  Message: Connection using old (pre-4.1.1) authentication protocol refused (client option 'secure_auth' enabled)

- Error: `2050` (`CR_FETCH_CANCELED`)

  Message: Row retrieval was canceled by mysql_stmt_close() call

- Error: `2051` (`CR_NO_DATA`)

  Message: Attempt to read column without prior row fetch

- Error: `2052` (`CR_NO_STMT_METADATA`)

  Message: Prepared statement contains no metadata

- Error: `2053` (`CR_NO_RESULT_SET`)

  Message: Attempt to read a row while there is no result set associated with the statement

- Error: `2054` (`CR_NOT_IMPLEMENTED`)

Message: This feature is not implemented yet

- Error: `2055` (`CR_SERVER_LOST_EXTENDED`)

  Message: Lost connection to MySQL server at '%s', system error: %d

- Error: `2056` (`CR_STMT_CLOSED`)

  Message: Statement closed indirectly because of a preceeding %s() call

- Error: `2057` (`CR_NEW_STMT_METADATA`)

  Message: The number of columns in the result set differs from the number of bound buffers. You must reset the statement, rebind the result set columns, and execute the statement again

- Error: `2058` (`CR_ALREADY_CONNECTED`)

  Message: This handle is already connected. Use a separate handle for each connection.

- Error: `2059` (`CR_AUTH_PLUGIN_CANNOT_LOAD`)

  Message: Authentication plugin '%s' cannot be loaded: %s

C.5. Problems and Common Errors

This section lists some common problems and error messages that you may encounter. It describes how to determine the causes of the problems and what to do to solve them.

C.5.1. How to Determine What Is Causing a Problem

When you run into a problem, the first thing you should do is to find out which program or piece of equipment is causing it:

- If you have one of the following symptoms, then it is probably a hardware problems (such as memory, motherboard, CPU, or hard disk) or kernel problem:

  - The keyboard doesn't work. This can normally be checked by pressing the Caps Lock key. If the Caps Lock light doesn't change, you have to replace your keyboard. (Before doing this, you should try to restart your computer and check all cables to the keyboard.)
  - The mouse pointer doesn't move.
  - The machine doesn't answer to a remote machine's pings.
  - Other programs that are not related to MySQL don't behave correctly.
  - Your system restarted unexpectedly. (A faulty user-level program should never be able to take down your system.)

  In this case, you should start by checking all your cables and run some diagnostic tool to check your hardware! You should also check whether there are any patches, updates, or service packs for your operating system that could likely solve your problem. Check also that all your libraries (such as `glibc`) are up to date.

  It is always good to use a machine with ECC memory to discover memory problems early.

- If your keyboard is locked up, you may be able to recover by logging in to your machine from another machine and executing `kbd_mode -a`.

- Please examine your system log file (`/var/log/messages` or similar) for reasons for your problem. If you think the problem is in MySQL, you should also examine MySQL's log files. See Section 5.2, “MySQL Server Logs”.

- If you don't think you have hardware problems, you should try to find out which program is causing problems. Try using `top`, `ps`, Task Manager, or some similar program, to check which program is taking all CPU or is locking the machine.

- Use `top`, `df`, or a similar program to check whether you are out of memory, disk space, file descriptors, or some other critical resource.

- If the problem is some runaway process, you can always try to kill it. If it doesn't want to die, there is probably a bug in the operating system.

If after you have examined all other possibilities and you have concluded that the MySQL server or a MySQL client is causing the problem, it is time to create a bug report for our mailing list or our support team. In the bug report, try to give a very detailed description of how the system is behaving and what you think is happening. You should also state why you think that MySQL is causing the problem. Take into consideration all the situations in this chapter. State any problems exactly how they appear when you examine your system. Use the “copy and paste” method for any output and error messages from programs and log files.

Try to describe in detail which program is not working and all symptoms you see. We have in the past received many bug reports that state only “the system doesn't work.” This doesn't provide us with any information about what could be the problem.

If a program fails, it is always useful to know the following information:

- Has the program in question made a segmentation fault (did it dump core)?
- Is the program taking up all available CPU time? Check with `top`. Let the program run for a while, it may simply be evaluating something computationally intensive.
- If the `mysqld` server is causing problems, can you get any response from it with `mysqladmin -u root ping` or `mysqladmin -u root processlist`?
- What does a client program say when you try to connect to the MySQL server? (Try with `mysql`, for example.) Does the client jam? Do you get any output from the program?

When sending a bug report, you should follow the outline described in Section 1.7, “How to Report Bugs or Problems”.

C.5.2. Common Errors When Using MySQL Programs

This section lists some errors that users frequently encounter when running MySQL programs. Although the problems show up when you try to run client programs, the solutions to many of the problems involves changing the configuration of the MySQL server.

C.5.2.1. `Access denied`

An `Access denied` error can have many causes. Often the problem is related to the MySQL accounts that the server permits client programs to use when connecting. See Section 5.4, “The MySQL Access Privilege System”, and Section 5.4.7, “Causes of Access-Denied Errors”.

C.5.2.2. `Can't connect to [local] MySQL server`

A MySQL client on Unix can connect to the `mysqld` server in two different ways: By using a Unix socket file to connect through a file in the file system (default `/tmp/mysql.sock`), or by using TCP/IP, which connects through a port number. A Unix socket file connection is faster than TCP/IP, but can be used only when connecting to a server on the same computer. A Unix socket file is used if you don't specify a host name or if you specify the special host name `localhost`.

If the MySQL server is running on Windows, you can connect using TCP/IP. If the server is started with the `--enable-named-pipe` option, you can also connect with named pipes if you run the client on the host where the server is running. The name of the named pipe is `MySQL` by default. If you don't give a host name when connecting to `mysqld`, a MySQL client first tries to connect to the named pipe. If that doesn't work, it connects to the TCP/IP port. You can force the use of named pipes on Windows by using `.` as the host name.

The error (2002) `Can't connect to ...` normally means that there is no MySQL server running on the system or that you are using an incorrect Unix socket file name or TCP/IP port number when trying to connect to the server. You should also check that the TCP/IP port you are using has not been blocked by a firewall or port blocking service.

The error (2003) `Can't connect to MySQL server on 'server' (10061)` indicates that the network connection has been refused. You should check that there is a MySQL server running, that it has network connections enabled, and that the network port you specified is the one configured on the server.

Start by checking whether there is a process named `mysqld` running on your server host. (Use `ps xa | grep mysqld` on Unix or the Task Manager on Windows.) If there is no such process, you should start the server. See Section 2.10.1.3, “Starting and Troubleshooting the MySQL Server”.

If a `mysqld` process is running, you can check it by trying the following commands. The port number or Unix socket file name might be different in your setup. `host_ip` represents the IP address of the machine where the server is running.

```
shell> mysqladmin version
shell> mysqladmin variables
shell> mysqladmin -h `hostname` version variables
shell> mysqladmin -h `hostname` --port=3306 version
shell> mysqladmin -h host_ip version
shell> mysqladmin --protocol=SOCKET --socket=/tmp/mysql.sock version
```

Note the use of backticks rather than forward quotation marks with the `hostname` command; these cause the output of `hostname` (that is, the current host name) to be substituted into the `mysqladmin` command. If you have no `hostname` command or are running on Windows, you can manually type the host name of your machine (without backticks) following the `-h` option. You can also try `-h 127.0.0.1` to connect with TCP/IP to the local host.

Make sure that the server has not been configured to ignore network connections or (if you are attempting to connect remotely) that it has not been configured to listen only locally on its network interfaces. If the server was started with `--skip-networking`, it will not accept TCP/IP connections at all. If the server was started with `--bind-address=127.0.0.1`, it will listen for TCP/IP connections only locally on the loopback interface and will not accept remote connections.

Check to make sure that there is no firewall blocking access to MySQL. Your firewall may be configured on the basis of the application being executed, or the port number used by MySQL for communication (3306 by default). Under Linux or Unix, check your IP tables (or similar) configuration to ensure that the port has not been blocked. Under Windows, applications such as ZoneAlarm or the Windows XP personal firewall may need to be configured not to block the MySQL port.

Here are some reasons the `Can't connect to local MySQL server` error might occur:

- `mysqld` is not running on the local host. Check your operating system's process list to ensure the `mysqld` process is present.
- You're running a MySQL server on Windows with many TCP/IP connections to it. If you're experiencing that quite often your clients get that error, you can find a workaround here: Section C.5.2.2.1, “`Connection to MySQL Server Failing on Windows`”.
- Someone has removed the Unix socket file that `mysqld` uses (`/tmp/mysql.sock` by default). For example, you might have a `cron` job that removes old files from the `/tmp` directory. You can always run `mysqladmin version` to check whether the Unix socket file that `mysqladmin` is trying to use really exists. The fix in this case is to change the `cron` job to not remove `mysql.sock` or to place the socket file somewhere else. See Section C.5.4.5, “How to Protect or Change the MySQL Unix Socket File”.
- You have started the `mysqld` server with the `--socket=/path/to/socket` option, but forgotten to tell client programs the new name of the socket file. If you change the socket path name for the server, you must also notify the MySQL clients. You can do this by providing the same `--socket` option when you run client programs. You also need to ensure that clients have permission to access the `mysql.sock` file. To find out where the socket file is, you can do:

  ```
  shell> netstat -ln | grep mysql
  ```

  See Section C.5.4.5, “How to Protect or Change the MySQL Unix Socket File”.
- You are using Linux and one server thread has died (dumped core). In this case, you must kill the other `mysqld` threads (for example, with `kill` or with the `mysql_zap` script) before you can restart the MySQL server. See Section C.5.4.2, “What to Do If MySQL Keeps Crashing”.
- The server or client program might not have the proper access privileges for the directory that holds the Unix socket file or the socket file itself. In this case, you must either change the access privileges for the directory or socket file so that the server and clients can access them, or restart `mysqld` with a `--socket` option that specifies a socket file name in a directory where the server can create it and where client programs can access it.

If you get the error message `Can't connect to MySQL server on some_host`, you can try the following things to find out what the problem is:

- Check whether the server is running on that host by executing `telnet some_host 3306` and pressing the Enter key a couple of times. (3306 is the default MySQL port number. Change the value if your server is listening to a different port.) If there is a MySQL server running and listening to the port, you should get a response that includes the server's version number. If you get an error such as `telnet: Unable to connect to remote host: Connection refused`, then there is no server running on the given port.
- If the server is running on the local host, try using `mysqladmin -h localhost variables` to connect using the Unix socket file. Verify the TCP/IP port number that the server is configured to listen to (it is the value of the `port` variable.)
- If you are running under Linux and Security-Enhanced Linux (SELinux) is enabled, make sure you have disabled SELinux protection for the `mysqld` process.

C.5.2.2.1. `Connection to MySQL Server Failing on Windows`

When you're running a MySQL server on Windows with many TCP/IP connections to it, and you're experiencing that quite often your clients get a `Can't connect to MySQL server` error, the reason might be that Windows does not allow for enough ephemeral (short-lived) ports to serve those connections.

The purpose of `TIME_WAIT` is to keep a connection accepting packets even after the connection has been closed. This is because Internet routing can cause a packet to take a slow route to its destination and it may arrive after both sides have agreed to close. If the port is in use for a new connection, that packet from the old connection could break the protocol or compromise personal information from the original connection. The `TIME_WAIT` delay prevents this by ensuring that the port cannot be reused until after some time has been permitted for those delayed packets to arrive.

It is safe to reduce `TIME_WAIT` greatly on LAN connections because there is little chance of packets arriving at very long delays, as they could through the Internet with its comparatively large distances and latencies.

Windows permits ephemeral (short-lived) TCP ports to the user. After any port is closed it will remain in a `TIME_WAIT` status for 120 seconds. The port will not be available again until this time expires. The default range of port numbers depends on the version of Windows, with a more limited number of ports in older versions:

- Windows through Server 2003: Ports in range 1025–5000
- Windows Vista, Server 2008, and newer: Ports in range 49152–65535

With a small stack of available TCP ports (5000) and a high number of TCP ports being open and closed over a short period of time along with the `TIME_WAIT` status you have a good chance for running out of ports. There are two ways to address this problem:

- Reduce the number of TCP ports consumed quickly by investigating connection pooling or persistent connections where possible
- Tune some settings in the Windows registry (see below)

IMPORTANT: The following procedure involves modifying the Windows registry. Before you modify the registry, make sure to back it up and make sure that you understand how to restore the registry if a problem occurs. For information about how to back up, restore, and edit the registry, view the following article in the Microsoft Knowledge Base: http://support.microsoft.com/kb/256986/EN-US/.

1. Start Registry Editor (`Regedt32.exe`).
2. Locate the following key in the registry:

   ```
   HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters
   ```

3. On the `Edit` menu, click `Add Value`, and then add the following registry value:

   ```
   Value Name: MaxUserPort
   Data Type: REG_DWORD
   Value: 65534
   ```

   This sets the number of ephemeral ports available to any user. The valid range is between 5000 and 65534 (decimal). The default value is 0x1388 (5000 decimal).

4. On the `Edit` menu, click `Add Value`, and then add the following registry value:

   ```
   Value Name: TcpTimedWaitDelay
   Data Type: REG_DWORD
   Value: 30
   ```

   This sets the number of seconds to hold a TCP port connection in `TIME_WAIT` state before closing. The valid range is between 0 (zero) and 300 (decimal). The default value is 0x78 (120 decimal).

5. Quit Registry Editor.
6. Reboot the machine.

Note: Undoing the above should be as simple as deleting the registry entries you've created.

C.5.2.3. `Lost connection to MySQL server`

There are three likely causes for this error message.

Usually it indicates network connectivity trouble and you should check the condition of your network if this error occurs frequently. If the error message includes “during query,” this is probably the case you are experiencing.

Sometimes the “during query” form happens when millions of rows are being sent as part of one or more queries. If you know that this is happening, you should try increasing `net_read_timeout` from its default of 30 seconds to 60 seconds or longer, sufficient for the data transfer to complete.

More rarely, it can happen when the client is attempting the initial connection to the server. In this case, if your `connect_timeout` value is set to only a few seconds, you may be able to resolve the problem by increasing it to ten seconds, perhaps more if you have a very long distance or slow connection. You can determine whether you are experiencing this more uncommon cause by using `SHOW GLOBAL STATUS LIKE 'Aborted_connects'`. It will increase by one for each initial connection attempt that the server aborts. You may see “reading authorization packet” as part of the error message; if so, that also suggests that this is the solution that you need.

If the cause is none of those just described, you may be experiencing a problem with `BLOB` values that are larger than `max_allowed_packet`, which can cause this error with some clients. Sometime you may see “packet too large” as part of the error message, and that confirms that you need to increase `max_allowed_packet`.

C.5.2.4. `Client does not support authentication protocol`

MySQL 5.5 uses an authentication protocol based on a password hashing algorithm that is incompatible with that used by older (pre-4.1) clients. If you upgrade the server from 4.0, attempts to connect to it with an older client may fail with the following message:

```
shell> mysql
Client does not support authentication protocol requested
by server; consider upgrading MySQL client
```

To solve this problem, you should use one of the following approaches:

- Upgrade all client programs to use a 4.1.1 or newer client library.
- When connecting to the server with a pre-4.1 client program, use an account that still has a pre-4.1-style password.
- Reset the password to pre-4.1 style for each user that needs to use a pre-4.1 client program. This can be done using the `SET PASSWORD` statement and the `OLD_PASSWORD()` function:

  ```
  mysql> SET PASSWORD FOR
      -> 'some_user'@'some_host' = OLD_PASSWORD('newpwd');
  ```

  Alternatively, use `UPDATE` and `FLUSH PRIVILEGES`:

  ```
  mysql> UPDATE mysql.user SET Password = OLD_PASSWORD('newpwd')
      -> WHERE Host = 'some_host' AND User = 'some_user';
  mysql> FLUSH PRIVILEGES;
  ```

  Substitute the password you want to use for “*newpwd*” in the preceding examples. MySQL cannot tell you what the original password was, so you'll need to pick a new one.
- Tell the server to use the older password hashing algorithm:

  1. Start `mysqld` with the `--old-passwords` option.
  2. Assign an old-format password to each account that has had its password updated to the longer 4.1 format. You can identify these accounts with the following query:

     ```
     mysql> SELECT Host, User, Password FROM mysql.user
         -> WHERE LENGTH(Password) > 16;
     ```

     For each account record displayed by the query, use the `Host` and `User` values and assign a password using the `OLD_PASSWORD()` function and either `SET PASSWORD` or `UPDATE`, as described earlier.

> **Note**
>
> In older versions of PHP, the `mysql` extension does not support the authentication protocol in MySQL 4.1.1 and higher. This is true regardless of the PHP version being used. If you wish to use the `mysql` extension with MySQL 4.1 or newer, you may need to follow one of the options discussed above for configuring MySQL to work with old

> clients. The `mysqli` extension (stands for "MySQL, Improved"; added in PHP 5) is compatible with the improved password hashing employed in MySQL 4.1 and higher, and no special configuration of MySQL need be done to use this MySQL client library. For more information about the `mysqli` extension, see http://php.net/mysqli.

It may also be possible to compile the older `mysql` extension against the new MySQL client library. This is beyond the scope of this Manual; consult the PHP documentation for more information. You also be able to obtain assistance with these issues in our MySQL with PHP forum.

For additional background on password hashing and authentication, see Section 5.3.2.3, "Password Hashing in MySQL".

C.5.2.5. Password Fails When Entered Interactively

MySQL client programs prompt for a password when invoked with a `--password` or `-p` option that has no following password value:

```
shell> mysql -u user_name -p
Enter password:
```

On some systems, you may find that your password works when specified in an option file or on the command line, but not when you enter it interactively at the `Enter password:` prompt. This occurs when the library provided by the system to read passwords limits password values to a small number of characters (typically eight). That is a problem with the system library, not with MySQL. To work around it, change your MySQL password to a value that is eight or fewer characters long, or put your password in an option file.

C.5.2.6. `Host 'host_name' is blocked`

If you get the following error, it means that `mysqld` has received many connect requests from the host `'host_name'` that have been interrupted in the middle:

```
Host 'host_name' is blocked because of many connection errors.
Unblock with 'mysqladmin flush-hosts'
```

The number of interrupted connect requests permitted is determined by the value of the `max_connect_errors` system variable. After `max_connect_errors` failed requests, `mysqld` assumes that something is wrong (for example, that someone is trying to break in), and blocks the host from further connections until you execute a `mysqladmin flush-hosts` command or issue a `FLUSH HOSTS` statement. See Section 5.1.3, "Server System Variables".

By default, `mysqld` blocks a host after 10 connection errors. You can adjust the value by starting the server like this:

```
shell> mysqld_safe --max_connect_errors=10000 &
```

If you get this error message for a given host, you should first verify that there isn't anything wrong with TCP/IP connections from that host. If you are having network problems, it does you no good to increase the value of the `max_connect_errors` variable.

C.5.2.7. `Too many connections`

If you get a `Too many connections` error when you try to connect to the `mysqld` server, this means that all available connections are in use by other clients.

The number of connections permitted is controlled by the `max_connections` system variable. The default value is 151 to improve performance when MySQL is used with the Apache Web server. (Previously, the default was 100.) If you need to support more connections, you should set a larger value for this variable.

`mysqld` actually permits `max_connections+1` clients to connect. The extra connection is reserved for use by accounts that have the `SUPER` privilege. By granting the `SUPER` privilege to administrators and not to normal users (who should not need it), an administrator can connect to the server and use `SHOW PROCESSLIST` to diagnose problems even if the maximum number of unprivileged clients are connected. See Section 12.4.5.30, "`SHOW PROCESSLIST` Syntax".

The maximum number of connections MySQL can support depends on the quality of the thread library on a given platform, the amount of RAM available, how much RAM is used for each connection, the workload from each connection, and the desired response time. Linux or Solaris should be able to support at 500 to 1000 simultaneous connections routinely and as many as 10,000 connections if you have many gigabytes of RAM available and the workload from each is low or the response time target undemanding. Windows is limited to (open tables × 2 + open connections) < 2048 due to the Posix compatibility layer used on that platform.

Increasing `open-files-limit` may be necessary. Also see Section 2.5, "Installing MySQL on Linux", for how to raise the operating system limit on how many handles can be used by MySQL.

C.5.2.8. `Out of memory`

If you issue a query using the `mysql` client program and receive an error like the following one, it means that `mysql` does not have enough memory to store the entire query result:

```
mysql: Out of memory at line 42, 'malloc.c'
mysql: needed 8136 byte (8k), memory in use: 12481367 bytes (12189k)
ERROR 2008: MySQL client ran out of memory
```

To remedy the problem, first check whether your query is correct. Is it reasonable that it should return so many rows? If not, correct the query and try again. Otherwise, you can invoke `mysql` with the `--quick` option. This causes it to use the `mysql_use_result()` C API function to retrieve the result set, which places less of a load on the client (but more on the server).

C.5.2.9. `MySQL server has gone away`

This section also covers the related `Lost connection to server during query` error.

The most common reason for the `MySQL server has gone away` error is that the server timed out and closed the connection. In this case, you normally get one of the following error codes (which one you get is operating system-dependent).

Error Code	Description
`CR_SERVER_GONE_ERROR`	The client couldn't send a question to the server.
`CR_SERVER_LOST`	The client didn't get an error when writing to the server, but it didn't get a full answer (or any answer) to the question.

By default, the server closes the connection after eight hours if nothing has happened. You can change the time limit by setting the `wait_timeout` variable when you start `mysqld`. See Section 5.1.3, “Server System Variables”.

If you have a script, you just have to issue the query again for the client to do an automatic reconnection. This assumes that you have automatic reconnection in the client enabled (which is the default for the `mysql` command-line client).

Some other common reasons for the `MySQL server has gone away` error are:

- You (or the db administrator) has killed the running thread with a `KILL` statement or a `mysqladmin kill` command.
- You tried to run a query after closing the connection to the server. This indicates a logic error in the application that should be corrected.
- A client application running on a different host does not have the necessary privileges to connect to the MySQL server from that host.
- You got a timeout from the TCP/IP connection on the client side. This may happen if you have been using the commands: `mysql_options(..., MYSQL_OPT_READ_TIMEOUT,...)` or `mysql_options(..., MYSQL_OPT_WRITE_TIMEOUT,...)`. In this case increasing the timeout may help solve the problem.
- You have encountered a timeout on the server side and the automatic reconnection in the client is disabled (the `reconnect` flag in the `MYSQL` structure is equal to 0).
- You are using a Windows client and the server had dropped the connection (probably because `wait_timeout` expired) before the command was issued.

  The problem on Windows is that in some cases MySQL doesn't get an error from the OS when writing to the TCP/IP connection to the server, but instead gets the error when trying to read the answer from the connection.

  The solution to this is to either do a `mysql_ping()` on the connection if there has been a long time since the last query (this is what `MyODBC` does) or set `wait_timeout` on the `mysqld` server so high that it in practice never times out.
- You can also get these errors if you send a query to the server that is incorrect or too large. If `mysqld` receives a packet that is too large or out of order, it assumes that something has gone wrong with the client and closes the connection. If you need big queries (for example, if you are working with big `BLOB` columns), you can increase the query limit by setting the server's `max_allowed_packet` variable, which has a default value of 1MB. You may also need to increase the maximum packet size on the client end. More information on setting the packet size is given in Section C.5.2.10, “`Packet too large`”.

  An `INSERT` or `REPLACE` statement that inserts a great many rows can also cause these sorts of errors. Either one of these statements sends a single request to the server irrespective of the number of rows to be inserted; thus, you can often avoid the error by reducing the number of rows sent per `INSERT` or `REPLACE`.
- You also get a lost connection if you are sending a packet 16MB or larger if your client is older than 4.0.8 and your server is

4.0.8 and above, or the other way around.

- It is also possible to see this error if host name lookups fail (for example, if the DNS server on which your server or network relies goes down). This is because MySQL is dependent on the host system for name resolution, but has no way of knowing whether it is working—from MySQL's point of view the problem is indistinguishable from any other network timeout.

  You may also see the `MySQL server has gone away` error if MySQL is started with the `--skip-networking` option.

  Another networking issue that can cause this error occurs if the MySQL port (default 3306) is blocked by your firewall, thus preventing any connections at all to the MySQL server.

- You can also encounter this error with applications that fork child processes, all of which try to use the same connection to the MySQL server. This can be avoided by using a separate connection for each child process.

- You have encountered a bug where the server died while executing the query.

You can check whether the MySQL server died and restarted by executing `mysqladmin version` and examining the server's uptime. If the client connection was broken because `mysqld` crashed and restarted, you should concentrate on finding the reason for the crash. Start by checking whether issuing the query again kills the server again. See Section C.5.4.2, “What to Do If MySQL Keeps Crashing”.

You can get more information about the lost connections by starting `mysqld` with the `--log-warnings=2` option. This logs some of the disconnected errors in the `hostname.err` file. See Section 5.2.2, “The Error Log”.

If you want to create a bug report regarding this problem, be sure that you include the following information:

- Indicate whether the MySQL server died. You can find information about this in the server error log. See Section C.5.4.2, “What to Do If MySQL Keeps Crashing”.

- If a specific query kills `mysqld` and the tables involved were checked with `CHECK TABLE` before you ran the query, can you provide a reproducible test case? See MySQL Internals: Porting.

- What is the value of the `wait_timeout` system variable in the MySQL server? (`mysqladmin variables` gives you the value of this variable.)

- Have you tried to run `mysqld` with the general query log enabled to determine whether the problem query appears in the log? (See Section 5.2.3, “The General Query Log”.)

See also Section C.5.2.11, “Communication Errors and Aborted Connections”, and Section 1.7, “How to Report Bugs or Problems”.

C.5.2.10. `Packet too large`

A communication packet is a single SQL statement sent to the MySQL server, a single row that is sent to the client, or a binary log event sent from a master replication server to a slave.

The largest possible packet that can be transmitted to or from a MySQL 5.5 server or client is 1GB.

When a MySQL client or the `mysqld` server receives a packet bigger than `max_allowed_packet` bytes, it issues a `Packet too large` error and closes the connection. With some clients, you may also get a `Lost connection to MySQL server during query` error if the communication packet is too large.

Both the client and the server have their own `max_allowed_packet` variable, so if you want to handle big packets, you must increase this variable both in the client and in the server.

If you are using the `mysql` client program, its default `max_allowed_packet` variable is 16MB. To set a larger value, start `mysql` like this:

```
shell> mysql --max_allowed_packet=32M
```

That sets the packet size to 32MB.

The server's default `max_allowed_packet` value is 1MB. You can increase this if the server needs to handle big queries (for example, if you are working with big `BLOB` columns). For example, to set the variable to 16MB, start the server like this:

```
shell> mysqld --max_allowed_packet=16M
```

You can also use an option file to set `max_allowed_packet`. For example, to set the size for the server to 16MB, add the following lines in an option file:

```
[mysqld]
max_allowed_packet=16M
```

It is safe to increase the value of this variable because the extra memory is allocated only when needed. For example, `mysqld` allocates more memory only when you issue a long query or when `mysqld` must return a large result row. The small default value of the variable is a precaution to catch incorrect packets between the client and server and also to ensure that you do not run out of memory by using large packets accidentally.

You can also get strange problems with large packets if you are using large `BLOB` values but have not given `mysqld` access to enough memory to handle the query. If you suspect this is the case, try adding `ulimit -d 256000` to the beginning of the `mysqld_safe` script and restarting `mysqld`.

C.5.2.11. Communication Errors and Aborted Connections

The server error log can be a useful source of information about connection problems. See Section 5.2.2, "The Error Log". If you start the server with the `--log-warnings` option, you might find messages like this in your error log:

```
010301 14:38:23  Aborted connection 854 to db: 'users' user: 'josh'
```

If a client successfully connects but later disconnects improperly or is terminated, the server increments the `Aborted_clients` status variable, and logs an ABORTED CONNECTION message to the error log. The cause can be any of the following:

- The client program did not call `mysql_close()` before exiting.
- The client had been sleeping more than `wait_timeout` or `interactive_timeout` seconds without issuing any requests to the server. See Section 5.1.3, "Server System Variables".
- The client program ended abruptly in the middle of a data transfer.

If a client is unable even to connect, the server increments the `Aborted_connects` status variable. Unsuccessful connect attempts can occur for the following reasons:

- A client doesn't have privileges to connect to a database.
- A client uses an incorrect password.
- A connection packet doesn't contain the right information.
- It takes more than `connect_timeout` seconds to get a connect packet. See Section 5.1.3, "Server System Variables".

If these kinds of things happen, it might indicate that someone is trying to break into your server! Messages for these types of problems are logged to the general query log if it is enabled.

Other reasons for problems with aborted clients or aborted connections:

- Use of Ethernet protocol with Linux, both half and full duplex. Many Linux Ethernet drivers have this bug. You should test for this bug by transferring a huge file using FTP between the client and server machines. If a transfer goes in burst-pause-burst-pause mode, you are experiencing a Linux duplex syndrome. The only solution is switching the duplex mode for both your network card and hub/switch to either full duplex or to half duplex and testing the results to determine the best setting.
- Some problem with the thread library that causes interrupts on reads.
- Badly configured TCP/IP.
- Faulty Ethernets, hubs, switches, cables, and so forth. This can be diagnosed properly only by replacing hardware.
- The `max_allowed_packet` variable value is too small or queries require more memory than you have allocated for `mysqld`. See Section C.5.2.10, "`Packet too large`".

See also Section C.5.2.9, "`MySQL server has gone away`".

C.5.2.12. `The table is full`

If a table-full error occurs, it may be that the disk is full or that the table has reached its maximum size. The effective maximum table size for MySQL databases is usually determined by operating system constraints on file sizes, not by MySQL internal limits. See Section E.9.3, “Limits on Table Size”.

C.5.2.13. `Can't create/write to file`

If you get an error of the following type for some queries, it means that MySQL cannot create a temporary file for the result set in the temporary directory:

```
Can't create/write to file '\\sqla3fe_0.ism'.
```

The preceding error is a typical message for Windows; the Unix message is similar.

One fix is to start `mysqld` with the `--tmpdir` option or to add the option to the `[mysqld]` section of your option file. For example, to specify a directory of `C:\temp`, use these lines:

```
[mysqld]
tmpdir=C:/temp
```

The `C:\temp` directory must exist and have sufficient space for the MySQL server to write to. See Section 4.2.3.3, “Using Option Files”.

Another cause of this error can be permissions issues. Make sure that the MySQL server can write to the `tmpdir` directory.

Check also the error code that you get with `perror`. One reason the server cannot write to a table is that the file system is full:

```
shell> perror 28
OS error code  28:  No space left on device
```

If you get an error of the following type during startup, it indicates that the file system or directory used for storing data files is write protected. Providing the write error is to a test file, This error is not serious and can be safely ignored.

```
Can't create test file /usr/local/mysql/data/master.lower-test
```

C.5.2.14. `Commands out of sync`

If you get `Commands out of sync; you can't run this command now` in your client code, you are calling client functions in the wrong order.

This can happen, for example, if you are using `mysql_use_result()` and try to execute a new query before you have called `mysql_free_result()`. It can also happen if you try to execute two queries that return data without calling `mysql_use_result()` or `mysql_store_result()` in between.

C.5.2.15. `Ignoring user`

If you get the following error, it means that when `mysqld` was started or when it reloaded the grant tables, it found an account in the `user` table that had an invalid password.

```
Found wrong password for user 'some_user'@'some_host'; ignoring user
```

As a result, the account is simply ignored by the permission system.

The following list indicates possible causes of and fixes for this problem:

- You may be running a new version of `mysqld` with an old `user` table. You can check this by executing `mysqlshow mysql user` to see whether the `Password` column is shorter than 16 characters. If so, you can correct this condition by running the `scripts/add_long_password` script.

- The account has an old password (eight characters long). Update the account in the `user` table to have a new password.

- You have specified a password in the `user` table without using the `PASSWORD()` function. Use `mysql` to update the account in the `user` table with a new password, making sure to use the `PASSWORD()` function:

  ```
  mysql> UPDATE user SET Password=PASSWORD('newpwd')
      -> WHERE User='some_user' AND Host='some_host';
  ```

C.5.2.16. `Table 'tbl_name' doesn't exist`

If you get either of the following errors, it usually means that no table exists in the default database with the given name:

```
Table 'tbl_name' doesn't exist
Can't find file: 'tbl_name' (errno: 2)
```

In some cases, it may be that the table does exist but that you are referring to it incorrectly:

- Because MySQL uses directories and files to store databases and tables, database and table names are case sensitive if they are located on a file system that has case-sensitive file names.
- Even for file systems that are not case sensitive, such as on Windows, all references to a given table within a query must use the same lettercase.

You can check which tables are in the default database with `SHOW TABLES`. See Section 12.4.5, “`SHOW` Syntax”.

C.5.2.17. `Can't initialize character set`

You might see an error like this if you have character set problems:

```
MySQL Connection Failed: Can't initialize character set charset_name
```

This error can have any of the following causes:

- The character set is a multi-byte character set and you have no support for the character set in the client. In this case, you need to recompile the client by running `CMake` with the `-DDEFAULT_CHARSET=charset_name` or `-DWITH_EXTRA_CHARSETS=charset_name` option. See Section 2.9.4, “MySQL Source-Configuration Options”.

  All standard MySQL binaries are compiled with `-DWITH_EXTRA_CHARSETS=all`, which enables support for all multi-byte character sets. See Section 2.9.4, “MySQL Source-Configuration Options”.

- The character set is a simple character set that is not compiled into `mysqld`, and the character set definition files are not in the place where the client expects to find them.

  In this case, you need to use one of the following methods to solve the problem:

  - Recompile the client with support for the character set. See Section 2.9.4, “MySQL Source-Configuration Options”.
  - Specify to the client the directory where the character set definition files are located. For many clients, you can do this with the `--character-sets-dir` option.
  - Copy the character definition files to the path where the client expects them to be.

C.5.2.18. `'FILE' NOT FOUND` and Similar Errors

If you get `ERROR '...' not found (errno: 23)`, `Can't open file: ... (errno: 24)`, or any other error with `errno 23` or `errno 24` from MySQL, it means that you haven't allocated enough file descriptors for the MySQL server. You can use the `perror` utility to get a description of what the error number means:

```
shell> perror 23
OS error code  23:  File table overflow
shell> perror 24
OS error code  24:  Too many open files
shell> perror 11
OS error code  11:  Resource temporarily unavailable
```

The problem here is that `mysqld` is trying to keep open too many files simultaneously. You can either tell `mysqld` not to open so many files at once or increase the number of file descriptors available to `mysqld`.

To tell `mysqld` to keep open fewer files at a time, you can make the table cache smaller by reducing the value of the `table_open_cache` system variable (the default value is 64). This may not entirely prevent running out of file descriptors because in some circumstances the server may attempt to extend the cache size temporarily, as described in Section 7.4.3.1, “How MySQL Opens and Closes Tables”. Reducing the value of `max_connections` also reduces the number of open files (the default value is 100).

To change the number of file descriptors available to `mysqld`, you can use the `--open-files-limit` option to `mysqld_safe` or set the `open_files_limit` system variable. See Section 5.1.3, “Server System Variables”. The easiest way to set these values is to add an option to your option file. See Section 4.2.3.3, “Using Option Files”. If you have an old version of `mysqld` that doesn't support setting the open files limit, you can edit the `mysqld_safe` script. There is a commented-out line `ulimit -n 256` in the script. You can remove the “`#`” character to uncomment this line, and change the number `256` to set the number of file descriptors to be made available to `mysqld`.

`--open-files-limit` and `ulimit` can increase the number of file descriptors, but only up to the limit imposed by the operating system. There is also a “hard” limit that can be overridden only if you start `mysqld_safe` or `mysqld` as `root` (just remember that you also need to start the server with the `--user` option in this case so that it does not continue to run as `root` after it starts up). If you need to increase the operating system limit on the number of file descriptors available to each process, consult the documentation for your system.

> **Note**
>
> If you run the `tcsh` shell, `ulimit` does not work! `tcsh` also reports incorrect values when you ask for the current limits. In this case, you should start `mysqld_safe` using `sh`.

C.5.2.19. Table-Corruption Issues

If you have started `mysqld` with `--myisam-recover-options`, MySQL automatically checks and tries to repair `MyISAM` tables if they are marked as 'not closed properly' or 'crashed'. If this happens, MySQL writes an entry in the `hostname.err` file `'Warning: Checking table ...'` which is followed by `Warning: Repairing table` if the table needs to be repaired. If you get a lot of these errors, without `mysqld` having died unexpectedly just before, then something is wrong and needs to be investigated further.

As of MySQL 5.5.3, when the server detects `MyISAM` table corruption, it writes additional information to the error log, such as the name and line number of the source file, and the list of threads accessing the table. Example: `Got an error from thread_id=1, mi_dynrec.c:368`. This is useful information to include in bug reports.

See also Section 5.1.2, “Server Command Options”, and Section 21.5.1.7, “Making a Test Case If You Experience Table Corruption”.

C.5.3. Installation-Related Issues

C.5.3.1. Problems with File Permissions

If you have problems with file permissions, the `UMASK` environment variable might be set incorrectly when `mysqld` starts. For example, MySQL might issue the following error message when you create a table:

```
ERROR: Can't find file: 'path/with/filename.frm' (Errcode: 13)
```

The default `UMASK` value is `0660`. You can change this behavior by starting `mysqld_safe` as follows:

```
shell> UMASK=384  # = 600 in octal
shell> export UMASK
shell> mysqld_safe &
```

By default, MySQL creates database directories with an access permission value of `0700`. You can modify this behavior by setting the `UMASK_DIR` variable. If you set its value, new directories are created with the combined `UMASK` and `UMASK_DIR` values. For example, if you want to give group access to all new directories, you can do this:

```
shell> UMASK_DIR=504  # = 770 in octal
shell> export UMASK_DIR
shell> mysqld_safe &
```

MySQL assumes that the value for `UMASK` or `UMASK_DIR` is in octal if it starts with a zero.

See Section 2.12, “Environment Variables”.

C.5.4. Administration-Related Issues

C.5.4.1. How to Reset the Root Password

If you have never set a `root` password for MySQL, the server does not require a password at all for connecting as `root`. However, this is insecure. For instructions on assigning passwords, see Section 2.10.2, “Securing the Initial MySQL Accounts”.

If you know the `root` password, but want to change it, see Section 12.4.1.6, “`SET PASSWORD` Syntax”.

If you set a `root` password previously, but have forgotten it, you can set a new password. The following sections provide instructions for Windows and Unix systems, as well as generic instructions that apply to any system.

C.5.4.1.1. Resetting the Root Password: Windows Systems

On Windows, use the following procedure to reset the password for all MySQL `root` accounts:

1. Log on to your system as Administrator.
2. Stop the MySQL server if it is running. For a server that is running as a Windows service, go to the Services manager: From the Start menu, select Control Panel, then Administrative Tools, then Services. Find the MySQL service in the list and stop it.

   If your server is not running as a service, you may need to use the Task Manager to force it to stop.
3. Create a text file containing the following statements. Replace the password with the password that you want to use.

   ```
   UPDATE mysql.user SET Password=PASSWORD('MyNewPass') WHERE User='root';
   FLUSH PRIVILEGES;
   ```

   Write the `UPDATE` and `FLUSH` statements each on a single line. The `UPDATE` statement resets the password for all `root` accounts, and the `FLUSH` statement tells the server to reload the grant tables into memory so that it notices the password change.
4. Save the file. For this example, the file will be named `C:\mysql-init.txt`.
5. Open a console window to get to the command prompt: From the Start menu, select Run, then enter `cmd` as the command to be run.
6. Start the MySQL server with the special `--init-file` option (notice that the backslash in the option value is doubled):

   ```
   C:\> C:\mysql\bin\mysqld --init-file=C:\\mysql-init.txt
   ```

   If you installed MySQL to a location other than `C:\mysql`, adjust the command accordingly.

   The server executes the contents of the file named by the `--init-file` option at startup, changing each `root` account password.

   You can also add the `--console` option to the command if you want server output to appear in the console window rather than in a log file.

   If you installed MySQL using the MySQL Installation Wizard, you may need to specify a `--defaults-file` option:

   ```
   C:\> "C:\Program Files\MySQL\MySQL Server 5.5\bin\mysqld.exe"
            --defaults-file="C:\\Program Files\\MySQL\\MySQL Server 5.5\\my.ini"
            --init-file=C:\\mysql-init.txt
   ```

   The appropriate `--defaults-file` setting can be found using the Services Manager: From the Start menu, select Control Panel, then Administrative Tools, then Services. Find the MySQL service in the list, right-click it, and choose the `Properties` option. The `Path to executable` field contains the `--defaults-file` setting.
7. After the server has started successfully, delete `C:\mysql-init.txt`.

You should now be able to connect to the MySQL server as `root` using the new password. Stop the MySQL server, then restart it in normal mode again. If you run the server as a service, start it from the Windows Services window. If you start the server manually, use whatever command you normally use.

C.5.4.1.2. Resetting the Root Password: Unix Systems

On Unix, use the following procedure to reset the password for all MySQL `root` accounts. The instructions assume that you will start the server so that it runs using the Unix login account that you normally use for running the server. For example, if you run the server using the `mysql` login account, you should log in as `mysql` before using the instructions. Alternatively, you can log in as `root`, but in this case you *must* start `mysqld` with the `--user=mysql` option. If you start the server as `root` without using `--user=mysql`, the server may create `root`-owned files in the data directory, such as log files, and these may cause permission-related problems for future server startups. If that happens, you will need to either change the ownership of the files to `mysql` or remove them.

1. Log on to your system as the Unix user that the `mysqld` server runs as (for example, `mysql`).
2. Locate the `.pid` file that contains the server's process ID. The exact location and name of this file depend on your distribu-

tion, host name, and configuration. Common locations are `/var/lib/mysql/`, `/var/run/mysqld/`, and `/usr/local/mysql/data/`. Generally, the file name has an extension of `.pid` and begins with either `mysqld` or your system's host name.

You can stop the MySQL server by sending a normal `kill` (not `kill -9`) to the `mysqld` process, using the path name of the `.pid` file in the following command:

```
shell> kill `cat /mysql-data-directory/host_name.pid`
```

Use backticks (not forward quotation marks) with the `cat` command. These cause the output of `cat` to be substituted into the `kill` command.

3. Create a text file containing the following statements. Replace the password with the password that you want to use.

   ```
   UPDATE mysql.user SET Password=PASSWORD('MyNewPass') WHERE User='root';
   FLUSH PRIVILEGES;
   ```

   Write the `UPDATE` and `FLUSH` statements each on a single line. The `UPDATE` statement resets the password for all `root` accounts, and the `FLUSH` statement tells the server to reload the grant tables into memory so that it notices the password change.

4. Save the file. For this example, the file will be named `/home/me/mysql-init`. The file contains the password, so it should not be saved where it can be read by other users. If you are not logged in as `mysql` (the user the server runs as), make sure that the file has permissions that permit `mysql` to read it.

5. Start the MySQL server with the special `--init-file` option:

   ```
   shell> mysqld_safe --init-file=/home/me/mysql-init &
   ```

   The server executes the contents of the file named by the `--init-file` option at startup, changing each `root` account password.

6. After the server has started successfully, delete `/home/me/mysql-init`.

You should now be able to connect to the MySQL server as `root` using the new password. Stop the server and restart it normally.

C.5.4.1.3. Resetting the Root Password: Generic Instructions

The preceding sections provide password-resetting instructions for Windows and Unix systems. Alternatively, on any platform, you can set the new password using the `mysql` client (but this approach is less secure):

1. Stop `mysqld` and restart it with the `--skip-grant-tables` option. This enables anyone to connect without a password and with all privileges. Because this is insecure, you might want to use `--skip-grant-tables` in conjunction with `--skip-networking` to prevent remote clients from connecting.

2. Connect to the `mysqld` server with this command:

   ```
   shell> mysql
   ```

3. Issue the following statements in the `mysql` client. Replace the password with the password that you want to use.

   ```
   mysql> UPDATE mysql.user SET Password=PASSWORD('MyNewPass')
       ->                   WHERE User='root';
   mysql> FLUSH PRIVILEGES;
   ```

   The `FLUSH` statement tells the server to reload the grant tables into memory so that it notices the password change.

You should now be able to connect to the MySQL server as `root` using the new password. Stop the server, then restart it normally (without the `--skip-grant-tables` and `--skip-networking` options).

C.5.4.2. What to Do If MySQL Keeps Crashing

Each MySQL version is tested on many platforms before it is released. This doesn't mean that there are no bugs in MySQL, but if there are bugs, they should be very few and can be hard to find. If you have a problem, it always helps if you try to find out exactly what crashes your system, because you have a much better chance of getting the problem fixed quickly.

First, you should try to find out whether the problem is that the `mysqld` server dies or whether your problem has to do with your client. You can check how long your `mysqld` server has been up by executing `mysqladmin version`. If `mysqld` has died and restarted, you may find the reason by looking in the server's error log. See Section 5.2.2, “The Error Log”.

On some systems, you can find in the error log a stack trace of where `mysqld` died that you can resolve with the `resolve_stack_dump` program. See MySQL Internals: Porting. Note that the variable values written in the error log may not always be 100% correct.

Many server crashes are caused by corrupted data files or index files. MySQL updates the files on disk with the `write()` system call after every SQL statement and before the client is notified about the result. (This is not true if you are running with `--delay-key-write`, in which case data files are written but not index files.) This means that data file contents are safe even if `mysqld` crashes, because the operating system ensures that the unflushed data is written to disk. You can force MySQL to flush everything to disk after every SQL statement by starting `mysqld` with the `--flush` option.

The preceding means that normally you should not get corrupted tables unless one of the following happens:

- The MySQL server or the server host was killed in the middle of an update.
- You have found a bug in `mysqld` that caused it to die in the middle of an update.
- Some external program is manipulating data files or index files at the same time as `mysqld` without locking the table properly.
- You are running many `mysqld` servers using the same data directory on a system that doesn't support good file system locks (normally handled by the `lockd` lock manager), or you are running multiple servers with external locking disabled.
- You have a crashed data file or index file that contains very corrupt data that confused `mysqld`.
- You have found a bug in the data storage code. This isn't likely, but it is at least possible. In this case, you can try to change the storage engine to another engine by using `ALTER TABLE` on a repaired copy of the table.

Because it is very difficult to know why something is crashing, first try to check whether things that work for others crash for you. Please try the following things:

- Stop the `mysqld` server with `mysqladmin shutdown`, run `myisamchk --silent --force */*.MYI` from the data directory to check all `MyISAM` tables, and restart `mysqld`. This ensures that you are running from a clean state. See Chapter 5, *MySQL Server Administration*.
- Start `mysqld` with the general query log enabled (see Section 5.2.3, “The General Query Log”). Then try to determine from the information written to the log whether some specific query kills the server. About 95% of all bugs are related to a particular query. Normally, this is one of the last queries in the log file just before the server restarts. See Section 5.2.3, “The General Query Log”. If you can repeatedly kill MySQL with a specific query, even when you have checked all tables just before issuing it, then you have been able to locate the bug and should submit a bug report for it. See Section 1.7, “How to Report Bugs or Problems”.
- Try to make a test case that we can use to repeat the problem. See MySQL Internals: Porting.
- Try running the tests in the `mysql-test` directory and the MySQL benchmarks. See Section 21.1.2, “The MySQL Test Suite”. They should test MySQL rather well. You can also add code to the benchmarks that simulates your application. The benchmarks can be found in the `sql-bench` directory in a source distribution or, for a binary distribution, in the `sql-bench` directory under your MySQL installation directory.
- Try the `fork_big.pl` script. (It is located in the `tests` directory of source distributions.)
- If you configure MySQL for debugging, it is much easier to gather information about possible errors if something goes wrong. Reconfigure MySQL with the `-DWITH_DEBUG=1` option to `CMake` and then recompile. See MySQL Internals: Porting.
- Make sure that you have applied the latest patches for your operating system.
- Use the `--skip-external-locking` option to `mysqld`. On some systems, the `lockd` lock manager does not work properly; the `--skip-external-locking` option tells `mysqld` not to use external locking. (This means that you cannot run two `mysqld` servers on the same data directory and that you must be careful if you use `myisamchk`. Nevertheless, it may be instructive to try the option as a test.)
- Have you tried `mysqladmin -u root processlist` when `mysqld` appears to be running but not responding? Sometimes `mysqld` is not comatose even though you might think so. The problem may be that all connections are in use, or there may be some internal lock problem. `mysqladmin -u root processlist` usually is able to make a connection even in these cases, and can provide useful information about the current number of connections and their status.
- Run the command `mysqladmin -i 5 status` or `mysqladmin -i 5 -r status` in a separate window to produce statistics while you run your other queries.

- Try the following:

  1. Start `mysqld` from `gdb` (or another debugger). See MySQL Internals: Porting.
  2. Run your test scripts.
  3. Print the backtrace and the local variables at the three lowest levels. In `gdb`, you can do this with the following commands when `mysqld` has crashed inside `gdb`:

     ```
     backtrace
     info local
     up
     info local
     up
     info local
     ```

     With `gdb`, you can also examine which threads exist with `info threads` and switch to a specific thread with `thread N`, where `N` is the thread ID.

- Try to simulate your application with a Perl script to force MySQL to crash or misbehave.

- Send a normal bug report. See Section 1.7, “How to Report Bugs or Problems”. Be even more detailed than usual. Because MySQL works for many people, it may be that the crash results from something that exists only on your computer (for example, an error that is related to your particular system libraries).

- If you have a problem with tables containing dynamic-length rows and you are using only `VARCHAR` columns (not `BLOB` or `TEXT` columns), you can try to change all `VARCHAR` to `CHAR` with `ALTER TABLE`. This forces MySQL to use fixed-size rows. Fixed-size rows take a little extra space, but are much more tolerant to corruption.

  The current dynamic row code has been in use for several years with very few problems, but dynamic-length rows are by nature more prone to errors, so it may be a good idea to try this strategy to see whether it helps.

- Do not rule out your server hardware when diagnosing problems. Defective hardware can be the cause of data corruption. Particular attention should be paid to your memory and disk subsystems when troubleshooting hardware.

C.5.4.3. How MySQL Handles a Full Disk

This section describes how MySQL responds to disk-full errors (such as “no space left on device”), and to quota-exceeded errors (such as “write failed” or “user block limit reached”).

This section is relevant for writes to `MyISAM` tables. It also applies for writes to binary log files and binary log index file, except that references to “row” and “record” should be understood to mean “event.”

When a disk-full condition occurs, MySQL does the following:

- It checks once every minute to see whether there is enough space to write the current row. If there is enough space, it continues as if nothing had happened.
- Every 10 minutes it writes an entry to the log file, warning about the disk-full condition.

To alleviate the problem, you can take the following actions:

- To continue, you only have to free enough disk space to insert all records.
- To abort the thread, you must use `mysqladmin kill`. The thread is aborted the next time it checks the disk (in one minute).
- Other threads might be waiting for the table that caused the disk-full condition. If you have several “locked” threads, killing the one thread that is waiting on the disk-full condition enables the other threads to continue.

Exceptions to the preceding behavior are when you use `REPAIR TABLE` or `OPTIMIZE TABLE` or when the indexes are created in a batch after `LOAD DATA INFILE` or after an `ALTER TABLE` statement. All of these statements may create large temporary files that, if left to themselves, would cause big problems for the rest of the system. If the disk becomes full while MySQL is doing any of these operations, it removes the big temporary files and mark the table as crashed. The exception is that for `ALTER TABLE`, the old table is left unchanged.

C.5.4.4. Where MySQL Stores Temporary Files

On Unix, MySQL uses the value of the `TMPDIR` environment variable as the path name of the directory in which to store temporary files. If `TMPDIR` is not set, MySQL uses the system default, which is usually `/tmp`, `/var/tmp`, or `/usr/tmp`.

On Windows, MySQL checks in order the values of the `TMPDIR`, `TEMP`, and `TMP` environment variables. For the first one found to be set, MySQL uses it and does not check those remaining. If none of `TMPDIR`, `TEMP`, or `TMP` are set, MySQL uses the Windows system default, which is usually `C:\windows\temp\`.

If the file system containing your temporary file directory is too small, you can use the `--tmpdir` option to `mysqld` to specify a directory in a file system where you have enough space.

In MySQL 5.5, the `--tmpdir` option can be set to a list of several paths that are used in round-robin fashion. Paths should be separated by colon characters ("`:`") on Unix and semicolon characters ("`;`") on Windows.

> **Note**
>
> To spread the load effectively, these paths should be located on different *physical* disks, not different partitions of the same disk.

If the MySQL server is acting as a replication slave, you should not set `--tmpdir` to point to a directory on a memory-based file system or to a directory that is cleared when the server host restarts. A replication slave needs some of its temporary files to survive a machine restart so that it can replicate temporary tables or `LOAD DATA INFILE` operations. If files in the temporary file directory are lost when the server restarts, replication fails.

MySQL creates all temporary files as hidden files. This ensures that the temporary files are removed if `mysqld` is terminated. The disadvantage of using hidden files is that you do not see a big temporary file that fills up the file system in which the temporary file directory is located.

When sorting (`ORDER BY` or `GROUP BY`), MySQL normally uses one or two temporary files. The maximum disk space required is determined by the following expression:

```
(length of what is sorted + sizeof(row pointer))
* number of matched rows
* 2
```

The row pointer size is usually four bytes, but may grow in the future for really big tables.

For some `SELECT` queries, MySQL also creates temporary SQL tables. These are not hidden and have names of the form `SQL_*`.

`ALTER TABLE` creates a temporary table in the same directory as the original table.

C.5.4.5. How to Protect or Change the MySQL Unix Socket File

The default location for the Unix socket file that the server uses for communication with local clients is `/tmp/mysql.sock`. (For some distribution formats, the directory might be different, such as `/var/lib/mysql` for RPMs.)

On some versions of Unix, anyone can delete files in the `/tmp` directory or other similar directories used for temporary files. If the socket file is located in such a directory on your system, this might cause problems.

On most versions of Unix, you can protect your `/tmp` directory so that files can be deleted only by their owners or the superuser (`root`). To do this, set the `sticky` bit on the `/tmp` directory by logging in as `root` and using the following command:

```
shell> chmod +t /tmp
```

You can check whether the `sticky` bit is set by executing `ls -ld /tmp`. If the last permission character is `t`, the bit is set.

Another approach is to change the place where the server creates the Unix socket file. If you do this, you should also let client programs know the new location of the file. You can specify the file location in several ways:

- Specify the path in a global or local option file. For example, put the following lines in `/etc/my.cnf`:

  ```
  [mysqld]
  socket=/path/to/socket

  [client]
  socket=/path/to/socket
  ```

  See Section 4.2.3.3, "Using Option Files".

- Specify a `--socket` option on the command line to `mysqld_safe` and when you run client programs.

- Set the `MYSQL_UNIX_PORT` environment variable to the path of the Unix socket file.
- Recompile MySQL from source to use a different default Unix socket file location. Define the path to the file with the `MYSQL_UNIX_ADDR` option when you run `CMake`. See Section 2.9.4, "MySQL Source-Configuration Options".

You can test whether the new socket location works by attempting to connect to the server with this command:

```
shell> mysqladmin --socket=/path/to/socket version
```

C.5.4.6. Time Zone Problems

If you have a problem with `SELECT NOW()` returning values in UTC and not your local time, you have to tell the server your current time zone. The same applies if `UNIX_TIMESTAMP()` returns the wrong value. This should be done for the environment in which the server runs; for example, in `mysqld_safe` or `mysql.server`. See Section 2.12, "Environment Variables".

You can set the time zone for the server with the `--timezone=`*`timezone_name`* option to `mysqld_safe`. You can also set it by setting the `TZ` environment variable before you start `mysqld`.

The permissible values for `--timezone` or `TZ` are system dependent. Consult your operating system documentation to see what values are acceptable.

C.5.5. Query-Related Issues

C.5.5.1. Case Sensitivity in String Searches

For nonbinary strings (`CHAR`, `VARCHAR`, `TEXT`), string searches use the collation of the comparison operands. For binary strings (`BINARY`, `VARBINARY`, `BLOB`), comparisons use the numeric values of the bytes in the operands; this means that for alphabetic characters, comparisons will be case sensitive.

A comparison between a nonbinary string and binary string is treated as a comparison of binary strings.

Simple comparison operations (`>=, >, =, <, <=`, sorting, and grouping) are based on each character's "sort value." Characters with the same sort value are treated as the same character. For example, if "`e`" and "`é`" have the same sort value in a given collation, they compare as equal.

The default character set and collation are `latin1` and `latin1_swedish_ci`, so nonbinary string comparisons are case insensitive by default. This means that if you search with *`col_name`* `LIKE 'a%'`, you get all column values that start with `A` or `a`. To make this search case sensitive, make sure that one of the operands has a case sensitive or binary collation. For example, if you are comparing a column and a string that both have the `latin1` character set, you can use the `COLLATE` operator to cause either operand to have the `latin1_general_cs` or `latin1_bin` collation:

```
col_name COLLATE latin1_general_cs LIKE 'a%'
col_name LIKE 'a%' COLLATE latin1_general_cs
col_name COLLATE latin1_bin LIKE 'a%'
col_name LIKE 'a%' COLLATE latin1_bin
```

If you want a column always to be treated in case-sensitive fashion, declare it with a case sensitive or binary collation. See Section 12.1.14, "`CREATE TABLE` Syntax".

To cause a case-sensitive comparison of nonbinary strings to be case insensitive, use `COLLATE` to name a case-insensitive collation. The strings in the following example normally are case sensitive, but `COLLATE` changes the comparison to be case insensitive:

```
mysql> SET @s1 = 'MySQL' COLLATE latin1_bin,
    ->     @s2 = 'mysql' COLLATE latin1_bin;
mysql> SELECT @s1 = @s2;
+-----------+
| @s1 = @s2 |
+-----------+
|         0 |
+-----------+
mysql> SELECT @s1 COLLATE latin1_swedish_ci = @s2;
+-------------------------------------+
| @s1 COLLATE latin1_swedish_ci = @s2 |
+-------------------------------------+
|                                   1 |
+-------------------------------------+
```

A binary string is case sensitive in comparisons. To compare the string as case insensitive, convert it to a nonbinary string and use `COLLATE` to name a case-insensitive collation:

```
mysql> SET @s = BINARY 'MySQL';
mysql> SELECT @s = 'mysql';
+--------------+
| @s = 'mysql' |
+--------------+
|            0 |
+--------------+
mysql> SELECT CONVERT(@s USING latin1) COLLATE latin1_swedish_ci = 'mysql';
+-------------------------------------------------------------+
| CONVERT(@s USING latin1) COLLATE latin1_swedish_ci = 'mysql' |
+-------------------------------------------------------------+
|                                                           1 |
+-------------------------------------------------------------+
```

To determine whether a value will compare as a nonbinary or binary string, use the `COLLATION()` function. This example shows that `VERSION()` returns a string that has a case-insensitive collation, so comparisons are case insensitive:

```
mysql> SELECT COLLATION(VERSION());
+----------------------+
| COLLATION(VERSION()) |
+----------------------+
| utf8_general_ci      |
+----------------------+
```

For binary strings, the collation value is `binary`, so comparisons will be case sensitive. One context in which you will see `binary` is for compression and encryption functions, which return binary strings as a general rule: string:

```
mysql> SELECT COLLATION(ENCRYPT('x')), COLLATION(SHA1('x'));
+-------------------------+----------------------+
| COLLATION(ENCRYPT('x')) | COLLATION(SHA1('x')) |
+-------------------------+----------------------+
| binary                  | binary               |
+-------------------------+----------------------+
```

C.5.5.2. Problems Using DATE Columns

The format of a `DATE` value is `'YYYY-MM-DD'`. According to standard SQL, no other format is permitted. You should use this format in `UPDATE` expressions and in the `WHERE` clause of `SELECT` statements. For example:

```
mysql> SELECT * FROM tbl_name WHERE date >= '2003-05-05';
```

As a convenience, MySQL automatically converts a date to a number if the date is used in a numeric context (and vice versa). It is also smart enough to permit a “relaxed” string form when updating and in a `WHERE` clause that compares a date to a `TIMESTAMP`, `DATE`, or `DATETIME` column. (“Relaxed form” means that any punctuation character may be used as the separator between parts. For example, `'2004-08-15'` and `'2004#08#15'` are equivalent.) MySQL can also convert a string containing no separators (such as `'20040815'`), provided it makes sense as a date.

When you compare a `DATE`, `TIME`, `DATETIME`, or `TIMESTAMP` to a constant string with the `<`, `<=`, `=`, `>=`, `>`, or `BETWEEN` operators, MySQL normally converts the string to an internal long integer for faster comparison (and also for a bit more “relaxed” string checking). However, this conversion is subject to the following exceptions:

- When you compare two columns
- When you compare a `DATE`, `TIME`, `DATETIME`, or `TIMESTAMP` column to an expression
- When you use any other comparison method than those just listed, such as `IN` or `STRCMP()`.

For these exceptional cases, the comparison is done by converting the objects to strings and performing a string comparison.

To keep things safe, assume that strings are compared as strings and use the appropriate string functions if you want to compare a temporal value to a string.

The special date `'0000-00-00'` can be stored and retrieved as `'0000-00-00'.` When using a `'0000-00-00'` date through MyODBC, it is automatically converted to `NULL` in MyODBC 2.50.12 and above, because ODBC can't handle this kind of date.

Because MySQL performs the conversions described above, the following statements work:

```
mysql> INSERT INTO tbl_name (idate) VALUES (19970505);
mysql> INSERT INTO tbl_name (idate) VALUES ('19970505');
mysql> INSERT INTO tbl_name (idate) VALUES ('97-05-05');
mysql> INSERT INTO tbl_name (idate) VALUES ('1997.05.05');
mysql> INSERT INTO tbl_name (idate) VALUES ('1997 05 05');
mysql> INSERT INTO tbl_name (idate) VALUES ('0000-00-00');

mysql> SELECT idate FROM tbl_name WHERE idate >= '1997-05-05';
mysql> SELECT idate FROM tbl_name WHERE idate >= 19970505;
mysql> SELECT MOD(idate,100) FROM tbl_name WHERE idate >= 19970505;
mysql> SELECT idate FROM tbl_name WHERE idate >= '19970505';
```

However, the following does not work:

```
mysql> SELECT idate FROM tbl_name WHERE STRCMP(idate,'20030505')=0;
```

`STRCMP()` is a string function, so it converts `idate` to a string in `'YYYY-MM-DD'` format and performs a string comparison. It does not convert `'20030505'` to the date `'2003-05-05'` and perform a date comparison.

If you are using the `ALLOW_INVALID_DATES` SQL mode, MySQL permits you to store dates that are given only limited checking: MySQL requires only that the day is in the range from 1 to 31 and the month is in the range from 1 to 12.

This makes MySQL very convenient for Web applications where you obtain year, month, and day in three different fields and you want to store exactly what the user inserted (without date validation).

If you are not using the `NO_ZERO_IN_DATE` SQL mode, the day or month part can be zero. This is convenient if you want to store a birthdate in a `DATE` column and you know only part of the date.

If you are not using the `NO_ZERO_DATE` SQL mode, MySQL also permits you to store `'0000-00-00'` as a “dummy date.” This is in some cases more convenient than using `NULL` values.

If the date cannot be converted to any reasonable value, a `0` is stored in the `DATE` column, which is retrieved as `'0000-00-00'`. This is both a speed and a convenience issue. We believe that the database server's responsibility is to retrieve the same date you stored (even if the data was not logically correct in all cases). We think it is up to the application and not the server to check the dates.

If you want MySQL to check all dates and accept only legal dates (unless overridden by IGNORE), you should set `sql_mode` to `"NO_ZERO_IN_DATE,NO_ZERO_DATE"`.

C.5.5.3. Problems with `NULL` Values

The concept of the `NULL` value is a common source of confusion for newcomers to SQL, who often think that `NULL` is the same thing as an empty string `''`. This is not the case. For example, the following statements are completely different:

```
mysql> INSERT INTO my_table (phone) VALUES (NULL);
mysql> INSERT INTO my_table (phone) VALUES ('');
```

Both statements insert a value into the `phone` column, but the first inserts a `NULL` value and the second inserts an empty string. The meaning of the first can be regarded as “phone number is not known” and the meaning of the second can be regarded as “the person is known to have no phone, and thus no phone number.”

To help with `NULL` handling, you can use the `IS NULL` and `IS NOT NULL` operators and the `IFNULL()` function.

In SQL, the `NULL` value is never true in comparison to any other value, even `NULL`. An expression that contains `NULL` always produces a `NULL` value unless otherwise indicated in the documentation for the operators and functions involved in the expression. All columns in the following example return `NULL`:

```
mysql> SELECT NULL, 1+NULL, CONCAT('Invisible',NULL);
```

If you want to search for column values that are `NULL`, you cannot use an `expr = NULL` test. The following statement returns no rows, because `expr = NULL` is never true for any expression:

```
mysql> SELECT * FROM my_table WHERE phone = NULL;
```

To look for `NULL` values, you must use the `IS NULL` test. The following statements show how to find the `NULL` phone number and the empty phone number:

```
mysql> SELECT * FROM my_table WHERE phone IS NULL;
mysql> SELECT * FROM my_table WHERE phone = '';
```

See Section 3.3.4.6, “Working with `NULL` Values”, for additional information and examples.

You can add an index on a column that can have `NULL` values if you are using the `MyISAM`, `InnoDB`, or `MEMORY` storage engine. Otherwise, you must declare an indexed column `NOT NULL`, and you cannot insert `NULL` into the column.

When reading data with `LOAD DATA INFILE`, empty or missing columns are updated with `''`. If you want a `NULL` value in a column, you should use `\N` in the data file. The literal word “`NULL`” may also be used under some circumstances. See Section 12.2.6, “`LOAD DATA INFILE` Syntax”.

When using `DISTINCT`, `GROUP BY`, or `ORDER BY`, all `NULL` values are regarded as equal.

When using `ORDER BY`, `NULL` values are presented first, or last if you specify `DESC` to sort in descending order.

Aggregate (summary) functions such as `COUNT()`, `MIN()`, and `SUM()` ignore `NULL` values. The exception to this is `COUNT(*)`, which counts rows and not individual column values. For example, the following statement produces two counts. The first is a count of the number of rows in the table, and the second is a count of the number of non-`NULL` values in the `age` column:

```
mysql> SELECT COUNT(*), COUNT(age) FROM person;
```

For some data types, MySQL handles `NULL` values specially. If you insert `NULL` into a `TIMESTAMP` column, the current date and time is inserted. If you insert `NULL` into an integer or floating-point column that has the `AUTO_INCREMENT` attribute, the next number in the sequence is inserted.

C.5.5.4. Problems with Column Aliases

An alias can be used in a query select list to give a column a different name. You can use the alias in `GROUP BY`, `ORDER BY`, or `HAVING` clauses to refer to the column:

```
SELECT SQRT(a*b) AS root FROM tbl_name
  GROUP BY root HAVING root > 0;
SELECT id, COUNT(*) AS cnt FROM tbl_name
  GROUP BY id HAVING cnt > 0;
SELECT id AS 'Customer identity' FROM tbl_name;
```

Standard SQL disallows references to column aliases in a `WHERE` clause. This restriction is imposed because when the `WHERE` clause is evaluated, the column value may not yet have been determined. For example, the following query is illegal:

```
SELECT id, COUNT(*) AS cnt FROM tbl_name
  WHERE cnt > 0 GROUP BY id;
```

The `WHERE` clause determines which rows should be included in the `GROUP BY` clause, but it refers to the alias of a column value that is not known until after the rows have been selected, and grouped by the `GROUP BY`.

In the select list of a query, a quoted column alias can be specified using identifier or string quoting characters:

```
SELECT 1 AS `one`, 2 AS 'two';
```

Elsewhere in the statement, quoted references to the alias must use identifier quoting or the reference is treated as a string literal. For example, this statement groups by the values in column `id`, referenced using the alias `` `a` ``:

```
SELECT id AS 'a', COUNT(*) AS cnt FROM tbl_name
  GROUP BY `a`;
```

But this statement groups by the literal string `'a'` and will not work as expected:

```
SELECT id AS 'a', COUNT(*) AS cnt FROM tbl_name
  GROUP BY 'a';
```

C.5.5.5. Rollback Failure for Nontransactional Tables

If you receive the following message when trying to perform a `ROLLBACK`, it means that one or more of the tables you used in the transaction do not support transactions:

```
Warning: Some non-transactional changed tables couldn't be rolled back
```

These nontransactional tables are not affected by the `ROLLBACK` statement.

If you were not deliberately mixing transactional and nontransactional tables within the transaction, the most likely cause for this message is that a table you thought was transactional actually is not. This can happen if you try to create a table using a transactional storage engine that is not supported by your `mysqld` server (or that was disabled with a startup option). If `mysqld` doesn't support a storage engine, it instead creates the table as a `MyISAM` table, which is nontransactional.

You can check the storage engine for a table by using either of these statements:

```
SHOW TABLE STATUS LIKE 'tbl_name';
SHOW CREATE TABLE tbl_name;
```

See Section 12.4.5.37, “`SHOW TABLE STATUS` Syntax”, and Section 12.4.5.12, “`SHOW CREATE TABLE` Syntax”.

You can check which storage engines your `mysqld` server supports by using this statement:

```
SHOW ENGINES;
```

You can also use the following statement, and check the value of the variable that is associated with the storage engine in which you are interested:

```
SHOW VARIABLES LIKE 'have_%';
```

For example, to determine whether the `InnoDB` storage engine is available, check the value of the `have_innodb` variable.

See Section 12.4.5.17, “`SHOW ENGINES` Syntax”, and Section 12.4.5.40, “`SHOW VARIABLES` Syntax”.

C.5.5.6. Deleting Rows from Related Tables

If the total length of the `DELETE` statement for `related_table` is more than 1MB (the default value of the `max_allowed_packet` system variable), you should split it into smaller parts and execute multiple `DELETE` statements. You probably get the fastest `DELETE` by specifying only 100 to 1,000 `related_column` values per statement if the `related_column` is indexed. If the `related_column` isn't indexed, the speed is independent of the number of arguments in the `IN` clause.

C.5.5.7. Solving Problems with No Matching Rows

If you have a complicated query that uses many tables but that doesn't return any rows, you should use the following procedure to find out what is wrong:

1. Test the query with `EXPLAIN` to check whether you can find something that is obviously wrong. See Section 12.8.2, “`EXPLAIN` Syntax”.

2. Select only those columns that are used in the `WHERE` clause.

3. Remove one table at a time from the query until it returns some rows. If the tables are large, it is a good idea to use `LIMIT 10` with the query.

4. Issue a `SELECT` for the column that should have matched a row against the table that was last removed from the query.

5. If you are comparing `FLOAT` or `DOUBLE` columns with numbers that have decimals, you can't use equality (`=`) comparisons. This problem is common in most computer languages because not all floating-point values can be stored with exact precision. In some cases, changing the `FLOAT` to a `DOUBLE` fixes this. See Section C.5.5.8, “Problems with Floating-Point Values”.

6. If you still can't figure out what is wrong, create a minimal test that can be run with `mysql test < query.sql` that shows your problems. You can create a test file by dumping the tables with `mysqldump --quick db_name` *`tbl_name_1`* `...` *`tbl_name_n`* `> query.sql`. Open the file in an editor, remove some insert lines (if there are more than needed to demonstrate the problem), and add your `SELECT` statement at the end of the file.

   Verify that the test file demonstrates the problem by executing these commands:

   ```
   shell> mysqladmin create test2
   shell> mysql test2 < query.sql
   ```

   Attach the test file to a bug report, which you can file using the instructions in Section 1.7, “How to Report Bugs or Problems”.

C.5.5.8. Problems with Floating-Point Values

Floating-point numbers sometimes cause confusion because they are approximate and not stored as exact values. A floating-point value as written in an SQL statement may not be the same as the value represented internally. Attempts to treat floating-point values as exact in comparisons may lead to problems. They are also subject to platform or implementation dependencies. The `FLOAT` and `DOUBLE` data types are subject to these issues. For `DECIMAL` columns, MySQL performs operations with a precision of 65 decimal digits, which should solve most common inaccuracy problems.

The following example uses `DOUBLE` to demonstrate how calculations that are done using floating-point operations are subject to floating-point error.

```
mysql> CREATE TABLE t1 (i INT, d1 DOUBLE, d2 DOUBLE);
mysql> INSERT INTO t1 VALUES (1, 101.40, 21.40), (1, -80.00, 0.00),
    -> (2, 0.00, 0.00), (2, -13.20, 0.00), (2, 59.60, 46.40),
    -> (2, 30.40, 30.40), (3, 37.00, 7.40), (3, -29.60, 0.00),
    -> (4, 60.00, 15.40), (4, -10.60, 0.00), (4, -34.00, 0.00),
```

```
    -> (5, 33.00, 0.00), (5, -25.80, 0.00), (5, 0.00, 7.20),
    -> (6, 0.00, 0.00), (6, -51.40, 0.00);

mysql> SELECT i, SUM(d1) AS a, SUM(d2) AS b
    -> FROM t1 GROUP BY i HAVING a <> b;

+------+-------+------+
| i    | a     | b    |
+------+-------+------+
|    1 |  21.4 | 21.4 |
|    2 |  76.8 | 76.8 |
|    3 |   7.4 |  7.4 |
|    4 |  15.4 | 15.4 |
|    5 |   7.2 |  7.2 |
|    6 | -51.4 |    0 |
+------+-------+------+
```

The result is correct. Although the first five records look like they should not satisfy the comparison (the values of `a` and `b` do not appear to be different), they may do so because the difference between the numbers shows up around the tenth decimal or so, depending on factors such as computer architecture or the compiler version or optimization level. For example, different CPUs may evaluate floating-point numbers differently.

If columns `d1` and `d2` had been defined as `DECIMAL` rather than `DOUBLE`, the result of the `SELECT` query would have contained only one row—the last one shown above.

The correct way to do floating-point number comparison is to first decide on an acceptable tolerance for differences between the numbers and then do the comparison against the tolerance value. For example, if we agree that floating-point numbers should be regarded the same if they are same within a precision of one in ten thousand (0.0001), the comparison should be written to find differences larger than the tolerance value:

```
mysql> SELECT i, SUM(d1) AS a, SUM(d2) AS b FROM t1
    -> GROUP BY i HAVING ABS(a - b) > 0.0001;
+------+-------+------+
| i    | a     | b    |
+------+-------+------+
|    6 | -51.4 |    0 |
+------+-------+------+
1 row in set (0.00 sec)
```

Conversely, to get rows where the numbers are the same, the test should find differences within the tolerance value:

```
mysql> SELECT i, SUM(d1) AS a, SUM(d2) AS b FROM t1
    -> GROUP BY i HAVING ABS(a - b) <= 0.0001;
+------+------+------+
| i    | a    | b    |
+------+------+------+
|    1 | 21.4 | 21.4 |
|    2 | 76.8 | 76.8 |
|    3 |  7.4 |  7.4 |
|    4 | 15.4 | 15.4 |
|    5 |  7.2 |  7.2 |
+------+------+------+
5 rows in set (0.03 sec)
```

Floating-point values are subject to platform or implementation dependencies. Suppose that you execute the following statements:

```
CREATE TABLE t1(c1 FLOAT(53,0), c2 FLOAT(53,0));
INSERT INTO t1 VALUES('1e+52','-1e+52');
SELECT * FROM t1;
```

On some platforms, the `SELECT` statement returns `inf` and `-inf`. Other others, it returns `0` and `-0`.

An implication of the preceding issues is that if you attempt to create a replication slave by dumping table contents with `mysqldump` on the master and reloading the dump file into the slave, tables containing floating-point columns might differ between the two hosts.

C.5.6. Optimizer-Related Issues

MySQL uses a cost-based optimizer to determine the best way to resolve a query. In many cases, MySQL can calculate the best possible query plan, but sometimes MySQL doesn't have enough information about the data at hand and has to make “educated” guesses about the data.

For the cases when MySQL does not do the "right" thing, tools that you have available to help MySQL are:

- Use the `EXPLAIN` statement to get information about how MySQL processes a query. To use it, just add the keyword `EXPLAIN` to the front of your `SELECT` statement:

  ```
  mysql> EXPLAIN SELECT * FROM t1, t2 WHERE t1.i = t2.i;
  ```

`EXPLAIN` is discussed in more detail in Section 12.8.2, “`EXPLAIN` Syntax”.

- Use `ANALYZE TABLE` *`tbl_name`* to update the key distributions for the scanned table. See Section 12.4.2.1, “`ANALYZE TABLE` Syntax”.
- Use `FORCE INDEX` for the scanned table to tell MySQL that table scans are very expensive compared to using the given index:

  ```
  SELECT * FROM t1, t2 FORCE INDEX (index_for_column)
  WHERE t1.col_name=t2.col_name;
  ```

  `USE INDEX` and `IGNORE INDEX` may also be useful. See Section 12.2.9.2, “Index Hint Syntax”.
- Global and table-level `STRAIGHT_JOIN`. See Section 12.2.9, “`SELECT` Syntax”.
- You can tune global or thread-specific system variables. For example, start `mysqld` with the `--max-seeks-for-key=1000` option or use `SET max_seeks_for_key=1000` to tell the optimizer to assume that no key scan causes more than 1,000 key seeks. See Section 5.1.3, “Server System Variables”.

C.5.7. Table Definition-Related Issues

C.5.7.1. Problems with `ALTER TABLE`

If you get a duplicate-key error when using `ALTER TABLE` to change the character set or collation of a character column, the cause is either that the new column collation maps two keys to the same value or that the table is corrupted. In the latter case, you should run `REPAIR TABLE` on the table.

If `ALTER TABLE` dies with the following error, the problem may be that MySQL crashed during an earlier `ALTER TABLE` operation and there is an old table named `A-`*`xxx`* or `B-`*`xxx`* lying around:

```
Error on rename of './database/name.frm'
to './database/B-xxx.frm' (Errcode: 17)
```

In this case, go to the MySQL data directory and delete all files that have names starting with `A-` or `B-`. (You may want to move them elsewhere instead of deleting them.)

`ALTER TABLE` works in the following way:

- Create a new table named `A-`*`xxx`* with the requested structural changes.
- Copy all rows from the original table to `A-`*`xxx`*.
- Rename the original table to `B-`*`xxx`*.
- Rename `A-`*`xxx`* to your original table name.
- Delete `B-`*`xxx`*.

If something goes wrong with the renaming operation, MySQL tries to undo the changes. If something goes seriously wrong (although this shouldn't happen), MySQL may leave the old table as `B-`*`xxx`*. A simple rename of the table files at the system level should get your data back.

If you use `ALTER TABLE` on a transactional table or if you are using Windows, `ALTER TABLE` unlocks the table if you had done a `LOCK TABLE` on it. This is done because `InnoDB` and these operating systems cannot drop a table that is in use.

C.5.7.2. `TEMPORARY` Table Problems

The following list indicates limitations on the use of `TEMPORARY` tables:

- A `TEMPORARY` table can only be of type `MEMORY`, `MyISAM`, `MERGE`, or `InnoDB`.

  Temporary tables are not supported for MySQL Cluster.
- You cannot refer to a `TEMPORARY` table more than once in the same query. For example, the following does not work:

```
mysql> SELECT * FROM temp_table, temp_table AS t2;
ERROR 1137: Can't reopen table: 'temp_table'
```

This error also occurs if you refer to a temporary table multiple times in a stored function under different aliases, even if the references occur in different statements within the function.

- The `SHOW TABLES` statement does not list `TEMPORARY` tables.
- You cannot use `RENAME` to rename a `TEMPORARY` table. However, you can use `ALTER TABLE` instead:

```
mysql> ALTER TABLE orig_name RENAME new_name;
```

- There are known issues in using temporary tables with replication. See Section 15.4.1, "Replication Features and Issues", for more information.

C.5.8. Known Issues in MySQL

This section lists known issues in recent versions of MySQL.

For information about platform-specific issues, see the installation and porting instructions in Section 2.1, "General Installation Guidance", and MySQL Internals: Porting.

The following problems are known:

- Subquery optimization for `IN` is not as effective as for `=`.
- Even if you use `lower_case_table_names=2` (which enables MySQL to remember the case used for databases and table names), MySQL does not remember the case used for database names for the function `DATABASE()` or within the various logs (on case-insensitive systems).
- Dropping a `FOREIGN KEY` constraint doesn't work in replication because the constraint may have another name on the slave.
- `REPLACE` (and `LOAD DATA` with the `REPLACE` option) does not trigger `ON DELETE CASCADE`.
- `DISTINCT` with `ORDER BY` doesn't work inside `GROUP_CONCAT()` if you don't use all and only those columns that are in the `DISTINCT` list.
- If one user has a long-running transaction and another user drops a table that is updated in the transaction, there is small chance that the binary log may contain the `DROP TABLE` statement before the table is used in the transaction itself. We plan to fix this by having the `DROP TABLE` statement wait until the table is not being used in any transaction.
- When inserting a big integer value (between 2^{63} and $2^{64}-1$) into a decimal or string column, it is inserted as a negative value because the number is evaluated in a signed integer context.
- `FLUSH TABLES WITH READ LOCK` does not block `COMMIT` if the server is running without binary logging, which may cause a problem (of consistency between tables) when doing a full backup.
- `ANALYZE TABLE`, `OPTIMIZE TABLE`, and `REPAIR TABLE` may cause problems on tables for which you are using `INSERT DELAYED`.
- Performing `LOCK TABLE ...` and `FLUSH TABLES ...` doesn't guarantee that there isn't a half-finished transaction in progress on the table.
- Replication uses query-level logging: The master writes the executed queries to the binary log. This is a very fast, compact, and efficient logging method that works perfectly in most cases.

  It is possible for the data on the master and slave to become different if a query is designed in such a way that the data modification is nondeterministic (generally not a recommended practice, even outside of replication).

  For example:

  - `CREATE TABLE ... SELECT` or `INSERT ... SELECT` statements that insert zero or `NULL` values into an `AUTO_INCREMENT` column.
  - `DELETE` if you are deleting rows from a table that has foreign keys with `ON DELETE CASCADE` properties.
  - `REPLACE ... SELECT`, `INSERT IGNORE ... SELECT` if you have duplicate key values in the inserted data.

If and only if the preceding queries have no `ORDER BY` clause guaranteeing a deterministic order.

For example, for `INSERT ... SELECT` with no `ORDER BY`, the `SELECT` may return rows in a different order (which results in a row having different ranks, hence getting a different number in the `AUTO_INCREMENT` column), depending on the choices made by the optimizers on the master and slave.

A query is optimized differently on the master and slave only if:

- The table is stored using a different storage engine on the master than on the slave. (It is possible to use different storage engines on the master and slave. For example, you can use `InnoDB` on the master, but `MyISAM` on the slave if the slave has less available disk space.)
- MySQL buffer sizes (`key_buffer_size`, and so on) are different on the master and slave.
- The master and slave run different MySQL versions, and the optimizer code differs between these versions.

This problem may also affect database restoration using `mysqlbinlog|mysql`.

The easiest way to avoid this problem is to add an `ORDER BY` clause to the aforementioned nondeterministic queries to ensure that the rows are always stored or modified in the same order.

In future MySQL versions, we will automatically add an `ORDER BY` clause when needed.

The following issues are known and will be fixed in due time:

- Log file names are based on the server host name (if you don't specify a file name with the startup option). You have to use options such as `--log-bin=`*`old_host_name`*`-bin` if you change your host name to something else. Another option is to rename the old files to reflect your host name change (if these are binary logs, you need to edit the binary log index file and fix the binary log file names there as well). See Section 5.1.2, “Server Command Options”.
- `mysqlbinlog` does not delete temporary files left after a `LOAD DATA INFILE` statement. See Section 4.6.7, “`mysqlbinlog` — Utility for Processing Binary Log Files”.
- `RENAME` doesn't work with `TEMPORARY` tables or tables used in a `MERGE` table.
- Due to the way table format (`.frm`) files are stored, you cannot use character 255 (`CHAR(255)`) in table names, column names, or enumerations.
- When using `SET CHARACTER SET`, you can't use translated characters in database, table, and column names.
- You can't use “`_`” or “`%`” with `ESCAPE` in `LIKE ... ESCAPE`.
- `BLOB` and `TEXT` values can't reliably be used in `GROUP BY`, `ORDER BY` or `DISTINCT`. Only the first `max_sort_length` bytes are used when comparing `BLOB` values in these cases. The default value of `max_sort_length` is 1024 and can be changed at server startup time or at runtime.
- Numeric calculations are done with `BIGINT` or `DOUBLE` (both are normally 64 bits long). Which precision you get depends on the function. The general rule is that bit functions are performed with `BIGINT` precision, `IF()` and `ELT()` with `BIGINT` or `DOUBLE` precision, and the rest with `DOUBLE` precision. You should try to avoid using unsigned long long values if they resolve to be larger than 63 bits (9223372036854775807) for anything other than bit fields.
- You can have up to 255 `ENUM` and `SET` columns in one table.
- In `MIN()`, `MAX()`, and other aggregate functions, MySQL currently compares `ENUM` and `SET` columns by their string value rather than by the string's relative position in the set.
- `mysqld_safe` redirects all messages from `mysqld` to the `mysqld` log. One problem with this is that if you execute `mysqladmin refresh` to close and reopen the log, `stdout` and `stderr` are still redirected to the old log. If you use the general query log extensively, you should edit `mysqld_safe` to log to *`host_name`*`.err` instead of *`host_name`*`.log` so that you can easily reclaim the space for the old log by deleting it and executing `mysqladmin refresh`.
- In an `UPDATE` statement, columns are updated from left to right. If you refer to an updated column, you get the updated value instead of the original value. For example, the following statement increments `KEY` by `2`, **not** `1`:

  ```
  mysql> UPDATE tbl_name SET KEY=KEY+1,KEY=KEY+1;
  ```

- You can refer to multiple temporary tables in the same query, but you cannot refer to any given temporary table more than once. For example, the following doesn't work:

```
mysql> SELECT * FROM temp_table, temp_table AS t2;
ERROR 1137: Can't reopen table: 'temp_table'
```

- The optimizer may handle `DISTINCT` differently when you are using “hidden” columns in a join than when you are not. In a join, hidden columns are counted as part of the result (even if they are not shown), whereas in normal queries, hidden columns don't participate in the `DISTINCT` comparison. We will probably change this in the future to never compare the hidden columns when executing `DISTINCT`.

  An example of this is:

  ```
  SELECT DISTINCT mp3id FROM band_downloads
         WHERE userid = 9 ORDER BY id DESC;
  ```

  and

  ```
  SELECT DISTINCT band_downloads.mp3id
         FROM band_downloads,band_mp3
         WHERE band_downloads.userid = 9
         AND band_mp3.id = band_downloads.mp3id
         ORDER BY band_downloads.id DESC;
  ```

  In the second case, using MySQL Server 3.23.x, you may get two identical rows in the result set (because the values in the hidden `id` column may differ).

  Note that this happens only for queries where that do not have the `ORDER BY` columns in the result.

- If you execute a `PROCEDURE` on a query that returns an empty set, in some cases the `PROCEDURE` does not transform the columns.

- Creation of a table of type `MERGE` doesn't check whether the underlying tables are compatible types.

- If you use `ALTER TABLE` to add a `UNIQUE` index to a table used in a `MERGE` table and then add a normal index on the `MERGE` table, the key order is different for the tables if there was an old, non-`UNIQUE` key in the table. This is because `ALTER TABLE` puts `UNIQUE` indexes before normal indexes to be able to detect duplicate keys as early as possible.

Appendix D. MySQL Change History

This appendix lists the changes from version to version in the MySQL source code through the latest version of MySQL 5.5, which is currently MySQL 5.5.16. We offer a version of the Manual for each series of MySQL releases (5.0, 5.1, and so forth). For information about changes in another release series of the MySQL database software, see the corresponding version of this Manual.

We update this section as we add new features in the 5.5 series, so that everybody can follow the development process.

Note that we tend to update the manual at the same time we make changes to MySQL. If you find a recent version of MySQL listed here that you can't find on our download page (http://dev.mysql.com/downloads/), it means that the version has not yet been released.

The date mentioned with a release version is the date of the last Bazaar ChangeSet on which the release was based, not the date when the packages were made available. The binaries are usually made available a few days after the date of the tagged ChangeSet, because building and testing all packages takes some time.

The manual included in the source and binary distributions may not be fully accurate when it comes to the release changelog entries, because the integration of the manual happens at build time. For the most up-to-date release changelog, please refer to the online version instead.

Previously, MySQL development proceeded by including a large set of features and moving them over many versions within a release series through several stages of maturity (Alpha, Beta, and so forth). This development model had a disadvantage in that problems with only part of the code could hinder timely release of the whole.

MySQL development now uses a milestone model. The move to this model provides for more frequent milestone releases, with each milestone proceeding through a small number of releases having a focus on a specific subset of thoroughly tested features. Following the releases for one milestone, development proceeds with the next milestone; that is, another small number of releases that focuses on the next small set of features, also thoroughly tested.

MySQL 5.5.0-m2 is the first release for Milestone 2. The new features of this milestone may be considered to be initially of beta quality. For subsequent Milestone 2 releases, we plan to use increasing version numbers (5.5.1 and higher) while continuing to employ the “-m2” suffix. For Milestone 3, we plan to change the suffix to “-m3”. Version designators with “-alpha” or “-beta” suffixes are no used.

You may notice that the MySQL 5.5.0 release is designated as Milestone 2 rather than Milestone 1. This is because MySQL 5.4 was actually designated as Milestone 1, although we had not yet begun referring to milestone numbers as part of version numbers at the time.

D.1. Changes in Release 5.5.x (Production)

An overview of features added in MySQL 5.5 can be found here: Section 1.5, “What Is New in MySQL 5.5”. For a full list of changes, please refer to the changelog sections for individual 5.5 releases.

For discussion of upgrade issues that you may encounter for upgrades from MySQL 5.1 to MySQL 5.5, see Section 2.11.1.1, “Upgrading from MySQL 5.1 to 5.5”.

For discussion of upgrade issues that you may encounter for upgrades from MySQL 5.4 to MySQL 5.5, see Section 2.11.1.2, “Upgrading from MySQL 5.4 to 5.5”.

D.1.1. Changes in MySQL 5.5.16 (Not yet released)

Functionality Added or Changed

- **Important Change**: **Replication**: The `RESET SLAVE` statement has been extended with an `ALL` keyword. In addition to deleting the `master.info`, `relay-log.info`, and all relay log files, `RESET SLAVE ALL` also clears all connection information otherwise held in memory following execution of `RESET SLAVE`. (Bug #11809016)

Bugs Fixed

- Compilation failed on Mac OS X 10.7 (Lion) with a warning: `Implicit declaration of function 'pthread_init'` (Bug #12779790)
- With profiling disabled or not compiled in, `set_thd_proc_info()` unnecessarily checked file name lengths. (Bug #12756017)
- `CHECK TABLE` and `REPAIR TABLE` failed to find problems with `MERGE` tables that had underlying tables missing or with

the wrong storage engine. Issues were reported only for the first underlying table. (Bug #11754210)

- **Replication**: Processing of corrupted table map events could cause the server to crash. This was especially likely if the events mapped different tables to the same identifier, such as could happen due to Bug#56226.

  Now, before applying a table map event, the server checks whether the table has already been mapped with different settings, and if so, an error is raised and the slave SQL thread stops. If it has been mapped with the same settings, or if the table is set to be ignored by filtering rules, there is no change in behavior: the event is skipped and IDs are not checked. (Bug #44360, Bug #11753004)

  See also Bug #11763509.

- For a `lower_case_table_names` value of 1 or 2 and a database having a mixed-case name, calling a stored function using a fully qualified name including the database name failed. (Bug #60347, Bug #11840395)

- Previously, Performance Schema table columns that held byte counts were `BIGINT UNSIGNED`. These were changed to `BIGINT` (signed). This makes it easier to perform calculations that compute differences between columns. (Bug #59631, Bug #11766504)

- The embedded server crashed when `argc = 0`. (Bug #57931, Bug #12561297)

- Upgrades using an RPM package recreated the `test` database, which is undesirable when the DBA had removed it. (Bug #45415, Bug #11753896)

D.1.2. Changes in MySQL 5.5.15 (28 July 2011)

Functionality Added or Changed

- The undocumented `--all` option for `perror` is deprecated and will be removed in MySQL 5.6.

Bugs Fixed

- **InnoDB Storage Engine**: A failed `CREATE INDEX` operation for an `InnoDB` table could result in some memory being allocated but not freed. This memory leak could affect tables created with the `ROW_FORMAT=DYNAMIC` or `ROW_FORMAT=COMPRESSED` setting. (Bug #12699505)

- **Partitioning**: Auto-increment columns of partitioned tables were checked even when they were not being written to. In debug builds, this could lead to a server crash. (Bug #11765667, Bug #58655)

- **Partitioning**: The `UNIX_TIMESTAMP()` function was not treated as a monotonic function for purposes of partition pruning. (Bug #11746819, Bug #28928)

- Compiling the server with maintainer mode enabled failed for `gcc` 4.6 or higher. (Bug #12727287)

- The option-parsing code for empty strings leaked memory. (Bug #12589928)

- Previously, an inappropriate error message was produced if a multiple-table update for an `InnoDB` table with a clustered primary key would update a table through multiple aliases, and perform an update that may physically move the row in at least one of these aliases. Now the error message is: `Primary key/partition key update is not permitted since the table is updated both as '`*`tbl_name1`*`' and '`*`tbl_name2`*`'` (Bug #11882110)

  See also Bug #11764529.

- **Replication**: If a `LOAD DATA INFILE` statement—replicated using statement-based replication—featured a `SET` clause, the name-value pairs were regenerated using a method (`Item::print()`) intended primarily for generating output for statements such as `EXPLAIN EXTENDED`, and which cannot be relied on to return valid SQL. This could in certain cases lead to a crash on the slave.

  To fix this problem, the server now names each value in its original, user-supplied form, and uses that to create `LOAD DATA INFILE` statements for statement-based replication. (Bug #60580, Bug #11902767)

  See also Bug #34283, Bug #11752526, Bug #43746.

- `ALTER TABLE {MODIFY|CHANGE} ... FIRST` did nothing except rename columns if the old and new versions of the table had exactly the same structure with respect to column data types. As a result, the mapping of column name to column data was incorrect. The same thing happened for `ALTER TABLE DROP COLUMN ... ADD COLUMN` statements intended to produce a new version of the table with exactly the same structure as the old version. (Bug #61493, Bug #12652385)

- Incorrect handling of metadata locking for `FLUSH TABLES WITH READ LOCK` for statements requiring prelocking caused two problems:
  - Execution of any data-changing statement that required prelocking (that is, involved a stored function or trigger) as part of a transaction slowed down somewhat all subsequent statements in the transaction. Performance in a transaction that periodically involved such statements gradually degraded over time.
  - Execution of any data-changing statement that required prelocking as part of a transaction prevented a concurrent `FLUSH TABLES WITH READ LOCK` from proceeding until the end of the transaction rather than at the end of the particular statement.

  (Bug #61401, Bug #12641342)
- The fractional part of the “Queries per second” value could be displayed incorrectly in MySQL status output (for example, in the output from `mysqladmin status` or the `mysql` `STATUS` command). (Bug #61205, Bug #12565712)
- `LOAD DATA INFILE` incorrectly parsed relative data file path names that ascended more than three levels in the file system and as a consequence was unable to find the file. (Bug #60987, Bug #12403662)
- For unknown users, the native password plugin reported incorrectly that no password had been specified even when it had. (Bug #59792, Bug #11766641)
- For `MyISAM` tables, attempts to insert incorrect data into an indexed `GEOMETRY` column could result in table corruption. (Bug #57323, Bug #11764487)
- In debug builds, `Field_new_decimal::store_value()` was subject to buffer overflows. (Bug #55436, Bug #11762799)
- A race condition between loading a stored routine using the name qualified by the database name and dropping that database resulted in a spurious error message: `The table mysql.proc is missing, corrupt, or contains bad data` (Bug #47870, Bug #11756013)

D.1.3. Changes in MySQL 5.5.14 (05 July 2011)

Functionality Added or Changed

- **Incompatible Change**: In the audit plugin interface, the `event_class` member was removed from the `mysql_event_general` structure and the calling sequence for the notification function changed. Originally, the second argument was a pointer to the event structure. The function now receives this information as two arguments: an event class number and a pointer to the event. Corresponding to these changes, `MYSQL_AUDIT_INTERFACE_VERSION` was increased to `0x0300`.

  The `plugin_audit.h` header file, and the `NULL_AUDIT` example plugin in the `plugin/audit_null` directory have been modified per these changes. See Section 21.2.4.8, “Writing Audit Plugins”.
- **InnoDB Storage Engine**: `InnoDB` now permits concurrent reads while creating a secondary index. (Bug #11853126)

  See also Bug #11751388, Bug #11784056, Bug #11815600.
- `CMake` configuration support on Linux now provides a boolean `ENABLE_GCOV` option to control whether to include support for `gcov`. (Bug #12549572)
- Client programs now display more information for SSL errors to aid in diagnosis and debugging of connection problems. (Bug #21287, Bug #11745920)

Bugs Fixed

- **InnoDB Storage Engine**: Stability is improved when using `BLOB` values within `InnoDB` tables in a heavily loaded system, especially for tables using the `ROW_FORMAT=DYNAMIC` or `ROW_FORMAT=COMPRESSED` setting. (Bug #12612184)
- **Replication**: A mistake in thread cleanup could cause a replication master to crash. (Bug #12578441)
- **Replication**: When using row-based replication and attribute promotion or demotion (see Section 15.4.1.6.2, “Replication of Columns Having Different Data Types”), memory allocated internally for conversion of `BLOB` columns was not freed afterwards. (Bug #12558519)
- Adding support for Windows authentication to `libmysql` introduced a link dependency on the system Secur32 library. The

Microsoft Visual C++ link information now pulls in this library automatically. (Bug #12612143)

- In some cases, memory allocated for `Query_tables_list::sroutines()` was not freed properly. (Bug #12429877)
- After the fix for Bug #11889186, `MAKEDATE()` arguments with a year part greater than 9999 raised an assertion. (Bug #12403504)
- An assertion could be raised due to a missing `NULL` value check in `Item_func_round::fix_length_and_dec()`. (Bug #12392636)
- An assertion could be raised during two-phase commits if the binary log was used as the transaction coordinator log. (Bug #12346411)
- A problem introduced in 5.5.11 caused very old (MySQL 4.0) clients to be unable to connect to the server. (Bug #61222, Bug #12563279)
- Using `CREATE EVENT IF NOT EXISTS` for an event that already existed and was enabled caused multiple instances of the event to run. (Bug #61005, Bug #12546938)
- An embedded client aborted rather than issuing an error message if it issued a `TEE` command (`\T` *`file_name`*) and the directory containing the file did not exist. This occurred because the wrong error handler was called. (Bug #57491, Bug #11764633)
- On some platforms, the `Incorrect value: xxx for column yyy at row zzz` error produced by `LOAD DATA INFILE` could have an incorrect value of *`zzz`*. (Bug #46895, Bug #11755168)
- An attempt to install nonexistent files during installation was corrected. (Bug #43247, Bug #11752142)
- On FreeBSD 64-bit builds of the embedded server, exceptions were not prevented from propagating into the embedded application. (Bug #38965, Bug #11749418)

D.1.4. Changes in MySQL 5.5.13 (31 May 2011)

> **Note**
>
> Very old (MySQL 4.0) clients are not working temporarily due to a problem discovered after the release of MySQL 5.5.12. We are looking at fixing the problem. Update: This is fixed in MySQL 5.5.14.

Bugs Fixed

- **InnoDB Storage Engine**: If the server crashed while an XA transaction was prepared but not yet committed, the transaction could remain in the system after restart, and cause a subsequent shutdown to hang. (Bug #11766513, Bug #59641)
- **InnoDB Storage Engine**: With the setting `lower_case_table_names=2`, inserts into `InnoDB` tables covered by foreign key constraints could fail after a server restart. This is a similar problem to the foreign key error in Bug #11831040 / Bug #60196 / Bug #60909, but with a different root cause and occurring on Mac OS X.
- **Partitioning**: The internal `get_partition_set()` function did not take into account the possibility that a key specification could be `NULL` in some cases. (Bug #12380149)
- **Partitioning**: When executing a row-ordered retrieval index merge, the partitioning handler used memory from that allocated for the table, rather than that allocated to the query, causing table object memory not to be freed until the table was closed. (Bug #11766249, Bug #59316)
- **Replication**: When `mysqlbinlog` was invoked using `--base64-output=decode-row` and `--start-position=`*`pos`*, (where *`pos`* is a point in the binary log past the format description log event), a spurious error of the type shown here was generated:

  ```
  malformed binlog: it does not contain any Format_description_log_event...
  ```

  However, since there is nothing unsafe about not printing the format description log event, the error has been removed for this case. (Bug #12354268)
- **Replication**: Typographical errors appeared in the text of several replication error messages. (The word “position” was misspelled as “postion”.) (Bug #11762616, Bug #55229)
- Assignments to `NEW.`*`var_name`* within triggers, where *`var_name`* had a `BLOB` or `TEXT` type, were not properly handled and produced incorrect results. (Bug #12362125)

- `XA COMMIT` could fail to clean up the error state if it discovered that the current XA transaction had to be rolled back. Consequently, the next XA transaction could raise an assertion when it checked for proper cleanup of the previous transaction. (Bug #12352846)
- An internal client macro reference was removed from the `client_plugin.h` header file. This reference made the file unusable. (Bug #60746, Bug #12325444)
- For repeated invocation of some stored procedures, the server consumed memory that it did not release until the connection terminated. (Bug #60025, Bug #11848763)
- The server did not check for certain invalid out of order sequences of XA statements, and these sequences raised an assertion. (Bug #59936, Bug #11766752, Bug #12348348)
- With the conversion from GNU autotools to `CMake` for configuring MySQL, the `USE_SYMDIR` preprocessor symbol was omitted. This caused failure of symbolic links (described at Section 7.11.3.1, "Using Symbolic Links"). (Bug #59408, Bug #11766320)
- An incorrect `max_length` value for `YEAR` values could be used in temporary result tables for `UNION`, leading to incorrect results. (Bug #59343, Bug #11766270)
- In `Item_func_in::fix_length_and_dec()`, a Valgrind warning for uninitialized values was corrected. (Bug #59270, Bug #11766212)
- In `ROUND()` calculations, a Valgrind warning for uninitialized memory was corrected. (Bug #58937, Bug #11765923)
- Valgrind warnings caused by comparing index values to an uninitialized field were corrected. (Bug #58705, Bug #11765713)
- `LOAD DATA INFILE` errors could leak I/O cache memory. (Bug #58072, Bug #11765141)
- For `LOAD DATA INFILE`, multibyte character sequences could be pushed onto a stack too small to accommodate them. (Bug #58069, Bug #11765139)
- Internal Performance Schema header files were unnecessarily installed publicly. (Bug #53281)
- On Linux, the `mysql` client built using the bundled `libedit` did not read `~/.editrc`. (Bug #49967, Bug #11757855)
- The optimizer sometimes incorrectly processed `HAVING` clauses for queries that did not also have an `ORDER BY` clause. (Bug #48916, Bug #11756928)
- `PROCEDURE ANALYZE()` could leak memory for `NULL` results, and could return incorrect results if used with a `LIMIT` clause. (Bug #48137, Bug #11756242)
- With `DISTINCT CONCAT(col_name,...)` returned incorrect results when the arguments to `CONCAT()` were columns with an integer data type declared with a display width narrower than the values in the column. (For example, if an `INT(1)` column contained `1111`.) (Bug #4082)

D.1.5. Changes in MySQL 5.5.12 (05 May 2011)

Functionality Added or Changed

- When invoked with the `--auto-generate-sql` option, `mysqlslap` dropped the schema specified with the `--create-schema` option at the end of the test run, which may have been unexpected by the user. `mysqlslap` no longer drops the schema, but has a new `--create-and-drop-schema` option that both creates and drops a schema. (Bug #58090, Bug #11765157)

Bugs Fixed

- **InnoDB Storage Engine**: **Replication**: Trying to update a column, previously set to `NULL`, of an `InnoDB` table with no primary key caused replication to fail with `CAN'T FIND RECORD IN 'TABLE' ON THE SLAVE`. (Bug #11766865, Bug #60091)
- **InnoDB Storage Engine**: The server could halt if `InnoDB` interpreted a very heavy I/O load for 15 minutes or more as an indication that the server was hung. This change fixes the logic that measures how long `InnoDB` threads were waiting, which formerly could produce false positives. (Bug #11877216, Bug #11755413, Bug #47183)
- **InnoDB Storage Engine**: With the setting `lower_case_table_names=2`, inserts into `InnoDB` tables covered by foreign key constraints could fail after a server restart. (Bug #11831040, Bug #60196, Bug #60909)

- On Windows, the server rejected client connections if no DNS server was available. (Bug #12325375)
- `mysql_upgrade` did not properly upgrade the `authentication_string` column of the `mysql.user` table. (Bug #11936829)
- `InnoDB` invoked some `zlib` functions without proper initialization. (Bug #11849231)
- `CREATE TABLE` permitted a `TABLESPACE` table option but did not write the option value to the `.frm` file. (Bug #11769356)
- **Replication**: Using the `--server-id` option with `mysqlbinlog` could cause format description log events to be filtered from the binary log, leaving `mysqlbinlog` unable to read the remainder of the log. Now such events are always read without regard to the value of this option.

  As part of the the fix for this problem, `mysqlbinlog` now also reads rotate log events without regard to the value of `--server-id`. (Bug #59530, Bug #11766427)
- Comparison of a `DATETIME` stored program variable and `NOW()` led to an “Illegal mix of collations error” when `character_set_connection` was set to `utf8`. (Bug #60625, Bug #11926811)
- Selecting from a view for which the definition included a `HAVING` clause failed with an error:

  ```
  1356: View '...' references invalid table(s) or column(s)
  or function(s) or definer/invoker of view lack rights to use them
  ```

  (Bug #60295, Bug #11829681)
- `CREATE TABLE` syntax permits specification of a `STORAGE {DEFAULT|DISK|MEMORY}` option. However, this value was not written to the `.frm` file, so that a subsequent `CREATE TABLE ... LIKE` for the table did not include that option.

  Also, `ALTER TABLE` of a table that had a tablespace incorrectly destroyed the tablespace. (Bug #60111, Bug #11766883, Bug #34047, Bug #11747789)
- The server permitted `max_allowed_packet` to be set lower than `net_buffer_length`, which does not make sense because `max_allowed_packet` is the upper limit on `net_buffer_length` values. Now a warning occurs and the value remains unchanged. (Bug #59959, Bug #11766769)
- A missing variable initialization for `Item_func_set_user_var` objects could raise an assertion. (Bug #59527, Bug #11766424)
- When the server was started with the `--skip-innodb` option, it initialized the `have_innodb` system variable to `YES` rather than `DISABLED`. (Bug #59393, Bug #11766306)
- In `Item_func_month::val_str()`, a Valgrind warning for a too-late `NULL` value check was corrected. (Bug #59166, Bug #11766126)
- In `Item::get_date`, a Valgrind warning for a missing `NULL` value check was corrected. (Bug #59164, Bug #11766124)
- In `extract_date_time()`, a Valgrind warning for a missing end-of-string check was corrected. (Bug #59151, Bug #11766112)
- In string context, the `MIN()` and `MAX()` functions did not take into account the unsignedness of a `BIGINT UNSIGNED` argument. (Bug #59132, Bug #11766094)
- In `Item_func::val_decimal`, a Valgrind warning for a missing `NULL` value check was corrected. (Bug #59125, Bug #11766087)
- In `Item_func_str_to_date::val_str`, a Valgrind warning for an uninitialized variable was corrected. (Bug #58154, Bug #11765216)
- An assertion could be raised in `Item_func_int_val::fix_num_length_and_dec()` due to overflow for geometry functions. (Bug #57900, Bug #11764994)
- With prepared statements, the server could attempt to send result set metadata after the table had been closed. (Bug #56115, Bug #11763413)
- With `lower_case_table_names=2`, resolution of objects qualified by database names could fail. (Bug #50924, Bug #11758687)
- `SHOW EVENTS` did not always show events from the correct database. (Bug #41907, Bug #11751148)

D.1.6. Changes in MySQL 5.5.11 (07 April 2011)

Functionality Added or Changed

- `InnoDB` now permits concurrent reads on a table while creating nonprimary unique indexes. (This was found to create problems and was reverted in 5.5.12.) (Bug #11784056)
- Previously, Performance Schema instrumentation for both the binary log and the relay log used these instruments:

  ```
  wait/io/file/sql/binlog
  wait/io/file/sql/binlog_index
  wait/synch/mutex/sql/MYSQL_BIN_LOG::LOCK_index
  wait/synch/cond/sql/MYSQL_BIN_LOG::update_cond
  ```

  Now instrumentation for the relay log uses these instruments, which makes it possible to distinguish events for the binary log from those for the relay log:

  ```
  wait/io/file/sql/relaylog
  wait/io/file/sql/relaylog_index
  wait/synch/mutex/sql/MYSQL_RELAY_LOG::LOCK_index
  wait/synch/cond/sql/MYSQL_RELAY_LOG::update_cond
  ```

  (Bug #59658, Bug #11766528)
- MySQL distributions now include an `INFO_SRC` file that contains information about the source distribution, such as the MySQL version from which it was created. MySQL binary distributions additionally include an `INFO_BIN` file that contains information about how the distribution was built, such as compiler options and feature flags. In RPM packages, these files are located in the `/usr/share/doc/packages/MySQL-server` directory. In `tar.gz` and derived packages, they are located in the `Docs` directory under the location where the distribution is unpacked. (Bug #42969, Bug #11751935)
- Previously, for queries that were aborted due to a sort problem or terminated with `KILL` in the middle of a sort, the server wrote the message `Sort aborted` to the error log. Now the server writes more information about the cause of the error. These causes include:
  - Insufficient disk space in the temporary file directory prevented a temp file from being created
  - Insufficient memory for `sort_buffer_size` to be allocated
  - Somebody ran `KILL` *`id`* in the middle of a filesort operation
  - The server was shut down while some queries were sorting
  - A transaction was rolled back or aborted due to a lock wait timeout or deadlock
  - Unexpected errors, such as a source table or even temp table was corrupt
  - Processing of a subquery failed which was also sorting

  (Bug #30771, Bug #11747102)
- A new system variable, `max_long_data_size`, now controls the maximum size of parameter values that can be sent with the `mysql_stmt_send_long_data()` C API function. If not set at server startup, the default is the value of the `max_allowed_packet` system variable. This variable is deprecated. In MySQL 5.6, it is removed and the maximum parameter size is controlled by `max_allowed_packet`.
- For the Windows installer, debug information files and the embedded MySQL server have been removed from the standard MSI distribution file to reduce the download size for the majority of users.

  If these files are needed, the Zip distribution must be downloaded separately and be extracted in the installation directory, which is most probably `C:\Program Files\MySQL\MySQL Server 5.5` on English systems.

  Please note that upon product de-installation, these extracted files from the Zip distribution must be removed from the system manually.
- The undocumented `SHOW NEW MASTER` statement has been removed.

Bugs Fixed

- **Partitioning**: A problem with a previous fix for poor performance of `INSERT ON DUPLICATE KEY UPDATE` statements on tables having many partitions caused the handler function for reading a row from a specific index to fail to store the ID of the partition last used. This caused some statements to fail with `CAN'T FIND RECORD` errors. (Bug #59297, Bug #11766232)

- Two unused test files in `storage/ndb/test/sql` contained incorrect versions of the GNU Lesser General Public License. The files and the directory containing them have been removed. (Bug #11810224)

  See also Bug #11810156.

- Division of large numbers could cause stack corruption. (Bug #11792200)

- **Replication**: A failed `DROP DATABASE` statement could break statement-based replication. (Bug #58381, Bug #11765416)

- The `mysql_load_client_plugin()` C API function did not clear the previous error. (Bug #60075, Bug #11766854)

- An assertion was raised if an `XA COMMIT` was issued when an XA transaction had already encountered an error (such as a deadlock) that required the transaction to be rolled back. (Bug #59986, Bug #11766788)

- On some systems, debug builds of `comp_err.c` could fail due to an uninitialized variable. (Bug #59906, Bug #11766729)

- The server read one byte too many when trying to process an XML string lacking a closing single quote (`'`) or double quote (`"`) character used as an argument for `UpdateXML()` or `ExtractValue()`. (Bug #59901, Bug #11766725)

  See also Bug #44332, Bug #11752979.

- Attempting to create a spatial index on a `CHAR` column longer than 31 bytes led to an assertion failure if the server was compiled with safemutex support. (Bug #59888, Bug #11766714)

- Aggregation followed by a subquery could produce an incorrect result. (Bug #59839, Bug #11766675)

- An incorrect character set pointer passed to `my_strtoll10_mb2()` caused an assertion to be raised. (Bug #59648, Bug #11766519)

- `FIND_IN_SET()` could work differently in MySQL 5.5 than in 5.1. (Bug #59405, Bug #11766317)

- `mysqldump` did not quote database names in `ALTER DATABASE` statements in its output, which could cause an error at reload time for database names containing a dash. (Bug #59398, Bug #11766310)

- The `MYSQL_HOME` environment variable was being ignored. (Bug #59280, Bug #11766219)

- An invalid pathname argument for the `--defaults-extra-file` option of MySQL programs caused a program crash. (Bug #59234, Bug #11766184)

- On Windows, the `authentication_string` column recently added to the `mysql.user` table caused the Configuration Wizard to fail. (Bug #59038, Bug #11766011)

- `CREATE TRIGGER` and `DROP TRIGGER` can change the prelocking list of stored routines, but the routine cache did not detect such changes, resulting in routine execution with an inaccurate locking list. (Bug #58674, Bug #11765684)

- The code for `PROCEDURE ANALYSE()` had a missing `DBUG_RETURN` statement, which could cause a server crash in debug builds. (Bug #58140, Bug #11765202)

- An assertion was raised if a statement tried to upgrade a metadata lock while there was an active `FLUSH TABLE` *`tbl_list`* `WITH READ LOCK` statement. Now if a statement tries to upgrade a metadata lock in this situation, the server returns an `ER_TABLE_NOT_LOCKED_FOR_WRITE` error to the client. (Bug #57649, Bug #11764779)

- If a multiple-table update updated a row through two aliases and the first update physically moved the row, the second update failed to locate the row. This resulted in different errors depending on the storage engine, although these errors did not accurately describe the problem:

  - `MyISAM`: `Got error 134 from storage engine`
  - `InnoDB`: `Can't find record in '`*`tbl`*`'`

  For `MyISAM`, which is nontransactional, the update executed first was performed but the second was not. In addition, for two equal multiple-table update statements, one could succeed and the other fail depending on whether the record actually moved, which is inconsistent.

  Now such an update returns an error if it will update a table through multiple aliases, and perform an update that may physically move the row in at least one of these aliases. (Bug #57373, Bug #11764529, Bug #55385, Bug #11762751)

- `SHOW WARNINGS` output following `EXPLAIN EXTENDED` could include unprintable characters. (Bug #57341, Bug #11764503)

- In some cases, `SHOW WARNINGS` returned an empty result when the previous statement failed. (Bug #55847, Bug #11763166)
- On Windows, an object in thread local storage could be used before the object was created. (Bug #55730, Bug #11763065)
- For a client connected using SSL, the `Ssl_cipher_list` status variable was empty and did not show the possible cipher types. (Bug #52596, Bug #11760210)
- When used to upgrade tables, `mysqlcheck` (and `mysql_upgrade`, which invokes `mysqlcheck`) did not upgrade some tables for which table repair was found to be necessary. In particular, it failed to upgrade `InnoDB` tables that needed repair, leaving them in a nonupgraded state. This occurred because:

  - `mysqlcheck --check-upgrade ---auto-repair` checks for tables that are incompatible with the current version of MySQL. It does this by issuing the `CHECK TABLE ... FOR UPGRADE` statement and examining the result.
  - For any table found to be incompatible, `mysqlcheck` issues a `REPAIR TABLE` statement. But this fails for storage engines such as `InnoDB` that do not support the repair operation. Consequently, the table remained unchanged.

  To fix the problem, the following changes were made to `CHECK TABLE ... FOR UPGRADE` and `mysqlcheck`. Because `mysql_upgrade` invokes `mysqlcheck`, these changes also fix the problem for `mysql_upgrade`.

  - `CHECK TABLE ... FOR UPGRADE` returns a different error if a table needs repair but its storage engine does not support `REPAIR TABLE`:

    Previous:

    ```
    Error: ER_TABLE_NEEDS_UPGRADE
    Table upgrade required. Please do "REPAIR TABLE `tbl_name`" or
    dump/reload to fix it!
    ```

    Now:

    ```
    Error: ER_TABLE_NEEDS_REBUILD
    Table rebuild required. Please do "ALTER TABLE `tbl_name` FORCE" or
    dump/reload to fix it!
    ```

  - `mysqlcheck` recognizes the new error and issues an `ALTER TABLE ... FORCE` statement. The `FORCE` option for `ALTER TABLE` was recognized but did nothing; now it is implemented and acts as a “null” alter operation that rebuilds the table.

  (Bug #47205, Bug #11755431)
- When `CASE ... WHEN` arguments had different character sets, 8-bit values could be referenced as `utf16` or `utf32` values, raising an assertion. (Bug #44793, Bug #11753363)
- Bitmap functions used in one thread could change bitmaps used by other threads, raising an assertion. (Bug #43152, Bug #11752069)

D.1.7. Changes in MySQL 5.5.10 (15 March 2011)

C API Notes

- **Incompatible Change**: The shared library version of the client library was increased to 18 to reflect ABI changes, and avoid compatibility problems with the client library in MySQL 5.1. Note that this is an incompatible change between 5.5.10 and earlier 5.5 versions, so client programs that use the 5.5 client library should be recompiled against the 5.5.10 client library. (Bug #60061, Bug #11827366)

Pluggable Authentication Notes

- MySQL distributions now include `auth_socket`, a server-side authentication plugin that authenticates clients that connect from the local host through the Unix socket file. The plugin uses the `SO_PEERCRED` socket option to obtain information about the user running the client program (and thus can be built only on systems that support this option). For a connection to succeed, the plugin requires a match between the login name of the connecting client user and the MySQL user name presented by the client program. For more information, see Section 5.5.6.4, “The Socket Peer-Credential Authentication Plugin”. (Bug #59017, Bug #11765993)
- MySQL distributions now include `mysql_clear_password`, a client-side authentication plugin that sends the password to the server without hashing or encryption. Although this is insecure, and thus appropriate precautions should be taken (such as

using an SSL connection), the plugin is useful in conjunction with server-side plugins that must have access to the original password in clear text. For more information, see Section 5.5.6.3, “The Clear Text Client-Side Authentication Plugin”.

Functionality Added or Changed

- The `mysql_upgrade`, `mysqlbinlog`, `mysqlcheck`, `mysqlimport`, `mysqlshow`, and `mysqlslap` clients now have `--default-auth` and `--plugin-dir` options for specifying which authentication plugin and plugin directory to use. (Bug #58139)
- Boolean system variables can be enabled at run time by setting them to the value `ON` or `OFF`, but previously this did not work at server startup. Now at startup such variables can be enabled by setting them to `ON` or `TRUE`, or disabled by setting them to `OFF` or `FALSE`. Any other nonnumeric variable is invalid. (Bug #46393)

  See also Bug #11754743, Bug #51631.
- Previously, for queries that were aborted due to a sort problem, the server wrote the message `Sort aborted` to the error log. Now the server writes more information to provide a more specific message, such as:

  ```
  Sort aborted: Out of memory (Needed 24 bytes)
  Out of sort memory, consider increasing server sort buffer size
  Sort aborted: Out of sort memory, consider increasing server sort
    buffer size
  Sort aborted: Incorrect number of arguments for FUNCTION test.f1;
    expected 0, got 1
  ```

  In addition, if the server was started with `--log-warnings=2`, the server write information about the host, user, and query. (Bug #36022, Bug #11748358)
- `mysqldump --xml` now displays comments from column definitions. (Bug #13618, Bug #11745324)

Bugs Fixed

- **Security Fix**: Bug #36544 was fixed.
- **InnoDB Storage Engine**: Raised the number of I/O requests that each AIO helper thread could process, from 32 to 256. The new limit applies to Linux and Unix platforms; the limit on Windows remains 32. (Bug #59472)
- **InnoDB Storage Engine**: `InnoDB` returned values for “rows examined” in the query plan that were higher than expected. `NULL` values were treated in an inconsistent way. The inaccurate statistics could trigger “false positives” in combination with the `max_join_size` setting, because the queries did not really examine as many rows as reported.

  A new configuration option `innodb_stats_method` lets you specify how `NULL` values are treated when calculating index statistics. Allowed values are `nulls_equal` (the default), `nulls_unequal` and `null_ignored`. The meanings of these values are similar to those of the `myisam_stats_method` option. (Bug #30423)
- **Replication**: When using the statement-based logging format, `INSERT ON DUPLICATE KEY UPDATE` and `INSERT IGNORE` statements affecting transactional tables that did not fail were not written to the binary log if they did not insert any rows. (With statement-based logging, all successful statements should be logged, whether they do or do not cause any rows to be changed.) (Bug #59338, Bug #11766266)
- **Replication**: Formerly, `STOP SLAVE` stopped the slave I/O thread first and then stopped the slave SQL thread; thus, it was possible for the I/O thread to stop after replicating only part of a transaction which the SQL thread was executing, in which case—if the transaction could not be rolled back safely—the SQL thread could hang.

  Now, `STOP SLAVE` stops the slave SQL thread first and then stops the I/O thread; this guarantees that the I/O thread can fetch any remaining events in the transaction that the SQL thread is executing, so that the SQL thread can finish the transaction if it cannot be rolled back safely. (Bug #58546, Bug #11765563)
- Setting the `optimizer_switch` system value to an invalid value caused a server crash. (Bug #59894, Bug #11766719)
- `DES_DECRYPT()` could crash if the argument was not produced by `DES_ENCRYPT()`. (Bug #59632, Bug #11766505)
- The server and client did not always properly negotiate authentication plugin names. (Bug #59453, Bug #11766356)
- `--autocommit=ON` did not work (it set the global `autocommit` value to 0, not 1). (Bug #59432, Bug #11766339)
- A query of the following form returned an incorrect result, where the values for *`col_name`* in the result set were entirely replaced with `NULL` values:

```
SELECT DISTINCT col_name ... ORDER BY col_name DESC;
```

(Bug #59308, Bug #11766241)

- `SHOW PRIVILEGES` did not display a row for the `PROXY` privilege. (Bug #59275, Bug #11766216)
- `SHOW PROFILE` could truncate source file names or fail to show function names. (Bug #59273, Bug #11766214)
- `DELETE` or `UPDATE` statements could fail if they used `DATE` or `DATETIME` values with a year, month, or day part of zero. (Bug #59173)
- The `ESCAPE` clause for the `LIKE` operator permits only expressions that evaluate to a constant at execution time, but aggregate functions were not being rejected. (Bug #59149, Bug #11766110)
- Memory leaks detected by Valgrind, some of which could cause incorrect query results, were corrected. (Bug #59110, Bug #11766075)
- There was an erroneous restriction on file attributes for `LOAD DATA INFILE`. (Bug #59085, Bug #11766052)
- The `DEFAULT_CHARSET` and `DEFAULT_COLLATION` `CMake` options did not work. (Bug #58991, Bug #11765967)
- An `OUTER JOIN` query using `WHERE col_name IS NULL` could return an incorrect result. (Bug #58490, Bug #11765513)
- Starting the server with the `--defaults-file=file_name` option, where the file name had no extension, caused a server crash. (Bug #58455, Bug #11765482)
- Outer joins with an empty table could produce incorrect results. (Bug #58422, Bug #11765451)
- In debug builds, `SUBSTRING_INDEX(FORMAT(...), FORMAT(...))` could cause a server crash. (Bug #58371, Bug #11765406)
- When `mysqladmin` was run with the `--sleep` and `--count` options, it went into an infinite loop executing the specified command. (Bug #58221, Bug #11765270)
- Some string-manipulating SQL functions use a shared string object intended to contain an immutable empty string. This object was used by the SQL function `SUBSTRING_INDEX()` to return an empty string when one argument was of the wrong data type. If the string object was then modified by the SQL function `INSERT()`, undefined behavior ensued. (Bug #58165, Bug #11765225)
- Parsing nested regular expressions could lead to recursion resulting in a stack overflow crash. (Bug #58026, Bug #11765099)
- The fix for Bug #25192 caused `load_defaults()` to add an argument separator to distinguish options loaded from option files from those provided on the command line, whether or not the application needed it. (Bug #57953, Bug #11765041)

  See also Bug #11746296.
- The `mysql` client went into an infinite loop if the standard input was a directory. (Bug #57450, Bug #11764598)
- Outer joins on a unique key could return incorrect results. (Bug #57034, Bug #11764219)
- The expression `const1 BETWEEN const2 AND field` was optimized incorrectly and produced incorrect results. (Bug #57030, Bug #11764215)
- Some RPM installation scripts used a hardcoded value for the data directory, which could result in a failed installation for users who have a nonstandard data directory location. The same was true for other configuration values such as the PID file name. (Bug #56581, Bug #11763817)
- On FreeBSD and OpenBSD, the server incorrectly checked the range of the system date, causing legal values to be rejected. (Bug #55755, Bug #11763089)
- Sorting using `ORDER BY AVG(DISTINCT decimal_col)` caused a server crash or incorrect results. (Bug #52123, Bug #11759784)
- When using `ExtractValue()` or `UpdateXML()`, if the XML to be read contained an incomplete XML comment, MySQL read beyond the end of the XML string when processing, leading to a crash of the server. (Bug #44332, Bug #11752979)
- `DATE_ADD()` and `DATE_SUB()` return a string if the first argument is a string, but incorrectly returned a binary string. Now they return a character string with a collation of `connection_collation`. (Bug #31384, Bug #11747221)

D.1.8. Changes in MySQL 5.5.9 (07 February 2011)

Functionality Added or Changed

- The `mysqladmin` and `mysqldump` clients now have `--default-auth` and `--plugin-dir` options for specifying which authentication plugin and plugin directory to use. (Bug #58139, Bug #11765201)
- `sql_priv.h` now includes an `OPTION_ALLOW_BATCH` flag for the `transaction_allow_batching` feature of MySQL Cluster. (Bug #57604)
- Boolean system variables can be enabled at run time by setting them to the value `ON` or `OFF`, but previously this did not work at server startup. Now at startup such variables can be enabled by setting them to `ON` or `TRUE`. Any other nonnumeric variable is interpreted as `OFF`. (Bug #46393 improves on this such that `ON`, `TRUE`, `OFF`, and `FALSE` are recognized, and other values are invalid.) (Bug #51631, Bug #11759326)

  See also Bug #11754743.
- In the audit plugin interface, the `MYSQL_AUDIT_CONNECTION_CLASS` event class was added, and the `MYSQL_AUDIT_GENERAL_STATUS` subclass was added to the `MYSQL_AUDIT_GENERAL_CLASS` event class. The new symbol definitions can be found in the `plugin_audit.h` header file.

Bugs Fixed

- **Performance**: **InnoDB Storage Engine**: `InnoDB` now uses the `PAUSE` instruction on all platforms where it is available. Previously, `InnoDB` used the `PAUSE` instruction only on Windows systems. (Bug #58666)
- **Performance**: Queries involving `InnoDB` tables in the `INFORMATON_SCHEMA` tables `TABLE_CONSTRAINTS`, `KEY_COLUMN_USAGE`, or `REFERENTIAL_CONSTRAINTS` were slower than necessary because statistics were rechecked more often than required, even more so when many foreign keys were present. The improvement to this may be of particular benefit to users of MySQL Enterprise Monitor with many monitored servers or tens of thousands of tables. (Bug #43818, Bug #11752585)
- **Security Fix**: Bug #57952 was fixed.
- **Incompatible Change**: When `auto_increment_increment` is greater than one, values generated by a bulk insert that reaches the maximum column value could wrap around rather producing an overflow error.

  As a consequence of the fix, it is no longer possible for an auto-generated value to be equal to the maximum `BIGINT UNSIGNED` value. It is still possible to store that value manually, if the column can accept it. (Bug #39828, Bug #11749800)
- **Important Change**: **Partitioning**: Date and time functions used as partitioning functions now have the types of their operands checked; use of a value of the wrong type is now disallowed in such cases. In addition, `EXTRACT(WEEK FROM col_name)`, where `col_name` is a `DATE` or `DATETIME` column, is now disallowed altogether because its return value depends on the value of the `default_week_format` system variable. (Bug #54483, Bug #11761948)

  See also Bug #57071, Bug #11764255.
- **Partitioning**: **InnoDB Storage Engine**: The partitioning handler did not pass locking information to a table's storage engine handler. This caused high contention and thus slower performance when working with partitioned `InnoDB` tables. (Bug #59013)
- **InnoDB Storage Engine**: When multiple `InnoDB` buffer pools were enabled, `SHOW ENGINE INNODB` statements displayed information about each one, but not summary information combining statistics for the entire buffer pool subsystem. Now, the aggregated information is displayed in the `BUFFER POOL AND MEMORY` section, and information about individual buffer pool instances is displayed in a new `INDIVIDUAL BUFFER POOL INFO` section. (Bug #58461)
- **InnoDB Storage Engine**: The command to create a debug build (`cmake -DWITH_DEBUG ...`) now automatically sets the `InnoDB` debugging flag `UNIV_DEBUG` on all platforms. Formerly, the `UNIV_DEBUG` flag might not be set for Windows platforms with Visual Studio and not on OS X with Xcode. (Bug #58279)
- **InnoDB Storage Engine**: In `InnoDB` status output, the value for `I/O sum[]` could be incorrect, displayed as a very large number. (Bug #57600)
- **InnoDB Storage Engine**: The server could crash with an assertion error, if a stored procedure, stored function, or trigger modified one `InnoDB` table containing an auto-increment column, and dropped another `InnoDB` table containing an auto-increment column. (Bug #56228)
- **InnoDB Storage Engine**: It was not possible to query the `information_schema.innodb_trx` table while other connec-

tions were running queries involving `BLOB` types. (Bug #55397, Bug #11762763)

- **InnoDB Storage Engine**: When the `lower_case_table_names` variable was set to 2, `InnoDB` could fail to restore a `mysqldump` dump of a table with foreign key constraints involving case-sensitive names. (Bug #55222)

- **InnoDB Storage Engine**: The `OPTIMIZE TABLE` statement reset the auto-increment counter for an `InnoDB` table. Now the auto-increment value is preserved across this operation. (Bug #18274)

- **Partitioning**: Failed `ALTER TABLE ... TRUNCATE PARTITION` statements were written to the binary log. (Bug #58147)

- **Partitioning**: Failed `ALTER TABLE ... PARTITION` statements could cause memory leaks. (Bug #56380, Bug #11763641)

  See also Bug #46949, Bug #11755209, Bug #56996, Bug #11764187.

- **Replication**: While an `INSERT DELAYED` statement with a single inserted value does not return any visible warnings, such a warning could be still written into the error log. (Bug #57666, Bug #11764793)

  See also Bug #49567.

- **Replication**: When closing a session that used temporary tables, binary logging could sometimes fail with a spurious FAILED TO WRITE THE DROP STATEMENT FOR TEMPORARY TABLES TO BINARY LOG. (Bug #57288)

- **Replication**: Due to changes made in MySQL 5.5.3, settings made in the `binlog_cache_size` and `max_binlog_cache_size` server system variables affected both the binary log statement cache (also introduced in that version) and the binary log transactional cache (formerly known simply as the binary log cache). This meant that the resources used as a result of setting either or both of these variables were double the amount expected. To rectify this problem, these variables now affect only the transactional cache. The fix for this issue also introduces two new system variables `binlog_stmt_cache_size` and `max_binlog_stmt_cache_size`, which affect only the binary log statement cache.

  In addition, the `Binlog_cache_use` status variable was incremented whenever either cache was used, and `Binlog_cache_disk_use` was incremented whenever the disk space from either cache was used, which caused problems with performance tuning of the statement and transactional caches, because it was not possible to determine which of these was being exceeded when attempting to troubleshoot excessive disk seeks and related problems. This issue is solved by changing the behavior of these two status variables such that they are incremented only in response to usage of the binary log transactional cache, as well as by introducing two new status variables `Binlog_stmt_cache_use` and `Binlog_stmt_cache_disk_use`, which are incremented only by usage of the binary log statement cache.

  The behavior of the `max_binlog_cache_size` system variable with regard to active sessions has also been changed to match that of the `binlog_cache_size` system variable: Previously, a change in `max_binlog_cache_size` took effect in existing sessions; now, as with a change in `binlog_cache_size`, a change in `max_binlog_cache_size` takes effect only in sessions begun after the value was changed.

  For more information, see System variables used with the binary log, and Section 5.1.5, “Server Status Variables”. (Bug #57275, Bug #11764443)

- **Replication**: By default, a value is generated for an `AUTO_INCREMENT` column by inserting either `NULL` or 0 into the column. Setting the `NO_AUTO_VALUE_ON_ZERO` server SQL mode suppresses this behavior for 0, so that it occurs only when `NULL` is inserted into the column.

  This behavior is also followed on a replication slave (by the slave SQL thread) when applying events that have been logged on the master using the statement-based format. However, when applying events that had been logged using the row-based format, `NO_AUTO_VALUE_ON_ZERO` was ignored, which could lead to an assertion.

  To fix this issue, the value of an `AUTO_INCREMENT` column is no longer generated when applying an event that was logged using the row-based row format, as this value is already contained in the changes applied on the slave. (Bug #56662)

- **Replication**: The `Binlog_cache_use` and `Binlog_cache_disk_use status` variables were incremented twice by a change to a table using a transactional storage engine. (Bug #56343, Bug #11763611)

- **Replication**: The `BINLOG` statement modified the values of session variables, which could lead to problems with operations such as point-in-time recovery. One such case occurred when replaying a row-based binary log which relied on setting `foreign_key_checks = OFF` at the session level to create and populate a set of `InnoDB` tables having foreign key constraints. (Bug #54903)

- **Replication**: `mysqlbinlog` printed `USE` statements to its output only when the default database changed between events. To illustrate how this could cause problems, suppose that a user issued the following sequence of statements:

```
CREATE DATABASE mydb;
USE mydb;
CREATE TABLE mytable (column_definitions);
```

```
DROP DATABASE mydb;
CREATE DATABASE mydb;
USE mydb;
CREATE TABLE mytable (column_definitions);
```

When played back using `mysqlbinlog`, the second `CREATE TABLE` statement failed with ERROR: NO DATABASE SELECTED because the second `USE` statement was not played back, due to the fact that a database other than `mydb` was never selected.

This fix insures that `mysqlbinlog` outputs a `USE` statement whenever it reads one from the binary log. (Bug #50914, Bug #11758677)

- **Replication**: Previously, when a statement failed with a different error on the slave than on the master, the slave SQL thread displayed a message containing:

  - The error message for the master error code
  - The master error code
  - The error message for the slaves error code
  - The slave error code

  However, the slave has no information with which to fill in any print format specifiers for the master message, so it actually displayed the message format string. To make it clearer that the slave is not displaying the actual message as it appears on the master, the slave now indicates that the master part of the output is the message format, not the actual message. For example, previously the slave displayed information like this:

  ```
  Error: "Query caused different errors on master and slave. Error
  on master: 'Duplicate entry '%-.192s' for key %d' (1062), Error on
  slave: 'no error' (0). Default database: 'test'. Query: 'insert
  into t1 values(1),(2)'" (expected different error codes on master
  and slave)
  ```

  Now the slave displays this:

  ```
  Error: "Query caused different errors on master and slave. Error
  on master: message format='Duplicate entry '%-.192s' for key %d'
  error code=1062 ; Error on slave: actual message='no error', error
  code=0. Default database: 'test'. Query: 'insert into t1 values(1),(2)'"
  (expected different error codes on master and slave)
  ```

  (Bug #46697)

- **Replication**: When an error occurred in the generation of the name for a new binary log file, the error was logged but not shown to the user. (Bug #46166)

  See also Bug #37148, Bug #11748696, Bug #40611, Bug #11750196, Bug #43929, Bug #51019.

- Comparisons of aggregate values with `TIMESTAMP` values were incorrect. (Bug #59330, Bug #11766259)

- For `DIV` expressions, assignment of the result to multiple variables could cause a server crash. (Bug #59241, Bug #11766191)

  See also Bug #8457.

- `MIN(year_col)` could return an incorrect result in some cases. (Bug #59211, Bug #11766165)

- `mysqlslap` failed to check for a `NULL` return from `mysql_store_result()` and crashed trying to process the result set. (Bug #59109, Bug #11766074)

- In a subquery, a `UNION` with no referenced tables (or only a reference to the virtual table `dual`) did not permit an `ORDER BY` clause. (Bug #58970, Bug #11765950)

- Configuring MySQL with `-DWITHOUT_PERFSCHEMA_STORAGE_ENGINE=1` caused build failures. (Bug #58953)

- Several Valgrind warnings were fixed. (Bug #58948, Bug #59021)

- `OPTIMIZE TABLE` for an `InnoDB` table could raise an assertion if the operation failed because it had been killed. (Bug #58933, Bug #11765920)

- If `max_allowed_packet` was set larger than 16MB, the server failed to reject too-large packets with “Packet too large” errors. (Bug #58887, Bug #11765878)

- A `NOT IN` predicate with a subquery containing a `HAVING` clause could retrieve too many rows, when the subquery itself returned `NULL`. (Bug #58818, Bug #11765815)

- `EXPLAIN` could crash for queries that accessed two derived tables. (Bug #58730)
- On Solaris, the MySQL build failed if it was configured with debugging enabled. (Bug #58699)
- Issuing `EXPLAIN EXTENDED` for a query that would use condition pushdown could cause `mysqld` to crash. (Bug #58553, Bug #11765570)
- An assertion could be raised for queries for which the optimizer could choose between Index Merge range access or const ref access methods. (Bug #58456)
- If MySQL was built with Visual Studio Express, the project wixca was not built. (Bug #58411)
- `EXPLAIN` could crash for queries that used `GROUP_CONCAT()`. (Bug #58396)
- `CMake` polluted the source tree by writing installation-related temporary files there. (Bug #58372)
- Security context references in `sp_head.cc` were rewritten for improved DTrace compatibility. (Bug #58350)
- The `ucs2` character set does not support characters outside the Basic Multilingual Plane (BMP), but converting to `ucs2` a string containing such characters did not produce a conversion-failure warning. (Bug #58321)
- A Valgrind failure occurred in `fn_format` when called from `archive_discover`. (Bug #58205, Bug #11765259)
- `CMake` did not add `LINK_LIBRARIES` for `MYSQL_ADD_PLUGIN` for `libmysqld`. (Bug #58158)
- An assertion could be raised if the server was closing a session at the same time the session was being killed by another thread. (Bug #58136)
- Condition pushdown optimization could push down conditions with incorrect column references. (Bug #58134, Bug #11765196)
- Configuration with maintainer mode enabled resulted in errors when compiling with `icc`. (Bug #57991, Bug #58871)
- An `ORDER BY` clause was bound to the incorrect substatement when used in `UNION` context. (Bug #57986)
- The `BIT_AND()` function could return incorrect results when a join returned no matching rows. (Bug #57954)
- If the set of values aggregated with `AVG(DISTINCT)` contained a `NULL` value, the function result could be incorrect. (Bug #57932)
- In rare cases, `LIKE` expressions failed for an indexed column that used a collation containing contractions. (Bug #57737)
- Unnecessary subquery evaluation in contexts such as statement preparation or view creation could cause a server crash. (Bug #57703)
- View creation could produce Valgrind warnings. (Bug #57352)
- `NULL` geometry values could cause a crash in `Item_func_spatial_collection::fix_length_and_dec`. (Bug #57321)
- It was possible to compile `mysqld` with Performance Schema support but with a dummy atomic-operations implementation, which caused a server crash. This problem does not affect binary distributions. It is helpful as a safety measure for users who build MySQL from source. (Bug #56769)
- The `cp1251` character set did not properly support the Euro sign (`0x88`). For example, converting a string containing this character to `utf8` resulted in `'?'` rather than the `utf8` Euro sign. (Bug #56639)
- Some unsigned system variables could be displayed with negative values. (Bug #55794)
- `CREATE DATABASE` and `DROP DATABASE` caused `mysql --one-database` to lose track of the statement-filtering context. (Bug #54899)
- An assertion could be raised during concurrent execution of `DROP DATABASE` and `REPAIR TABLE` if the drop deleted a table's `.TMD` file at the same time the repair tried to read details from the old file that was just removed.

  A problem could also occur when `DROP TABLE` tried to remove all files belonging to a table at the same time `REPAIR TABLE` had just deleted the table's `.TMD` file. (Bug #54486)
- After compilation from source, all header files were installed in the same directory, even those that should be installed into subdirectories of the installation include directory. (Bug #51925)

- When `mysqld` printed crash dump information, it incorrectly indicated that some valid pointers were invalid. (Bug #51817)
- On Mac OS X, a configuration error caused the preference pane to fail. (Bug #51264)
- On FreeBSD, if `mysqld` was killed with a `SIGHUP` signal, it could corrupt `InnoDB .ibd` files. (Bug #51023, Bug #11758773)
- An assertion could be raised if –1 was inserted into an `AUTO_INCREMENT` column by a statement writing more than one row. (Bug #50619, Bug #11758417)
- If a client supplied a user name longer than the maximum 16 characters permitted for names stored in the MySQL grant tables, all characters were being considered significant when checking for a match. Historically, only the first 16 characters were used for matching; this behavior was restored. (Bug #49752)
- The `my_seek()` and `my_tell()` functions ignored the `MY_WME` flag when they returned an error, which could cause client programs to hang. (Bug #48451)
- During assignment of values to system variables, legality checks on the value range occurred too late, preventing proper error checking. (Bug #43233)
- On Solaris, time-related functions such as `NOW()` or `SYSDATE()` could return a constant value. (Bug #42054)
- If the remote server for a `FEDERATED` table could not be accessed, queries for the `INFORMATION_SCHEMA.TABLES` table failed. (Bug #35333)

D.1.9. Changes in MySQL 5.5.8 (03 December 2010 General Availability)

Configuration Notes

- MySQL releases are now built on all platforms using `CMake` rather than the GNU autotools, so autotools support has been removed. For instructions on building MySQL with `CMake`, see Section 2.9, “Installing MySQL from Source”. If you are familiar with autotools but not `CMake`, you might find this transition document helpful: http://forge.mysql.com/wiki/Autotools_to_CMake_Transition_Guide Third-party tools that need to extract the MySQL version number formerly found in `configure.in` can use the `VERSION` file. See Section 2.9.6, “MySQL Configuration and Third-Party Tools”.

Functionality Added or Changed

- Support for the `IBMDB2I` storage engine has been removed. (Bug #58079)
- The following words are no longer reserved words the way they are in earlier MySQL 5.5 releases: `SLOW`, `GENERAL`, `IGNORE_SERVER_IDS`, `MASTER_HEARTBEAT_PERIOD` (Bug #57899)
- For an upgrade to MySQL 5.5.7 from a previous release, the server exited if the `mysql.proxies_priv` table did not exist, making upgrades inconvenient. Now the server treats a missing `proxies_priv` table as equivalent to an empty table. However, after starting the server, you should still run `mysql_upgrade` to create the table. (Bug #57551)
- The `autocommit` system variable is enabled by default for all user connections, and the session value can be set for each new connection by setting the `init_connect` system variable to `SET autocommit=0`. However, this has no effect for users who have the `SUPER` privilege.

  Now the global `autocommit` value can be set at server startup, and this value is used to initialize the session value for all new connections, including those for users with the `SUPER` privilege. The variable is treated as a boolean value so it can be enabled with `--autocommit`, `--autocommit=1`, or `--enable-autocommit`. It can be disabled with `--autocommit=0`, `--skip-autocommit`, or `--disable-autocommit`. (Bug #57316)
- The client/server protocol now includes a `SERVER_QUERY_WAS_SLOW` flag to indicate when a query is slow; that is, when query execution exceeds the value of the `long_query_time` system variable. (Bug #57058)
- The time zone tables available at http://dev.mysql.com/downloads/timezones.html have been updated. These tables can be used on systems such as Windows or HP-UX that do not include zoneinfo files. (Bug #40230)
- Changes to replication in MySQL 5.6 make `mysqlbinlog` output generated by the `--base64-output=ALWAYS` option unusable, so `ALWAYS` is now deprecated and will be an invalid option value in MySQL 5.6. This should not be a significant problem because `--base64-output` values other than `AUTO` are supposed to be used only for debugging, not for production environments.

See also Bug #28760.

- A `--bind-address` option has been added to a number of MySQL client programs: `mysql`, `mysqldump`, `mysqladmin`, `mysqlbinlog`, `mysqlcheck`, `mysqlimport`, and `mysqlshow`. This is for use on a computer having multiple network interfaces, and enables you to choose which interface is used to connect to the MySQL server.

  A corresponding change was made to the `mysql_options()` C API function, which now has a `MYSQL_OPT_BIND` option for specifying the interface. The argument is a host name or IP address (specified as a string).

Bugs Fixed

- **Performance**: **InnoDB Storage Engine**: Improved concurrency when several `ANALYZE TABLE` or `SHOW TABLE STATUS` statements are run simultaneously for `InnoDB` tables. (Bug #53046)
- **InnoDB Storage Engine**: **Security Fix**: A failed `CREATE TABLE` statement for an `InnoDB` table could allocate memory that was never freed. (Bug #56947)
- **Security Fix**: Bug #58005 was fixed.
- **Security Fix**: Bug #57687 was fixed.
- **Security Fix**: Bug #57659 was fixed.
- **Security Fix**: Bug #57477 was fixed.
- **Security Fix**: Bug #57272 was fixed.
- **Security Fix**: Bug #57130 was fixed.
- **Security Fix**: Bug #56814 was fixed.
- **Security Fix**: Bug #55146 and Bug #56287 were fixed.
- **Security Fix**: Bug #54484 was fixed.
- **Incompatible Change**: Previously, tables in the `performance_schema` database had uppercase names. This was incompatible with the `lower_case_table_names` system variable, and caused issues when the variable value was changed *after* installing or upgrading.

  Now `performance_schema` table names are lowercase, so they appear in uniform lettercase regardless of the `lower_case_table_names` setting. References to these tables in SQL statements should be given in lowercase. This is an incompatible change, but provides compatible behavior across different values of `lower_case_table_names`.

  If you upgrade to MySQL 5.5.8 from an earlier version of MySQL 5.5, be sure to run `mysql_upgrade` (and restart the server) to change the names of existing `performance_schema` tables from uppercase to lowercase. If `mysql_upgrade` does not work, use this procedure:

  1. Stop `mysqld`.
  2. Remove the `performance_schema/*.frm` files from the data directory.
  3. Create a separate “dummy” MySQL 5.5.8 installation.
  4. Copy the `performance_schema/*.frm` files from the dummy installation to the installation you are upgrading.
  5. Restart `mysqld` and run `mysqld_upgrade --force` and check that it does not produce errors.
  6. Remove the dummy installation.

  (Bug #57609)
- **Incompatible Change**: The following changes were made to the `performance_schema.threads` table for conformance with the implementation in MySQL 5.6:

  - `ID` column: Renamed to `PROCESSLIST_ID`, removed `NOT NULL` from definition.
  - `NAME` column: Changed from `VARCHAR(64)` to `VARCHAR(128)`.

  (Bug #57154)

- **Incompatible Change**: Starvation of `FLUSH TABLES WITH READ LOCK` statements occurred when there was a constant load of concurrent DML statements in two or more connections. Deadlock occurred when a connection that had some table open through a `HANDLER` statement tried to update data through a DML statement while another connection tried to execute `FLUSH TABLES WITH READ LOCK` concurrently.

  These problems resulted from the global read lock implementation, which was reimplemented with the following consequences:

  - To solve deadlock in event-handling code that was exposed by this patch, the `LOCK_event_metadata` mutex was replaced with metadata locks on events. As a result, DDL operations on events are now prohibited under `LOCK TABLES`. This is an incompatible change.
  - The global read lock (`FLUSH TABLES WITH READ LOCK`) no longer blocks DML and DDL on temporary tables. Before this patch, server behavior was not consistent in this respect: In some cases, DML/DDL statements on temporary tables were blocked; in others, they were not. Since the main use cases for `FLUSH TABLES WITH READ LOCK` are various forms of backups and temporary tables are not preserved during backups, the server now consistently permits DML/DDL on temporary tables under the global read lock.
  - The set of thread states has changed:
    - `Waiting for global metadata lock` is replaced by `Waiting for global read lock`.
    - Previously, `Waiting for release of readlock` was used to indicate that DML/DDL statements were waiting for release of a read lock and `Waiting to get readlock` was used to indicate that `FLUSH TABLES WITH READ LOCK` was waiting to acquire a global read lock. Now `Waiting for global read lock` is used for both cases.
    - Previously, `Waiting for release of readlock` was used for all statements that caused an explicit or implicit commit to indicate that they were waiting for release of a read lock and `Waiting for all running commits to finish` was used by `FLUSH TABLES WITH READ LOCK`. Now `Waiting for commit lock` is used for both cases.
    - There are two other new states, `Waiting for trigger metadata lock` and `Waiting for event metadata lock`.

  (Bug #57006, Bug #11764195, Bug #54673, Bug #11762116)

- **InnoDB Storage Engine**: Values could be truncated in certain `INFORMATION_SCHEMA` columns, such as `REFERENTIAL_CONSTRAINTS.REFERENCED_TABLE_NAME` and `KEY_COLUMN_USAGE.REFERENCED_TABLE_NAME`. (Bug #57960)
- **InnoDB Storage Engine**: For an `InnoDB` table created with `ROW_FORMAT=COMPRESSED` or `ROW_FORMAT=DYNAMIC`, a query using the `READ UNCOMMITTED` isolation level could cause the server to stop with an assertion error, if `BLOB` or other large columns that use off-page storage were being inserted at the same time. (Bug #57799)
- **InnoDB Storage Engine**: The server could stop with an assertion error on Windows Vista and Windows 7 systems. (Bug #57720)
- **InnoDB Storage Engine**: A followup fix to bug #54678. `TRUNCATE TABLE` could still cause a crash (assertion error) in the debug version of the server. (Bug #57700)
- **InnoDB Storage Engine**: The `InnoDB` system tablespace could grow continually for a server under heavy load. (Bug #57611)
- **InnoDB Storage Engine**: Heavy concurrent updates of a `BLOB` column in an `InnoDB` table could cause a hang. (Bug #57579)
- **InnoDB Storage Engine**: Turning off the `innodb_stats_on_metadata` option could prevent the `ANALYZE TABLE` statement from updating the cardinality statistics of `InnoDB` tables. (Bug #57252)
- **InnoDB Storage Engine**: A query for an `InnoDB` table could return the wrong value if a column value was changed to a different case, and the column had a case-insensitive index. (Bug #56680)
- **InnoDB Storage Engine**: An existing `InnoDB` table could be switched to `ROW_FORMAT=COMPRESSED` implicitly by a `KEY_BLOCK_SIZE` clause in an `ALTER TABLE` statement. Now, the row format is only switched to compressed if there is an explicit `ROW_FORMAT=COMPRESSED` clause. on the `ALTER TABLE` statement.

  Any valid, nondefault `ROW_FORMAT` parameter takes precedence over `KEY_BLOCK_SIZE` when both are specified. `KEY_BLOCK_SIZE` only enables `ROW_FORMAT=COMPRESSED` if `ROW_FORMAT` is not specified on either the `CREATE TABLE` or `ALTER TABLE` statement, or is specified as `DEFAULT`. In case of a conflict between `KEY_BLOCK_SIZE` and `ROW_FORMAT` clauses, the `KEY_BLOCK_SIZE` is ignored if `innodb_strict_mode` is off, and the statement causes an error if `innodb_strict_mode` is on. (Bug #56632)

- **InnoDB Storage Engine**: The clause `KEY_BLOCK_SIZE=0` is now permitted on `CREATE TABLE` and `ALTER TABLE` statements for `InnoDB` tables, regardless of the setting of `innodb_strict_mode`. The zero value has the effect of resetting the `KEY_BLOCK_SIZE` table parameter to its default value, depending on the `ROW_FORMAT` parameter, as if it had not been specified. That default is 8 if `ROW_FORMAT=COMPRESSED`. Otherwise, `KEY_BLOCK_SIZE` is not used or stored with the table parameters.

  As a consequence of this fix, `ROW_FORMAT=FIXED` is not permitted when `innodb_strict_mode` is enabled. (Bug #56628)

- **InnoDB Storage Engine**: A large number of foreign key declarations could cause the output of the `SHOW CREATE STATEMENT` statement to be truncated. (Bug #56143)

- **InnoDB Storage Engine**: Clarified the message when a `CREATE TABLE` statement fails because a foreign key constraint does not have the required indexes. (Bug #16290)

- **Partitioning**: In-place `ALTER TABLE` operations (that do not involve a table copy) on a partitioned table could leave the table in an unusable state. (Bug #57985)

- **Partitioning**: In debug builds, an `INSERT ... ON DUPLICATE KEY UPDATE col_name = 0` statement on an `AUTO_INCREMENT` column caused the server to crash. (Bug #57890)

- **Partitioning**: Issuing `ALTER TABLE ... ADD PRIMARY KEY` on a partitioned `InnoDB` table could cause the MySQL Server to crash. (Bug #57778)

- **Replication**: Concurrent statements using a stored function and a `DROP DATABASE` statement that caused the same stored function to be dropped could cause statement-based replication to fail. This problem is resolved by making sure that `DROP DATABASE` takes an exclusive metadata lock on all stored functions and stored procedures that it causes to be dropped. (Bug #57663)

  See also Bug #30977.

- **Replication**: When `STOP SLAVE` is issued, the slave SQL thread rolls back the current transaction and stops immediately if the transaction updates only tables which use transactional storage engines. Previously, this occurred even when the transaction contained `CREATE TEMPORARY TABLE` statements, `DROP TEMPORARY TABLE` statements, or both, although these statements cannot be rolled back. Because temporary tables persist for the lifetime of a user session (in the case, the replication user), they remain until the slave is stopped or reset. When the transaction is restarted following a subsequent `START SLAVE` statement, the SQL thread aborts with an error that a temporary table to be created (or dropped) already exists (or does not exist, in the latter case).

  Following this fix, if an ongoing transaction contains `CREATE TEMPORARY TABLE` statements, `DROP TEMPORARY TABLE` statements, or both, the SQL thread now waits until the transaction ends, then stops. (Bug #56118, Bug #11763416)

- **Replication**: If there exist both a temporary table and a nontemporary table having the same name, updates normally apply only to the temporary table, with the exception of a `CREATE TABLE ... SELECT` statement that creates a nontemporary table having the same name as an existing temporary table. When such a statement was replicated using the `MIXED` logging format, and the statement was unsafe for row-based logging, updates were misapplied to the temporary table.

  Updates were also applied wrongly when a temporary table that used a transactional storage engine was dropped inside a transaction, followed by updates within the same transaction to a nontemporary table having the same name. (Bug #55478)

  See also Bug #47899, Bug #55709.

- **Replication**: When making changes to relay log settings using `CHANGE MASTER TO`, the I/O cache was not cleared. This could result in replication failure when the slave attempted to read stale data from the cache and then stopped with an assertion. (Bug #55263)

- **Replication**: Replication of `SET` and `ENUM` columns represented using more than 1 byte (that is, `SET` columns with more than 8 members and `ENUM` columns with more than 256 constants) between platforms using different endianness failed when using the row-based format. This was because columns of these types are represented internally using integers, but the internal functions used by MySQL to handle them treated them as strings. (Bug #52131)

  See also Bug #53528.

- **Replication**: Trying to read from a binary log containing a log event of an invalid type caused the slave to crash. (Bug #38718)

- **Replication**: When replicating the `mysql.tables_priv` table, the `Grantor` column was not replicated, and was thus left empty on the slave. (Bug #27606)

- Setting the `read_only` system variable at server startup did not work. (Bug #58669)

- `mysql_upgrade` failed after an upgrade from MySQL 5.1. (Bug #58514)

- When configuring the build with `-DBUILD_CONFIG=mysql_release` and building with Visual Studio Express, the build failed if `signtool.exe` was not present. (Bug #58313)
- With `CMake` 2.8.3, the `-DBUILD_CONFIG=mysql_release` option did not work. (Bug #58272)
- When configuring the build with `-DBUILD_CONFIG=mysql_release` on Linux, `libaio` is required, but the error message if it was missing was uninformative. (Bug #58227)
- Use of `NAME_CONST()` in a `HAVING` clause caused a server crash. (Bug #58199)
- `BETWEEN` did not use indexes for `DATE` or `DATETIME` columns. (Bug #58190)
- Memory was allocated in `fn_expand()` for storing path names, but not freed anywhere. (Bug #58173)
- In debug builds, inserting a `FLOAT` value into a `CHAR(0)` column could cause a server crash. (Bug #58137)
- Failure to create a thread to handle a user connection could cause a server crash. (Bug #58080)
- During configuration, `ADD_VERSION_INFO` in `cmake/mysql_version.cmake` failed if `LINK_FLAGS` was modified. (Bug #58074)
- The Performance Schema did not count I/O for the binary log file. (Bug #58052)
- Several compilation problems were fixed. (Bug #57992, Bug #57993, Bug #57994, Bug #57995, Bug #57996, Bug #57997, Bug #58057)
- After creation of a table with two foreign key constraints, the `INFORMATION_SCHEMA.REFERENTIAL_CONSTRAINTS` table displayed only one of them. (Bug #57904)
- Incorrect error handling raised an assertion if character set conversion wrapped an item that failed. (Bug #57882)
- In debug builds, a missing `DBUG_RETURN` macro in `sql/client.c` caused `mysql` to be unable to connect to the server. (Bug #57744)
- Clients using a client library older than MySQL 5.5.7 suffered loss of connection after executing `mysql_change_user()` while connected to a 5.5.7 server. (Bug #57689)
- The `MySQL-shared` RPM package failed to provide the lowercase virtual identifier `'mysql-shared'` in the RPM `'Provides'` tags (usually used for backward compatibility). (Bug #57596)
- `SHOW PROCESSLIST` displayed non-ASCII characters improperly. (Bug #57306)
- Passing a string that was not null-terminated to `UpdateXML()` or `ExtractValue()` caused the server to fail with an assertion. (Bug #57279, Bug #11764447)
- `SET GLOBAL debug` could cause a crash on Solaris if the server failed to open the trace file. (Bug #57274)
- In debug builds, an assertion could be raised during conversion of strings to floating-point values. (Bug #57203)
- If the *`file_name`* argument to the `--defaults-file` or `--defaults-extra-file` option was not a full path name, it could be interpreted incorrectly in some contexts and cause a server crash. Now the *`file_name`* argument is interpreted as relative to the current working directory if given as a relative path name rather than as a full path name. (Bug #57108)
- A user with no privileges on a stored routine or the `mysql.proc` table could discover the routine's existence. (Bug #57061)
- Queries executed using the Index Merge access method and a temporary file could return incorrect results. (Bug #56862)
- The server could crash inside `memcpy()` when reading certain Performance Schema tables. (Bug #56761, Bug #58003)
- The server could crash as a result of accessing freed memory when populating `INFORMATION_SCHEMA.VIEWS` if a view could not be opened properly. (Bug #56540)
- Valgrind warnings about overlapping memory when double-assigning the same variable were corrected. (Bug #56138)
- If a `STOP SLAVE` statement was issued while the slave SQL thread was executing a statement that invoked the `SLEEP()` function, both statements hung. (Bug #56096)
- `OPTIMIZE TABLE` for `InnoDB` tables could raise an assertion. (Bug #55930)
- Warnings raised by a trigger were not cleared upon successful completion. Now warnings are cleared if the trigger completes successfully, per the SQL standard. (Bug #55850)

- For `CMake` builds, some parts of the source were unnecessarily compiled twice if the embedded server was built. (Bug #55647)
- In debug builds, an assertion could be raised if a `send_eof()` method was called after an error occurred. (Bug #54812)
- Boolean command options caused an error if given with an option value and the `loose-` option prefix. (Bug #54569)
- An error in a stored procedure could leave the session in a different default database. (Bug #54375)
- The `CMake` “wrapper” for `configure` (`configure.pl`) did not handle the `--with-comment` option properly. (Bug #52275)
- Grouping by a `TIME_TO_SEC()` function result could cause a server crash or incorrect results. Grouping by a function returning a `BLOB` could cause an unexpected “Duplicate entry” error and incorrect result. (Bug #52160)
- The `find_files()` function used by `SHOW` statements performed redundant and unnecessary memory allocation. (Bug #51208)
- The Windows sample option files contained values more appropriate for Linux. (Bug #50021)
- A failed `RENAME TABLE` operation could prevent a `FLUSH TABLES WITH READ LOCK` from completing. (Bug #47924)
- Error messages for several delegate-related initialization error conditions that should not occur were changed to help identify the area of failure and to instruct the user to file a bug report if they do occur. A delegate is a set of internal data structures and algorithms. (Bug #47027)
- On file systems with case insensitive file names, and `lower_case_table_names=2`, the server could crash due to a table definition cache inconsistency. (Bug #46941)
- Handling of host name lettercase in `GRANT` statements was inconsistent. (Bug #36742)
- `SET NAMES utf8 COLLATE utf8_sinhala_ci` did not work. (Bug #26474)
- The `utf16_bin` collation uses code-point order, not byte-by-byte order, as described at Section 9.1.14.1, “Unicode Character Sets”. (The order was byte-by-byte in MySQL 5.5.7.)

D.1.10. Changes in MySQL 5.5.7 (14 October 2010)

Configuration Notes

- MySQL releases now are built using `CMake` rather than the GNU autotools. Accordingly, the instructions for installing MySQL from source have been updated to discuss how to build MySQL using `CMake`. See Section 2.9, “Installing MySQL from Source”. If you are familiar with autotools but not `CMake`, you might find this transition document helpful: http://forge.mysql.com/wiki/Autotools_to_CMake_Transition_Guide

  The build process is now similar enough on all platforms, including Windows, that there are no longer sections dedicated to notes for specific platforms.

  The default installation layout when compiling from source now matches that used for binary distributions. You will notice these differences for installations from source distributions:

  - `mysqld` is installed in `bin`, not `libexec`.
  - `mysql_install_db` is installed in `scripts`, not `bin`.
  - The data directory is `data`, not `var`.

  The `make_binary_distribution` and `make_win_bin_dist` scripts are now obsolete. To create a binary distribution, use `make package`.

Authentication Changes

- MySQL authentication supports two new capabilities, pluggable authentication and proxy users:
  - With pluggable authentication, the server uses plugins to authenticate incoming client connections, and clients load an authentication plugin that interacts properly with the corresponding server plugin. This capability enables clients to connect to the MySQL server with credentials that are appropriate for authentication methods other than the built-in MySQL authentication based on native MySQL passwords stored in the `mysql.user` table. For example, plugins can be created to use ex-

ternal authentication methods such as LDAP, Kerberos, PAM, or Windows login IDs.

- Proxy user capability enables a client who connects and authenticates as one user to be treated, for purposes of access control while connected, as having the privileges of a different user. In effect, one user impersonates another. Proxy capability depends on pluggable authentication because it is based on having an authentication plugin return to the server the user name that the connecting user impersonates.

Pluggable authentication entails these changes:

- For user specifications in the `CREATE USER` and `GRANT` statements, there is a new `IDENTIFIED WITH` clause for specifying the authentication plugin.
- For the `mysql.user` table, there are new columns that specify plugin information. The `plugin` column, if nonempty, indicates which plugin authenticates connections for an account. The `authentication_string` column is a string that the server passes to the plugin for connections by clients that authenticate using the plugin.
- For the `mysql_options()` C API function, there are new `MYSQL_DEFAULT_AUTH` and `MYSQL_PLUGIN_DIR` options that enable client programs to load authentication plugins.
- For the `mysql` client, there are new `--default-auth` and `--plugin-dir` options for specifying which authentication plugin and plugin directory to use. These options will be added to other clients in future releases.
- For the `mysqltest` client, there is a new `--plugin-dir` option for specifying which plugin directory to use, and a new `connect()` command argument to specify an authentication plugin.
- For the server plugin API, there is a new `MYSQL_AUTHENTICATION_PLUGIN` plugin type.
- A new client plugin API enables client programs to manage plugins.
- The built-in authentication methods previously supported in MySQL have been reimplemented as plugins. These methods provide native password checking and pre-MySQL 4.1.1 authentication that uses shorter password hash values. This change reimplements the built-in methods as plugins that cannot be unloaded. Existing clients authenticate as before with no changes needed. In particular, starting the server with the `--secure-auth` option still prevents clients that have pre-4.1.1 password hashes from conecting, and `--skip-grant-tables` still disables all password checking.

Proxy user capability entails these changes:

- There is a new `PROXY` privilege that can be managed with the `GRANT` and `REVOKE` statements.
- The new `proxy_user` and `external_user` system variables indicate whether the current session uses proxying.
- A new `mysql.proxies_priv` grant table records proxy information for MySQL accounts.

Due to these changes, the server requires that a new grant table, `proxies_priv`, be present in the `mysql` database. If you are upgrading to MySQL 5.5.7 from a previous MySQL release rather than performing a new installation, the server will find that this table is missing and exit during startup with the following message:

```
Table 'mysql.proxies_priv' doesn't exist
```

To create the `proxies_priv` table, start the server with the `--skip-grant-tables` option to cause it to skip the normal grant table checks, then run `mysql_upgrade`. For example:

```
shell> mysqld --skip-grant-tables &
shell> mysql_upgrade
```

Then stop the server and restart it normally.

You can specify other options on the `mysqld` command line if necessary. Alternatively, if your installation is configured so that the server normally reads options from an option file, use the `--defaults-file` option to specify the file (enter each command on a single line):

```
shell> mysqld --defaults-file=/usr/local/mysql/etc/my.cnf
         --skip-grant-tables &
shell> mysql_upgrade
```

With the `--skip-grant-tables` option, the server does no password or privilege checking, so any client can connect and effectively have all privileges. For additional security, use the `--skip-networking` option as well to prevent remote clients from connecting.

Note

> The upgrade problem just described is fixed in MySQL 5.5.8. The server treats a missing `proxies_priv` table as equivalent to an empty table.

For additional information, consult these references:

- Information about pluggable authentication, including installation and usage instructions: Section 5.5.6, “Pluggable Authentication”.
- Information about proxy users: Section 5.5.7, “Proxy Users”.
- Information about the server and client plugin API: Section 21.2.4, “Writing Plugins”.
- Information about the C API functions for managing client plugins: See Section 20.9.10, “C API Client Plugin Functions”.

Functionality Added or Changed

- The unused and undocumented `thread_pool_size` system variable was removed. (Bug #57338)
- The `pstack` library was nonfunctional and has been removed, along with the `--with-pstack` option for `configure` and the `--enable-pstack` option for `mysqld`. (Bug #57210)
- Added a new `SHOW PROCESSLIST` state, `Waiting for query cache lock`. This indicates that a session is waiting to take the query cache lock while it performs some query cache operation. (Bug #56822)
- A new status variable, `Handler_read_last`, displays the number of requests to read the last key in an index. With `ORDER BY`, the server issues a first-key request followed by several next-key requests, whereas with `ORDER BY DESC`, the server issues a last-key request followed by several previous-key requests. (Bug #52312)
- Previously, the server supported values of `OFF`, `ON`, and `FORCE` for the `--plugin_name=value` option format for controlling plugin loading using an option named after the plugin. Such options now support a `FORCE_PLUS_PERMANENT` value. This value is like `FORCE`, but in addition prevents the plugin from being unloaded at runtime. If a user attempts to do so with `UNINSTALL PLUGIN`, an error occurs. See Section 5.1.7.1, “Installing and Uninstalling Plugins”.

  In addition, the `INFORMATION_SCHEMA.PLUGINS` table now has a `LOAD_OPTION` column that indicates the plugin loading value (`OFF`, `ON`, `FORCE`, or `FORCE_PLUS_PERMANENT`). See Section 18.17, “The `INFORMATION_SCHEMA PLUGINS` Table”.

Bugs Fixed

- **Performance**: **InnoDB Storage Engine**: The master `InnoDB` background thread could sometimes cause transient performance drops due to excessive flushing of modified pages. (Bug #56933)
- **InnoDB Storage Engine**: **Incompatible Change**: **Security Fix**: Issuing `TRUNCATE TABLE` and examining the same table's information in the `INFORMATION_SCHEMA` database at the same time could cause a crash in the debug version of the server.

  As a result of this change, `InnoDB` always uses the fast truncation technique, equivalent to `DROP TABLE` and `CREATE TABLE`. It no longer performs a row-by-row delete for tables with parent-child foreign key relationships. `TRUNCATE TABLE` returns an error for such tables. Modify your SQL to issue `DELETE FROM table_name` for such tables instead. (Bug #54678)
- **Security Fix**: The server crashed for assignment of values of types other than `Geometry` to items of type `GeometryCollection` (`MultiPoint`, `MultiCurve`, `MultiSurface`). Now the server checks the value type and fails with `bad geometry value` if it detects incorrect parameters. (Bug #55531)
- **Security Fix**: The `CONVERT_TZ()` function crashed the server when the timezone argument was an empty `SET` column value. (Bug #55424)
- **Security Fix**: `EXPLAIN EXTENDED` caused a server crash with some prepared statements. (Bug #54494)
- **Security Fix**: In prepared-statement mode, `EXPLAIN` for a `SELECT` from a derived table caused a server crash. (Bug #54488)
- **Security Fix**: The `PolyFromWKB()` function could crash the server when improper WKB data was passed to the function. (Bug #51875, CVE-2010-3840)
- **Incompatible Change**: **Replication**: The behavior of `INSERT DELAYED` statements when using statement-based replication has changed as follows:

  Previously, when using `binlog_format=STATEMENT`, a warning was issued in the client when executing `INSERT`

`DELAYED`; now, no warning is issued in such cases.

Previously, when using `binlog_format=STATEMENT`, `INSERT DELAYED` was logged as `INSERT DELAYED`; now, it is logged as an `INSERT`, without the `DELAYED` option.

However, when `binlog_format=STATEMENT`, `INSERT DELAYED` continues to be executed as `INSERT` (without the `DELAYED` option). The behavior of `INSERT DELAYED` remains unchanged when using `binlog_format=ROW`: `INSERT DELAYED` generates no warnings, is executed as `INSERT DELAYED`, and is logged using the row-based format.

This change also affects `binlog_format=MIXED`, because `INSERT DELAYED` is no longer considered unsafe. Now, when the logging format is `MIXED`, no switch to row-based logging occurs. This means that the statement is logged as a simple `INSERT` (that is, without the `DELAYED` option), using the statement-based logging format. (Bug #54579, Bug #11762035)

See also Bug #56678, Bug #11763907, Bug #57666.

This regression was introduced by Bug #39934, Bug #11749859.

- **Incompatible Change**: `HANDLER ... READ` statements that invoke stored functions can cause replication errors. Such statements are now disallowed and result in an `ER_NOT_SUPPORTED_YET` error. (Bug #54920)
- **Incompatible Change**: Previously, if you flushed the logs using `FLUSH LOGS` or `mysqladmin flush-logs` and `mysqld` was writing the error log to a file (for example, if it was started with the `--log-error` option), it renamed the current log file with the suffix `-old`, then created a new empty log file. This had the problem that a second log-flushing operation thus caused the original error log to be lost unless you saved it under a different name. For example, you could use the following commands to save the file:

```
shell> mysqladmin flush-logs
shell> mv host_name.err-old backup-directory
```

To avoid the preceding file-loss problem, renaming no longer occurs. The server merely closes and reopens the log file. To rename the file, you can do so manually before flushing. Then flushing the logs reopens a new file with the original file name. For example, you can rename the file and create a new one using the following commands:

```
shell> mv host_name.err host_name.err-old
shell> mysqladmin flush-logs
shell> mv host_name.err-old backup-directory
```

(Bug #29751)

See also Bug #56821.

- **Important Change**: **InnoDB Storage Engine**: The server could crash with an assertion, possibly leading to data corruption, while updating the primary key of an `InnoDB` table containing `BLOB` or other columns requiring off-page storage. This fix applies to the `InnoDB` Plugin in MySQL 5.1, and to `InnoDB` 1.1 in MySQL 5.5. (Bug #55543)
- **InnoDB Storage Engine**: **Replication**: If the master had `innodb_file_per_table=OFF`, `innodb_file_format=Antelope` (and `innodb_strict_mode=OFF`), or both, certain `CREATE TABLE` options, such as `KEY_BLOCK_SIZE`, were ignored. This could permit the master to avoid raising `ER_TOO_BIG_ROWSIZE` errors.

However, the ignored `CREATE TABLE` options were still written into the binary log, so that, if the slave had `innodb_file_per_table=ON` and `innodb_file_format=Barracuda`, it could encounter an `ER_TOO_BIG_ROWSIZE` error while executing the record from the log, causing the slave SQL thread to abort and replication to fail.

In the case where the master was running MySQL 5.1 and the slave was MySQL 5.5 (or later), the failure occurred when both master and slave were running with default values for `innodb_file_per_table` and `innodb_file_format`. This could cause problems during upgrades.

To address this issue, the default values for `innodb_file_per_table` and `innodb_file_format` are reverted to the MySQL 5.1 default values—that is, `OFF` and `Antelope`, respectively. (Bug #56318, Bug #11763590)

- **InnoDB Storage Engine**: The server could crash with a high volume of concurrent `LOCK TABLES` and `UNLOCK TABLES` statements. (Bug #57345)
- **InnoDB Storage Engine**: `InnoDB` incorrectly reported an error when a cascading foreign key constraint deleted more than 250 rows. (Bug #57255)
- **InnoDB Storage Engine**: If the server crashed during an `ALTER TABLE` operation on an `InnoDB` table, examining the table through `SHOW CREATE TABLE` or querying the `INFORMATION_SCHEMA` tables could cause the server to stop with an assertion error. (Bug #56982)

- **InnoDB Storage Engine**: The output from the `SHOW ENGINE INNODB STATUS` command can now be up to 1MB. Formerly, it was truncated at 64KB. Monitoring applications that parse that output can check whether it exceeds this new, larger limit by testing the `Innodb_truncated_status_writes` status variable. (Bug #56922)
- **InnoDB Storage Engine**: For debug builds, a `SELECT ... FOR UPDATE` statement affecting a range of rows in an `InnoDB` table could cause a server crash. (Bug #56716)
- **InnoDB Storage Engine**: Improved the performance of `UPDATE` operations on `InnoDB` tables, when only non-indexed columns are changed. (Bug #56340)
- **InnoDB Storage Engine**: When MySQL was restarted after a crash with the option `innodb_force_recovery=6`, certain queries against `InnoDB` tables could fail, depending on `WHERE` or `ORDER BY` clauses.

  Usually in such a disaster recovery situation, you dump the entire table using a query without these clauses. During advanced troubleshooting, you might use queries with these clauses to diagnose the position of the corrupted data, or to recover data following the corrupted part. (Bug #55832)
- **InnoDB Storage Engine**: The `CHECK TABLE` command could cause a time-consuming verification of the `InnoDB` adaptive hash index memory structure. Now this extra checking is only performed in binaries built for debugging. (Bug #55716)
- **InnoDB Storage Engine**: A heavy workload with a large number of threads could cause a crash in the debug version of the server. (Bug #55699)
- **InnoDB Storage Engine**: The server could crash on shutdown, if started with `--innodb-use-system-malloc=0`. (Bug #55627)
- **InnoDB Storage Engine**: If the server crashed during a `RENAME TABLE` operation on an `InnoDB` table, subsequent crash recovery could fail. This problem could also affect an `ALTER TABLE` statement that caused a rename operation internally. (Bug #55027)
- **InnoDB Storage Engine**: Setting the `PACK_KEYS=0` table option for an `InnoDB` table prevented new indexes from being added to the table. (Bug #54606)
- **InnoDB Storage Engine**: The server could crash when opening an `InnoDB` table linked through foreign keys to a long chain of child tables. (Bug #54582)
- **InnoDB Storage Engine**: Changed the locking mechanism for the `InnoDB` data dictionary during `ROLLBACK` operations, to improve concurrency for `REPLACE` statements. (Bug #54538)
- **InnoDB Storage Engine**: With multiple buffer pools enabled, `InnoDB` could flush more data from the buffer pool than necessary, causing extra I/O overhead. (Bug #54346)
- **InnoDB Storage Engine**: `InnoDB` transactions could be incorrectly committed during recovery, rather than rolled back, if the server crashed and was restarted after performing `ALTER TABLE ... ADD PRIMARY KEY` on an `InnoDB` table, or some other operation that involves copying the entire table. (Bug #53756)
- **InnoDB Storage Engine**: `InnoDB` startup messages now include the start and end times for buffer pool initialization, and the total buffer pool size. (Bug #48026)
- **Partitioning**: An `ALTER TABLE` statement acting on table partitions that failed while the affected table was locked could cause the server to crash. (Bug #56172)
- **Partitioning**: Multiple-table `UPDATE` statements involving a partitioned `MyISAM` table could cause this table to become corrupted. Not all tables affected by the `UPDATE` needed to be partitioned for this issue to be observed. (Bug #55458)
- **Partitioning**: `EXPLAIN PARTITIONS` returned bad estimates for range queries on partitioned `MyISAM` tables. In addition, values in the `rows` column of `EXPLAIN PARTITIONS` output did not take partition pruning into account. (Bug #53806, Bug #46754)
- **Replication**: `SET PASSWORD` caused failure of row-based replication between a MySQL 5.1 master and a MySQL 5.5 slave.

  This fix makes it possible to replicate `SET PASSWORD` correctly, using row-based replication between a master running MySQL 5.1.53 or a later MySQL 5.1 release to a slave running MySQL 5.5.7 or a later MySQL 5.5 release. (Bug #57098)

  See also Bug #55452, Bug #57357.
- **Replication**: Prepared multiple-row `INSERT DELAYED` statements were written to the binary log without `DELAYED`. (Bug #56678, Bug #11763907)
- **Replication**: Backticks used to enclose identifiers for savepoints were not preserved in the binary log, which could lead to replication failure when the identifier, stripped of backticks, could be misinterpreted, causing a syntax or other error.

This could cause problems with MySQL application programs making use of generated savepoint IDs. If, for instance, `java.sql.Connection.setSavepoint()` is called without any parameters, Connector/J automatically generates a savepoint identifier consisting of a string of hexadecimal digits `0`-`F` encased in backtick (`` ` ``) characters. If such an ID took the form `` `NeN` `` (where *`N`* represents a string of the decimal digits `0`-`9`, and `e` is a literal uppercase or lowercase "E" character). Removing the backticks when writing the identifier into the binary log left behind a substring which the slave MySQL server tried to interpret as a floating point number, rather than as an identifier. The resulting syntax error caused loss of replication. (Bug #55961)

See also Bug #55962.

- **Replication**: When a slave tried to execute a transaction larger than the slave's value for `max_binlog_cache_size`, it crashed. This was caused by an assertion that the server should roll back only the statement but not the entire transaction when the error `ER_TRANS_CACHE_FULL` occurred. However, the slave SQL thread always rolled back the entire transaction whenever any error occurred, regardless of the type of error. (Bug #55375)
- **Replication**: The error message for `ER_SLAVE_HEARTBEAT_VALUE_OUT_OF_RANGE` was hard coded in English in `sql_yacc.yy`, so that it could not be translated in `errmsg.txt` for other languages.

  Additionally, this same error message was used for three separate error conditions:

  - When the heartbeat period exceeded the value of `slave_net_timeout`.
  - When the heartbeat period was nonnegative but shorter than 1 millisecond.
  - When the value for the heartbeat period was either negative or greater than the maximum permitted.

  These issues have been addressed as follows:

  - By using three distinct error messages for each of the conditions listed previously.
  - By moving the sources for these error messages into the `errmsg-utf8.txt` file to facilitate translations into languages other than English.

  (Bug #54144)
- A buffer overrun could occur when formatting `DBL_MAX` numbers. (Bug #57209)
- `COALESCE()` in MySQL 5.5 could return a result different from MySQL 5.1 for some arguments. (Bug #57095)
- Constant `SUBTIME()` expressions could return incorrect results. (Bug #57039)
- When `mysqld` was started as a service on Windows and `mysqld` was writing the error log to a file (for example, if it was started with the `--log-error` option), the server reassigned the file descriptors of the `stdout` and `stderr` streams to the file descriptor of the log file. On Windows, if `stdout` or `stderr` is not associated with an output stream, the file descriptor returns a negative value. Previously, this caused the file descriptor reassignment to fail and the server to abort. To avoid this problem on Windows, the server now first assigns the `stdout` and `stderr` streams to the log file stream by opening this file. This causes the `stdout` and `stderr` file descriptors to be nonzero and the server can successfully reassign them to the file descriptor of the log file. (Bug #56821)
- The server could crash inside `memcpy()` when reading certain Performance Schema tables. (Bug #56761, Bug #58003)
- Deadlock could occur for heavily concurrent workloads consisting of a mix of DML, DDL, and `FLUSH TABLES` statements affecting the same set of tables. (Bug #56715, Bug #56404, Bug #56405)
- Memory leaks detected by Valgrind were corrected. (Bug #56709)
- On Mac OS X, `RENAME TABLE` raised an assertion if the `lower_case_table_names` system variable was 2 and the old table name was specified in uppercase. (Bug #56595)
- Performance for certain read-only queries, in particular `point_select`, had deteriorated compared to previous versions. (Bug #56585)
- It was possible to compile `mysqld` with Performance Schema support but with a dummy atomic-operations implementation, which caused a server crash. This problem does not affect binary distributions. It is helpful as a safety measure for users who build MySQL from source. (Bug #56521)
- Executing `XA END` after an XA transaction was already ended raised an assertion. (Bug #56448)
- A `SELECT` statement could produce a number of rows different from a `CREATE TABLE ... SELECT` that was supposed to select the same rows. (Bug #56423)

- The server crashed if a table maintenance statement such as `ANALYZE TABLE` or `REPAIR TABLE` was executed on a `MERGE` table and opening and locking a child table failed. For example, this could happen if a child table did not exist or if a lock timeout happened while waiting for a conflicting metadata lock to disappear.

  As a consequence of this bug fix, it is now possible to use `CHECK TABLE` for log tables without producing an error. (Bug #56422, Bug #56494)
- `ALTER TABLE` on a `MERGE` table could result in deadlock with other connections. (Bug #56292, Bug #57002)
- Comparison of one `STR_TO_DATE()` result with another could return incorrect results. (Bug #56271)
- The `tcmalloc` library was missing from binary MySQL packages for Linux. (Bug #56267)
- An `INSERT DELAYED` statement for a `MERGE` table could cause deadlock if it occurred as part of a transaction or under `LOCK TABLES`, and there was a concurrent DDL or `LOCK TABLES ... WRITE` statement that tried to lock one of its underlying tables. (Bug #56251)
- In debug builds, the server raised an assertion for `DROP DATABASE` in installations that had an outdated or corrupted `mysql.proc` table. For example, this affected `mysql_upgrade` when run as part of a MySQL 5.1 to 5.5 upgrade. (Bug #56137)
- A negative `TIME` argument to `MIN()` or `MAX()` could raise an assertion. (Bug #56120)
- The ordering for supplementary characters in the `utf8mb4_bin`, `utf16_bin`, and `utf32_bin` collations was incorrect. (Bug #55980)
- On Solaris with `gcc` 3.4.6, `ha_example.so` was built with DTrace support even if the server was not, causing plugin loading problems. (Bug #55966)
- Short (single-letter) command-line options did not work. (Bug #55873)
- If a query specified a `DATE` or `DATETIME` value in a format different from `'YYYY-MM-DD HH:MM:SS'`, a greater-than-or-equal (`>=`) condition matched only greater-than values in an indexed `TIMESTAMP` column. (Bug #55779, Bug #50774, Bug #11758558)
- If a view was named as the destination table for `CREATE TABLE ... SELECT`, the server produced a warning whether or not `IF NOT EXISTS` was used. Now it produces a warning only when `IF NOT EXISTS` is used, and an error otherwise. (Bug #55777)
- `CASE` expressions with a mix of operands in different character sets sometimes returned incorrect results. (Bug #55744)
- After the fix for Bug #39653, the shortest available secondary index was used for full table scans. The primary clustered key was used only if no secondary index could be used. However, when the chosen secondary index includes all columns of the table being scanned, it is better to use the primary index because the amount of data to scan is the same but the primary index is clustered. This is now taken into account. (Bug #55656)
- The server entered an infinite loop with high CPU utilization after an error occurred during flushing of the I/O cache. (Bug #55629)
- For the Performance Schema, the default number of rwlock classes was increased to 30, and the default number of rwlock and mutex instances was increased to 1 million. These changes were made to account for the volume of data instrumented when the `InnoDB` storage engine is used (because of the `InnoDB` buffer pool). (Bug #55576)
- If there was an active `SELECT` statement, an error arising during trigger execution could cause a server crash. (Bug #55421)
- Assignment of `InnoDB` scalar subquery results to a variable resulted in unexpected `S` locks in `READ COMMITTED` transation isolation level. (Bug #55382)
- In debug builds, `FLUSH TABLE` *`table_list`* `WITH READ LOCK` for a `MERGE` table led to an assertion failure if one of the table's children was not present in the list of tables to be flushed. (Bug #55273)
- The server could crash during shutdown due to a race condition relating to Performance Schema cleanup. (Bug #55105, Bug #56324)
- Queries involving predicates of the form *`const`* `NOT BETWEEN` *`not_indexed_column`* `AND` *`indexed_column`* could return incorrect data due to incorrect handling by the range optimizer. (Bug #54802)
- With an `UPDATE IGNORE` statement including a subquery that was evaluated using a temporary table, an error transferring the data from the temporary was ignored, causing an assertion to be raised. (Bug #54543)
- A bad `DBUG_PRINT` statement in `fill_schema_schemata()` caused server crashes on Solaris. (Bug #54478)

- `MIN()` or `MAX()` with a subquery argument could raise a debug assertion for debug builds or return incorrect data for nondebug builds. (Bug #54465)
- If one session attempted to drop a database containing a table which another session had opened with `HANDLER`, any instance of `ALTER DATABASE`, `CREATE DATABASE`, or `DROP DATABASE` issued by the latter session produced a deadlock. (Bug #54360)
- `INFORMATION_SCHEMA` plugins with no `deinit()` method resulted in a memory leak. (Bug #54253)
- Row subqueries producing no rows were not handled as `UNKNOWN` values in row-comparison expressions. (Bug #54190)
- Setting `SETUP_INSTRUMENTS.TIMER = 'NO'` caused `TIMER_WAIT` values for aggregations to be `NULL` rather than 0. (Bug #53874)
- The `max_length` metadata value of `MEDIUMBLOB` types was reported as 1 byte greater than the correct value. (Bug #53296)
- If an application using the embedded server called `mysql_library_init()` a second time after calling `mysql_library_init()` and `mysql_library_end()` to start and stop the server, the application crashed when reading option files. (Bug #53251)
- The fix for Bug #30234 caused the server to reject the `DELETE` *`tbl_name`*`.* ...` Access compatibility syntax for multiple-table `DELETE` statements. (Bug #53034)
- The `plugin_ftparser.h` and `plugin_audit.h` include files are part of the public API/ABI, but were not tested by the ABI check. (Bug #52821)
- An atomic “compare and swap” operation using x86 assembly code (32 bit) could access incorrect data, which would make it work incorrectly and lose the intended atomicity. This in turn caused the MySQL server to work on inconsistent data structures and return incorrect data. That code affected only 32-bit builds; the effect has been observed when `icc` was used to build binaries. With `gcc`, no incorrect results have been observed during tests, so this fix is a proactive one. Other compilers do not use this assembly code. (Bug #52419)
- In `LOAD DATA INFILE`, using a `SET` clause to set a column equal to itself caused a server crash. (Bug #51850)
- An assertion could be raised by `DELETE` on a view that referenced another view which in turn (directly or indirectly) referenced more than one table. (Bug #51099)
- In some cases, when the left part of a `NOT IN` subquery predicate was a row and contained `NULL` values, the query result was incorrect. (Bug #51070)
- `CHECKSUM TABLE` for Performance Schema tables could cause a server crash due to uninitialized memory reads. (Bug #50557)
- For some queries, the optimizer produced incorrect results using the Index Merge access method with `InnoDB` tables. (Bug #50402)
- `EXPLAIN` produced an incorrect `rows` value for queries evaluated using an index scan and that included `LIMIT`, `GROUP BY`, and `ORDER BY` on a computed column. (Bug #50394)
- `mysql_store_result()` and `mysql_use_result()` are not for use with prepared statements and are not intended to be called following `mysql_stmt_execute()`, but failed to return an error when invoked that way. (Bug #47485)
- Using `REPAIR TABLE` *`tbl_name`* `USE_FRM` on a `MERGE` table caused the server to crash. (Bug #46339)
- If the global and session `debug` system variables had the same value, the debug trace file could be closed twice, leading to freeing already freed memory and a server crash. (Bug #46165)
- If `ALTER EVENT` failed to load an event after altering it, an assertion could be raised. This could occur, for example, if `ALTER EVENT` was killed with `KILL QUERY`. (Bug #44171)
- Trailing space removal for `utf32` strings was done with non-multibyte-safe code, leading to incorrect result length and assertion failure. (Bug #42511)
- A malformed packet sent by the server when the query cache was in use resulted in lost-connection errors. (Bug #42503)
- Multiple-statement execution could fail. (Bug #40877)
- `CREATE TABLE` failed if a column referred to in an index definition and foreign key definition had different lettercases in the two definitions. (Bug #39932)
- `mysqlcheck` behaved differently depending on the order in which options were given on the command line. (Bug #35269)

- When invoked to display a help message, `mysqld` also displayed spurious warning or error messages. (Bug #30025)

D.1.11. Changes in MySQL 5.5.6 (13 September 2010 Release Candidate)

Functionality Added or Changed

- **Incompatible Change**: The `SHA2()` function now returns a character string with the connection character set and collation. Previously, it returned a binary string. This is the same change made for several other encryption functions in MySQL 5.5.3. (Bug #54661)

- **InnoDB Storage Engine**: The mechanism that checks if there is enough space for redo logs was improved, reducing the chance of encountering this message: `ERROR: the age of the last checkpoint is x, which exceeds the log group capacity y`. (Bug #39168)

- **InnoDB Storage Engine**: Improved performance and scalability on Windows systems, especially for Windows Vista and higher. Re-enabled the use of atomic instructions on Windows systems. For Windows Vista and higher, reduced the number of event handles used. To compile on Windows systems now requires Windows SDK v6.0 or later; either upgrade to Visual Studio 2008 or 2010, or for Visual Studio 2005, install Windows SDK Update for Windows Vista. (Bug #22268)

- Previously, `MySQL-shared-compat` RPMs for Linux contained both the current and previous client library versions for the target platform. Thus, the package contents overlapped with `MySQL-shared` RPMs, which contain only the current client library version. This can result in problems in two cases:

  - When the `MySQL-shared` RPM is installed but later it is determined that the `MySQL-shared-compat` RPM is needed (an application is installed that was linked against an older client library). Installing the `MySQL-shared-compat` RPM results in a conflict because both include the current library version. This can be overcome by using the `--force` option to RPM, or by first uninstalling the `MySQL-shared` RPM (which breaks dependencies).

  - When the `MySQL-shared-compat` RPM is installed, but old applications that require it are removed or upgraded to the current library version. In this case, `MySQL-shared-compat` cannot be replaced with `MySQL-shared` as long as current applications are installed. This can be overcome by using the `--force` option to RPM, which incurs the risk of breaking dependencies.

  Now the `MySQL-shared-compat` RPMs include only older client library versions and no longer include the current version, so that the `MySQL-shared` and `MySQL-shared-compat` RPM contents no longer overlap. The `MySQL-shared-compat` RPM can be installed even if the `MySQL-shared` RPM is installed, without producing conflicts related to the current library version. The `MySQL-shared-compat` RPM can be uninstalled when old applications are removed or upgraded to the current library version, without breaking applications that already use the current library version.

  If you previously installed the `MySQL-shared-compat` RPM because you needed both the current and previous libraries, you should install both the `MySQL-shared` and `MySQL-shared-compat` RPMs now. (Bug #56150)

- Overhead for the Performance Schema interface was reduced. (Bug #55087)

- Within stored programs, `LIMIT` clauses now permit integer-valued routine parameters or local variables as parameters. (Bug #11918)

- Code was removed for the following no-longer-supported platforms: NetWare, MS-DOS, VMS, QNX, and 32-bit SPARC.

Bugs Fixed

- **Performance**: **InnoDB Storage Engine**: The setting `innodb_change_buffering=all` could produce slower performance for some operations than the previous default, `innodb_change_buffering=inserts`. (Bug #54914)

- **Performance**: **InnoDB Storage Engine**: An `EXPLAIN` plan for an `InnoDB` table could vary greatly in the estimated cost for a `BETWEEN` clause. (Bug #53761)

- **InnoDB Storage Engine**: **Security Fix**: After changing the values of the `innodb_file_format` or `innodb_file_per_table` configuration parameters, DDL statements could cause a server crash. (Bug #55039, CVE-2010-3676)

- **Security Fix**: During evaluation of arguments to extreme-value functions such as `LEAST()` and `GREATEST()`, type errors did not propagate properly, causing the server to crash. (Bug #55826, CVE-2010-3833)

- **Security Fix**: The server could crash after materializing a derived table that required a temporary table for grouping. (Bug #55568, CVE-2010-3834)

- **Security Fix**: A user-variable assignment expression that is evaluated in a logical expression context can be precalculated in a temporary table for `GROUP BY`. However, when the expression value is used after creation of the temporary table, it was re-evaluated, not read from the table, and a server crash resulted. (Bug #55564, CVE-2010-3835)
- **Security Fix**: Joins involving a table with a unique `SET` column could cause a server crash. (Bug #54575, CVE-2010-3677)
- **Security Fix**: Pre-evaluation of `LIKE` predicates during view preparation could cause a server crash. (Bug #54568, CVE-2010-3836)
- **Security Fix**: Incorrect handling of `NULL` arguments could lead to a crash for `IN()` or `CASE` operations when `NULL` arguments were either passed explicitly as arguments (for `IN()`) or implicitly generated by the `WITH ROLLUP` modifier (for `IN()` and `CASE`). (Bug #54477, CVE-2010-3678)
- **Security Fix**: `GROUP_CONCAT()` and `WITH ROLLUP` together could cause a server crash. (Bug #54476, CVE-2010-3837)
- **Security Fix**: Queries could cause a server crash if the `GREATEST()` or `LEAST()` function had a mixed list of numeric and `LONGBLOB` arguments, and the result of such a function was processed using an intermediate temporary table. (Bug #54461, CVE-2010-3838)
- **Security Fix**: A malformed argument to the `BINLOG` statement could result in Valgrind warnings or a server crash. (Bug #54393, CVE-2010-3679)
- **Security Fix**: After `ALTER TABLE` was used on a temporary transactional table locked by `LOCK TABLES`, any later attempts to execute `LOCK TABLES` or `UNLOCK TABLES` caused a server crash. (Bug #54117)
- **Security Fix**: Use of `TEMPORARY` `InnoDB` tables with nullable columns could cause a server crash. (Bug #54044, CVE-2010-3680)
- **Security Fix**: Queries with nested joins could cause an infinite loop in the server when used from stored procedures and prepared statements. (Bug #53544, CVE-2010-3839)
- **Security Fix**: Using `EXPLAIN` with queries of the form `SELECT ... UNION ... ORDER BY (SELECT ... WHERE ...)` could cause a server crash. (Bug #52711, CVE-2010-3682)
- **Security Fix**: Bug #49124 was fixed.
- **Security Fix**: Bug #49124 and Bug #11757121 were fixed.
- **Incompatible Change**: **Replication**: As of MySQL 5.5.6, handling of `CREATE TABLE IF NOT EXISTS ... SELECT` statements has been changed for the case that the destination table already exists:

  - Previously, for `CREATE TABLE IF NOT EXISTS ... SELECT`, MySQL produced a warning that the table exists, but inserted the rows and wrote the statement to the binary log anyway. By contrast, `CREATE TABLE ... SELECT` (without `IF NOT EXISTS`) failed with an error, but MySQL inserted no rows and did not write the statement to the binary log.
  - MySQL now handles both statements the same way when the destination table exists, in that neither statement inserts rows or is written to the binary log. The difference between them is that MySQL produces a warning when `IF NOT EXISTS` is present and an error when it is not.

  This change in handling of `IF NOT EXISTS` results in an incompatibility for statement-based replication from a MySQL 5.1 master with the original behavior and a MySQL 5.5 slave with the new behavior. Suppose that `CREATE TABLE IF NOT EXISTS ... SELECT` is executed on the master and the destination table exists. The result is that rows are inserted on the master but not on the slave. (Row-based replication does not have this problem.)

  To address this issue, statement-based binary logging for `CREATE TABLE IF NOT EXISTS ... SELECT` is changed in MySQL 5.1 as of 5.1.51:

  - If the destination table does not exist, there is no change: The statement is logged as is.
  - If the destination table does exist, the statement is logged as the equivalent pair of `CREATE TABLE IF NOT EXISTS` and `INSERT ... SELECT` statements. (If the `SELECT` in the original statement is preceded by `IGNORE` or `REPLACE`, the `INSERT` becomes `INSERT IGNORE` or `REPLACE`, respectively.)

  This change provides forward compatibility for statement-based replication from MySQL 5.1 to 5.5 because when the destination table exists, the rows will be inserted on both the master and slave. To take advantage of this compatibility measure, the 5.1 server must be at least 5.1.51 and the 5.5 server must be at least 5.5.6.

  To upgrade an existing 5.1-to-5.5 replication scenario, upgrade the master first to 5.1.51 or higher. Note that this differs from the usual replication upgrade advice of upgrading the slave first.

A workaround for applications that wish to achieve the original effect (rows inserted regardless of whether the destination table exists) is to use `CREATE TABLE IF NOT EXISTS` and `INSERT ... SELECT` statements rather than `CREATE TABLE IF NOT EXISTS ... SELECT` statements.

Along with the change just described, the following related change was made: Previously, if an existing view was named as the destination table for `CREATE TABLE IF NOT EXISTS ... SELECT`, rows were inserted into the underlying base table and the statement was written to the binary log. As of MySQL 5.1.51 and 5.5.6, nothing is inserted or logged. (Bug #47442, Bug #47132, Bug #48814, Bug #49494)

- **Incompatible Change**: Several changes were made to Performance Schema tables:

  - The `SETUP_OBJECTS` table was removed.

  - The `PROCESSLIST` table was renamed to `THREADS`.

  - The `EVENTS_WAITS_SUMMARY_BY_EVENT_NAME` table was renamed to `EVENTS_WAITS_SUMMARY_GLOBAL_BY_EVENT_NAME`.

  (Bug #55416)

- **Incompatible Change**: Handling of warnings and errors during stored program execution was problematic:

  - If one statement generated several warnings or errors, only the handler for the first was activated, even if another might be more appropriate. Now the server chooses the more appropriate handler.

  - Warning or error information could be lost.

  (Bug #36185, Bug #5889, Bug #9857, Bug #23032)

- **Incompatible Change**: If the server was started with `character_set_server` set to `utf16`, it crashed during full-text stopword initialization. Now the stopword file is loaded and searched using `latin1` if `character_set_server` is `ucs2`, `utf16`, or `utf32`.

  If any table was created with `FULLTEXT` indexes while the server character set was `ucs2`, `utf16`, or `utf32`, it should be repaired using this statement:

  ```
  REPAIR TABLE tbl_name QUICK;
  ```

  (Bug #32391)

- **Important Change**: **Replication**: The `LOAD DATA INFILE` statement is now considered unsafe for statement-based replication. When using statement-based logging mode, the statement now produces a warning; when using mixed-format logging, the statement is made using the row-based format. (Bug #34283)

- **InnoDB Storage Engine**: An assertion was raised if (1) an `InnoDB` table was created using `CREATE TABLE ... SELECT` where the query used an `INFORMATION_SCHEMA` table and a view existed in the database; or (2) any statement that modified an `InnoDB` table had a subquery referencing an `INFORMATION_SCHEMA` table. (Bug #55973)

- **InnoDB Storage Engine**: The `InnoDB` storage engine was not included in the default installation when using the `configure` script. (Bug #55547)

- **InnoDB Storage Engine**: For an `InnoDB` table with an auto-increment column, the server could crash if the first statement that references the table after a server restart is a `SHOW CREATE TABLE` statement. (Bug #55277)

- **InnoDB Storage Engine**: The `mysql_config` tool did not output the requirement for the `aio` library for `mysqld-libs`. (Bug #55215)

- **InnoDB Storage Engine**: Some memory used for `InnoDB` asynchronous I/O was not freed at shutdown. (Bug #54764)

- **InnoDB Storage Engine**: Implementation of the 64-bit `dulint` structure in `InnoDB` was not optimized for 64-bit processors, resulting in excessive storage and reduced performance. (Bug #54728)

- **InnoDB Storage Engine**: The output from the `SHOW ENGINE INNODB STATUS` command now includes information about “spin rounds” for RW-locks (both shared and exclusive locks). (Bug #54726)

- **InnoDB Storage Engine**: An `ALTER TABLE` statement could convert an `InnoDB` compressed table (with `row_format=compressed`) back to an uncompressed table (with `row_format=compact`). (Bug #54679)

- **InnoDB Storage Engine**: `InnoDB` could issue an incorrect message on startup, if tables were created under the setting `innodb_file_per_table=ON`. The message was of the form `InnoDB: Warning: allocated tablespace n,` `old maximum was 0` and is no longer displayed during restarts after you have upgraded the MySQL server and created at least one `InnoDB` table with `innodb_file_per_table=ON`. If you continue to encounter this message, you might have corruption in your shared tablespace; if so, back up and reload your data. (Bug #54658)

- **InnoDB Storage Engine**: For debug builds, the database server could crash when renaming a table that had active transactions. (Bug #54453)
- **InnoDB Storage Engine**: The server could crash during the recovery phase of startup, if it previously crashed while inserting `BLOB` or other large columns that use off-page storage into an `InnoDB` table created with `ROW_FORMAT=REDUNDANT` or `ROW_FORMAT=COMPACT`. (Bug #54408)
- **InnoDB Storage Engine**: For an `InnoDB` table created with `ROW_FORMAT=COMPRESSED` or `ROW_FORMAT=DYNAMIC`, a query using the `READ UNCOMMITTED` isolation level could cause the server to stop with an assertion error, if `BLOB` or other large columns that use off-page storage were being inserted at the same time. (Bug #54358)
- **InnoDB Storage Engine**: Fast index creation in the `InnoDB Plugin` could fail, leaving the new secondary index corrupted. (Bug #54330)
- **InnoDB Storage Engine**: If a session executing `TRUNCATE TABLE` on an `InnoDB` table was killed during `open_tables()`, an assertion could be raised. (Bug #53757)
- **InnoDB Storage Engine**: The `Lock_time` field in the slow query log now reports a larger value, including the time for `InnoDB` lock waits at the statement level. (Bug #53496)
- **InnoDB Storage Engine**: Misimplementation of the `os_fast_mutex_trylock()` function in `InnoDB` resulted in unnecessary blocking and reduced performance. (Bug #53204)
- **InnoDB Storage Engine**: `InnoDB` could not create tables that used the `utf32` character set. (Bug #52199)
- **InnoDB Storage Engine**: Performing large numbers of `RENAME TABLE` statements caused excessive memory use. (Bug #47991)
- **Partitioning**: With `innodb_thread_concurrency = 1`, `ALTER TABLE ... REORGANIZE PARTITION` and `SELECT` could deadlock. There were unreleased latches in the `ALTER TABLE ... REORGANIZE PARTITION` thread which were needed by the `SELECT` thread to be able to continue. (Bug #54747)
- **Partitioning**: An `ALTER TABLE ... ADD PARTITION` statement run concurrently with a read lock caused spurious `ER_TABLE_EXISTS_ERROR` and `ER_NO_SUCH_TABLE` errors on subsequent attempts. (Bug #53676)

  See also Bug #53770.
- **Partitioning**: `UPDATE` and `INSERT` statements affecting partitioned tables performed poorly when using row-based replication. (Bug #52517)
- **Partitioning**: `INSERT ON DUPLICATE KEY UPDATE` statements performed poorly on tables having many partitions. The handler function for reading a row from a specific index was not optimized in the partitioning handler. (Bug #52455)
- **Partitioning**: `ALTER TABLE ... TRUNCATE PARTITION`, when called concurrently with transactional DML on the table, was executed immediately and did not wait for the concurrent transaction to release locks. As a result, the `ALTER TABLE` statement was written into the binary log before the DML statement, which led to replication failures when using row-based logging. (Bug #49907)

  See also Bug #42643.
- **Partitioning**: When the storage engine used to create a partitioned table was disabled, attempting to drop the table caused the server to crash. (Bug #46086)
- **Replication**: When using the row-based logging format, a failed `CREATE TABLE ... SELECT` statement was written to the binary log, causing replication to break if the failed statement was later re-run on the master. In such cases, a `DROP TABLE ... IF EXIST` statement is now logged in the event that a `CREATE TABLE ... SELECT` fails. (Bug #55625)
- **Replication**: When using the row-based logging format, a `SET PASSWORD` statement was written to the binary log twice. (Bug #55452)
- **Replication**: When closing temporary tables, after the session connection was already closed, if the writing of the implicit `DROP TABLE` statement into the binary log failed, it was possible for the resulting error to be mishandled, triggering an assertion. (Bug #55387)
- **Replication**: Executing `SHOW BINLOG EVENTS` increased the value of `max_allowed_packet` applying to the session that executed the statement. (Bug #55322)

- **Replication**: Setting `binlog_format` to `ROW`, then creating and dropping a temporary table led to an assertion. (Bug #54925)

- **Replication**: When using mixed-format replication, changes made to a nontransactional temporary table within a transaction were not written into the binary log when the transaction was rolled back. This could lead to a failure in replication if the temporary table was used again afterwards. (Bug #54872)

  See also Bug #53259.

- **Replication**: If `binlog_format` was explicitly switched from `STATEMENT` to `ROW` following the creation of a temporary table, then on disconnection the master failed to write the expected `DROP TEMPORARY TABLE` statement into the binary log. As a consequence, temporary tables (and their corresponding files) accumulated as this scenario was repeated. (Bug #54842)

  See also Bug #52616.

- **Replication**: If the SQL thread was started while the I/O thread was performing rotation of the relay log, the two threads could begin to race for the same I/O cache, leading to a server crash. (Bug #54509)

  See also Bug #50364.

- **Replication**: Two related issues involving temporary tables and transactions were introduced by a fix made in MySQL 5.1.37:

  1. When a temporary table was created or dropped within a transaction, any failed statement that following the `CREATE TEMPORARY TABLE` or `DROP TEMPORARY TABLE` statement triggered a rollback, which caused the slave to diverge from the master.

  2. When a `CREATE TEMPORARY TABLE ... SELECT * FROM ...` statement was executed within a transaction in which only tables using transactional storage engines were used and the transaction was rolled back at the end, the changes—including the creation of the temporary table—were not written to the binary log.

  The current fix restores the correct behavior in both of these cases. (Bug #53560)

  This regression was introduced by Bug #43929.

- **Replication**: The value of `binlog_direct_non_transactional_updates` had no effect on statements mixing transactional tables and nontransactional tables, or mixing temporary tables and nontransactional tables.

  As part of the fix for this issue, updates to temporary tables are now handled as transactional or nontransactional according to their storage engine types. (In effect, the current fix reverts a change made previously as part of the fix for Bug #53259.)

  In addition, unsafe mixed statements (that is, statements which access transactional table as well nontransactional or temporary tables, and write to any of them) are now handled as transactional when the statement-based logging format is in use. (Bug #53452)

  See also Bug #51894.

- **Replication**: A number of statements generated unnecessary warnings as potentially unsafe statements. (Due to the fix for Bug #51894, a temporary table is treated in this context as a transactional table, so that any mixed statement such as `t_innodb` + `t_myisam` or `t_temp` + `t_myisam` is flagged as unsafe.)

  To reduce the number of spurious warnings produced when this happened, some of the criteria used to classify a statements as safe or unsafe have been changed. For more information about handling of mixed statements, see Transactional, nontransactional, and mixed statements. (Bug #53259)

  See also Bug #53452, Bug #54872.

- **Replication**: When `binlog_format=STATEMENT`, any statement that is flagged as being unsafe, possibly causing the slave to go out of sync, generates a warning. This warning is written to the server log, the warning count is returned to the client in the server's response, and the warnings are accessible through `SHOW WARNINGS`.

  The current bug affects only the counts for warnings to the client and that are visible through `SHOW WARNINGS`; it does not affect which warnings are written to the log. The current issue came about because the fix for an earlier issue caused warnings for substatements to be cleared whenever a new substatement was started. However, this suppressed warnings for unsafe statements in some cases. Now, such warnings are no longer cleared. (Bug #50312)

  This regression was introduced by Bug #36649.

- **Replication**: Replication could break if a transaction involving both transactional and nontransactional tables was rolled back to a savepoint. It broke if a concurrent connection tried to drop a transactional table which was locked after the savepoint was set. This `DROP TABLE` completed when `ROLLBACK TO SAVEPOINT` was executed because the lock on the table was dropped by the transaction. When the slave later tried to apply the binary log events, it failed because the table had already been dropped. (Bug #50124)

- **Replication**: When `CURRENT_USER()` or `CURRENT_USER` was used to supply the name and host of the affected user or of the definer in any of the statements `DROP USER`, `RENAME USER`, `GRANT`, `REVOKE`, and `ALTER EVENT`, the reference to `CURRENT_USER()` or `CURRENT_USER` was not expanded when written to the binary log. This resulted in `CURRENT_USER()` or `CURRENT_USER` being expanded to the user and host of the slave SQL thread on the slave, thus breaking replication. Now `CURRENT_USER()` and `CURRENT_USER` are expanded prior to being written to the binary log in such cases, so that the correct user and host are referenced on both the master and the slave. (Bug #48321)
- After an RPM installation, `mysqld` would be started with the `root` user, rather than the `mysql` user. (Bug #56574)
- The embedded server raised an assertion when it attempted to load plugins. (Bug #56085)
- `FORMAT()` did not respect the decimal point character if the locale was changed and always returned an ASCII value. (Bug #55912)
- `CMake` produced bad dependencies for the `sql/lex_hash.h` file during configuration. (Bug #55842)
- `mysql_upgrade` did not handle the `--ssl` option properly. (Bug #55672)
- Using `MIN()` or `MAX()` on a column containing the maximum `TIME` value caused a server crash. (Bug #55648)
- Incorrect handling of user variable assignments as subexpressions could lead to incorrect results or server crashes. (Bug #55615)
- The default compiler options for Mac OS X 10.5 were set incorrectly. (Bug #55601)
- The server was not checking for errors generated during the execution of `Item::val_xxx()` methods when copying data to a group, order, or distinct temp table's row. (Bug #55580)
- `ORDER BY` clauses that included user-variable expressions could raise a debug assertion. (Bug #55565)
- `SHOW CREATE TRIGGER` took a stronger metadata lock than required. This caused the statement to be blocked unnecessarily. For example, `LOCK TABLES ... WRITE` in one session blocked `SHOW CREATE TRIGGER` in another session.

  Also, a `SHOW CREATE TRIGGER` statement issued inside a transaction did not release its metadata locks at the end of statement execution. Consequently, `SHOW CREATE TRIGGER` was able to block other sessions from accessing the table (for example, using `ALTER TABLE`). (Bug #55498)
- A single-table `DELETE` ordered by a column that had a hash-type index could raise an assertion or cause a server crash. (Bug #55472)
- A call to `mysql_library_init()` following a call to `mysql_library_end()` caused a client crash. (Bug #55345)
- The `-features=no%except` option was missing from the build for Solaris/x86. (Bug #55250)
- A statement that was aborted by `KILL QUERY` while it waited on a metadata lock could raise an assertion in debug builds, or send OK to the client instead of `ER_QUERY_INTERRUPTED` in regular builds. (Bug #55223)
- `GROUP BY` operations used `max_sort_length` inconsistently. (Bug #55188)
- The Windows MSI installer failed during installation to preserve custom settings, such as the configured data directory. (Bug #55169)
- `InnoDB` produced no warning at startup about illegal `innodb_file_format_check` values. (Bug #55095)
- `IF()` with a subquery argument could raise a debug assertion for debug builds under some circumstances. (Bug #55077)
- Building MySQL on Solaris 8 x86 failed when using Sun Studio due to `gcc` inline assembly code. (Bug #55061)
- When upgrading an existing install with an RPM on Linux, the MySQL server might not have been restarted properly. This was due to a naming conflict when upgrading from a `community` named RPM. Previous installations are now correctly removed, the MySQL initialization script is recreated, and the MySQL server is restarted as normal. (Bug #55015)
- The `thread_concurrency` system variable was unavailable on non-Solaris systems. (Bug #55001)
- `mysqld_safe` contained a syntax error that prevented it from restarting the server. (Bug #54991)
- If audit plugins were installed that were interested in `MYSQL_AUDIT_GENERAL_CLASS` events and the general query log was disabled, failed `INSTALL PLUGIN` or `UNINSTALL PLUGIN` statements caused a server crash. (Bug #54989)

- Some functions did not calculate their `max_length` metadata value correctly. (Bug #54916)
- A `SHOW CREATE TABLE` statement issued inside a transaction did not release its metadata locks at the end of statement execution. Consequently, `SHOW CREATE TABLE` was able to block other sessions from accessing the table (for example, using `ALTER TABLE`). (Bug #54905)
- `INFORMATION_SCHEMA.ENGINES` and `SHOW ENGINES` described `MyISAM` as the default storage engine, but this is not true as of MySQL 5.5.5. (Bug #54832)
- The `MERGE` storage engine tried to use memory mapping on the underlying `MyISAM` tables even on platforms that do not support it and even when `myisam_use_mmap` was disabled. This led to a hang for `INSERT INTO ... SELECT FROM` statements that selected from a `MyISAM` table into a `MERGE` table that contained the same `MyISAM` table. (Bug #54811, Bug #50788)
- Incorrect error handling could result in an `OPTIMIZE TABLE` crash. (Bug #54783)
- Performance Schema event collection for a thread could “leak” from one connection to another if the thread was used for one connection, then cached, then reused for another connection. (Bug #54782)
- In debug builds, an assertion could be raised when the server tried to send an OK packet to the client after having failed to detect errors during processing of the `WHERE` condition of an `UPDATE` statement. (Bug #54734)
- In a slave SQL thread or Event Scheduler thread, the `SLEEP()` function could not sleep more than five seconds. (Bug #54729)
- `SET sql_select_limit = 0` did not work. (Bug #54682)
- Assignments of the `PASSWORD()` or `OLD_PASSWORD()` function to a user variable did not preserve the character set of the function return value. (Bug #54668)
- A signal-handler redefinition for `SIGUSR1` was removed. The redefinition could cause the server to encounter a kernel deadlock on Solaris when there are many active threads. Other POSIX platforms might also be affected. (Bug #54667)
- Queries that named view columns in a `GROUP BY` clause could cause a server crash. (Bug #54515)
- The Performance Schema displayed spurious startup error messages when the server was run in bootstrap mode. (Bug #54467)
- For distributions built with `CMake` rather than the GNU autotools, `mysql` lacked `pager` support, and some scripts were built without the execute bit set. (Bug #54466, Bug #54129)
- The server failed to disregard sort order for some zero-length tuples, leading to an assertion failure. (Bug #54459)
- A join with an aggregated function and impossible `WHERE` condition returned an extra row. (Bug #54416)
- Errors during processing of `WHERE` conditions in `HANDLER ... READ` statements were not detected, so the handler code still tried to send EOF to the client, raising an assertion. (Bug #54401)
- If a session tried to drop a database containing a table opened with `HANDLER` in another session, any `DATABASE` statement (`CREATE`, `DROP`, `ALTER`) executed by that session produced a deadlock. (Bug #54360)
- Deadlocks involving `INSERT DELAYED` statements were not detected. The server could crash if the delayed handler thread was killed due to a conflicting shared metadata lock. (Bug #54332)
- After `ALTER TABLE` was used on a temporary transactional table locked by `LOCK TABLES`, any later attempts to execute `LOCK TABLES` or `UNLOCK TABLES` caused a server crash. (Bug #54117)
- `INSERT IGNORE INTO ... SELECT` statements could raise a debug assertion. (Bug #54106)
- `SHOW CREATE EVENT` released all metadata locks held by the current transaction. This invalidated any existing savepoints and raised an assertion if `ROLLBACK TO SAVEPOINT` was executed. (Bug #54105)
- A client could supply data in chunks to a prepared statement parameter other than of type `TEXT` or `BLOB` using the `mysql_stmt_send_long_data()` C API function (or `COM_STMT_SEND_LONG_DATA` command). This led to a crash because other data types are not valid for long data. (Bug #54041)
- `mysql_secure_installation` did not properly identify local accounts and could incorrectly remove nonlocal `root` accounts. (Bug #54004)
- A client with automatic reconnection enabled saw the error message `Lost connection to MySQL server during query` if the connection was lost between the `mysql_stmt_prepare()` and `mysql_stmt_execute()` C API functions. However, `mysql_stmt_errno()` returned 0, not the corresponding error number 2013. (Bug #53899)

- `INFORMATION_SCHEMA.COLUMNS` reported incorrect precision for `BIGINT UNSIGNED` columns. (Bug #53814)
- The patch for Bug #36569 caused performance regressions and incorrect execution of some `UPDATE` statements. (Bug #53737, Bug #53742)
- Missing Performance Schema tables were not reported in the error log at server startup. (Bug #53617)
- `mysql_upgrade` could incorrectly remove `TRIGGER` privileges. (Bug #53613)
- `SHOW ENGINE PERFORMANCE_SCHEMA STATUS` underreported the amount of memory allocated by the Performance Schema. (Bug #53566)
- Portability problems in `SHOW STATUS` could lead to incorrect results on some platforms. (Bug #53493)
- Builds of MySQL generated a large number of warnings. (Bug #53445)
- Performance Schema header files were not installed in the correct directory. (Bug #53255)
- The server could crash when processing subqueries with empty results. (Bug #53236)
- With `lower_case_table_names` set to a nonzero value, searches for table or database names in `INFORMATION_SCHEMA` tables could produce incorrect results. (Bug #53095)
- Use of `uint` in `typelib.h` caused compilation problems in Windows. This was changed to `unsigned int`. (Bug #52959)
- The `mysql-debug.pdb` supplied with releases did not match the corresponding `mysqld.exe`. (Bug #52850)
- The `PERFORMANCE_SCHEMA` database was not correctly created and populated on Windows. (Bug #52809)
- The `large_pages` system variable was tied to the `--large-files` command-line option, not the `--large-pages` option. (Bug #52716)
- Attempts to access a nonexistent Performance Schema table resulted in a misleading error message. (Bug #52586)
- The ABI check for MySQL failed to compile with `gcc` 4.5. (Bug #52514)
- The Performance Schema could enter an infinite loop if required to create a large number of mutex instances. (Bug #52502)
- `mysql_secure_installation` sometimes failed to locate the `mysql` client. (Bug #52274)
- Some queries involving `GROUP BY` and a function that returned `DATE` raised a debug assertion. (Bug #52159)
- If a symbolic link was used in a file path name, the Performance Schema did not resolve all file I/O events to the same name. (Bug #52134)
- `PARTITION BY KEY` on a `utf32` `ENUM` column raised a debugging assertion. (Bug #52121)
- A pending `FLUSH TABLES` *`tbl_list`* `WITH READ LOCK` statement unnecessarily aborted transactions. (Bug #52117)
- `FLUSH TABLES WITH READ LOCK` in one session and `FLUSH TABLES` *`tbl_list`* `WITH READ LOCK` in another session were mutually exclusive.

  This bug fix involved several changes to the states displayed by `SHOW PROCESSLIST`:

  - `Table lock` was replaced with `Waiting for table level lock`.
  - `Waiting for table` was replaced with `Waiting for table flush`.
  - These states are new: `Waiting for global metadata lock`, `Waiting for schema metadata lock`, `Waiting for stored function metadata lock`, `Waiting for stored procedure metadata lock`, `Waiting for table metadata lock`.

  (Bug #52044)
- Reading a `ucs2` data file with `LOAD DATA INFILE` was subject to three problems. 1) Incorrect parsing of the file as `ucs2` data, resulting in incorrect length of the parsed string. This is fixed by truncating the invalid trailing bytes (incomplete multibyte characters) when reading from the file. 2) Reads from a proper `ucs2` file did not recognize newline characters. This is fixed by first checking whether a byte is a newline (or any other special character) before reading it as a part of a multibyte character. 3) When using user variables to hold column data, the character set of the user variable was set incorrectly to the database charset. This is fixed by setting it to the character set specified in the `LOAD DATA INFILE` statement, if any. (Bug #51876)

- `XA START` had a race condition that could cause a server crash. (Bug #51855)
- The results of some `ORDER BY ... DESC` queries were sorted incorrectly. (Bug #51431)
- `Index Merge` between three indexes could return incorrect results. (Bug #50389)
- `MIN()` and `MAX()` returned incorrect results for `DATE` columns if the set of values included `'0000-00-00'`. (Bug #49771)
- Searches in `INFORMATION_SCHEMA` tables for rows matching a nonexistent database produced an error instead of an empty query result. (Bug #49542)
- `DROP DATABASE` failed if there was a `TEMPORARY` table with the same name as a non-`TEMPORARY` table in the database. (Bug #48067)
- An assertion occurred in `ha_myisammrg.cc` line 1137:

  ```
  DBUG_ASSERT(this->file->children_attached);
  ```

  The problem was found while running RQG tests and the assertion occurred during `REPAIR`, `OPTIMIZE`, and `ANALYZE` operations. (Bug #47633)
- The optimization method of the `ARCHIVE` storage engine did not preserve the `.frm` file embedded in the `.ARZ` file when rewriting the `.ARZ` file for optimization. This meant an `ARCHIVE` table that had been optimized could not be discovered.

  The `ARCHIVE` engine stores the `.frm` file in the `.ARZ` file so it can be transferred from machine to machine without also needing to copy the `.frm` file. The engine subsequently restores the embedded `.frm` during discovery. (Bug #45377)
- With `character_set_connection` set to `utf16` or `utf32`, `CREATE TABLE t1 AS SELECT HEX() ...` caused a server crash. (Bug #45263)
- The `my_like_range_xxx()` functions returned badly formed maximum strings for Asian character sets, which caused problems for storage engines. (Bug #45012)
- A debugging assertion could be raised after a write failure to a closed socket. (Bug #42496)
- Enumeration plugin variables were subject to a type-casting error, causing inconsistent results between different platforms. (Bug #42144)
- Sort-`index_merge` for join tables other than the first table used excessive memory. (Bug #41660)
- `DROP TABLE` held a lock during `unlink()` file system operations, causing performance problems if `unlink()` took a long time. (Bug #41158)
- Rows inserted in a table by one session were not immediately visible to another session that queried the table, even if the insert had committed. (Bug #37521)
- Statements of the form `UPDATE ... WHERE ... ORDER BY` used a `filesort` even when not required. (Bug #36569)

  See also Bug #53737, Bug #53742.
- Reading from a temporary `MERGE` table, with two nontemporary child `MyISAM` tables, resulted in the error:

  ```
  ERROR 1168 (HY000): Unable to open underlying table which is differently
  defined or of non-MyISAM type or doesn't exist
  ```

  (Bug #36171)
- `safemalloc` was excessively slow under certain conditions and has been removed. The `--skip-safemalloc` server option has also been removed, and the `--with-debug=full` configuration option is no different from `--with-debug`. (Bug #34043)
- Threads that were calculating the estimated number of records for a range scan did not respond to the `KILL` statement. That is, if a `range` join type is possible (even if not selected by the optimizer as a join type of choice and thus not shown by `EXPLAIN`), the query in the `statistics` state (shown by the `SHOW PROCESSLIST`) did not respond to the `KILL` statement. (Bug #25421)
- Problems in the atomic operations implementation could lead to server crashes. (Bug #22320, Bug #52261)

D.1.12. Changes in MySQL 5.5.5 (06 July 2010)

icc Notes

- This is the final release of MySQL 5.5 for which Generic Linux MySQL binary packages built with the `icc` compiler on x86 and x86_64 will be offered. These were previously produced as an alternative to our main packages built using `gcc`, as they provided noticeable performance benefits. In recent times the performance differences have diminished and build and runtime problems have surfaced, thus it is no longer viable to continue producing them.

  We continue to use the `icc` compiler to produce our distribution-specific RPM packages on ia64.

InnoDB Notes

- `InnoDB` has been upgraded to version 1.1.1. This version is considered of “early adopter” quality.

  `InnoDB` is now the default storage engine, rather than `MyISAM`, in the regular and enterprise versions of MySQL. This change has the following consequences:

  - Existing tables are not affected by this change, only new tables that are created.
  - Some of the `InnoDB` option settings also change, so that the default configuration represents the best practices for `InnoDB` functionality, reliability, and file management: `innodb_file_format=Barracuda` rather than `Antelope`, `innodb_strict_mode=ON` rather than `OFF`, and `innodb_file_per_table=ON` rather than `OFF`.
  - The system tables remain in `MyISAM` format.
  - `MyISAM` remains the default storage engine for the embedded version of MySQL.

  Follow these steps to ensure a smooth transition when upgrading:

  - Familiarize yourself with the new default setting for the `InnoDB` file-per-table option, which creates a separate `.ibd` file for each user table. Adapt any backup procedure to include these files. For details, see Section 13.3.3, “Using Per-Table Tablespaces”.
  - Test the installation and operation for any applications that you run on the database server, to determine if they use any features specific to `MyISAM` that cause problems during installation (when the tables are created) or at runtime (when `MyISAM`-specific features might fail, or reliance on `MyISAM` settings for performance might become apparent). The `InnoDB` “strict” mode might also alert you to problems while setting up tables for an application.
  - As a preliminary test for individual tables rather than an entire application, you can use the statement `ALTER TABLE table_name ENGINE=INNODB;` to convert an existing table to use the `InnoDB` storage engine, and then run compatibility and performance tests.
  - Where necessary, add `ENGINE=MYISAM` clauses to `CREATE TABLE` statements, for tables that require features specific to `MyISAM`, such as full-text search.
  - Benchmark the most important queries, to check whether you need to make changes to the table indexes.
  - Measure the performance of applications under typical load, to check whether you need to change any additional `InnoDB` configuration settings.
  - As a last resort, if a database server is devoted entirely to applications that can only run with `MyISAM` tables, you could add a `default-storage-engine` line in the configuration file, or a `--default-storage-engine` option in the database server startup command, to re-enable `MyISAM` as the default storage engine for that server. For details about setting the default storage engine, see Section 13.1, “Setting the Storage Engine”.

Functionality Added or Changed

- **Incompatible Change**: All numeric operators and functions on integer, floating-point and `DECIMAL` values now throw an “out of range” error (`ER_DATA_OUT_OF_RANGE`) rather than returning an incorrect value or `NULL`, when the result is out of the supported range for the corresponding data type. See Section 10.6, “Out-of-Range and Overflow Handling”. (Bug #8433)
- **InnoDB Storage Engine**: The `INFORMATION_SCHEMA.INNODB_TRX` table now includes a number of fields that duplicate information from the `SHOW ENGINE INNODB STATUS` output. You no longer need to parse that output to get complete transaction information. (Bug #53336)
- **InnoDB Storage Engine**: `InnoDB` stores redo log records in a hash table during recovery. On 64-bit systems, this hash table

was 1/8 of the buffer pool size. To reduce memory usage, the dimension of the hash table was reduced to 1/64 of the buffer pool size (or 1/128 on 32-bit systems). (Bug #53122)

- Previously, the `innodb_file_format_check` system variable served a dual purpose. Setting it at server startup would keep `InnoDB` from starting if any tables used a more recent file format than supported by the current level of `InnoDB`. If `InnoDB` could start, the same system variable was set to the "highest" file format value used by any `InnoDB` table in the database. Thus, its value could change from the value you specified.

  Now, checking and recording the file format tag are handled using separate variables. `innodb_file_format_check` can be set to 1 or 0 at server startup to enable or disable whether `InnoDB` checks the file format tag in the system tablespace. If the tag is checked and is higher than that supported by the current version of `InnoDB`, an error occurs and `InnoDB` does not start. If the tag is not higher, `InnoDB` sets the value of `innodb_file_format_max` to the file format tag.

  For background information about `InnoDB` file-format management, see Section 13.4.4, "InnoDB File-Format Management". (Bug #49792, Bug #53654)

- The `Rows_examined` value in slow query log rows now is nonzero for `UPDATE` and `DELETE` statements that modify rows. (Bug #49756)

- For events of `MYSQL_AUDIT_GENERAL_CLASS`, the event subclass was not passed to audit plugins even though the server passed the subclass to the plugin handler. The subclass is now available through the following changes:

  - The `struct mysql_event_general` structure has a new `event_subclass` member.

  - The new member changes the interface, so the audit plugin interface version, `MYSQL_AUDIT_INTERFACE_VERSION`, has been incremented from `0x0100` to `0x0200`. Plugins that require access to the new member must be recompiled to use version `0x0200` or higher.

  The `NULL_AUDIT` example plugin in the `plugin/audit_null` directory has been modified to count events of each subclass, based on the `event_subclass` value. See Section 21.2.4.8, "Writing Audit Plugins". (Bug #47059)

- The deprecated `mysql_fix_privilege_tables` script has been removed. (Bug #42589)

- A new system variable, `skip_name_resolve`, is set from the value of the `--skip-name-resolve` server option. This provides a way to determine at runtime whether the server uses name resolution for client connections. (Bug #37168)

- Added the `SHA2()` function, which calculates the SHA-2 family of hash functions (SHA-224, SHA-256, SHA-384, and SHA-512). (Contributed by Bill Karwin) (Bug #13174)

- Windows MSI package installers create and set up the data directory that the installed server will use, but now also create a pristine "template" data directory named `data` under the installation directory. This directory can be useful when the machine will be used to run multiple instances of MySQL: After an installation has been performed using an MSI package, the template data directory can be copied to set up additional MySQL instances. See Section 5.6, "Running Multiple MySQL Instances on One Machine".

- It is now possible to build MySQL on all platforms using `CMake` instead of the GNU autotools. (Prior to MySQL 5.5.5, `CMake` support was limited to Windows.) For instructions on using `CMake` to build MySQL, see Section 2.9, "Installing MySQL from Source".

Bugs Fixed

- **Performance**: **InnoDB Storage Engine**: Deadlock detection could be a bottleneck in `InnoDB` processing, if many transactions attempted to update the same row simultaneously. The algorithm has been improved to enhance performance and scalability, in the InnoDB Plugin for MySQL 5.1, and in InnoDB 1.1 for MySQL 5.5. (Bug #49047)

- **Performance**: While looking for the shortest index for a covering index scan, the optimizer did not consider the full row length for a clustered primary key, as in `InnoDB`. Secondary covering indexes are now preferred, making full table scans less likely. (Bug #39653)

  See also Bug #55656.

- **Security Fix**: The server could crash if there were alternate reads from two indexes on a table using the `HANDLER` interface. (Bug #54007, CVE-2010-3681)

- **Security Fix**: Bug #53933 was fixed.

- **Security Fix**: Bug #53907 was fixed.

- **Security Fix**: The server failed to check the table name argument of a `COM_FIELD_LIST` command packet for validity and compliance to acceptable table name standards. This could be exploited to bypass almost all forms of checks for privileges and table-level grants by providing a specially crafted table name argument to `COM_FIELD_LIST`.

In MySQL 5.0 and above, this permitted an authenticated user with `SELECT` privileges on one table to obtain the field definitions of any table in all other databases and potentially of other MySQL instances accessible from the server's file system.

Additionally, for MySQL version 5.1 and above, an authenticated user with `DELETE` or `SELECT` privileges on one table could delete or read content from any other table in all databases on this server, and potentially of other MySQL instances accessible from the server's file system. (Bug #53371, CVE-2010-1848)

- **Security Fix**: The server was susceptible to a buffer-overflow attack due to a failure to perform bounds checking on the table name argument of a `COM_FIELD_LIST` command packet. By sending long data for the table name, a buffer is overflown, which could be exploited by an authenticated user to inject malicious code. (Bug #53237, CVE-2010-1850)

- **Security Fix**: `LOAD DATA INFILE` did not check for SQL errors and sent an OK packet even when errors were already reported. Also, an assert related to client/server protocol checking in debug servers sometimes was raised when it should not have been. (Bug #52512, CVE-2010-3683)

- **Security Fix**: Bug #52357 was fixed.

- **Security Fix**: Bug #52315 was fixed.

- **Security Fix**: Privilege checking for `UNINSTALL PLUGIN` was incorrect. (Bug #51770, CVE-2010-1621)

- **Security Fix**: The server could be tricked into reading packets indefinitely if it received a packet larger than the maximum size of one packet. (Bug #50974, CVE-2010-1849)

- **Security Fix**: Bug #48157 was fixed.

- **Incompatible Change**: `TRUNCATE TABLE` did not take an exclusive lock on a table if truncation was done by deleting all rows in the table. For `InnoDB` tables, this could break proper isolation because `InnoDB` ended up aborting some granted locks when truncating a table. Now an exclusive metadata lock is taken before `TRUNCATE TABLE` can proceed. This guarantees that no other transaction is using the table.

  Incompatible change: Truncation using delete no longer fails if `sql_safe_updates` is enabled (this was an undocumented side effect). (Bug #42643)

- **Incompatible Change**: After `SET TRANSACTION ISOLATION LEVEL` to set the isolation level for the next transaction, the session value of the `tx_isolation` system variable could appear to change to the transaction isolation level after completion of statements within the transaction. Now the current transaction isolation level is now established at transaction start. If there was a `SET TRANSACTION ISOLATION LEVEL statement`, the value is taken from it. Otherwise, the session `tx_isolation` value is used. A change in the session value while a transaction is active is still permitted, but no longer affects the current transaction isolation level. This is an incompatible change. A change in the session isolation level made while there is no active transaction overrides a `SET TRANSACTION ISOLATION LEVEL` statement, if there was any. (Bug #20837)

- **Important Change**: **Replication**: It was possible to set `sql_log_bin` with session scope inside a transaction or subquery. (Bug #53437)

- **Important Change**: **Replication**: When changing `binlog_format` or `binlog_direct_non_transactional_updates`, permissions were not checked prior to checking the scope and context of the variable being changed.

  As a result of this fix, an error is no longer reported when—in the context of a transaction or a stored function—you try to set a value for a session variable that is the same as its previous value, or for a variable whose scope is global only. (Bug #51277)

- **Important Change**: **Replication**: When invoked, `CHANGE MASTER TO` and `SET GLOBAL sql_slave_skip_counter` now cause information to be written to the error log about the slave's state prior to execution of the statement. For `CHANGE MASTER TO`, this information includes the previous values of `MASTER_HOST`, `MASTER_PORT`, `MASTER_LOG_FILE`, and `MASTER_LOG_POS`. For `SET GLOBAL sql_slave_skip_counter`, this information includes the previous values of `RELAY_LOG_FILE`, `RELAY_LOG_POS`, and `sql_slave_skip_counter`. (Bug #43406, Bug #43407)

- **Important Change**: When using fast `ALTER TABLE`, different internal ordering of indexes in the MySQL optimizer and the `InnoDB` storage engine could cause error messages about possibly mixed up `.frm` files and incorrect index use. (Bug #47622)

- **InnoDB Storage Engine**: **Replication**: `TRUNCATE TABLE` performed on a temporary table using the `InnoDB` storage engine was logged even when using row-based mode. (Bug #51251)

- **InnoDB Storage Engine**: **Replication**: Reading from a table that used a self-logging storage engine and updating a table that used a transactional engine (such as `InnoDB`) generated changes that were written to the binary log using statement format which could make slaves diverge. However, when using mixed logging format, such changes should be written to the binary log using row format. (This issue did not occur when reading from tables using a self-logging engine and updating `MyISAM` tables, as this was already handled by checking for combinations of nontransactional and transactional engines.) Now such statements are classified as unsafe, and in mixed mode, cause a switch to row-based logging. (Bug #49019)

- **InnoDB Storage Engine**: The server could crash with a message `InnoDB: Assertion failure in thread nnnn`, typically during shutdown on a Windows system. (Bug #53947)
- **InnoDB Storage Engine**: Some combinations of `SELECT` and `SELECT FOR UPDATE` statements could fail with errors about locks, or incorrectly release a row lock during a semi-consistent read operation. (Bug #53674)
- **InnoDB Storage Engine**: Adding a unique key on multiple columns, where one of the columns is `NULL`, could mistakenly report duplicate key errors. (Bug #53290)
- **InnoDB Storage Engine**: Fixed a checksum error reported for compressed tables when the `--innodb_checksums` option is enabled. Although the message stated that the table was corrupted, the table is actually fine. (Bug #53248)
- **InnoDB Storage Engine**: When reporting a foreign key constraint violation during `INSERT`, `InnoDB` could display uninitialized data for the `DB_TRX_ID` and `DB_ROLL_PTR` system columns. (Bug #53202)
- **InnoDB Storage Engine**: The values of `innodb_buffer_pool_pages_total` and `innodb_buffer_pool_pages_misc` in the `information_schema.global_status` table could be computed incorrectly. (Bug #52983)
- **InnoDB Storage Engine**: `InnoDB` page splitting could enter an infinite loop for compressed tables. (Bug #52964)
- **InnoDB Storage Engine**: An overly strict assertion could fail during the purge of delete-marked records in `DYNAMIC` or `COMPRESSED` `InnoDB` tables that contain column prefix indexes. (Bug #52746)
- **InnoDB Storage Engine**: `InnoDB` attempted to choose off-page storage without ensuring that there was an “off-page storage” flag in the record header. To correct this, in `DYNAMIC` and `COMPRESSED` formats, `InnoDB` stores locally any non-`BLOB` columns having a maximum length not exceeding 256 bytes. This is because there is no room for the “external storage” flag when the maximum length is 255 bytes or less. This restriction trivially holds in `REDUNDANT` and `COMPACT` formats, because there `InnoDB` always stores locally columns having a length up to `local_len` = 788 bytes. (Bug #52745)
- **InnoDB Storage Engine**: The server could crash during shutdown, if started with the option `--innodb_use_sys_malloc=0`. (Bug #52546)
- **InnoDB Storage Engine**: Connections waiting for an `InnoDB` row lock ignored `KILL` until the row lock wait ended. Now, `KILL` during lock wait results in “query interrupted” instead of “lock wait timeout exceeded”. The corresponding transaction is rolled back. (Bug #51920)
- **InnoDB Storage Engine**: `InnoDB` checks to see whether a row could possibly exceed the maximum size if all columns are fully used. This produced `Row size too large` errors for some tables that could be created with the built-in `InnoDB` from older MySQL versions. Now the check is only done when `innodb_strict_mode` is enabled or if the table is dynamic or compressed. (Bug #50495)
- **InnoDB Storage Engine**: Multi-statement execution could fail with an error about foreign key constraints. This problem could affect calls to `mysql_query()` and `mysql_real_query()`, and `CALL` statements that invoke stored procedures. (Bug #48024)
- **InnoDB Storage Engine**: A mismatch between index information maintained within the `.frm` files and the corresponding information in the InnoDB system tablespace could produce this error: `[ERROR] Index index of table has n columns unique inside InnoDB, but MySQL is asking statistics for m columns. Have you mixed up .frm files from different installations?` (Bug #44571)
- **Partitioning**: **Replication**: Attempting to execute `LOAD DATA` on a partitioned `MyISAM` table while using statement-based logging mode caused the master to hang or crash. (Bug #51851)
- **Partitioning**: **Replication**: The `NO_DIR_IN_CREATE` server SQL mode was not enforced when defining subpartitions. In certain cases, this could lead to failures on replication slaves. (Bug #42954)
- **Partitioning**: Rows inserted into a table created using a `PARTITION BY LIST COLUMNS` option referencing multiple columns could be inserted into the wrong partition. (Bug #52815)
- **Partitioning**: Partition pruning on `RANGE` partitioned tables did not always work correctly; the last partition was not excluded if the range was beyond it (when not using `MAXVALUE`). Now the last partition is not included if the partitioning function value is not within the range. (Bug #51830)
- **Partitioning**: Attempting to partition a table using a `DECIMAL` column caused the server to crash; this was not supported and is now specifically not permitted. (Bug #51347)

- **Partitioning**: `ALTER TABLE` statements that cause table partitions to be renamed or dropped (such as `ALTER TABLE ... ADD PARTITION`, `ALTER TABLE ... DROP PARTITION`, and `ALTER TABLE ... REORGANIZE PARTITION`) — when run concurrently with queries against the `INFORMATION_SCHEMA.PARTITIONS` table — could fail, cause the affected partitioned tables to become unusable, or both. This was due to the fact that the `INFORMATION_SCHEMA` database ignored the name lock imposed by the `ALTER TABLE` statement on the partitions affected. In particular, this led to problems with `InnoDB` tables, because `InnoDB` would accept the rename operation, but put it in a background queue, so that subsequent rename operations failed when `InnoDB` was unable to find the correct partition. Now, `INFORMATION_SCHEMA` honors name locks imposed by ongoing `ALTER TABLE` statements that cause partitions to be renamed or dropped. (Bug #50561)

  See also Bug #47343, Bug #45808.

- **Partitioning**: The `insert_id` server system variable was not reset following an insert that failed on a partitioned `MyISAM` table having an `AUTO_INCREMENT` column. (Bug #50392)

- **Partitioning**: Foreign keys are not supported on partitioned tables. However, it was possible using an `ALTER TABLE` statement to set a foreign key on a partitioned table; it was also possible to partition a table with a single foreign key. (Bug #50104)

- **Partitioning**: It was possible to execute a `CREATE TEMPORARY TABLE tmp LIKE pt` statement, where `pt` is a partitioned table, even though partitioned temporary tables are not permitted. This caused the server to crash. Now a check is performed to prevent such statements from being executed. (Bug #49477)

- **Partitioning**: When attempting to perform DDL on a partitioned table and the table's `.par` file could not be found, the server returned the inaccurate error message `OUT OF MEMORY; RESTART SERVER AND TRY AGAIN (NEEDED 2 BYTES)`. Now in such cases, the server returns the error `FAILED TO INITIALIZE PARTITIONS FROM .PAR FILE`. (Bug #49161)

- **Partitioning**: `GROUP BY` queries performed poorly for some partitioned tables. This was due to the block size not being set for partitioned tables, thus the keys per block was not correct, which could cause such queries to be optimized incorrectly. (Bug #48229)

  See also Bug #37252.

- **Partitioning**: `REPAIR TABLE` failed for partitioned `ARCHIVE` tables. (Bug #46565)

- **Replication**: When using unique keys on `NULL` columns in row-based replication, the slave sometimes chose the wrong row when performing an update. This happened because a table having a unique key on such a column could have multiple rows containing `NULL` for the column used by the unique key, and the slave merely picked the first row containing `NULL` in that column. (Bug #53893)

- **Replication**: When a `CREATE TEMPORARY TABLE ... SELECT` statement was executed within a transaction that updated only transactional engines and was later rolled back (for example, due to a deadlock) the changes—including the creation of the temporary table—were not written to the binary log, which caused subsequent updates to this table to fail on the slave. (Bug #53421)

- **Replication**: When using the statement-based logging format, statements that used `CONNECTION_ID()` were always kept in the transaction cache; consequently, nontransactional changes that should have been flushed before the transaction were kept in the transaction cache. (Bug #53075)

  This regression was introduced by Bug #51894.

- **Replication**: In some cases, attempting to update a column with a value of an incompatible type resulted in a mismatch between master and slave because the column value was set to its implicit default value on the master (as expected), but the same column on the slave was set to `NULL`. (Bug #52868)

- **Replication**: ACK packets in semisynchronous replication were not checked for length and malformed packets could cause a server crash. (Bug #52748)

- **Replication**: When temporary tables were in use, switching the binary logging format from `STATEMENT` to `ROW` did not take effect until all temporary tables were dropped. (The existence of temporary tables should prevent switching the format only from `ROW` to `STATEMENT` from taking effect, not the reverse.) (Bug #52616)

- **Replication**: A buffer overrun in the handling of `DATE` column values could cause `mysqlbinlog` to fail when reading logs containing certain combinations of DML statements on a table having a `DATE` column followed by dropping the table. (Bug #52202)

- **Replication**: The failure of a `REVOKE` statement was logged with the wrong error code, causing replication slaves to stop even when the failure was expected on the master. (Bug #51987)

- **Replication**: Issuing any DML on a temporary table `temp` followed by `DROP TEMPORARY TABLE temp`, both within the same transaction, caused replication to fail.

  The fix introduces a change to statement-based binary logging with respect to temporary tables. Within a transaction, changes to temporary tables are saved to the transaction cache and written to the binary log when the transaction commits. Otherwise, out-of-order logging of events could occur. This means that temporary tables are treated similar to transactional tables for purposes of caching and logging. This affects assessment of statements as safe or unsafe and the associated error message was changed from:

```
Unsafe statement written to the binary log using statement format
since BINLOG_FORMAT = STATEMENT. Statements that read from both
transactional and non-transactional tables and write to any of them
are unsafe.
```

To:

```
Unsafe statement written to the binary log using statement format
since BINLOG_FORMAT = STATEMENT. Statements that read from both
transactional (or a temporary table of any engine type) and
non-transactional tables and write to any of them are unsafe.
```

(Bug #51894)

See also Bug #51291, Bug #53075, Bug #53259, Bug #53452, Bug #54872.

This regression was introduced by Bug #46364.

- **Replication**: The internal flag indicating whether a user value was signed or unsigned (`unsigned_flag`) could sometimes change between the time that the user value was recorded for logging purposes and the time that the value was actually written to the binary log, which could lead to inconsistency. Now `unsigned_flag` is copied when the user variable value is copied, and the copy of `unsigned_flag` is then used for logging. (Bug #51426, Bug #11759138)

  See also Bug #49562, Bug #11757508.

- **Replication**: Enabling `binlog_direct_non_transactional_updates` causes nontransactional changes to be written to the binary log upon committing the statement. However, even when not enabled, the addition of this variable introduced a number of undesired changes in behavior:

  1. When using `ROW` or `MIXED` logging mode: Nontransactional changes executed within a transaction prior to any transactional changes were written to the statement cache, but those following any transactional changes were written to the transactional cache instead, causing these (later) nontransactional changes to be lost.

  2. When using `ROW` or `MIXED` logging mode: When rolling back a transaction, any nontransactional changes that might be in the transaction cache were disregarded and truncated along with the transactional changes.

  3. When using `STATEMENT` logging mode: A statement that combined transactional and nontransactional changes prior to any other transactional changes within the transaction, but failed, was kept in the transactional cache until the transaction ended, rather than being written to the binary log at the instant of failure (and not deferred to the end of the transaction).

  These problems have been handled as follows:

  - The setting for `binlog_direct_non_transactional_updates` no longer has any effect when the value of `binlog_format` is either `ROW` or `MIXED`. This addresses the first two issues previously listed.

  - When using statement-based logging with `binlog_direct_non_transactional_updates` set to `ON`, any statement combining transactional and nontransactional changes within the same transaction is now stored in the transaction cache, whether or not it succeeds, and regardless of its order of execution among any transactional statements within that transaction. This means that such a statement is now written to the binary log only on transaction commit or rollback.

  (Bug #51291)

  This regression was introduced by Bug #46364.

- **Replication**: When using temporary tables, the binary log needs to insert a pseudo-thread ID for threads that are using temporary tables, each time a switch happens between two threads, both of which are using temporary tables. However, if a thread issued a failing statement before exit, its ID was not recorded in the binary log, and this in turn caused the ID for the next thread that tried to do something with a temporary table not to be logged as well. Subsequent replays of the binary log failed with the error `TABLE ... DOESN'T EXIST`. (Bug #51226)

- **Replication**: If the master was using `sql_mode='TRADITIONAL'`, duplicate key errors were not sent to the slave, which received `0` rather than the expected error code. This caused replication to fail even when such an error was expected. (Bug #51055)

- **Replication**: DDL statements that lock tables (such as `ALTER TABLE`, `CREATE INDEX`, and `CREATE TRIGGER`) caused spurious `ER_BINLOG_ROW_MODE_AND_STMT_ENGINE` or `ER_BINLOG_STMT_MODE_AND_ROW_ENGINE` errors, even though they did not insert rows into any tables.

> **Note**
>
> The error `ER_BINLOG_ROW_MODE_AND_STMT_ENGINE` is generated when `binlog_format=ROW` and a statement modifies a table restricted to statement-based logging; `ER_BINLOG_STMT_MODE_AND_ROW_ENGINE` is generated when `binlog_format=STATEMENT` and a statement modifies a table restricted to row-based logging.

(Bug #50479)

This regression was introduced by Bug #39934, Bug #11749859.

- **Replication**: When run with the `--database` option, `mysqlbinlog` printed `ROLLBACK` statements but did not print any corresponding `SAVEPOINT` statements. (Bug #50407)
- **Replication**: When a `CREATE EVENT` statement was followed by an additional statement and the statements were executed together as a single statement, the `CREATE EVENT` statement was padded with “garbage” characters when written to the binary log. This led to a syntax error when the event was read from the log. (Bug #50095)
- **Replication**: When using a nontransactional table on the master with autocommit disabled, no `COMMIT` was recorded in the binary log following a statement affecting this table. If the slave's copy of the table used a transactional storage engine, the result on the slave was as though a transaction had been started, but never completed. (Bug #49522)

  See also Bug #29288.
- The `make_binary_distribution` target to `make` could fail on some platforms because the lines generated were too long for the shell. (Bug #54590)
- Inconsistent checking of the relationship between `SHOW` statements and `INFORMATION_SCHEMA` queries caused such queries to fail sometimes. (Bug #54422)
- A crash occurred if a table that was locked with `LOCK TABLES` was listed twice in a `DROP TABLE` statement. (Bug #54282)
- `ALTER TABLE` for views is not legal but did not produce an error. (If you need to rename a view, use `RENAME TABLE`.) (Bug #53976)
- Valgrind warnings resulting from passing incomplete `DATETIME` values to the `TIMESTAMP()` function were corrected. (Bug #53942)
- Builds of the embedded `mysqld` failed due to a missing element of the `struct NET`. (Bug #53908, Bug #53912)
- The definition of the `MY_INIT` macro in `my_sys.h` included an extraneous semicolon, which could cause compilation failure. (Bug #53906)
- Queries that used `MIN()` or `MAX()` on indexed columns could be optimized incorrectly. (Bug #53859)
- `UPDATE` on an `InnoDB` table modifying the same index that was used to satisfy the `WHERE` condition could trigger a debug assertion under some circumstances. (Bug #53830)
- MySQL incorrectly processed `` ALTER DATABASE `#mysql50#special` UPGRADE DATA DIRECTORY NAME `` where *`special`* was `.`, `..`, or a sequence starting with `./` or `../`. It used the server data directory (which contains other regular databases) as the database directory. (Bug #53804, CVE-2010-2008)
- `OPTIMIZE TABLE` could be run on a table in use by a transaction in a different session, causing repeatable read to break. (Bug #53798)
- `InnoDB` crashed when replacing duplicates in a table after a fast `ALTER TABLE` added a unique index. (Bug #53592)
- For `InnoDB` tables, the error handler for a fast `CREATE INDEX` did not reset the error state of the transaction before attempting to undo a failed operation, resulting in a crash. (Bug #53591)
- For single-table `DELETE` statements that used quick select and index scan simultaneously caused a server crash or assertion failure. (Bug #53450)
- Certain path names passed to `LOAD_FILE()` could cause a server crash. (Bug #53417)
- If the `completion_type` session variable was changed after a stored procedure or prepared statement had been cached, the change had no effect on subsequent executions of the procedure or statement. (Bug #53346)
- The `AND CHAIN` option for `COMMIT` and `ROLLBACK` failed to preserve the current transaction isolation level. Setting `completion_type` to 1 also failed to do so. (Bug #53343)

- Incorrect results could be returned for `LEFT JOIN` of `InnoDB` tables with an impossible `WHERE` condition. (Bug #53334)
- The `Lock_time` value in the slow query log was negative for stored routines. (Bug #53191)
- Setting the `innodb_change_buffering` system variable to `DEFAULT` produced an incorrect result. (Bug #53165)
- `mysqldump` and `SELECT ... INTO OUTFILE` truncated long `BLOB` and `TEXT` values to 766 bytes. (Bug #53088)
- On some systems, such as Mac OS X, the `sockaddr_in` and `sockaddr_in6` structures contain a non-standard field (`sin_len` / `sin6_len`) that must be set but was not. This resulted in hostname lookup failure. (Bug #52923)
- In the debug version of the server, the `FreeState()` function could in some circumstances be called twice, leading to an assertion failure. (Bug #52884)
- Concurrent `SHOW COLUMNS` statements could cause a server crash. (Bug #52856)
- With a non-`latin1` ASCII-based current character set, the server inappropriately converted `DATETIME` values to strings. This resulted in the optimizer not using indexes on such columns. (Bug #52849)
- `mysqld_safe` set `plugin_dir` using a hardcoded default path name rather than a path depending on `basedir`. (Bug #52737)
- Semi-consistent read was implemented for `InnoDB` to address Bug #3300. Semi-consistent reads do not block when a nonmatching record is already locked by some other transaction. If the record is not locked, a lock is acquired, but is released if the record does not match the `WHERE` condition. However, semi-consistent read was attempted even for `UPDATE` statements having a `WHERE` condition of the form `pk_col1=constant1, ..., pk_colN=constantN`. Some code failed that was designed with the assumption that semi-consistent read would be only attempted on table scans. (Bug #52663)
- Setting `@@GLOBAL.debug` to an empty string failed to clear the current debug settings. (Bug #52629)
- `SHOW CREATE TABLE` was blocked if the table was write locked by another session. (Bug #52593)
- The `length` and `max_length` metadata values were incorrect for columns with the `TEXT` family of data types that used multibyte character sets. This bug was introduced in MySQL 5.5.3. (Bug #52520)
- `mysql_upgrade` attempted to work with stored routines before they were available. (Bug #52444)
- The `check_table_is_closed()` debugging function did not protect access to the `MyISAM` open tables list, with the result that server crashes could occur during table drop or rename operations. (Bug #52432)
- Spurious duplicate-key errors occurred for multiple-column indexes on `BINARY` columns. (Bug #52430)
- `EXPLAIN EXTENDED` crashed trying to resolve references to freed temporary table columns for `GROUP_CONCAT()` `ORDER BY` arguments. (Bug #52397)
- During MySQL server installation using the MSI package on Windows, the `default-character-set` option would be included in the default configuration template file. This caused the MySQL server to fail to start properly. (Bug #52380)
- Two sessions trying to set the global `event_scheduler` system variable to `OFF` resulted in one of them hanging waiting for the event scheduler to stop. (Bug #52367)
- There was a race condition between flags used for signaling that a query was killed, which led to error-reporting and lock-acquisition problems. (Bug #52356)
- For a concurrent load of 16 or more connections containing many `LOCK TABLES WRITE` statements for the same table, server throughput was significantly lower for MySQL 5.5.3 and 5.5.4 than for earlier versions (10%–40% lower depending on concurrency). (Bug #52289)
- Operations on geometry data types failed on some systems for builds compiled with Sun Studio. (Bug #52208)
- The optimizer could attempt to evaluate the `WHERE` clause before any rows had been read, resulting in a server crash. (Bug #52177)
- Cast operations on `NULL` `DECIMAL` values could cause server crashes or Valgrind warnings. (Bug #52168)
- An assertion was raised as a result of a `NULL` string being passed to the `dtoa` code. (Bug #52165)
- A memory leak occurred due to missing deallocation of the `comparators` array (a member of the `Arg_comparator` class). (Bug #52124)
- For debug builds, creating a view containing a subquery that might require collation adjustment caused an assertion to be

raised. For example, this could occur if some items had different collations but the result collation could be adjusted to the one of them. (Bug #52120)

- Aggregate functions could incorrectly return `NULL` in outer join queries. (Bug #52051)
- For outer joins, the optimizer could fail to properly calculate table dependencies. (Bug #52005)
- A `COUNT(DISTINCT)` query on a view could cause a server crash. (Bug #51980)
- For LDML-defined collations, some data structures were not initialized properly to enable `UPPER()` and `LOWER()` to work correctly. (Bug #51976)
- On Windows, `LOAD_FILE()` could cause a crash for some pathnames. (Bug #51893)
- Invalid memory reads occurred for `HANDLER ... READ NEXT` after a failed `HANDLER ... READ FIRST`. (Bug #51877)
- After `TRUNCATE TABLE` of a `MyISAM` table, subsequent queries could crash the server if `myisam_use_mmap` was enabled. (Bug #51868)
- If `myisam_sort_buffer_size` was set to a small value, table repair for `MyISAM` tables with `FULLTEXT` indexes could crash the server. (Bug #51866)
- Stored routine DDL statements were written to the binary log using statement-based format regardless of the current logging format. (Bug #51839)
- A problem with equality propagation optimization for prepared statements and stored procedures caused a server crash upon re-execution of the prepared statement or stored procedure. (Bug #51650)

  See also Bug #8115, Bug #8849.
- The optimizer performed an incorrect join type when `COALESCE()` appeared within an `IN()` operation. (Bug #51598)
- Locking involving the `LOCK_plugin`, `LOCK_global_system_variables`, and `LOCK_status` mutexes could deadlock. (Bug #51591)
- Executing a `LOAD XML INFILE` statement could sometimes lead to a server crash. (Bug #51571)
- The server crashed when the optimizer attempted to determine constant tables but a table storage engine did not support exact record count. (Bug #51494)
- The server could crash populating the `INFORMATION_SCHEMA.PROCESSLIST` table due to lack of mutex protection. (Bug #51377)
- Use of `HANDLER` statements with tables that had spatial indexes caused a server crash. (Bug #51357)
- With an XA transaction active, `SET autocommit = 1` could cause side effects such as memory corruption or a server crash. (Bug #51342)
- Corrupt `MyISAM` tables were automatically repaired even when `myisam_recover_options` was set to `OFF`. (Bug #51327)
- Following a bulk insert into a `MyISAM` table, if `MyISAM` failed to build indexes using repair by sort, data file corruption could occur. (Bug #51307)
- `CHECKSUM TABLE` could compute the checksum for `BIT` columns incorrectly. (Bug #51304)
- `ALTER TABLE` on `InnoDB` tables (including partitioned tables) acquired exclusive locks on rows of the table being altered. If there was a concurrent transaction that did locking reads from this table, this sometimes led to a deadlock that was not detected by the metadata lock subsystem or by InnoDB (and was reported only after exceeding `innodb_lock_wait_timeout`). (Bug #51263)
- A `HAVING` clause on a joined table in some cases failed to eliminate rows which should have been excluded from the result set. (Bug #51242)
- Two sessions trying to set the global `event_scheduler` system variable to different values could deadlock. (Bug #51160)
- `InnoDB` fast index creation could incorrectly use a table copy in some cases. (Bug #50946)
- The Loose Index Scan optimization method assumed that it could depend on the partitioning engine to maintain interval endpoint information, as if it were a storage engine. (Bug #50939)

- The type inference used for view columns caused some columns in views to be handled as the wrong type, as compared to the same columns in base tables. `DATE` columns in base tables were treated as `TIME` columns in views, and base table `TIME` columns as view `DATETIME` columns. (Bug #50918)
- A syntactically invalid trigger could cause the server to crash when trying to list triggers. (Bug #50755)
- Previously, the server held a global mutex while performing file operations such as deleting an `.frm` or data file, or reading index statistics from a data file. Now the mutex is not held for these operations. Instead, the server uses metadata locks. (Bug #50589, Bug #51557, Bug #49463)
- User-defined variables of type `REAL` that contained `NULL` were handled improperly when assigned to a column of another type. (Bug #50511)
- Setting `--secure-file-priv` to the empty string left the value unaffected. (Bug #50373)
- Calculation of intervals for Event Scheduler events was not portable. (Bug #50087)
- The `YEAR` values `2000` and `0000` could be treated as equal. (Bug #49910)
- Performing a single in-place `ALTER TABLE` containing `ADD INDEX` and `DROP INDEX` options that used the same index name could result in a corrupt table definition file. Now such `ALTER TABLE` statements are no longer performed in place. (Bug #49838)
- `mysql_upgrade` did not detect when `CSV` log tables incorrectly contained columns that could be `NULL`. Now these columns are altered to be `NOT NULL`. (Bug #49823)
- `support-files/mysql.spec.sh` had unnecessary Perl dependencies. (Bug #49723)
- Selecting from `INFORMATION_SCHEMA.ROUTINES` or `INFORMATION_SCHEMA.PARAMETERS` resulted in a memory leak. (Bug #48729)
- In MySQL 5.1, `READ COMMITTED` was changed to use less locking due to the availability of row-based binary logging (see the Note under `READ COMMITTED` at Section 12.3.6, “`SET TRANSACTION` Syntax”). However, `READ UNCOMMITTED` did not have the same change, so it was using more locks than the higher isolation level, which is unexpected. This was changed so that `READ UNCOMMITTED` now also uses the lesser amount of locking and has the same restrictions for binary logging. (Bug #48607)
- On Intel x86 machines, the optimizer could choose different execution plans for a query depending on the compiler version and optimization flags used to build the server binary. (Bug #48537)
- A trigger could change the behavior of assigning `NULL` to a `NOT NULL` column. (Bug #48525)
- The server crashed when it could not determine the best execution plan for queries involving outer joins with nondeterministic `ON` clauses such as the ones containing the `RAND()` function, a user-defined function, or a `NOT DETERMINISTIC` stored function. (Bug #48483)
- `EXPLAIN` could cause a server crash for some queries with subqueries. (Bug #48419)
- The `MERGE` engine failed to open a child table from a different database if the child table or database name contained characters that were subject to table name to file name encoding.

  Further, the `MERGE` engine did not properly open a child table from the same database if the child table name contained characters such as `'/'`, or `'#'`. (Bug #48265)
- On Windows, the server failed to find a description for Event ID 100. (Bug #48042)
- A query that read from a derived table (of the form `SELECT ... FROM (SELECT ...)`) produced incorrect results when the following conditions were present:
  - The table subquery contained a derived query (`(SELECT ...) AS *column*`).
  - The derived query could potentially produce zero rows or a single `NULL` (that is, no rows matched, or the query used an aggregate function such as `SUM()` running over zero rows).
  - The table subquery joined at least two tables.
  - The join condition involved an index.

  (Bug #47904)
- The optimization to read `MIN()` or `MAX()` values from an index did not properly handle comparisons with `NULL` values. This

could produce incorrect results for `MIN()` or `MAX()` when the `WHERE` clause tested a `NOT NULL` column for `NULL`. (Bug #47762)

- Killing a query during the optimization phase of a subquery could cause a server crash. (Bug #47761)
- Using `REPLACE` to update a previously inserted negative value in an `AUTO_INCREMENT` coumn of an `InnoDB` table caused the table auto-increment value to be updated to 2147483647. (Bug #47720)
- The query shown by `EXPLAIN EXTENDED` plus `SHOW WARNINGS` could produce results different from the original query. (Bug #47669)
- `MyISAM` could write uninitialized data to new index pages. Now zeros are written to unused bytes in the pages. (Bug #47598)
- `OPTIMIZE TABLE` for an `InnoDB` table could raise an assertion if another session issued a concurrent `DROP TABLE`. (Bug #47459)
- For updates to `InnoDB` tables, `TIMESTAMP` columns could be updated even when no values actually changed. (Bug #47453)
- Setting `myisam_repair_threads` larger than 1 could result in the cardinality for all indexes of a `MyISAM` table being set to 1 after parallel index repair. (Bug #47444)
- `mysqld_safe` did not always pass `--open-files-limit` through to `mysqld`. `mysqld_safe` did not treat dashes and underscores as equivalent in option names. (Bug #47095)
- When the transaction isolation level was `REPEATABLE READ` and binary logging used statement or mixed format, `SELECT` statements with subqueries referencing `InnoDB` tables unnecessarily acquired shared locks on rows in these tables. (Bug #46947)
- In debug builds, if the listed columns in the view definition of the table used in an `INSERT ... SELECT` statement mismatched, an assertion was raised in the query cache invalidation code following the failing statement. (Bug #46615)
- For the `COMMIT` and `ROLLBACK` statements, the `AND CHAIN` and `RELEASE` modifiers should be mutually exclusive, but the parser permitted both to be specified. (Bug #46527)
- If the server is started with `--skip-grant-tables`, plugin loading and unloading should be prohibited, but the server failed to reject `INSTALL PLUGIN` and `UNINSTALL PLUGIN` statements. (Bug #46261)
- `gcc` 4.4.0 could fail to compile `dtoa.c`. (Bug #45882)
- `ALTER TABLE ... ADD COLUMN` for a table with multiple foreign keys caused a server crash. (Bug #45052)
- Manual pages for a few little-used programs were missing from RPM packages. (Bug #44370)
- Using an initial command with `mysql_options(..., MYSQL_INIT_COMMAND, ...)` that generated multiple result sets (such as a stored procedure or a multi-statement command) left the connection unusable. (Bug #42373)
- The server could crash with an out of memory error when trying to parse a query that was too long to fit in memory. Now the parser rejects such queries with an `ER_OUT_OF_RESOURCES` error. (Bug #42064)
- `InnoDB` could fail to create a unique index on `NULL` columns. (Bug #41904)
- For a query that selected from a view and used an alias for the view, the metadata used the alias name rather than the view name in the `MYSQL_FIELD.table` member. (Bug #41788)
- `mysql_upgrade` did not create temporary files properly. (Bug #41057)
- It was possible for `DROP TABLE` of one `MyISAM` table to remove the data and index files of a different `MyISAM` table. (Bug #40980)
- If the arguments to a `CONCAT()` call included a local routine variable, selecting the return value into a user variable could produce an incorrect result. (Bug #40625)
- Column names displayed from the `PARTITION_EXPRESSION` column of the `INFORMATION_SCHEMA.PARTITIONS` table did not include escape characters as necessary. (Bug #39338)
- When `SET TRANSACTION ISOLATION LEVEL` was used to set the isolation level for the next transaction, the level could persist for subsequent transactions. (Bug #39170)
- When using `UNINSTALL PLUGIN` to remove a loaded plugin, open tables and connections caused `mysqld` to hang until the open connections had been closed. (Bug #39053)

- Valgrind warnings in the `InnoDB` `compare_record()` function were corrected. (Bug #38999)
- The optimizer sometimes used `filesort` for `ORDER BY` when it should have used an index. (Bug #38745)
- Setting the session value of the `debug` system variable also set the global value. (Bug #38054)
- Accessing a `MERGE` table with an empty underlying table list incorrectly resulted in a “wrong index” error message rather than “end of file.” (Bug #35274)
- The test for `readline` during configuration failed when trying to build MySQL in a directory other than the source tree root. (Bug #35250)
- `mysqld` could fail during execution when using SSL. (Bug #34236)
- A query on a `FEDERATED` table in which the data was ordered by a `TEXT` column returned incorrect results. For example, a query such as the following produced incorrect results if column `column1` was a `TEXT` column:

  ```
  SELECT * FROM table1 ORDER BY column1;
  ```

  (Bug #32426)
- MySQL Makefiles relied on GNU extensions. (Bug #30708)
- The parser allocated too much memory for a query string containing multiple statements. (Bug #27863)
- The behavior of the RPM installation for both new installations and upgrade installations has changed.

  During a new installation, the server boot scripts are installed, but the MySQL server is not started at the end of the installation, since the status of the system during an unattended installation is not known.

  During an upgrade installation using the RPM packages, if the server is running when the upgrade occurs, the server is stopped, the upgrade occurs, and server is restarted. If the server is not already running when the RPM upgrade occurs, the server is not started at the end of the installation.

  The boot scripts for MySQL are installed in the appropriate directories in `/etc`, so the MySQL server will be restarted automatically at the next machine reboot. (Bug #27072)
- `ROW_COUNT()` returned a meaningful value only for some DML statements. Now it returns a value as follows:
  - DDL statements: 0. This applies to statements such as `CREATE TABLE` or `DROP TABLE`.
  - DML statements other than `SELECT`: The number of affected rows. This applies to statements such as `UPDATE`, `INSERT`, or `DELETE` (as before), but now also to statements such as `ALTER TABLE` and `LOAD DATA INFILE`.
  - `SELECT`: -1 if the statement returns a result set, or the number of rows “affected” if it does not. For example, for `SELECT * FROM t1`, `ROW_COUNT()` returns -1. For `SELECT * FROM t1 INTO OUTFILE '`*`file_name`*`'`, `ROW_COUNT()` returns the number of rows written to the file.
  - `SIGNAL` statements: 0.

  (Bug #21818)

D.1.13. Changes in MySQL 5.5.4 (09 April 2010)

InnoDB Notes

- `InnoDB` has been upgraded to version 1.1. This version is considered of Beta quality.

  For information about `InnoDB` features, see Section 13.4, “New Features of InnoDB 1.1”. For general information about using `InnoDB` in MySQL, see Section 13.3, “The `InnoDB` Storage Engine”.

Functionality Added or Changed

- **InnoDB Storage Engine**: `InnoDB` now has a `innodb_use_native_aio` system variable that can be disabled at startup if there is a problem with the asynchronous I/O subsystem in the OS. This variable applies to Linux systems only, where the MySQL server now has a dependency on the `libaio` library.

Bugs Fixed

- **Performance**: **InnoDB Storage Engine**: The redo scan during `InnoDB` recovery used excessive CPU. The efficiency of this scan was improved, significantly speeding up crash recovery. (Bug #49535, Bug #29847)
- **Performance**: **InnoDB Storage Engine**: `InnoDB` page-freeing operations were made faster for compressed blocks, speeding up `ALTER TABLE`, `DROP TABLE`, and other operations on compressed tables that free compressed blocks. One symptom of the older behavior could be 100% CPU use during these operations. (Bug #35077)
- **InnoDB Storage Engine**: The AIX implementation of `readdir_r()` caused `InnoDB` errors. (Bug #50691)
- **InnoDB Storage Engine**: The limit of 1023 concurrent data-modifying transactions has been raised. The limit is now 128 × 1023 concurrent transactions that generate undo records. You can remove any workarounds that require changing the proper structure of your transactions, such as committing more frequently or delaying DML operations to the end of a transaction. See Section 13.4.7.19, “Better Scalability with Multiple Rollback Segments”. (Bug #26590)
- A unique index on a column prefix could not be upgraded to a primary index even if there was no primary index already defined. (Bug #51378)
- `InnoDB` did not reset table `AUTO_INCREMENT` values to the last used values after a server restart. (Bug #49032)
- When using the `EXAMPLE` storage engine, when the engine had been built as a plugin (instead of built in), and DTrace probes had been enabled during the build, loading the storage engine library failed due to a missing object table entry.

D.1.14. Changes in MySQL 5.5.3 (24 March 2010 Milestone 3)

Performance Schema Notes

- MySQL Server now includes the Performance Schema, a feature for monitoring server execution at a low level. The implementation uses the `PERFORMANCE_SCHEMA` storage engine and the `performance_schema` database. The Performance Schema focuses primarily on performance data. This differs from `INFORMATION_SCHEMA`, which serves for inspection of metadata. For more information, see Chapter 19, *MySQL Performance Schema*.

  Performance Schema support is included in binary MySQL distributions but is disabled by default. To enable it, start the server with the `--performance_schema` option.

  To create the `performance_schema` database if you are upgrading from an earlier release, run `mysql_upgrade` and restart the server. See Section 4.4.7, “`mysql_upgrade` — Check Tables for MySQL Upgrade”.

InnoDB Notes

- This release includes `InnoDB` 1.0.6. This version is considered of Release Candidate (RC) quality.

Functionality Added or Changed

- **Performance**: The performance of internal functions that trim multiple spaces from strings when comparing them has been improved. (Bug #14637)
- **Incompatible Change**: `CREATE VIEW` and `DROP VIEW` now are prohibited while a `LOCK TABLES` statement is in effect. (Bug #56571)
- **Incompatible Change**: The following obsolete constructs have been removed. Where alternatives are shown, applications should be updated to use them.
  - The `log_bin_trust_routine_creators` system variable (use `log_bin_trust_function_creators`).
  - The `myisam_max_extra_sort_file_size` system variable.
  - The `record_buffer` system variable (use `read_buffer_size`).
  - The `sql_log_update` system variable.
  - The `table_type` system variable (use `storage_engine`).

  - The `FRAC_SECOND` modifier for the `TIMESTAMPADD()` function (use `MICROSECOND`).
  - The `TYPE` table option to specify the storage engine for `CREATE TABLE` or `ALTER TABLE` (use `ENGINE`).
  - The `SHOW TABLE TYPES` SQL statement (use `SHOW ENGINES`).
  - The `SHOW INNODB STATUS` and `SHOW MUTEX STATUS` SQL statements (use `SHOW ENGINE INNODB STATUS` `SHOW ENGINE INNODB MUTEX`).
  - The `SHOW PLUGIN` SQL statement (use `SHOW PLUGINS`).
  - The `LOAD TABLE ... FROM MASTER` and `LOAD DATA FROM MASTER` SQL statements (use `mysqldump` or `mysqlhotcopy` to dump tables and `mysql` to reload dump files).
  - The `BACKUP TABLE` and `RESTORE TABLE` SQL statements (use `mysqldump` or `mysqlhotcopy` to dump tables and `mysql` to reload dump files).
  - `TIMESTAMP(N)` data type: The ability to specify a display width of `N` (use without `N`).
  - The `--default-character-set` and `--default-collation` server options (use `--character-set-server` and `--collation-server`).
  - The `--delay-key-write-for-all-tables` server option (use `--delay-key-write=ALL`).
  - The `--enable-locking` and `--skip-locking` server options (use `--external-locking` and `--skip-external-locking`).
  - The `--log-bin-trust-routine-creators` server option (use `--log-bin-trust-function-creators`).
  - The `--log-long-format` server option.
  - The `--log-update` server option.
  - The `--master-xxx` server options to set replication parameters (use the `CHANGE MASTER TO` statement instead): `--master-host`, `--master-user`, `--master-password` , `--master-port`, `--master-connect-retry`, `--master-ssl`, `--master-ssl-ca`, `--master-ssl-capath`, `--master-ssl-cert`, `--master-ssl-cipher`, `--master-ssl-key`.
  - The `--safe-show-database` server option.
  - The `--skip-symlink` and `--use-symbolic-links` server options (use `--skip-symbolic-links` and `--symbolic-links`).
  - The `--sql-bin-update-same` server option.
  - The `--warnings` server option (use `--log-warnings`).
  - The `--no-named-commands` option for `mysql` (use `--skip-named-commands`).
  - The `--no-pager` option for `mysql` (use `--skip-pager`).
  - The `--no-tee` option for `mysql` (use `--skip-tee`).
  - The `--position` option for `mysqlbinlog` (use `--start-position`).
  - The `--all` option for `mysqldump` (use `--create-options`).
  - The `--first-slave` option for `mysqldump` (use `--lock-all-tables`).
  - The `--config-file` option for `mysqld_multi` (use `--defaults-extra-file`).
  - The `--set-variable=var_name=value` and `-O var_name=value` general-purpose options for setting program variables (use `--var_name=value`).

  (Bug #48048)

  See also Bug #47974, Bug #56408.

- **Incompatible Change**: Aliases for wildcards (as in `SELECT t.* AS 'alias' FROM t`) are no longer accepted and result in an error. Previously, such aliases were ignored silently. (Bug #27249)

- **Incompatible Change**: Implicit conversion of a number or temporal value to string now produces a value that has a character set and collation determined by the `character_set_connection` and `collation_connection` system variables. (These variables commonly are set with `SET NAMES`. For information about connection character sets, see Section 9.1.4, “Connection Character Sets and Collations”.)

  This change means that such a conversion results in a character (nonbinary) string (a `CHAR`, `VARCHAR`, or `LONGTEXT` value), except when the connection character set is set to `binary`. In that case, the conversion result is a binary string (a `BINARY`, `VARBINARY`, or `LONGBLOB` value).

  Previously, an implicit conversion always produced a binary string, regardless of the connection character set. Such implicit conversions to string typically occur for functions that are passed numeric or temporal values when string values are more usual, and thus could have effects beyond the type of the converted value. Consider the expression `CONCAT(1, 'abc')`. The numeric argument `1` was converted to the binary string `'1'` and the concatenation of that value with the nonbinary string `'abc'` produced the binary string `'1abc'`.

  This change in conversion behavior affects several functions that expect string arguments because a numeric or temporal argument converted to a string now results in a character rather than binary string argument:

  - String functions: `CONCAT()`, `CONCAT_WS()`, `ELT()`, `EXPORT_SET()`, `INSERT()`, `LCASE()`, `LEFT()`, `LOWER()`, `LPAD()`, `LTRIM()`, `MID()`, `QUOTE()`, `REPEAT()`, `REPLACE()`, `REVERSE()`, `RIGHT()`, `RPAD()`, `RTRIM()`, `SOUNDEX()`, `SUBSTRING()`, `TRIM()`, `UCASE()`, `UPPER()`.

  - Date and time functions: `ADDDATE()`, `ADDTIME()`, `DATE_ADD()`, `DATE_SUB()`, `DAYNAME()`, `GET_FORMAT()`, `MONTHNAME()`, `SUBDATE()`, `SUBTIME()`, `TIMESTAMPADD()`.

  These functions remain unaffected:

  - `CHAR()` without a `USING` clause still returns `VARBINARY`.

  - Functions that previously returned `utf8` strings still do so. Examples include `CHARSET()` and `COLLATION()`.

  Encryption and compression functions that expect string arguments and previously returned binary strings are affected depending on the content of the return value:

  - If the return value contains only ASCII characters, the function now returns a character string with the connection character set and collation: `MD5()`, `OLD_PASSWORD()`, `PASSWORD()`, `SHA()`, `SHA1()`. The `ASTEXT()` and `ASWKT()` spatial functions also fall into this category.

  - If the return value can contain non-ASCII characters, the function still returns a binary string: `AES_ENCRYPT()`, `COMPRESS()`, `DES_ENCRYPT()`, `ENCODE()`, `ENCRYPT()`.

  The `INET_NTOA()` return value contains only ASCII characters, and this function now returns a character string with the connection character set and collation rather than a binary string.

- **Incompatible Change**: Several changes were made to processing of server system variables and command-line options to make their treatment more consistent.

  General changes:

  - The help message text displayed by `mysqld --verbose --help` now consistently uses dashes to show the names of options and system variables that can be set at server startup. Previously, the message used both dashes and underscores (generally with dashes for options and underscores for system variables). For example, the help message now displays `--log-output` and `--general-log`, whereas previously it displayed `--log-output` and `--general_log`.

    This is a display-only change. The permissible syntax for setting options and variables remains unchanged:

    - At server startup, you can specify options and variables on the command line or in option files using either dashes or underscores.

    - For those system variables that can be set at runtime (for example, using `SET`), you must specify them using underscores.

  - There are fewer session-only system variables. These variables now have a global value: `autocommit`, `foreign_key_checks`, `profiling`, `sql_auto_is_null`, `sql_big_selects`, `sql_buffer_result`, `sql_log_bin`, `sql_log_off`, `sql_notes`, `sql_quote_show_create`, `sql_safe_updates`, `sql_warnings`, `unique_checks`.

    For those variables, you can now set the global value to change the value from which the session value is initialized for new sessions.

    The following list shows the variables that remain session-only. They apply only in the context of a specific session so that a global value is of no use: `debug_sync`, `error_count`, `identity`, `insert_id`, `last_insert_id`, `pseudo_thread_id`, `rand_seed1`, `rand_seed2`, `timestamp`, `warning_count`.

- All system variables are accessible at runtime using `@@` syntax (`@@GLOBAL.var_name`, `@@SESSION.var_name`, `@@var_name`). Previously, this syntax produced an error for some variables.
- All system variables are included as appropriate in the output from `SHOW {GLOBAL, SESSION} VARIABLES` and the `INFORMATION_SCHEMA.GLOBAL_VARIABLES` and `INFORMATION_SCHEMA.SESSION_VARIABLES` tables. Previously, some variables were not displayed.
- “As appropriate” in the preceding item means that `SHOW GLOBAL VARIABLES` and `INFORMATION_SCHEMA.GLOBAL_VARIABLES` no longer include session-only system variables. Previously, these included the global value of a variable if it had one, and the session value if not. (`SHOW SESSION VARIABLES` still includes global-only variables.)
- The server now enforces type checking for assignments to system variables, so it is more consistent and strict about rejecting invalid values.
- For attempts to assign a negative value to an unsigned system variable, the server truncates the value to the minimum permitted value. Previously, there was sometimes wraparound to a large positive value.
- Some system variables (typically those that control memory or disk allocation) are permitted to take only values that are a multiple of a given block size, and assigning a value not a block size multiple causes truncation to the nearest multiple. (For example, `net_buffer_length` must be a multiple of 1024. Assigning 16384 results in a value of 16384, whereas assigning 16383 results in a value of 15360.) A warning now occurs when adjustment of the specified value takes place. Previously, adjustment was silent.
- More system variables can be assigned the value `DEFAULT` to set them to their default value. Previously, this syntax produced an error in some cases.
- All variables that have a `SET` data type value can be set to an integer value that is treated like a bit mask. Previously, this did not work for some SET-type variables.
- The default value for several system variables no longer differs between 32-bit and 64-bit builds. Previously, the values differed by about 100 bytes for some variables.
- There are no longer any write-only system variables. For example, `SELECT @@rand_seed1` returns 0, not `Variable 'rand_seed1' can only be set, not read`.

Variable-specific changes:

- The `concurrent_insert` system variable now is handled as an enumeration with the permissible values `NEVER`, `AUTO`, and `ALWAYS`. The corresponding integer values 0, 1, and 2 are still recognized.
- The `completion_type` system variable now is handled as an enumeration with the permissible values `NO_CHAIN`, `CHAIN`, and `RELEASE`. The corresponding integer values 0, 1, and 2 are still recognized.
- For `concurrent_insert` and `completion_type`, the string form of the value is displayed by `SHOW VARIABLES` and `SELECT @@var_name`.
- The unused `rpl_recovery_rank` system variable is deprecated.
- The `storage_engine` system variable is deprecated in favor of the new system variable `default_storage_engine`. This enables pairing of the `--default-storage-engine` command-line option with a system variable of a more closely corresponding name.
- The `--myisam-recover` option is renamed to `--myisam-recover-options` to pair better with the name of the `myisam_recover_options` system variable. The old option name still works because it is recognized as an unambiguous prefix of the new name. (Option prefix recognition occurs as described in Section 4.2.3, “Specifying Program Options”.)
- `--myisam-recover-options` has a new permissible value `OFF`.
- Attempts to drop the default key cache produce an error. Previously, it produced only a warning and status of success even though the attempt failed.

See also Bug #34437, Bug #34635, Bug #11747961, Bug #34829, Bug #34878, Bug #25430.

- **Incompatible Change**: The server now includes `dtoa`, a library for conversion between strings and numbers by David M.

Gay. In MySQL, this library provides the basis for improved conversion between string or `DECIMAL` values and approximate-value (`FLOAT`/`DOUBLE`) numbers:

  - Consistent conversion results across platforms, which eliminates, for example, Unix versus Windows conversion differences.
  - Accurate representation of values in cases where results previously did not provide sufficient precision, such as for values close to IEEE limits.
  - Conversion of numbers to string format with the best possible precision. The precision of `dtoa` is always the same or better than that of the standard C library functions.

  Because the conversions produced by this library differ in some cases from previous results, the potential exists for incompatibilities in applications that rely on previous results. For example, applications that depend on a specific exact result from previous conversions might need adjustment to accommodate additional precision.

  For additional information about the properties of `dtoa` conversions, see Section 11.2, “Type Conversion in Expression Evaluation”.

  See also Bug #12860, Bug #21497, Bug #26788, Bug #24541, Bug #34015.

- **Incompatible Change**: The Unicode implementation has been extended to provide support for supplementary characters that lie outside the Basic Multilingual Plane (BMP). Noteworthy features:

  - `utf16` and `utf32` character sets have been added. These correspond to the UTF-16 and UTF-32 encodings of the Unicode character set, and they both support supplementary characters.
  - The `utf8mb4` character set has been added. This is similar to `utf8`, but its encoding allows up to four bytes per character to enable support for supplementary characters.
  - The `ucs2` character set is essentially unchanged except for the inclusion of some newer BMP characters.

  In most respects, upgrading to MySQL 5.5 should present few problems with regard to Unicode usage, although there are some potential areas of incompatibility. These are the primary areas of concern:

  - For the variable-length character data types (`VARCHAR` and the `TEXT` types), the maximum length in characters is less for `utf8mb4` columns than for `utf8` columns.
  - For all character data types (`CHAR`, `VARCHAR`, and the `TEXT` types), the maximum number of characters that can be indexed is less for `utf8mb4` columns than for `utf8` columns.

  Consequently, if you want to upgrade tables from `utf8` to `utf8mb4` to take advantage of supplementary-character support, it may be necessary to change some column or index definitions.

  For additional details about the new Unicode character sets and potential incompatibilities, see Section 9.1.10, “Unicode Support”, and Section 9.1.11, “Upgrading from Previous to Current Unicode Support”.

- **Incompatible Change**: Several columns were added to the `INFORMATION_SCHEMA.ROUTINES` table to provide information about the `RETURNS` clause data type for stored functions: `DATA_TYPE`, `CHARACTER_MAXIMUM_LENGTH`, `CHARACTER_OCTET_LENGTH`, `NUMERIC_PRECISION`, `NUMERIC_SCALE`, `CHARACTER_SET_NAME`, and `COLLATION_NAME`.

  This change produces an incompatibility for applications that depend on column order in the `ROUTINES` table because the new columns appear between the `ROUTINE_TYPE` and `DTD_IDENTIFIER` columns. Such applications may need to be adjusted to account for the new columns.

- **Important Change**: **Replication**: `RESET MASTER` and `RESET SLAVE` now reset the values shown for `Last_IO_Error`, `Last_IO_Errno`, `Last_SQL_Error`, and `Last_SQL_Errno` in the output of `SHOW SLAVE STATUS`. (Bug #34654)

  See also Bug #44270.

- **Important Change**: The `--skip-thread-priority` option is now deprecated such that the server will not change the thread priorities by default. Giving threads different priorities might yield marginal improvements in some platforms (where it actually works), but it might instead cause significant degradation depending on the thread count and number of processors. Meddling with the thread priorities is a not a safe bet as it is very dependent on the behavior of the CPU scheduler and system where MySQL is being run. (Bug #35164, Bug #37536)

- **Cluster Replication**: **Replication**: MySQL Replication now supports attribute promotion and demotion for row-based replication between columns of different but similar types on the master and the slave. For example, it is possible to promote an `INT` column on the master to a `BIGINT` column on the slave, and to demote a `TEXT` column to a `VARCHAR` column.

  The implementation of type demotion distinguishes between lossy and non-lossy type conversions, and their use on the slave can be controlled by setting the `slave_type_conversions` global server system variable.

For more information, see Row-based replication: attribute promotion and demotion. (Bug #47163, Bug #46584)

- **Replication**: For replication based on row-based and mix-format binary logging, it is now safe to mix transactional and nontransactional statements within a transaction. The nontransactional statements are logged immediately rather than waiting until the transaction ends, ensuring that their results are logged and replicated correctly regardless of the result of the transaction.

- `mysqltest` has a new `--max-connections` option to set a higher number of maximum permitted server connections than the default 128. This option can also be passed using `mysql-test-run.pl`. (Bug #51135)

- `mysql-test-run.pl` has a new `--portbase` option and a corresponding `MTR_PORT_BASE` environment variable for setting the port range, as an alternative to the existing `--build-thread` option. (Bug #50182)

- `SHOW PROFILE CPU` has been ported to Windows. Thanks to Alex Budovski for the patch. (Bug #50057)

- `mysql-test-run.pl` now has a `--gprof` option that runs the server through the `gprof` profiler, much the same way the currently supported `--gcov` option runs it through `gcov`. (Bug #49345)

- `mysqltest` now has a `lowercase_result` command that converts the output of the next statement to lowercase. This is useful for test cases where the lettercase may vary between platforms. (Bug #48863)

- `mysqltest` now has a `remove_files_wildcard` command that removes files matching a pattern from a directory. (Bug #39774)

- MySQL support for adding collations using LDML specifications did not support the `<i>` identity rule that indicates one character sorts identically to another. The `<i>` rule now is supported. See Section 9.4.4.2, "LDML Syntax Supported in MySQL". (Bug #37129)

- For boolean options, the option-processing library now prints additional information in the `--help` message: If the option is enabled by default, the message says so and indicates that the `--skip` form of the option disables the option. This affects all compiled MySQL programs that use the library. (Bug #35224)

- The use of the `SQL_CACHE` and `SQL_NO_CACHE` options in `SELECT` statements now is checked more restrictively: 1) Previously, both options could be given in the same statement. This is no longer true; only one can be given. 2) Previously, these options could be given in `SELECT` statements that were not at the top-level. This is no longer true; the options are not permitted in subqueries (including subqueries in the `FROM` clause, and `SELECT` statements in unions other than the first `SELECT`. (Bug #35020)

- The `mysql` client now has an `--auto-vertical-output` option, which causes result sets to be displayed vertically if they are too wide for the current window, and uses normal tabular format otherwise. (This applies to statements terminated by `;` or `\G`.) (Bug #26780)

- `TRUNCATE TABLE` now is permitted for a table for which a `WRITE` lock has been acquired with `LOCK TABLES`. (Bug #20667)

  See also Bug #46452.

- `FLUSH LOGS` now takes an optional *`log_type`* value so that `FLUSH log_type LOGS` can be used to flush only a specified log type. These *`log_type`* options are permitted:

  - `BINARY` closes and reopens the binary log files.
  - `ENGINE` closes and reopens any flushable logs for installed storage engines.
  - `ERROR` closes and reopens the error log file.
  - `GENERAL` closes and reopens the general query log file.
  - `RELAY` closes and reopens the relay log files.
  - `SLOW` closes and reopens the slow query log file.

  Thanks to Eric Bergen for the patch to implement this feature. (Bug #14104)

- Previously, prepared `CALL` statements could be used through the C API only for stored procedures that produce at most one result set, and applications could not use placeholders for `OUT` or `INOUT` parameters. For prepared `CALL` statements used using `PREPARE` and `EXECUTE`, placeholders could not be used for `OUT` or `INOUT` parameters.

  For the C API, prepared `CALL` support now is expanded in the following ways:

  - A stored procedure can produce any number of result sets. The number of columns and the data types of the columns need not be the same for all result sets.
  - The final values of `OUT` and `INOUT` parameters are available to the calling application after the procedure returns. These parameters are returned as an extra single-row result set following any result sets produced by the procedure itself. The row contains the values of the `OUT` and `INOUT` parameters in the order in which they are declared in the procedure parameter list.
  - A new C API function, `mysql_stmt_next_result()`, is available for processing stored procedure results. See Section 20.9.16, “C API Support for Prepared `CALL` Statements”.
  - The `CLIENT_MULTI_RESULTS` flag now is enabled by default. It no longer needs to be enabled when you call `mysql_real_connect()`. (This flag is necessary for executing stored procedures because they can produce multiple result sets.)

  For `PREPARE` and `EXECUTE`, placeholder support for `OUT` and `INOUT` parameters is now available. See Section 12.2.1, “`CALL` Syntax”. (Bug #11638, Bug #17898)

- MySQL now supports IPv6 connections to the local host, using the address `::1`. For example:

  ```
  shell> mysql -h ::1
  ```

  The address `::1` can be specified in account names in statements such as `CREATE USER`, `GRANT`, and `REVOKE`. For example:

  ```
  mysql> CREATE USER 'bill'@'::1' IDENTIFIED BY 'secret';
  mysql> GRANT SELECT ON mydb.* TO 'bill'@'::1';
  ```

  The default set of accounts created during MySQL installation now includes an account for `'root'@'::1'`.

  See Section 5.4.3, “Specifying Account Names”, and Section 2.10.2, “Securing the Initial MySQL Accounts”. (Bug #8836)

- Three options were added to `mysqldump` make it easier to generate a dump from a slave server:

  - `--dump-slave` is similar to `--master-data`, but the `CHANGE MASTER TO` statement contains binary log coordinates for the slave's master host, not the slave itself.
  - `--apply-slave-statements` causes `STOP SLAVE` and `START SLAVE` statements to be added before the `CHANGE MASTER TO` statement and at the end of the output, respectively.
  - `--include-master-host-port` causes the `CHANGE MASTER TO` statement to include `MASTER_PORT` and `MASTER_HOST` options for the slave's master.

  (Bug #8368)

- `mysqladmin` now permits the password value to be omitted following the `password` command. In this case, `mysqladmin` prompts for the password value, which enables you to avoid specifying the password on the command line. Omitting the password value should be done only if `password` is the final command on the `mysqladmin` command line. Otherwise, the next argument is taken as the password. (Bug #5724)

- Code that produces query IDs and updates the value of the `Threads_running` status variable no longer acquires a global lock that also protects the list of all connections. Instead, it relies on atomic increment and decrement instructions. This improves scalability and to a certain extent alleviates the problem described in Bug #11751904.

  See also Bug #42930.

- The `optimizer_switch` system variable now has an `engine_condition_pushdown` flag to control whether storage engine condition pushdown optimization is used. As a consequence, the `engine_condition_pushdown` system variable now is deprecated.

- The server now provides a pluggable audit interface that enables information about server operations to be reported to interested parties. Audit plugins may register with the audit interface to receive notification about server operations. When an auditable event occurs within the server, the server determines whether notification is needed. For each registered audit plugin, the server checks the event against those event classes in which the plugin is interested and passes the event to the plugin if there is a match. For more information, see Section 21.2.3.6, “Audit Plugins”.

- Some conversions between Japanese character sets are more efficient.

- When the server detects `MyISAM` table corruption, it now writes additional information to the error log, such as the name and line number of the source file, and the list of threads accessing the table. Example: `Got an error from thread_id=1, mi_dynrec.c:368`. This is useful information to include in bug reports.

- The `TABLESPACES` table has been added to `INFORMATION_SCHEMA` for tracking tablespace details.
- Added the `PARAMETERS` table to `INFORMATION_SCHEMA`. The `PARAMETERS` table provides information about stored procedure and function parameters, and about return values for stored functions.
- The maximum length of table comments was extended from 60 to 2048 characters. The maximum length of column comments was extended from 255 to 1024 characters. Index definitions now can include a comment of up to 1024 characters.

Bugs Fixed

- **Performance**: **Replication**: When writing events to the binary log, transactional events (that is, events that operate on transactional tables) are written to a thread-specific transaction cache, which is then written to the binary log on commit. To handle nontransactional events, there was a lock taken on the binary log (when entering the function `MYSQL_BIN_LOG::write()`), even when the event was written to the transaction cache instead of the binary log, causing a major bottleneck in replication performance. (Bug #42757)
- **Security Fix**: The server crashed if an account with the `CREATE ROUTINE` privilege but not the `EXECUTE` privilege attempted to create a stored procedure. (Bug #44798)
- **Security Enhancement**: When the `DATA DIRECTORY` or `INDEX DIRECTORY` clause of a `CREATE TABLE` statement referred to a subdirectory of the data directory through a symlinked component of the data directory path, it was accepted, when for security reasons it should be rejected. (Bug #39277)
- **Incompatible Change**: **Replication**: The `binlog_format` system variable can no longer be set inside a transaction. In other words, the binary logging format can no longer be changed while a transaction is in progress. (Bug #47863)
- **Incompatible Change**: **Replication**: Concurrent statements using a stored function and `DROP FUNCTION` for that function could break statement-based replication.

  DDL statements for stored procedures and functions are now prohibited while a `LOCK TABLES` statement is in effect. (Bug #30977)

  See also Bug #57663.
- **Incompatible Change**: For debug builds, attempts to execute `RESET` statements within a transaction that had acquired metadata locks led to an assertion failure.

  As a result of this bug fix, `RESET` statements now cause an implicit commit. (Bug #51336)
- **Incompatible Change**: A deadlock occurred for this sequence of events: Session 1 locked a table using `LOCK TABLES`; Session 2 dropped the database containing the table; Session 1 created any database.

  As a consequence of this bug fix, `CREATE DATABASE` is not permitted within a session that has an active `LOCK TABLES` statement. (Bug #49988)
- **Incompatible Change**: `CREATE TABLE` statements (including `CREATE TABLE ... LIKE`) are now prohibited whenever a `LOCK TABLES` statement is in effect.

  One consequence of this change is that `CREATE TABLE ... LIKE` makes the same checks as `CREATE TABLE` and does not just copy the `.frm` file. This means that if the current SQL mode is different from the mode in effect when the original table was created, the table definition might be considered invalid for the new mode and the statement will fail. (Bug #42546, Bug #11751609)
- **Incompatible Change**: Due to work done for Bug #989, `FLUSH TABLES` is not permitted when there is an active `LOCK TABLES ... READ`. This caused a problem with `mysqlhotcopy`, which used that sequence of statements. `mysqlhotcopy` now uses `FLUSH TABLES tbl_list WITH READ LOCK` to flush and lock tables. If `mysqlhotcopy` is used with a server older than MySQL 5.5.3 that does not support this statement, it has a new option `--old_server` that causes it to use the previous statement sequence.

  To provide a workaround for the restriction that `FLUSH TABLES` is no longer permitted when there is an active `LOCK TABLES ... READ`, `FLUSH TABLES` has a new variant, `FLUSH TABLES tbl_list WITH READ LOCK`, that enables tables to be flushed and locked in a single operation. As a result of this change, applications that previously used this statement sequence to lock and flush tables will fail:

  ```
  LOCK TABLES tbl_list READ;
  FLUSH TABLES tbl_list;
  ```

Such applications should now use this statement instead:

```
FLUSH TABLES tbl_list WITH READ LOCK;
```

(Bug #42465)

- **Incompatible Change**: For application compatibility reasons, when `sql_auto_is_null` is 1, MySQL converts *`auto_inc_col`* `IS NULL` to *`auto_inc_col`* `= LAST_INSERT_ID()`. However, this was being done regardless of whether the predicate was alone or at the top level. Now it occurs only when it is a single top-level predicate.

  In conjunction with this bug fix, the default value of the `sql_auto_is_null` system variable has been changed from 1 to 0, which may cause incompatibilities with existing applications. (Bug #41371)

- **Incompatible Change**: The parser accepted illegal syntax in a `FOREIGN KEY` clause:

  - Multiple `MATCH` clauses.
  - Multiple `ON DELETE` clauses.
  - Multiple `ON UPDATE` clauses.
  - `MATCH` clauses specified after `ON UPDATE` or `ON DELETE`. In case of multiple redundant clauses, this leads to confusion, and implementation-dependent results.

  These illegal syntaxes are now properly rejected. Existing applications that used them will require adjustment. (Bug #34455)

- **Incompatible Change**: The parser accepted an `INTO` clause in nested `SELECT` statements, which is invalid because such statements must return their results to the outer context. This syntax is no longer permitted. (Bug #33204)

- **Incompatible Change**: The `Locked` thread state was equivalent to the `Table lock` state and has been removed. It no longer appears in `SHOW PROCESSLIST` output. (Bug #28870)

- **Incompatible Change**: Several changes were made to alias resolution in multiple-table `DELETE` statements so that it is no longer possible to have inconsistent or ambiguous table aliases.

  - In MySQL 5.1.23, alias declarations outside the *`table_references`* part of the statement were disallowed for the `USING` variant of multiple-table `DELETE` syntax, to reduce the possibility of ambiguous aliases that could lead to ambiguous statements that have unexpected results such as deleting rows from the wrong table.

    Now alias declarations outside *`table_references`* are disallowed for all multiple-table `DELETE` statements. Alias declarations are permitted only in the *`table_references`* part.

    Incorrect:

    ```
    DELETE FROM t1 AS a2 USING t1 AS a1 INNER JOIN t2 AS a2;
    DELETE t1 AS a2 FROM t1 AS a1 INNER JOIN t2 AS a2;
    ```

    Correct:

    ```
    DELETE FROM t1 USING t1 AS a1 INNER JOIN t2 AS a2;
    DELETE t1 FROM t1 AS a1 INNER JOIN t2 AS a2;
    ```

  - Previously, for alias references in the list of tables from which to delete rows in a multiple-table delete, the default database is used unless one is specified explicitly. For example, if the default database is `db1`, the following statement does not work because the unqualified alias reference `a2` is interpreted as having a database of `db1`:

    ```
    DELETE a1, a2 FROM db1.t1 AS a1 INNER JOIN db2.t2 AS a2
    WHERE a1.id=a2.id;
    ```

    To correctly match an alias that refers to a table outside the default database, you must explicitly qualify the reference with the name of the proper database:

    ```
    DELETE a1, db2.a2 FROM db1.t1 AS a1 INNER JOIN db2.t2 AS a2
    WHERE a1.id=a2.id;
    ```

    Now alias resolution does not require qualification and alias references should not be qualified with the database name. Qualified names are interpreted as referring to tables, not aliases.

  Statements containing alias constructs that are no longer permitted must be rewritten. (Bug #27525)

See also Bug #30234.

- **Incompatible Change**: `DROP TABLE` now is permitted only if you have acquired a `WRITE` lock with `LOCK TABLES`, or if you hold no locks, or if the table is a `TEMPORARY` table.

  Previously, if other tables were locked, you could drop a table with a read lock or no lock, which could lead to deadlocks between clients. The new stricter behavior means that some usage scenarios will fail when previously they did not. (Bug #25858)

- **Incompatible Change**: If a data definition language (DDL) statement occurred for a table that was being used by another session in an active transaction, statements could be written to the binary log in the wrong order. For example, this could happen if `DROP TABLE` occurred for a table being used in a transaction. This is now prevented by deferring release of metadata locks on tables used within a transaction until the transaction ends.

  This bug fix results in some incompatibilities with previous versions:

  - A table that is being used by a transaction within one session cannot be used in DDL statements by other sessions until the transaction ends.

  - `FLUSH TABLES` is not permitted when there is an active `LOCK TABLES ... READ`. Use `FLUSH TABLES` *`tbl_list`* `WITH READ LOCK` instead. This causes a problem with `mysqlhotcopy`, fixed in Bug #42465.

  (Bug #989, Bug #39675)

- **Important Change**: **Replication**: For an engine that supported only row-based replication, replication stopped with an error when executing row events.

  For information about changes in how the binary logging format is determined in relation to statement type and storage engine logging capabilities, see Section 5.2.4.3, “Mixed Binary Logging Format”.

  As part of the fix for this issue, the `EXAMPLE` storage engine is now changed so that it supports statement-based logging only. Previously, it supported row-based logging only. (Bug #39934, Bug #11749859)

- **Important Change**: The IPv6 loopback address `::1` was interpeted as a hostname rather than a numeric IP address.

  In addition, the IPv6-enabled server on Windows interpeted the hostname `localhost` as `::1` only, which failed to match the default `'root'@'127.0.0.1'` account in the `mysql.user` privilege table.

  > **Note**
  >
  > As a result of this fix, a `'root'@'::1'` account is added to the `mysql.user` table as one of the default accounts created during MySQL installation.

  (Bug #43006)

  See also Bug #38247, Bug #45283, Bug #45584, Bug #45606.

- **InnoDB Storage Engine**: **Replication**: Column length information generated by `InnoDB` did not match that generated by `MyISAM`, which caused invalid metadata to be written to the binary log when trying to replicate `BIT` columns. (Bug #49618)

- **InnoDB Storage Engine**: `SHOW INNODB STATUS` could display incorrect information about deadlocks, when the deadlock detection routine stops early (to avoid excessive CPU usage). (Bug #49001)

- **InnoDB Storage Engine**: Concurrent execution of `ALTER TABLE` for `InnoDB` table and a transaction that tried to read and then update the table could result in a deadlock between table-level locks and `InnoDB` row locks, which was detected only after the `innodb_lock_wait_timeout` timeout occurred. (Bug #37346)

- **Partitioning**: When using a debug build of MySQL, if a query against a partitioned table having an index on one or more `DOUBLE` columns used that index, the server failed with an assertion. (Bug #45816)

- **Partitioning**: The first time that a query against the `INFORMATION_SCHEMA.TABLES` table for partitioned tables using the `ARCHIVE` engine was run, it returned invalid data. If the server had been restarted since such a table had been created, or if the table had never actually been opened, its `DATA_LENGTH` was reported as 0 bytes. (The second and subsequent attempts to issue the same query returned the expected result.) (Bug #44622)

- **Partitioning**: `ALTER TABLE` on a partitioned table caused unnecessary deadlocks. (Bug #43867)

  See also Bug #46654.

- **Partitioning**: Attempting to drop a partitioned table from one connection while waiting for the completion of an `ALTER TA-`

`BLE` that had been issued from a different connection, and that changed the storage engine used by the table, could cause the server to crash. (Bug #42438)

- **Partitioning**: After attempting to create a duplicate index on a partitioned table (and having the attempt fail as expected), a subsequent attempt to create a new index on the table caused the server to hang. (Bug #40181)

- **Partitioning**: When used on a partitioned table, `ALTER TABLE` produced the wrong error message when the name of a nonexistent storage engine was used in the `ENGINE` clause. (Bug #35765)

- **Partitioning**: When one user was in the midst of a transaction on a partitioned table, a second user performing an `ALTER TABLE` on this table caused the server to hang. (Bug #34604)

- **Partitioning**: Portions of the partitioning code were refactored in response to potential regression issues uncovered while working on the fix for Bug #31210. (Bug #32115)

  See also Bug #40281.

- **Replication**: When using the row-based or mixed replication format with a debug build of the MySQL server, inserts into columns using the `utf32` character set on the master caused the slave to crash. (Bug #51787)

  See also Bug #51716.

- **Replication**: When using the row-based or mixed replication format, column values using the `utf16` character set on the master were padded incorrectly on the slave. (Bug #51716)

  See also Bug #51787.

- **Replication**: An issue internal to the code, first seen in Bug #49132 but not completely resolved in the fix for that bug, was removed. This should prevent similar issues to those in the previous bug with `binlog_format` changes following DDL statements.

  For developers working with the MySQL Server code: the public class variable `THD::current_stmt_binlog_row_based` was supposed to have been removed as part of the fix for Bug #39934, but was still present in the code. If a developer later tried to use this variable, it could cause the previous issues to re-occur, and possibly new ones to arise. The variable has now been removed; the previously added class functions `THD::is_current_stmt_binlog_format_row()`, `THD::set_current_stmt_binlog_format_row()`, and `THD::clear_current_stmt_binlog_format_row()` should be used instead. (Bug #51021)

  See also Bug #11749859.

- **Replication**: Adding an index to a table on the master caused the slave to stop logging slow queries to the slow query log. (Bug #50620)

- **Replication**: If a `CHANGE MASTER TO` statement set `MASTER_HEARTBEAT_PERIOD` to 30 or higher, `Slave_received_heartbeats` did not increase on the slave. This caused the slave to reconnect before the time indicated by `slave_net_timeout` had elapsed.

  This issue affected big-endian 64-bit platforms such as Solaris/SPARC. (Bug #50296)

- **Replication**: The error message given when trying to replicate (using statement-based mode) insertions into an `AUTO_INCREMENT` column by a stored function or a trigger was improved. (Bug #50192)

- **Replication**: The server could deadlock when `FLUSH LOGS` was executed concurrently with DML statements. To fix this problem, nontransactional changes are now always flushed before transactional changes. (Bug #50038)

- **Replication**: Metadata for `GEOMETRY` fields was not properly stored by the slave in its definitions of tables. (Bug #49836)

  See also Bug #48776.

- **Replication**: Statement-based replication of user variables having numeric data types did not always work correctly. (Bug #49562, Bug #11757508)

- **Replication**: When using the semisynchronous replication plugin on Windows, the wait time calculated when the master was waiting for reply from the slave was incorrect. In addition, when the wait time was less than the current time, the master did not wait for a reply at all.

  This issue was caused by the fact that a different internal function was used to get current time by the plugin on Windows as opposed to other platforms, and this function was not correctly implemented. Now the Windows version of the plugin uses the same function as other platforms for this purpose. (Bug #49557)

- **Replication**: Due to a change in the format of the information used by the slave to connect to the master, which could cause to reject connection attempts to older masters by newer slaves. (Bug #49259)

This regression was introduced by Bug #13963.

- **Replication**: When using row-based logging, a failing `INSERT ... SELECT` statement on a nontransactional table was not flagged correctly, such that, if a rollback was requested and no other nontransactional table had been updated, nothing was written to the binary log. (Bug #47175)

  See also Bug #40278.

- **Replication**: When using row-based replication, the incomplete logging of a group of events involving both transaction and nontransactional tables could cause `STOP SLAVE` to hang. (Bug #45940)

  See also Bug #319, Bug #38205.

- **Replication**: There were two related issues concerning handling of unsafe statements and setting of the binary logging format when there were open temporary tables on the master, and the existing replication format was row-based or mixed:

  1. When using `binlog_format=ROW`, and an unsafe statement was executed while there were open temporary tables on the master, the statement `SET @@session.binlog_format = MIXED` failed with the error `Cannot switch out of the row-based binary log format when the session has open temporary tables`.
  2. When using `binlog_format=MIXED`, and an unsafe statement was executed while there were open temporary tables on the master, the statement `SET @@session.binlog_format = STATEMENT` caused any subsequent DML statements to be written to the binary log using the row-based format instead of the statement-based format.

  (Bug #45855, Bug #45856)

- **Replication**: Statements that updated `AUTO_INCREMENT` columns in multiple tables were logged using the row-based format when `--binlog_format` was set to `MIXED`, but did not cause an `Unsafe statement` warning to be generated when `--binlog_format` was set to `STATEMENT`. (Bug #45827)

  See also Bug #39934, Bug #11749859.

- **Replication**: Even though `INSERT DELAYED` statements are unsafe for statement-based replication, they caused the statement only to be logged in row format when the binary logging format was `MIXED`, but did not cause a warning to be generated when the binary logging format was `STATEMENT`. (Bug #45825)

- **Replication**: When using `MIXED` binary logging format, statements containing a `LIMIT` clause and occurring in stored routines were not written to the log as row events. (Bug #45785)

- **Replication**: When using statement-based replication, database-level character sets were not always honored by the replication SQL thread. This could cause data inserted on the master using `LOAD DATA` to be replicated using the wrong character set.

  > **Note**
  >
  > This was not an issue when using row-based replication.

  (Bug #45516)

- **Replication**: `STOP SLAVE` did not flush the relay log or the `master.info` or `relay-log.info` files, which could lead to corruption if the server crashed. (Bug #44188)

- **Replication**: Large transactions and statements could corrupt the binary log if the size of the cache (as set by `max_binlog_cache_size`) was not large enough to store the changes.

  Now, for transactions that do not fit into the cache, the statement is not logged, and the statement generates an error instead.

  For nontransactional changes that do not fit into the cache, the statement is also not logged—an incident event is logged after committing or rolling back any pending transaction, and the statement then raises an error.

  > **Note**
  >
  > If a failure occurs before the incident event is written the binary log, the slave does not stop, and the master does not report any errors.

  (Bug #43929, Bug #11752675)

  See also Bug #37148, Bug #11748696, Bug #46166, Bug #11754544.

- **Replication**: On Windows, `RESET MASTER` failed in the event of a missing binlog file rather than issuing a warning and completing the rest of the statement. (Bug #42150, Bug #42218)

- **Replication**: Executing the sequence of statements `RESET SLAVE`, `RESET MASTER`, and `FLUSH LOGS`, when binary log or relay log files listed in the index file could not be found, could cause the server to crash. This could happen, for example, when these files had been moved or deleted manually. (Bug #41902)

- **Replication**: MySQL creates binary logs in a numbered sequence, with a maximum possible 4294967295 concurrent log files, 4294967295 being the maximum value for an unsigned long integer. However, binary log file extensions were turned into negative numbers once the variable used to hold the value reached the maximum value for a signed long integer (2147483647). Consequently, when the sequence value was incremented to the next (negative) number, MySQL tried to create the file using a `.000000` extension, causing the server to fail since this file already existed.

  Negative file extensions are no longer permitted, and an error is returned when the limit is reached. In addition, `FLUSH LOGS` now also reports warnings to the user, if the extension number has reached the limit, and warnings are printed to the error log when the limit is approaching. (Bug #40611)

- **Replication**: Issuing concurrent `STOP SLAVE`, `START SLAVE`, and `RESET SLAVE` statements using different connections caused the replication slave to crash. (Bug #38716)

  See also Bug #38715, Bug #44312.

- **Replication**: A slave compiled using `--with-libevent` and run with `--thread-handling=pool-of-threads` could sometimes crash. (Bug #36929)

- **Replication**: `mysqlbinlog` sometimes failed when trying to create temporary files; this was because it ignored the specified temp file directory and tried to use the system `/tmp` directory instead. (Bug #35546)

  See also Bug #35543.

- **Replication**: A `CHANGE MASTER TO` statement with no `MASTER_HEARTBEAT_PERIOD` option failed to reset the heartbeat period to its default value. (Bug #34686)

- **Replication**: Formerly, only slaves that had been started with the `--report-hosts` option were visible in the output of `SHOW SLAVE HOSTS`. Now, all slaves that are registered with the master appear in `SHOW SLAVE HOSTS` output.

  As part of the fix for this issue, the `Rpl_recovery_rank` column, which had appeared in the output of `SHOW SLAVE HOSTS` in some MySQL releases, was removed because the corresponding server variable `rpl_recovery_rank` (now deprecated) was never actually used. (Bug #13963)

  See also Bug #21132, Bug #21869.

- `mysqld_safe` did not pass the correct default value of `plugin_dir` to `mysqld`. (Bug #51938)

- `mysqld_multi` failed due to a syntax error in the script. (Bug #51468)

- `ALTER TABLE` on a `MERGE` table that has been locked using `LOCK TABLES ... WRITE` incorrectly produced an `ER_TABLE_NOT_LOCKED_FOR_WRITE` error. (Bug #51240)

- The `mysql` could default to the `ascii` character set, which is not a valid character set choice for MySQL. The `latin1` character set will now be used when an ASCII environment has been identified. (Bug #51166)

- On some Unix/Linux platforms, an error during build from source could be produced, referring to a missing `LT_INIT` program. This is due to versions of `libtool` 2.1 and earlier. (Bug #51009)

- Referring to a subquery result in a `HAVING` clause could produce incorrect results. (Bug #50995)

- Aggregate functions on `TIMESTAMP` columns could yield incorrect or undefined results. (Bug #50888)

- The optimizer normally prefers use of `filesort` plus the join cache to a full index scan. But this combination was used even if the index is clustered, in which case, the clustered index scan can be faster. (Bug #50843)

- For debug builds, `SHOW BINARY LOGS` raised an assertion if binary logging was not enabled. (Bug #50780)

- The server did not recognize that the stored procedure cache became invalid if a view was created or modified within a procedure, resulting in a crash. (Bug #50624)

- Incorrect handling of `BIT` columns in temporary tables could lead to spurious duplicate-key errors. (Bug #50591)

- The second or subsequent invocation of a stored procedure containing `DROP TRIGGER` could cause a server crash. (Bug #50423)

- The return values for calls to put information into the stored routine cache were not consistently checked, raising an assertion. (Bug #50412)
- Full-text queries that used the truncation operator (`*`) could enter an infinite loop. (Bug #50351)
- For debug builds, an assertion was incorrectly raised in the optimizer when matching `ORDER BY` expressions. (Bug #50335)
- Queries optimized with `GROUP_MIN_MAX` did not clean up `KEYREAD` optimizations properly, causing subsequent queries to return incomplete rows. (Bug #49902)
- `mysql --show-warnings` crashed if the server connection was lost. (Bug #49646)
- For string-valued system variables containing multibyte characters, the byte length was used in contexts where the character length was more appropriate. (Bug #49645)
- `SHOW VARIABLES` did not correctly display string-valued system variables that contained `\0` characters. (Bug #49644)
- MySQL program option-processing code incorrectly displayed some options when printing ambiguous-option errors. (Bug #49640)
- For dynamic format `MyISAM` tables containing `LONGTEXT` columns, a bulk `INSERT ... ON DUPLICATE KEY UPDATE` or bulk `REPLACE` could cause corruption. (Bug #49628)
- Setting `binlog_format` to `DEFAULT` assigned a value different from the default. (Bug #49540)
- For debug builds, with `sql_safe_updates` enabled, a multiple-table `UPDATE` with the `IGNORE` modifier could raise an assertion. (Bug #49534)
- `EXPLAIN EXTENDED` crashed trying to print column names for a subquery in the `FROM` clause when the table had gone out of scope. (Bug #49487)
- For `InnoDB` tables, the test for using an index for `ORDER BY` sorting did not distinguish between primary keys and secondary indexes and expected primary key values to be concatenated to index values the way they are to secondary key values. (Bug #49324)
- `mysqltest` no longer permits you to execute an SQL statement on a connection after doing a `send` command, unless you do a `reap` first. This was previously accepted but could produce unpredictable results. (Bug #49269)
- Valgrind warnings for several logging messages were corrected. (Bug #49130)
- For debug builds on Windows, warnings about incorrect use of debugging directives were written to the error log. The directives were rewritten to eliminate these messages. (Bug #49025)
- Plugins in a binary release could not be installed into a debug version of the server. (Bug #49022)
- On POSIX systems, calls to `select()` with a file descriptor set larger than `FD_SETSIZE` resulted in unpredictable I/O errors; for example, when a large number of tables required repair. (Bug #48929)
- A dependent subquery containing `COUNT(DISTINCT col_name)` could be evaluated incorrectly. (Bug #48920)
- If a stored function contained a `RETURN` statement with an `ENUM` value in the `ucs2` character set, `SHOW CREATE FUNCTION` and `SELECT DTD_IDENTIFIER FROM INFORMATION_SCHEMA.ROUTINES` returned incorrect values. (Bug #48766)
- An `.ARZ` file missing from the database directory caused the server to crash. (Bug #48757)
- Running `SHOW CREATE TABLE` on a view `v1` that contained a function which accessed another view `v2` could trigger a infinite loop if the view referenced within the function (`v2`) caused a warning to be raised while being opened. (Bug #48449)
- Invalid memory reads could occur following a query that referenced a `MyISAM` table multiple times with a write lock. (Bug #48438)
- For debug builds, creating a view containing a row constructor raised an assertion. (Bug #48294)
- An aliasing violation in the C API could lead to a crash. (Bug #48284)
- Slow `CALL` statements were not always logged to the slow query log because execution time for multiple-statement stored procedures was assessed incorrectly. (Bug #47905)
- For debug builds, killing a `SELECT` retrieving from a view that was processing a function raised an assertion. (Bug #47736)

- Failure to open a view with a nonexistent `DEFINER` was improperly handled and the server crashed later attempting to lock the view. (Bug #47734)

- If a prepared statement used both a `MERGE` table and a stored function or trigger, execution sometimes failed with a `No such table` error. (Bug #47648)

- `CREATE VIEW` raised an assertion if a temporary table existed with the same name as the view. (Bug #47635)

- Renaming a column of an `InnoDB` table caused the server to go out of sync with the `InnoDB` data dictionary. To avoid this issue, renaming a column uses the older technique of copying all the table data rather than updating the table in-place. (Bug #47621)

- If a temporary table was created with the same name as a view referenced in a stored routine, routine execution could raise an assertion. (Bug #47313)

- Selecting from the process list in the embedded server caused a crash. (Bug #47304)

  See also Bug #43733.

- Programs did not exit if the option file specified by `--defaults-file` was not found. (Bug #47216)

- Attempts to print octal numbers with `my_vsnprintf()` could cause a crash. (Bug #47212)

- Corrected a potential problem of unintended file overwriting when the `MY_DONT_OVERWRITE_FILE` flag was used. (Bug #47126)

- Deadlock occurred if one session was running a multiple-statement transaction that involved a single partitioned table and another session attempted to alter the table. (Bug #46654)

- Valgrind warnings about memory allocation overruns for handling `CREATE FUNCTION` statements for UDFs were corrected. (Bug #46570)

- The server could crash attempting to flush privileges after receipt of a `SIGHUP` signal. (Bug #46495)

- If `INSERT INTO` *`tbl_name`* invoked a stored function that modified *`tbl_name`*, the server crashed. (Bug #46374)

- `HANDLER` statements within a transaction that already holds metadata locks could lead to deadlocks.

  Before this fix, all handlers for `TEMPORARY` tables were reset whenever any base table was opened. (Bug #46224)

- For queries that used `GROUP_CONCAT(DISTINCT ...)`, the value of `max_heap_table_size` was used for memory allocation, which could be excessive. Now the minimum of `max_heap_table_size` and `tmp_table_size` is used. (Bug #46018)

- Improperly closing tables when `INSERT DELAYED` needed to reopen tables could cause an assertion failure. (Bug #45949)

  See also Bug #18484.

- Grouping by a subquery in a query with a `DISTINCT` aggregate function led to incorrect and unordered grouping values. (Bug #45640)

- For an IPv6-enabled MySQL server, privileges specified using standard IPv4 addresses for hosts were not matched (only IPv4-mapped addresses were handled correctly).

  As part of the fix for this bug, a new build option `--disable-ipv6` has been introduced. Compiling MySQL with this option causes all IPv6-specific code in the server to be ignored.

  > **Important**
  >
  > If the server has been compiled using `--disable-ipv6`, it is not able to resolve hostnames correctly when run in an IPv6 environment.

  (Bug #45606)

  See also Bug #38247, Bug #43006, Bug #45283, Bug #45584.

- The hostname cache failed to work correctly. (Bug #45584)

  See also Bug #38247, Bug #43006, Bug #45283, Bug #45606.

- A Windows Installation using the GUI installer would fail with:

```
MySQL Server 5.1 Setup Wizard ended prematurely

The wizard was interrupted before MySQL Server 5.1. could be completely installed.

Your system has not been modified. To complete installation at another time, please run
setup again.

Click Finish to exit the wizard
```

This was due to a step in the MSI installer that could fail to execute correctly on some environments. (Bug #45418)

- Propagation of a large unsigned numeric constant in `WHERE` expressions could lead to incorrect results. This also affected `EXPLAIN EXTENDED`, which printed incorrect numeric constants in such transformed `WHERE` expressions. (Bug #45360)
- There was no timeout for attempts to acquire metadata locks (for example, a `DROP TABLE` attempt for a table that was open in another transaction would not time out).

  To handle such situations, there is now a `lock_wait_timeout` system variable that specifies the timeout in seconds for attempts to acquire metadata locks. The permitted values range from 1 to 3153600 (1 year). The default is 3153600.

  This timeout applies to all statements that use metadata locks. These include DML and DDL operations on tables, views, stored procedures, and stored functions, as well as `LOCK TABLES`, `FLUSH TABLES WITH READ LOCK`, and `HANDLER` statements.

  The timeout value applies separately for each metadata lock attempt. A given statement can require more than one lock, so it is possible for the statement to block for longer than the `lock_wait_timeout` value before reporting a timeout error. When lock timeout occurs, `ER_LOCK_WAIT_TIMEOUT` is reported.

  `lock_wait_timeout` does not apply to delayed inserts, which always execute with a timeout of 1 year. This is done to avoid unnecessary timeouts because a session that issues a delayed insert receives no notification of delayed insert timeouts.

  In addition, the unused `table_lock_wait_timeout` system variable was removed. (Bug #45225)
- Valgrind warnings about uninitialized variables in optimizer code were corrected. (Bug #45195)
- Killing a delayed-insert thread could cause a server crash. (Bug #45067)
- Execution of `FLUSH TABLES` or `FLUSH TABLES WITH READ LOCK` concurrently with `LOCK TABLES` resulted in deadlock. (Bug #45066)
- The `mysql_real_connect()` C API function only attempted to connect to the first IP address returned for a hostname. This could be a problem if a hostname mapped to multiple IP address and the server was not bound to the first one returned. Now `mysql_real_connect()` attempts to connect to all IPv4 or IPv6 addresses that a domain name maps to. (Bug #45017)

  See also Bug #47757.
- For plugins that did not have command-line options other than the ones to select the plugin itself, those options were not displayed in the `mysqld` help message. (Bug #44797)
- Some plugins configured as mandatory could be disabled at server startup. (Bug #44691)
- `InnoDB` took a shared row lock when executing `SELECT` statements inside a stored function as a part of a transaction using `REPEATABLE READ`. This prevented other transactions from updating the row. (Bug #44613)
- MySQL Server permitted the creation of a merge table based on views but crashed when attempts were made to read from that table. The following example demonstrates this:

  ```
  #Create a test table
  CREATE TABLE tmp (id int, c char(2));

  #Create two VIEWs upon it
  CREATE VIEW v1 AS SELECT * FROM tmp;
  CREATE VIEW v2 AS SELECT * FROM tmp;

  #Finally create a MERGE table upon the VIEWs
  CREATE TABLE merge (id int, c char(2))
  ENGINE=MERGE UNION(v1, v2);

  #Reading from the merge table lead to a crash
  SELECT * FROM merge;
  ```

  The final statement generated the crash. (Bug #44040)

- A natural join of `INFORMATION_SCHEMA` tables could cause an assertion failure. (Bug #43834)
- When used in conjunction with `LOCK TABLES`, `FLUSH TABLE tbl_list` waited for all tables with old versions to clear from the table definition list, rather than only the named tables. (Bug #43685)
- `HANDLER` statements are now not permitted if a table lock has been acquired with `LOCK TABLES`. (Bug #43272)
- In the embedded server, stack overflow checks for recursive stored procedure calls did not work and stack overflow could occur. (Bug #43201)
- The server could crash if an attempt to open a `MERGE` table child `MyISAM` table failed. (Bug #42862)
- Sign loss could occur in several contexts:
  - `SEC_TO_TIME()` could lose the sign of negative arguments.
  - `MAKETIME()` could lose the sign of negative arguments.
  - Comparison of `TIME` values could lose the sign of operands.

  (Bug #42661, Bug #42662, Bug #42664)
- Setting `key_buffer_size` to a negative value could lead to very large allocations. Now an error occurs. (Bug #42103)
- An assertion failure could occur if `OPTIMIZE TABLE` was started on an `InnoDB` table and the table was altered to a different storage engine during the optimization operation. (Bug #42074)
- The state of a thread for the embedded server was always displayed as `Writing to net`, which is incorrect because there is no network connection for the embedded server. (Bug #41971)
- The patch for Bug #10374 broke named-pipe and shared-memory connections on Windows. (Bug #41860)
- Purging the stored-routine cache could take a long time and render the server unresponsive. (Bug #41804)
- Command-line options for enumeration-type plugin variables were not honored. (Bug #41010)
- System variables could be set to invalid values. (Bug #40988)
- The `CSV` storage engine did not parse `'\X'` characters when they occurred in unquoted fields. (Bug #40814)
- When archive tables were joined on their primary keys, a query returned no result if the optimizer chose to use this index. (Bug #40677)
- `mysqld_safe` did not treat dashes and underscores as equivalent in option names. Thanks to Erik Ljungstrom for the patch to fix this bug. (Bug #40368)
- `SHOW CREATE VIEW` returned invalid SQL if the definition contained a `SELECT 'string'` statement where the `string` was longer than the maximum length of a column name, due to the fact that this text was also used as an alias (in the `AS` clause).

  Because not all names retrieved from arbitrary `SELECT` statements can be used as view column names due to length and format restrictions, the server now checks the conformity of automatically generated column names and rewrites according to a predefined format any names that are not acceptable as view column names before storing the final view definition on disk.

  In such cases, the name is now rewritten as `Name_exp_pos`, where `pos` is the position of the column. To avoid this conversion scheme, define explicit, valid names for view columns using the `column_list` clause of the `CREATE VIEW` statement.

  As part of this fix, aliases are now generated only for top-level statements. (Bug #40277)
- Threads were set to the `Table lock` state in such a way that use of this state by other threads to check for a lock wait was subject to a race condition. (Bug #39897)
- Plugin shutdown could lead to an assertion failure caused by using an already destroyed mutex in the metadata locking subsystem. (Bug #39674)
- Dropping a locked `Maria` table leads to an assertion failure. (Bug #39395)
- Host name lookup failure could lead to a server crash. (Bug #39153)
- `flush_cache_records()` did not correctly check for errors that should cause statement execution to stop, leading to a server crash. (Bug #39022)

- `InnoDB` logged an error repeatedly trying to load a page into the buffer pool, filling the error log and using excessive disk space. Now the number of attempts is limited to 100, after which the operation aborts with a message. (Bug #38901)
- Valgrind warnings that occurred for `SHOW TABLE STATUS` with `InnoDB` tables were silenced. (Bug #38479)
- An IPv6-enabled MySQL server did not resolve the IP addresses of incoming connections correctly, with the result that a connection that attempted to match any privilege table entries using fully-qualified domain names for hostnames or hostnames using wildcards were dropped. (Bug #38247)

  See also Bug #43006, Bug #45283, Bug #45584, Bug #45606.
- For `CREATE TABLE ... LIKE` with a `MERGE` source table that included a `UNION` clause, that clause was omitted from the definition of the destination table. (Bug #37371)
- Previously, statements inside a stored program did not clear the warning list. For example, warnings or errors generated by statements within a trigger or stored function would be accumulated and added to the message list for the statement that activated the trigger or invoked the function, “polluting” the output of `SHOW WARNINGS` or `SHOW ERRORS` for the outer statement. Normally, messages for a statement that can generate messages replace messages from the previous such statement. The effect was that a statement could have a different effect on the message list depending on whether it executed inside or outside of a stored program.

  Now within a stored program, successive statements that can generate messages update the message list and replace messages from the previous such statement. Only messages from the last of these statements is copied to the message list for the outer statement. (Bug #36649)
- `myisampack --join` did not create the destination table `.frm` file. (Bug #36573)
- The parser incorrectly permitted MySQL error code 0 to be specified for a condition handler. (This is incorrect because the condition must be a failure condition and 0 indicates success.) (Bug #36510)
- When parsing or formatting interval values of `DAY_MICROSECOND` type, fractional seconds were not handled correctly when more-significant fields were implied or omitted. (Bug #36466)
- `mysql_install_db` failed if run as `root` and the root directory (`/`) was not writable. (Bug #36462)
- `mysql_stmt_prepare()` did not reset the list of messages (those messages available using `SHOW WARNINGS`). (Bug #36004)
- A global read lock obtained with `FLUSH TABLES WITH READ LOCK` did not prevent sessions from creating tables. (Bug #35935)
- `mysqlbinlog` left temporary files on the disk after shutdown, leading to the pollution of the temporary directory, which eventually caused `mysqlbinlog` to fail. This caused problems in testing and other situations where `mysqlbinlog` might be invoked many times in a relatively short period of time. (Bug #35543)
- When building MySQL when using a different target directory (for example using the `VPATH` environment variable), the build of the embedded `readline` component failed. (Bug #35250)
- String-valued system variables could be assigned literal values, but could not be assigned values using expressions. Now expressions are legal. (Bug #34883, Bug #46314)
- The `sql_mode` system variable could be assigned the illegal value of `'?'`. (Bug #34834)
- Compiling MySQL on FreeBSD failed due to missing definitions for certain network constants. (Bug #34292)
- Creation of a temporary `BLOB` or `TEXT` column could create a column with the wrong maximum length. (Bug #33969)
- `INSERT INTO ... VALUES(DEFAULT)` failed to insert the correct value for `ENUM` columns. For `MyISAM` tables, an empty value was inserted. For `CSV` tables, the table became corrupt. (Bug #33717)
- When `read_only` was enabled, the server incorrectly prevented data modifications to `TEMPORARY` tables belonging to transactional storage engines such as `InnoDB`. (Bug #33669)
- Constant expressions in `WHERE`, `HAVING`, or `ON` clauses were not cached, but were evaluated for each row. This caused a slowdown of query execution, especially if constant user-defined functions or stored functions were used. (Bug #33546)
- Plugins could find the unqualified form of their system variables but not the qualified form. For example, a plugin `p` with a system variable `sv` could find `sv` but not `p_sv`. (Bug #32902)
- Killing a statement that invoked a stored function could return an incorrect error message indicating table corruption rather than that the statement had been interrupted. (Bug #32140)

- Occurrence of an error within a stored routine did not always cause immediate statement termination. (Bug #31881)
- For `DROP FUNCTION db_name.func_name` (that is, when the function name is qualified with the database name), the statement should apply only to a stored function named `func_name` in the given database. However, if a UDF with the same name existed, the statement dropped the UDF instead. (Bug #31767)
- `mysqld` sometimes miscalculated the number of digits required when storing a floating-point number in a `CHAR` column. This caused the value to be truncated, or (when using a debug build) caused the server to crash. (Bug #26788)

  See also Bug #12860.
- `ALTER TABLE` could not be used to add columns to a table if the table had an index on a `utf8` column with a `TEXT` data type. (Bug #26180)
- If an operation had an `InnoDB` table, and two triggers, `AFTER UPDATE` and `AFTER INSERT`, competing for different resources (such as two distinct `MyISAM` tables), the triggers were unable to execute concurrently. In addition, `INSERT` and `UPDATE` statements for the `InnoDB` table were unable to run concurrently. (Bug #26141)
- Statements to create, alter, or drop a view were not waiting for completion of statements that were using the view, which led to incorrect sequences of statements in the binary log when statement-based logging was enabled. (Bug #25144)
- Previously, the server handled character data types for a stored routine parameter, local routine variable created with `DECLARE`, or stored function return value as follows: If the `CHARACTER SET` attribute was present, the `COLLATE` attribute was not supported, so the character set's default collation was used. (This includes use of `BINARY`, which in this context specifies the binary collation of the character set.) If there was no `CHARACTER SET` attribute, the database character set and its default collation were used.

  Now for character data types, if there is a `CHARACTER SET` attribute in the declaration, the specified character set and its default collation is used. If the `COLLATE` is also present, that collation is used rather than the default collation. If there is no `CHARACTER SET` attribute, the database character set and collation in effect at routine creation time are used. (The database character set and collation are given by the value of the `character_set_database` and `collation_database` system variables.) (Bug #24690)
- `Data truncated for column col_num at row row_num` warnings were generated for some (constant) values that did not have too high precision. (Bug #24541)
- A statement that caused a circular wait among statements did not return a deadlock error. Now the server detects deadlock and returns `ER_LOCK_DEADLOCK`. (Bug #22876)
- `CREATE TABLE ... LIKE` did not always produce an error is the source table column defaults were illegal for the current version of MySQL. (This could occur if the table was created using an older server that was less restrictive about legal default values.) (Bug #22090)
- Several data-modification statements were not being counted toward the `MAX_UPDATES_PER_HOUR` user resource limit. (Bug #21793)
- When inserting an extraordinary large value into a `DOUBLE` column, the value could be truncated in such a way that the new value cannot be reloaded manually or from the output of `mysqldump`. (Bug #21497)
- The value of `sql_slave_skip_counter` was empty when displayed by `SHOW VARIABLES` or `INFORMATION_SCHEMA.GLOBAL_VARIABLES`. (Bug #20413, Bug #37187)
- For `INSERT DELAYED` statements issued for a table while an `ALTER TABLE` operation on the table was in progress, the server could return a spurious `Server shutdown in progress` error. (Bug #18484)

  See also Bug #45949.
- Delayed-insert threads were counted as connected but not as created, incorrectly leading to a `Threads_connected` value greater than the `Threads_created` value. (Bug #17954)
- The character set was not being properly initialized for `CAST()` with a type such as `CHAR(2) BINARY`, which resulted in incorrect results or a server crash. (Bug #17903)
- Stored procedure exception handlers were catching fatal errors (such as out of memory errors), which could cause execution not to stop to due a continue handler. Now fatal errors are not caught by exception handlers and a fatal error is returned to the client. (Bug #15192)
- Zero-padding of exponent values was not the same across platforms. (Bug #12860)
- For `CREATE TABLE`, the parser did not enforce that parentheses were present in a `CHECK (expr)` clause; now it does. The parser did not enforce that `CONSTRAINT [symbol]` without a following `CHECK` clause was illegal; now it does. (Bug

#11714, Bug #35578, Bug #38696)

- If a connection was waiting for a `GET_LOCK()` lock or a `SLEEP()` call, and the connection aborted, the server did not detect this and thus did not close the connection. This caused a waste of system resources allocated to dead connections. Now the server checks such a connection every five seconds to see whether it has been aborted. If so, the connection is killed (and any lock request is aborted). (Bug #10374)
- `perror` did not work for errors described in the `sql/share/errmsg.txt` file. (Bug #10143)
- The grammar for `GROUP BY`, when used with `WITH CUBE` or `WITH ROLLUP`, caused a conflict with the grammar for view definitions that included `WITH CHECK OPTION`. (Bug #9801)
- For the `DIV` operator, incorrect results could occur for noninteger operands that exceed `BIGINT` range. Now, if either operand has a noninteger type, the operands are converted to `DECIMAL` and divided using `DECIMAL` arithmetic before converting the result to `BIGINT`. If the result exceeds `BIGINT` range, an error occurs. (Bug #8457, Bug #11745058)

  See also Bug #59241.
- Labels in stored routines did not work if the character set was not `latin1`. (Bug #7088)
- Previously, for some Asian CJK character sets, the `UPPER()` and `LOWER()` functions worked only for basic Latin letters (`A-Z`, `a-z`). The affected character sets are `ujis`, `sjis`, `gb2312`, `cp932`, `eucjpms`, `big5`, `euckr`, and `gbk`.

  Now `UPPER()` and `LOWER()` perform case conversion correctly for all characters in these character sets, with the exception that if a character set contains a character in only one lettercase, conversion to the other lettercase cannot be done.

D.1.15. Changes in MySQL 5.5.2 (12 February 2010)

InnoDB Notes

- This release includes `InnoDB` 1.0.6. This version is considered of Release Candidate (RC) quality.

Functionality Added or Changed

- **Replication**: Introduced the `binlog_direct_non_transactional_updates` system variable. Enabling this variable causes updates using the statement-based logging format to tables using nontransactional engines to be written directly to the binary log, rather than to the transaction cache.

  Before enabling this variable, be certain that you have no dependencies between transactional and nontransactional tables. A statement that both selects from an `InnoDB` table and inserts into a `MyISAM` table is an example of such a dependency. For more information, see Section 15.1.3.4, “Binary Log Options and Variables”. (Bug #46364)

  See also Bug #28976, Bug #40116.

Bugs Fixed

- **Performance**: **Partitioning**: When used on partitioned tables, the `records_in_range` handler call checked more partitions than necessary. The fix for this issue reduces the number of unpruned partitions checked for statistics in partition range checking, which has resulted in some partition operations being performed up to 2-10 times faster than before this change was made, when testing with tables having 1024 partitions. (Bug #48846)

  See also Bug #37252, Bug #47261.
- **Performance**: The method for comparing `INFORMATION_SCHEMA` names and database names was nonoptimal and an improvement was made: When the database name length is already known, a length check is made first and content comparison skipped if the lengths are unequal. (Bug #49501)
- **Performance**: The `MD5()` and `SHA1()` functions had excessive overhead for short strings. (Bug #49491)
- **Security Fix**: For servers built with yaSSL, a preauthorization buffer overflow could cause memory corruption or a server crash. We thank Evgeny Legerov from Intevydis for providing us with a proof-of-concept script that permitted us to reproduce this bug. (Bug #50227, CVE-2009-4484)
- **Incompatible Change**: In `plugin.h`, the `MYSQL_REPLICATION_PLUGIN` symbol was out of synchrony with its value in MySQL 6.0 because the lower-valued `MYSQL_AUDIT_PLUGIN` was not present. To correct this, `MYSQL_AUDIT_PLUGIN`

has been added in MySQL 5.5, changing the value of `MYSQL_REPLICATION_PLUGIN` from 5 to 6. Attempts to load the audit plugin produce an error occurs because only the `MYSQL_AUDIT_PLUGIN` symbol was added, not the audit plugin itself. This error will go away when the audit plugin is added to MySQL 5.5 (in 5.5.3). Replication plugins from earlier 5.5.x releases must be recompiled against the current release before they will work with the current release. (Bug #49894)

- **Important Change**: **Replication**: The `RAND()` function is now marked as unsafe for statement-based replication. Using this function now generates a warning when `binlog_format=STATEMENT` and causes the format to switch to row-based logging when `binlog_format=MIXED`.

  This change is being introduced because, when `RAND()` was logged in statement mode, the seed was also written to the binary log, so the replication slave generated the same sequence of random numbers as was generated on the master. While this could make replication work in some cases, the order of affected rows was still not guaranteed when this function was used in statements that could update multiple rows, such as `UPDATE` or `INSERT ... SELECT`; if the master and the slave retrieved rows in different order, they began to diverge. (Bug #49222)

- **Partitioning**: **InnoDB Storage Engine**: When an `ALTER TABLE ... REORGANIZE PARTITION` statement on an `InnoDB` table failed due to `innodb_lock_wait_timeout` expiring while waiting for a lock, `InnoDB` did not clean up any temporary files or tables which it had created. Attempting to reissue the `ALTER TABLE` statement following the timeout could lead to storage engine errors, or possibly a crash of the server. (Bug #47343)

- **InnoDB Storage Engine**: Creating or dropping a table with 1023 transactions active caused an assertion failure. (Bug #49238)

- **InnoDB Storage Engine**: If `innodb_force_recovery` was set to 4 or higher, the server could crash when opening an `InnoDB` table containing an auto-increment column. MySQL versions 5.1.31 and later were affected. (Bug #46193)

- **Replication**: `FLUSH LOGS` could in some circumstances crash the server. This occurred because the I/O thread could concurrently access the relay log I/O cache while another thread was performing the `FLUSH LOGS`, which closes and reopens the relay log and, while doing so, initializes (or re-initializes) its I/O cache. This could cause problems if some other thread (in this case, the I/O thread) is accessing it at the same time.

  Now the thread performing the `FLUSH LOGS` operation takes a lock on the relay log before actually flushing it. (Bug #50364)

  See also Bug #53657.

- **Replication**: With semisynchronous replication, memory allocated for handling transactions could be freed while still in use, resulting in a server crash. (Bug #50157)

- **Replication**: In some cases, inserting into a table with many columns could cause the binary log to become corrupted. (Bug #50018)

  See also Bug #42749.

- **Replication**: When using row-based replication, setting a `BIT` or `CHAR` column of a `MyISAM` table to `NULL`, then trying to delete from the table, caused the slave to fail with the error CAN'T FIND RECORD IN *TABLE*. (Bug #49481, Bug #49482)

- **Replication**: A `LOAD DATA INFILE` statement that loaded data into a table having a column name that had to be quoted (such as `` `key` INT``) caused replication to fail when logging in mixed or statement mode. In such cases, the master wrote the `LOAD DATA` event into the binary log without quoting the column name. (Bug #49479)

  See also Bug #47927.

- **Replication**: When logging in row-based mode, DDL statements are actually logged as statements; however, statements that affected temporary tables and followed DDL statements failed to reset the binary log format to `ROW`, with the result that these statements were logged using the statement-based format. Now the state of `binlog_format` is restored after a DDL statement has been written to the binary log. (Bug #49132)

- **Replication**: Spatial data types caused row-based replication to crash. (Bug #48776)

- **Replication**: When using row-based logging, the statement `CREATE TABLE t IF NOT EXIST ... SELECT` was logged as `CREATE TEMPORARY TABLE t IF NOT EXIST ... SELECT` when `t` already existed as a temporary table. This was caused by the fact that the temporary table was opened and the results of the `SELECT` were inserted into it when a temporary table existed and had the same name.

  Now, when this statement is executed, `t` is created as a base table, the results of the `SELECT` are inserted into it—even if there already exists a temporary table having the same name—and the statement is logged correctly. (Bug #47418)

  See also Bug #47442.

- **Replication**: Due to a change in the size of event representations in the binary log, when replicating from a MySQL 4.1 master to a slave running MySQL 5.0.60 or later, the `START SLAVE UNTIL` statement did not function correctly, stopping at the wrong position in the log. Now the slave detects that the master is using the older version of the binary log format, and corrects for the difference in event size, so that the slave stops in the correct position. (Bug #47142)

- **Replication**: Manually removing entries from the binary log index file on a replication master could cause the server to repeatedly send the same binary log file to slaves. (Bug #28421)
- The SSL certificates in the test suite were about to expire. They have been updated with expiration dates in the year 2015. (Bug #50642)
- `SPATIAL` indexes were permitted on columns with nonspatial data types, resulting in a server crash for subsequent table inserts. (Bug #50574)
- Index prefixes could be specified with a length greater than the associated column, resulting in a server crash for subsequent table inserts. (Bug #50542)
- Use of loose index scan optimization for an aggregate function with `DISTINCT` (for example, `COUNT(DISTINCT)`) could produce incorrect results. (Bug #50539)
- The `printstack` function does not exist on Solaris 8 or earlier, which led to a compilation failure. (Bug #50409)
- A user could see tables in `INFORMATION_SCHEMA.TABLES` without appropriate privileges for them. (Bug #50276)
- Debug output for join structures was garbled. (Bug #50271)
- The server crashed when an `InnoDB` background thread attempted to write a message containing a partitioned table name to the error log. (Bug #50201)
- Within a stored routine, selecting the result of `CONCAT_WS()` with a routine parameter argument into a user variable could return incorrect results. (Bug #50096)
- The `filesort` sorting method applied to a `CHAR(0)` column could lead to a server crash. (Bug #49897)
- `EXPLAIN EXTENDED UNION ... ORDER BY` caused a crash when the `ORDER BY` referred to a nonconstant or full-text function or a subquery. (Bug #49734)
- Some prepared statements could raise an assertion when re-executed. (Bug #49570)
- `sql_buffer_result` had an effect on non-`SELECT` statements, contrary to the documentation. (Bug #49552)
- In some cases a subquery need not be evaluated because it returns only aggregate values that can be calculated from table metadata. This sometimes was not handled by the enclosing subquery, resulting in a server crash. (Bug #49512)
- Mixing full-text searches and row expressions caused a crash. (Bug #49445)
- `mysql-test-run.pl` now recognizes the `MTR_TESTCASE_TIMEOUT`, `MTR_SUITE_TIMEOUT`, `MTR_SHUTDOWN_TIMEOUT`, and `MTR_START_TIMEOUT` environment variables. If they are set, their values are used to set the `--testcase-timeout`, `--suite-timeout`, `--shutdown-timeout`, and `--start-timeout` options, respectively. (Bug #49210)
- Several `strmake()` calls had an incorrect length argument (too large by one). (Bug #48983)
- On Fedora 12, `strmov()` did not guarantee correct operation for overlapping source and destination buffer. Calls were fixed to use an overlap-safe version instead. (Bug #48866)
- With one thread waiting for a lock on a table, if another thread dropped the table and created a new table with the same name and structure, the first thread did not notice that the table had been re-created and tried to used cached metadata that belonged to the old table but had been freed. (Bug #48157)
- If an invocation of a stored procedure failed in the table-open stage, subsequent invocations that did not fail in that stage could cause a crash. (Bug #47649)
- A crash occurred when a user variable that was assigned to a subquery result was used as a result field in a `SELECT` statement with aggregate functions. (Bug #47371)
- When the `mysql` client was invoked with the `--vertical` option, it ignored the `--skip-column-names` option. (Bug #47147)
- The optimizer could continue to execute a query after a storage engine reported an error, leading to a server crash. (Bug #46175)
- If `EXPLAIN` encountered an error in the query, a memory leak occurred. (Bug #45989)

- A race condition on the privilege hash tables permitted one thread to try to delete elements that had already been deleted by another thread. A consequence was that `SET PASSWORD` or `FLUSH PRIVILEGES` could cause a crash. (Bug #35589, Bug #35591)
- 1) In rare cases, if a thread was interrupted during a `FLUSH PRIVILEGES` operation, a debug assertion occurred later due to improper diagnostics area setup. 2) A `KILL` operation could cause a console error message referring to a diagnostic area state without first ensuring that the state existed. (Bug #33982)
- `ALTER TABLE` with both `DROP COLUMN` and `ADD COLUMN` clauses could crash or lock up the server. (Bug #31145)
- The `Table_locks_waited` waited variable was not incremented in the cases that a lock had to be waited for but the waiting thread was killed or the request was aborted. (Bug #30331)

D.1.16. Changes in MySQL 5.5.1 (04 January 2010)

When the publishing process for MySQL 5.5.1 was already running, the MySQL team was informed about a security problem in the SSL connect area (a possibility to crash the server). The problem is caused by a buffer overflow in the yaSSL library. MySQL Servers using OpenSSL are not affected; it can occur only when SSL (using yaSSL) is enabled.

This problem is under detailed investigation with the various versions, configurations, and platforms. When that has finished, the problem will be fixed as soon as possible, and new binaries for the affected versions will be released. However, building and testing these binaries in the various configurations on the various platforms will take some time. The bug is tracked with CVE ID CVE-2009-4484. We repeat the general security hint: If it is not *absolutely* necessary that external machines can connect to your database instance, we recommend that the server's connection port be blocked by a firewall to prevent any such illegitimate accesses.

Update: This bug is fixed in MySQL 5.5.2.

InnoDB Notes

- `InnoDB` has been upgraded to version 1.0.6. This version is considered of Release Candidate (RC) quality. Section 13.4.12, “InnoDB Storage Engine Change History”, may contain information in addition to those changes reported here.

RPM Notes

- The version information in RPM package files has been changed:
  - The “level” field of a MySQL version number is now also included in the RPM version and in the package file name.
  - The RPM “release” value now counts from 1, not 0.

  For example, the generic x86 server RPM file of 5.5.1-m2 is named `MySQL-server-5.5.1_m2-1.glibc23.i386.rpm`. This improves consistency with other formats that also include the level in the file name (for this version: “m2”). For example, the `tar.gz` file name is `mysql-5.5.1-m2-linux-i686-glibc23.tar.gz`. The different separator, underscore `'_'` for RPM, is required by the syntax of RPM.

Functionality Added or Changed

- **Partitioning**: The `UNIX_TIMESTAMP()` function is now supported in partitioning expressions using `TIMESTAMP` columns. For example, it now possible to create a partitioned table such as this one:

  ```
  CREATE TABLE t (c TIMESTAMP)
  PARTITION BY RANGE ( UNIX_TIMESTAMP(c) ) (
      PARTITION p0 VALUES LESS THAN (631148400),
      PARTITION p1 VALUES LESS THAN (946681200),
      PARTITION p2 VALUES LESS THAN (MAXVALUE)
  );
  ```

  All other expressions involving `TIMESTAMP` values are now rejected with an error for attempts to create a new partitioned table or to alter an existing partitioned table.

  When accessing an existing partitioned table having a timezone-dependent partitioning function (where the table was using a previous version of MySQL), a warning rather than an error is issued. In such cases, you should fix the table. One way of doing this is to alter the table's partitioning expression so that it uses `UNIX_TIMESTAMP()`. (Bug #42849)

Bugs Fixed

- **Performance**: When the query cache is fragmented, the size of the free block lists in the memory bins grows, which causes query cache invalidation to become slow. There is now a 50ms timeout for a `SELECT` statement waiting for the query cache lock. If the timeout expires, the statement executes without using the query cache. (Bug #39253)

  See also Bug #21074.

- **Incompatible Change**: **Replication**: The file names for the semisynchronous plugins were prefixed with `lib`, unlike file names for other plugins. The file names no longer have a `lib` prefix.

  This change introduces an incompatibility if the plugins had been installed using the previous names. To handle this, uninstall the older version before installing the newer version. For example, use these statements for the master side plugins on Unix:

  ```
  mysql> UNINSTALL PLUGIN rpl_semi_sync_master;
  mysql> INSTALL PLUGIN rpl_semi_sync_master SONAME 'semisync_master.so';
  ```

  If you do not uninstall the older version first, attempting to install the newer version results in an error:

  ```
  mysql> INSTALL PLUGIN rpl_semi_sync_master SONAME 'semisync_master.so';
  ERROR 1125 (HY000): Function 'rpl_semi_sync_master' already exists
  ```

  For the slave side, similar statements apply:

  ```
  mysql> UNINSTALL PLUGIN rpl_semi_sync_slave;
  mysql> INSTALL PLUGIN rpl_semi_sync_slave SONAME 'semisync_slave.so';
  ```

- **Important Change**: **Replication**: The following functions have been marked unsafe for statement-based replication:

  - `GET_LOCK()`
  - `IS_FREE_LOCK()`
  - `IS_USED_LOCK()`
  - `MASTER_POS_WAIT()`
  - `RELEASE_LOCK()`
  - `SLEEP()`
  - `SYSDATE()`
  - `VERSION()`

  None of the functions just listed are guaranteed to replicate correctly when using the statement-based format because they can produce different results on the master and the slave. The use of any of these functions while `binlog_format` is set to `STATEMENT` is logged with the warning, `Statement is not safe to log in statement format`. When `binlog_format` is set to `MIXED`, the binary logging format is automatically switched to the row-based format whenever one of these functions is used. (Bug #47995)

- **Important Change**: After a binary upgrade to MySQL 5.1 from a MySQL 5.0 installation that contains `ARCHIVE` tables:

  - Before MySQL 5.1.42, accessing those tables will cause the server to crash, even if you have run `mysql_upgrade` or `CHECK TABLE ... FOR UPGRADE`.
  - As of MySQL 5.1.42, the server will not open 5.0 `ARCHIVE` tables at all.

  In either case, the solution is to use `mysqldump` to dump all 5.0 `ARCHIVE` tables before upgrading, and reload them into MySQL 5.1 after upgrading. The same problem occurs for binary downgrades from MySQL 5.1 to 5.0. (Bug #47012)

- **InnoDB Storage Engine**: When compiling on Windows, an error in the `CMake` definitions for `InnoDB` caused the engine to be built incorrectly. (Bug #49502)

- **Partitioning**: When `SHOW CREATE TABLE` was invoked for a table that had been created using the `COLUMNS` keyword or the `TO_SECONDS()` function, the output contained the wrong MySQL version number in the conditional comments. (Bug #49591)

- **Partitioning**: A query that searched on a `ucs2` column failed if the table was partitioned. (Bug #48737)

- **Partitioning**: In some cases, it was not possible to add a new column to a table that had subpartitions. (Bug #48276)
- **Partitioning**: `SELECT COUNT(*)` from a partitioned table failed when using the `ONLY_FULL_GROUP_BY` SQL mode. (Bug #46923)

  This regression was introduced by Bug #45807.
- **Partitioning**: `SUBPARTITION BY KEY` failed with `DEFAULT CHARSET=utf8`. (Bug #45904)
- **Replication**: When using row-based logging, `TRUNCATE TABLE` was written to the binary log even if the affected table was temporary, causing replication to fail. (Bug #48350)
- **Replication**: A flaw in the implementation of the purging of binary logs could result in orphaned files being left behind in the following circumstances:
  - If the server failed or was killed while purging binary logs.

    If the server failed or was killed after creating of a new binary log when the new log file was opened for the first time.

  In addition, if the slave was not connected during the purge operation, it was possible for a log file that was in use to be removed; this could lead data loss and possible inconsistencies between the master and slave. (Bug #45292)
- **Replication**: When using the `STATEMENT` or `MIXED` logging format, the statements `LOAD DATA CONCURRENT LOCAL INFILE` and `LOAD DATA CONCURRENT INFILE` were logged as `LOAD DATA LOCAL INFILE` and `LOAD DATA LOCAL INFILE`, respectively (in other words, the `CONCURRENT` keyword was omitted). As a result, when using replication with either of these logging modes, queries on the slaves were blocked by the replication SQL thread while trying to execute the affected statements. (Bug #34628)
- **Cluster Replication**: When `expire_logs_days` was set, the thread performing the purge of the log files could deadlock, causing all binary log operations to stop. (Bug #49536)
- For debug builds on Windows, `SAFEMALLOC` was defined inconsistently, leading to mismatches when using `my_malloc()` and `my_free()`. (Bug #49811)
- The `mysql.server` script had incorrect shutdown logic. (Bug #49772)
- The `push_warning_printf()` function was being called with an invalid error level, `MYSQL_ERROR::WARN_LEVEL_ERROR`, causing an assertion failure. To fix the problem, `MYSQL_ERROR::WARN_LEVEL_ERROR` has been replaced by `MYSQL_ERROR::WARN_LEVEL_WARN`. (Bug #49638)
- The result of comparison between nullable `BIGINT` and `INT` columns was inconsistent. (Bug #49517)
- A Valgrind error in `make_cond_for_table_from_pred()` was corrected. Thanks to Sergey Petrunya for the patch to fix this bug. (Bug #49506)
- Incorrect cache initialization prevented storage of converted constant values and could produce incorrect comparison results. (Bug #49489)
- Comparisons involving `YEAR` values could produce incorrect results. (Bug #49480)

  See also Bug #43668.
- Valgrind warnings for `CHECKSUM TABLE` were corrected. (Bug #49465)
- Specifying an index algorithm (such as `BTREE`) for `SPATIAL` or `FULLTEXT` indexes caused a server crash. These index types do not support algorithm specification, and it is not longer permitted to do so. (Bug #49250)
- The optimizer sometimes incorrectly handled conditions of the form `WHERE col_name='const1' AND col_name='const2'`. (Bug #49199)
- Execution of `DECODE()` and `ENCODE()` could be inefficient because multiple executions within a single statement reinitialized the random generator multiple times even with constant parameters. (Bug #49141)
- With binary logging enabled, `REVOKE ... ON {PROCEDURE|FUNCTION} FROM ...` could cause a crash. (Bug #49119)
- The `LIKE` operator did not work correctly when using an index for a `ucs2` column. (Bug #49028)
- `check_key_in_view()` was missing a `DBUG_RETURN` in one code branch, causing a crash in debug builds. (Bug #48995)
- If a query involving a table was terminated with `KILL`, a subsequent `SHOW CREATE TABLE` for that table caused a server

crash. (Bug #48985)

- Privileges for stored routines were ignored for mixed-case routine names. (Bug #48872)

  See also Bug #41049.

- Building MySQL on Fedora Core 12 64-bit failed, due to errors in `comp_err`. (Bug #48864)

- Concurrent `ALTER TABLE` operations on an `InnoDB` table could raise an assertion. (Bug #48782)

- Incomplete reset of internal `TABLE` structures could cause a crash with `eq_ref` table access in subqueries. (Bug #48709)

- During query execution, ranges could be merged incorrectly for `OR` operations and return an incorrect result. (Bug #48665)

- The `InnoDB` Table Monitor reported the `FLOAT` and `DOUBLE` data types incorrectly. (Bug #48526)

- Re-execution of a prepared statement could cause a server crash. (Bug #48508)

- With row-based binary logging, the server crashed for statements of the form `CREATE TABLE IF NOT EXISTS existing_view LIKE temporary_table`. This occurred because the server handled the existing view as a table when logging the statement. (Bug #48506)

- The error message for `ER_UPDATE_INFO` was subject to buffer overflow or truncation. (Bug #48500)

- `DISTINCT` was ignored for queries with `GROUP BY WITH ROLLUP` and only `const` tables. (Bug #48475)

- Loose index scan was inappropriately chosen for some `WHERE` conditions. (Bug #48472)

- The server could crash and corrupt the tablespace if the `InnoDB` tablespace was configured with too small a value, or if `innodb_file_per_table` was enabled and many `CREATE TEMPORARY TABLE` statements were executed and the temporary file directory filled up. (Bug #48469)

- Parts of the range optimizer could be initialized incorrectly, resulting in Valgrind errors. (Bug #48459)

- A bad typecast could cause query execution to allocate large amounts of memory. (Bug #48458)

- `SHOW BINLOG EVENTS` could fail with a error: `Wrong offset or I/O error`. (Bug #48357)

- Valgrind warnings related to binary logging of `LOAD DATA INFILE` statements were corrected. (Bug #48340)

- On Windows, `InnoDB` could not be built as a statically linked library. (Bug #48317)

- `mysql_secure_installation` did not work on Solaris. (Bug #48086)

- When running `mysql_secure_installation`, the command failed if the `root` password contained multiple space, `'\'`, `'#'`, or quote characters. (Bug #48031)

- `MATCH IN BOOLEAN MODE` searches could return too many results inside a subquery. (Bug #47930)

- User-defined collations with an ID less than 256 were not initialized correctly when loaded and caused a server crash. (Bug #47756)

- If a session acquired a global read lock with `FLUSH TABLES WITH READ LOCK`, acquired a lock for one table with `LOCK TABLES`, and issued an `INSERT DELAYED` statement for another table, deadlock could occur. (Bug #47682)

- The `mysql` client `status` command displayed an incorrect value for the server character set. (Bug #47671)

- Connecting to a 4.1.x server from a 5.1.x or higher `mysql` client resulted in a memory-free error when disconnecting. (Bug #47655)

- Queries containing `GROUP BY ... WITH ROLLUP` that did not use indexes could return incorrect results. (Bug #47650)

- Assignment of a system variable sharing the same base name as a declared stored program variable in the same context could lead to a crash. (Bug #47627)

- On Solaris, the server printed no stack trace to the error log after a crash. (Bug #47391)

- The first execution of `STOP SLAVE UNTIL` stopped too early. (Bug #47210)

- The `innodb_file_format_check` system variable could not be set at runtime to `DEFAULT` or to the value of a user-defined variable. (Bug #47167)

- The `IGNORE` clause on a `DELETE` statement masked an SQL statement error that occurred during trigger processing. (Bug #46425)
- Valgrind errors for `InnoDB` were corrected. (Bug #45992, Bug #46656)
- The return value was not checked for some `my_hash_insert()` calls. (Bug #45613)
- It was possible for `init_available_charsets()` not to initialize correctly. (Bug #45058)
- `GROUP BY` on a `constant` (single-row) `InnoDB` table joined to other tables caused a server crash. (Bug #44886)
- For a `VARCHAR(N)` column, `ORDER BY BINARY(col_name)` sorted using only the first `N` bytes of the column, even though column values could be longer than `N` bytes if they contained multibyte characters. (Bug #44131)
- For `YEAR(2)` values, `MIN()`, `MAX()`, and comparisons could yield incorrect results. (Bug #43668)
- Comparison with `NULL` values sometimes did not produce a correct result. (Bug #42760)
- In debug builds, killing a `LOAD XML INFILE` statement raised an assertion.

  Implemented in the course of fixing this bug, `mysqltest` has a new `send_eval` command that combines the functionality of the existing `send` and `eval` commands. (Bug #42520)
- The server could crash when attempting to access a non-conformant `mysql.proc` system table. For example, the server could crash when invoking stored procedure-related statements after an upgrade from MySQL 5.0 to 5.1 without running `mysql_upgrade`. (Bug #41726)
- The `mysql_upgrade` command added three columns to the `mysql.proc` table (`character_set_client`, `collation_connection`, and `db_collation`), but did not populate the columns with correct values. This led to error messages reported during stored procedure execution. (Bug #41569)
- Use of `InnoDB` monitoring (`SHOW ENGINE INNODB STATUS` or one of the `InnoDB` Monitor tables) could cause a server crash due to invalid access to a shared variable in a concurrent environment. (Bug #38883)
- When compressed `MyISAM` files were opened, they were always memory mapped, sometimes causing memory-swapping problems. To deal with this, a new system variable, `myisam_mmap_size`, was added to permit limiting the amount of memory used for memory mapping of `MyISAM` files. (Bug #37408)
- On Windows, the `mysql_secure_installation` command failed to load the `Term::ReadKey` module, which was required for correct operation. (Bug #35106)
- If the `--log-bin` server option was set to a directory name with a trailing component separator character, the basename of the binary log files was empty, so that the created files were named `.000001` and `.index`. The same thing occurred with the `--log-bin-index`, `--relay-log`, and `--relay-log-index` options. Now the server reports and error and exits. (Bug #34739)
- If a comparison involved a constant value that required type conversion, the converted value might not be cached, resulting in repeated conversion and poorer performance. (Bug #34384)
- Using the `SHOW ENGINE INNODB STATUS` statement when using partitions in `InnoDB` tables caused `Invalid (old?) table or database name` errors to be logged. (Bug #32430)
- Output from `mysql --html` did not encode the `'<'`, `'>'`, or `'&'` characters. (Bug #27884)
- Under heavy load with a large query cache, invalidating part of the cache could cause the server to freeze (that is, to be unable to service other operations until the invalidation was complete). (Bug #21074)

  See also Bug #39253.
- On some Windows systems, `InnoDB` could report `Operating system error number 995 in a file operation` due to transient driver or hardware problems. `InnoDB` now retries the operation and adds `Retry attempt is made` to the error message. (Bug #3139)

D.1.17. Changes in MySQL 5.5.0 (07 December 2009 Milestone 2)

Previously, MySQL development proceeded by including a large set of features and moving them over many versions within a release series through several stages of maturity (Alpha, Beta, and so forth). This development model had a disadvantage in that problems with only part of the code could hinder timely release of the whole. As you might have found when testing MySQL Server 6.0, alpha quality code could jeopardize the stability of the entire release. (One consequence of this was that MySQL Server 6.0 has been withdrawn.)

MySQL development now uses a milestone model. The move to this model provides for more frequent milestone releases, with each milestone proceeding through a small number of releases having a focus on a specific subset of thoroughly tested features. Following the releases for one milestone, development proceeds with the next milestone; that is, another small number of releases that focuses on the next small set of features, also thoroughly tested.

MySQL 5.5.0-m2 is the first release for Milestone 2. The new features of this milestone may be considered to be initially of beta quality. For subsequent Milestone 2 releases, we plan to use increasing version numbers (5.5.1 and higher) while continuing to employ the “-m2” suffix. For Milestone 3, we plan to change the suffix to “-m3”. Version designators with “-alpha” or “-beta” suffixes are no used.

You may notice that the MySQL 5.5.0 release is designated as Milestone 2 rather than Milestone 1. This is because MySQL 5.4 was actually designated as Milestone 1, although we had not yet begun referring to milestone numbers as part of version numbers at the time.

InnoDB Notes

- The `InnoDB Plugin` is included in MySQL 5.5 releases as the built-in version of `InnoDB`. The version of the `InnoDB` in this release is 1.0.5 and is considered of Release Candidate (RC) quality.

  This version of `InnoDB` offers new features, improved performance and scalability, enhanced reliability and new capabilities for flexibility and ease of use. Among the features are “Fast index creation,” table and index compression, file format management, new `INFORMATION_SCHEMA` tables, capacity tuning, multiple background I/O threads, and group commit.

  For information about these features, see InnoDB Plugin 1.0 for MySQL 5.1 User’s Guide. For general information about using `InnoDB` in MySQL, see Section 13.3, “The `InnoDB` Storage Engine”.

  In this version of `InnoDB`, the `innodb_file_io_threads` system variable has been removed and replaced with `innodb_read_io_threads` and `innodb_write_io_threads`. If you upgrade from MySQL 5.1 to MySQL 5.5 and previously explicitly set `innodb_file_io_threads` at server startup, you must change your configuration. Either remove any reference to `innodb_file_io_threads` or replace it with references to `innodb_read_io_threads` and `innodb_write_io_threads`.

Functionality Added or Changed

- **Incompatible Change**: MySQL Server now includes a plugin services interface that complements the plugin API. The services interface enables server functionality to be exposed as a “service” that plugins can access using function calls. The `libmysqlservices` library provides access to the available services and dynamic plugins now must be linked against this library (use the `-lmysqlservices` flag). See Section 21.2.5, “MySQL Services for Plugins”. (Bug #48461)

- **Incompatible Change**: Two status variables have been added to `SHOW STATUS` output. `Innodb_buffer_pool_read_ahead` and `Innodb_buffer_pool_read_ahead_evicted` indicate the number of pages read in by the `InnoDB` read-ahead background thread, and the number of such pages evicted without ever being accessed, respectively. Also, the status variables `Innodb_buffer_pool_read_ahead_rnd` and `Innodb_buffer_pool_read_ahead_seq` status variables have been removed. (Bug #42885)

- **Incompatible Change**: The deprecated `--default-table-type` server option has been removed (use `--default-storage-engine`). (Bug #34818)

- **Incompatible Change**: The `TRADITIONAL` SQL mode now includes `NO_ENGINE_SUBSTITUTION`. (Bug #21099)

- **Incompatible Change**: Several changes have been made regarding the language and character set of error messages:

  - The `--language` option for specifying the directory for the error message file is now deprecated. The new `--lc-messages-dir` and `--lc-messages` options should be used instead, and `--language` is handled as an alias for `--lc-messages-dir`.

  - The `language` system variable has been removed and replaced with the new `lc_messages_dir` and `lc_messages` system variables. `lc_messages_dir` has only a global value and is read only. `lc_messages` has global and session values and can be modified at runtime, so the error message language can be changed while the server is running, and individual clients each can have a different error message language by changing their session `lc_messages` value to a different locale name.

  - Error messages previously were constructed in a mix of character sets. This issue is resolved by constructing error messages internally within the server using UTF-8 and returning them to the client in the character set specified by the `character_set_results` system variable. The content of error messages therefore may in some cases differ from the messags returned previously.

  See Section 9.2, “Setting the Error Message Language”, and Section 9.1.6, “Character Set for Error Messages”.

See also Bug #46218, Bug #46236.

- **Partitioning**: New `PARTITION BY RANGE COLUMNS(column_list)` and `PARTITION BY LIST COLUMNS(column_list)` options are added for the `CREATE TABLE` and `ALTER TABLE` statements.

  A major benefit of `RANGE COLUMNS` and `LIST COLUMNS` partitioning is that they make it possible to define ranges or lists based on column values that use string, date, or datetime values.

  These new extensions also broaden the scope of partition pruning to provide better coverage for queries using comparisons on multiple columns in the `WHERE` clause, some examples being `WHERE a = 1 AND b < 10` and `WHERE a = 1 AND b = 10 AND c < 10`.

  See Section 16.2.1, "`RANGE` Partitioning", Section 16.2.2, "`LIST` Partitioning", and Section 16.4, "Partition Pruning".

- **Partitioning**: A new `ALTER TABLE` option, `TRUNCATE PARTITION`, makes it possible to delete rows from one or more selected partitions only. Unlike the case with `ALTER TABLE ... DROP PARTITION`, `ALTER TABLE ... TRUNCATE PARTITION` merely deletes all rows from the specified partition or partitions, and does not change the definition of the table.

- **Partitioning**: It is now possible to assign indexes on partitioned `MyISAM` tables to key caches using the `CACHE INDEX` and to preload such indexes into the cache using `LOAD INDEX INTO CACHE` statements. Cache assignment and preloading of indexes for such tables can be performed for one, several, or all partitions of the table.

  This functionality is supported for only those partitioned tables that employ the `MyISAM` storage engine.

- **Replication**: The global server variable `sync_relay_log` is introduced for use on replication slaves. Setting this variable to a nonzero integer value `N` causes the slave to synchronize the relay log to disk after every `N` events. Setting its value to 0 permits the operating system to handle synchronization of the file. The action of this variable, when enabled, is analogous to how the `sync_binlog` variable works with regard to binary logs on a replication master.

  The global server variables `sync_master_info` and `sync_relay_log_info` are introduced for use on replication slaves to control synchronization of, respectively, the `master.info` and `relay.info` files.

  In each case, setting the variable to a nonzero integer value `N` causes the slave to synchronize the corresponding file to disk after every `N` events. Setting its value to 0 permits the operating system to handle synchronization of the file instead.

  The actions of these variables, when enabled, are analogous to how the `sync_binlog` variable works with regard to binary logs on a replication master.

  An additional system variable `relay_log_recovery` is also now available. When enabled, this variable causes a replication slave to discard relay log files obtained from the replication master following a crash.

  These variables can also be set in `my.cnf`, or by using the `--sync-relay-log`, `--sync-master-info`, `--sync-relay-log-info`, and `--relay-log-recovery` server options.

  For more information, see Section 15.1.3.3, "Replication Slave Options and Variables". (Bug #31665, Bug #35542, Bug #40337)

- **Replication**: Because `SHOW BINLOG EVENTS` cannot be used to read events from relay log files, a new `SHOW RELAYLOG EVENTS` statement has been added for this purpose. (Bug #28777)

- **Replication**: In circular replication, it was sometimes possible for an event to propagate such that it would be reapplied on all servers. This could occur when the originating server was removed from the replication circle and so could no longer act as the terminator of its own events, as normally happens in circular replication.

  To prevent this from occurring, a new `IGNORE_SERVER_IDS` option is introduced for the `CHANGE MASTER TO` statement. This option takes a list of replication server IDs; events having a server ID which appears in this list are ignored and not applied. For more information, see Section 12.5.2.1, "`CHANGE MASTER TO` Syntax".

  In conjunction with the introduction of `IGNORE_SERVER_IDS`, `SHOW SLAVE STATUS` has two new fields. `Replicate_Ignore_Server_Ids` displays information about ignored servers. `Master_Server_Id` displays the `server_id` value from the master. (Bug #25998)

  See also Bug #27808.

- **Replication**: A replication heartbeat mechanism has been added to facilitate monitoring. This provides an alternative to checking log files, making it possible to detect in real time when a slave has failed.

  Configuration of heartbeats is done using a new `MASTER_HEARTBEAT_PERIOD = interval` clause for the `CHANGE MASTER TO` statement (see Section 12.5.2.1, "`CHANGE MASTER TO` Syntax"); monitoring can be done by checking the values of the status variables `Slave_heartbeat_period` and `Slave_received_heartbeats` (see Section 5.1.5, "Server Status Variables").

The addition of replication heartbeats addresses a number of issues:

- Relay logs were rotated every `slave_net_timeout` seconds even if no statements were being replicated.
- `SHOW SLAVE STATUS` displayed an incorrect value for `Seconds_Behind_Master` following a `FLUSH LOGS` statement.
- Replication master-slave connections used `slave_net_timeout` for connection timeouts.

(Bug #20435, Bug #29309, Bug #30932)

- **Replication**: MySQL now supports an interface for semisynchronous replication: A commit performed on the master side blocks before returning to the session that performed the transaction until at least one slave acknowledges that it has received and logged the events for the transaction. Semisynchronous replication is implemented through an optional plugin component. See Section 15.3.8, "Semisynchronous Replication".
- On Linux (and perhaps other systems), the performance of MySQL Server can be improved by using a different `malloc()` implementation, developed by Google and called `tcmalloc`. The gain is noticeable with a higher number of simultaneous users. To support use of this library, the following changes have been made:

  - The server is linked against the default `malloc()` provided by the respective platform.
  - Binary distributions for Linux include `libtcmalloc_minimal.so` (a shared library that can be linked against at runtime) in `pkglibdir` (that is, the same directory within the package where server plugins and similar object files are located). The version of `tcmalloc` included with MySQL comes from `google-perftools` 1.4.

    If you want to try `tcmalloc` but are using a binary distribution for a non-Linux platform or a source distribution, you can install Google's `tcmalloc`. Some distributions provide it in a `google-perftools` package or with a similar name, or you can download it from Google at http://code.google.com/p/google-perftools/ and compile it yourself.
  - `mysqld_safe` now supports a `--malloc-lib` option that enables administrators to specify that `mysqld` should use `tcmalloc`.

  The `--malloc-lib` option works by modifying the `LD_PRELOAD` environment value to affect dynamic linking to enable the loader to find the memory-allocation library when `mysqld` runs:

  - If the option is not given, or is given without a value (`--malloc-lib=`), `LD_PRELOAD` is not modified and no attempt is made to use `tcmalloc`.
  - If the option is given as `--malloc-lib=tcmalloc`, `mysqld_safe` looks for a `tcmalloc` library in `/usr/lib` and then in the MySQL `pkglibdir` location (for example, `/usr/local/mysql/lib` or whatever is appropriate). If `tmalloc` is found, its path name is added to the beginning of the `LD_PRELOAD` value for `mysqld`. If `tcmalloc` is not found, `mysqld_safe` aborts with an error.
  - If the option is given as `--malloc-lib=/path/to/some/library`, that full path is added to the beginning of the `LD_PRELOAD` value. If the full path points to a nonexistent or unreadable file, `mysqld_safe` aborts with an error.
  - For cases where `mysqld_safe` adds a path name to `LD_PRELOAD`, it adds the path to the beginning of any existing value the variable already has.

  As a result of the preceding changes, Linux users can use the `libtcmalloc_minimal.so` now included in binary packages by adding these lines to the `my.cnf` file:

  ```
  [mysqld_safe]
  malloc-lib=tcmalloc
  ```

  Those lines also suffice for users on any platform who have installed a `tcmalloc` package in `/usr/lib`. To use a specific `tcmalloc` library, specify its full path name. Example:

  ```
  [mysqld_safe]
  malloc-lib=/opt/lib/libtcmalloc_minimal.so
  ```

  (Bug #47549)
- The `InnoDB` buffer pool is divided into two sublists: A new sublist containing blocks that are heavily used by queries, and an old sublist containing less-used blocks and from which candidates for eviction are taken. In the default operation of the buffer pool, a block when read in is loaded at the midpoint and then moved immediately to the head of the new sublist as soon as an access occurs. In the case of a table scan (such as performed for a `mysqldump` operation), each block read by the scan ends up moving to the head of the new sublist because multiple rows are accessed from each block. This occurs even for a one-time

scan, where the blocks are not otherwise used by other queries. Blocks may also be loaded by the read-ahead background thread and then moved to the head of the new sublist by a single access. These effects can be disadvantageous because they push blocks that are in heavy use by other queries out of the new sublist to the old sublist where they become subject to eviction.

`InnoDB` now provides two system variables that enable LRU algorithm tuning:

- `innodb_old_blocks_pct`

  Specifies the approximate percentage of the buffer pool used for the old block sublist. The range of values is 5 to 95. The default value is 37 (that is, 3/8 of the pool).

- `innodb_old_blocks_time`

  Specifies how long in milliseconds (ms) a block inserted into the old sublist must stay there after its first access before it can be moved to the new sublist. The default value is 0: A block inserted into the old sublist moves immediately to the new sublist the first time it is accessed, no matter how soon after insertion the access occurs. If the value is greater than 0, blocks remain in the old sublist until an access occurs at least that many ms after the first access. For example, a value of 1000 causes blocks to stay in the old sublist for 1 second after the first access before they become eligible to move to the new sublist.

See Section 7.9.1, “The `InnoDB` Buffer Pool”. (Bug #45015)

- The `have_community_features` system variable was renamed to `have_profiling`.

  Previously, to enable profiling, it was necessary to run `configure` with the `--enable-community-features` and `--enable-profiling` options. Now only `--enable-profiling` is needed. (Bug #44651)

- Columns that provide a catalog value in `INFORMATION_SCHEMA` tables (for example, `TABLES.TABLE_CATALOG`) now have a value of `def` rather than `NULL`. (Bug #35427)

- Previously, `mysqldump` would not dump the `INFORMATION_SCHEMA` database and ignored it if it was named on the command line. Now, `mysqldump` will dump `INFORMATION_SCHEMA` if it is named on the command line. Currently, this requires that the `--skip-lock-tables` (or `--skip-opt`) option be given. (Bug #33762)

- Several undocumented C API functions were removed: `mysql_manager_close()`, `mysql_manager_command()`, `mysql_manager_connect()`, `mysql_manager_fetch_line()`, `mysql_manager_init()`, `mysql_disable_reads_from_master()`, `mysql_disable_rpl_parse()`, `mysql_enable_reads_from_master()`, `mysql_enable_rpl_parse()`, `mysql_master_query()`, `mysql_master_send_query()`, `mysql_reads_from_master_enabled()`, `mysql_rpl_parse_enabled()`, `mysql_rpl_probe()`, `mysql_rpl_query_type()`, `mysql_set_master()`, `mysql_slave_query()`, and `mysql_slave_send_query()`. (Bug #31952, Bug #31954)

- Sinhala collations `utf8_sinhala_ci` and `ucs2_sinhala_ci` were added for the `utf8` and `ucs2` character sets. (Bug #26474)

- If the value of the `--log-warnings` option is greater than 1, the server now writes access-denied errors for new connection attempts to the error log (for example, if a client user name or password is incorrect). (Bug #25822)

- On Windows, use of POSIX I/O interfaces in `mysys` was replaced with Win32 API calls (`CreateFile()`, `WriteFile()`, and so forth) and the default maximum number of open files has been increased to 16384. The maximum can be increased further by using the `--open-files-limit=N` option at server startup. (Bug #24509)

- MySQL now implements the SQL standard `SIGNAL` and `RESIGNAL` statements. See Section 12.7.8, “`SIGNAL` and `RESIGNAL`”. (Bug #11661)

- The undocumented, deprecated, and not useful `SHOW COLUMN TYPES` statement has been removed. (Bug #5299)

- The `libmysqlclient` client library is now built as a thread-safe library. The `libmysqlclient_r` client library is still present for compatibility, but is just a symlink to `libmysqlclient`.

- The `FORMAT()` function now supports an optional third parameter that enables a locale to be specified to be used for the result number's decimal point, thousands separator, and grouping between separators. Permissible locale values are the same as the legal values for the `lc_time_names` system variable (see Section 9.7, “MySQL Server Locale Support”). For example, the result from `FORMAT(1234567.89,2,'de_DE')` is `1.234.567,89`. If no locale is specified, the default is `'en_US'`.

- The Greek locale `'el_GR'` is now a permissible value for the `lc_time_names` system variable.

- Previously, in the absence of other information, the MySQL client programs `mysql`, `mysqladmin`, `mysqlcheck`, `mysqlimport`, and `mysqlshow` used the compiled-in default character set, usually `latin1`.

  Now these clients can autodetect which character set to use based on the operating system setting, such as the value of the

`LANG` or `LC_ALL` locale environment language on Unix system or the code page setting on Windows systems. For systems on which the locale is available from the OS, the client uses it to set the default character set rather than using the compiled-in default. Thus, users can configure the locale in their environment for use by MySQL clients. For example, setting `LANG` to `ru_RU.KOI8-R` causes the `koi8r` character set to be used. The OS character set is mapped to the closest MySQL character set if there is no exact match. If the client does not support the matching character set, it uses the compiled-in default. (For example, `ucs2` is not supported as a connection character set.)

An implication of this change is that if your environment is configured to use a non-`latin1` locale, MySQL client programs will use a different connection character set than previously, as though you had issued an implicit `SET NAMES` statement. If the previous behavior is required, start the client with the `--default-character-set=latin1` option.

Third-party applications that wish to use character set autodetection based on the OS setting can use the following `mysql_options()` call before connecting to the server:

```
mysql_options(mysql,
              MYSQL_SET_CHARSET_NAME,
              MYSQL_AUTODETECT_CHARSET_NAME);
```

See Section 9.1.4, “Connection Character Sets and Collations”.

- `mysql_upgrade` now has an `--upgrade-system-tables` option that causes only the system tables to be upgraded. With this option, data upgrades are not performed.

- The `CREATE TABLESPACE` privilege has been introduced. This privilege exists at the global (superuser) level and enables you to create, alter, and drop tablespaces and logfile groups.

- The server now supports a Debug Sync facility for thread synchronization during testing and debugging. To compile in this facility, configure MySQL with the `--enable-debug-sync` option. The `debug_sync` system variable provides the user interface Debug Sync. `mysqld` and `mysql-test-run.pl` support a `--debug-sync-timeout` option to enable the facility and set the default synchronization point timeout.

- Added the `TO_SECONDS()` function, which converts a date or datetime value to a number of seconds since the year 0. This is a general-purpose function, but is useful for partitioning. You may use this function in partitioning expressions, and partition pruning is supported for tables defined using such expressions.

- Parser performance was improved for identifier scanning and conversion of ASCII string literals.

- The `LOAD XML INFILE` statement was added. This statement makes it possible to read data directly from XML files into database tables. For more information, see Section 12.2.7, “`LOAD XML` Syntax”.

Bugs Fixed

- **Performance**: The server unnecessarily acquired a query cache mutex even with the query cache disabled, resulting in a small performance decrement which could show up as threads often in the “invalidating query cache entries (table)” state, particularly on a replication slave with row-based replication. Now if the server is started with `query_cache_type` set to 0, it does not acquire the query cache mutex. This has the implication that the query cache cannot be enabled at runtime. (Bug #38551)

- **Performance**: The `InnoDB` adaptive hash latch is released (if held) for several potentially long-running operations. This improves throughput for other queries if the current query is removing a temporary table, changing a temporary table from memory to disk, using `CREATE TABLE ... SELECT`, or performing a `MyISAM` repair on a table used within a transaction. (Bug #32149)

- **Important Change**: **Security Fix**: It was possible to circumvent privileges through the creation of `MyISAM` tables employing the `DATA DIRECTORY` and `INDEX DIRECTORY` options to overwrite existing table files in the MySQL data directory. Use of the MySQL data directory in `DATA DIRECTORY` and `INDEX DIRECTORY` is no longer permitted. This is now also true of these options when used with partitioned tables and individual partitions of such tables. (Bug #32167, CVE-2008-2079)

  See also Bug #39277.

- **Security Fix**: MySQL clients linked against OpenSSL could be tricked not to check server certificates. (Bug #47320, CVE-2009-4028)

- **Security Fix**: The server crashed if an account without the proper privileges attempted to create a stored procedure. (Bug #44658)

- **Incompatible Change**: **Replication**: Concurrent transactions that inserted rows into a table with an `AUTO_INCREMENT` column could break statement-based or mixed-format replication error 1062 `Duplicate entry '...' for key 'PRIMARY'` on the slave. This was especially likely to happen when one of the transactions activated a trigger that inserted rows into the table with the `AUTO_INCREMENT` column, although other conditions could also cause the issue to manifest.

As part of the fix for this issue, any statement that causes a trigger or function to update an `AUTO_INCREMENT` column is now considered unsafe for statement-based replication. For more information, see Section 15.4.1.1, "Replication and `AUTO_INCREMENT`". (Bug #45677)

See also Bug #42415, Bug #48608, Bug #50440, Bug #53079.

- **Incompatible Change**: For system variables that take values of `ON` or `OFF`, `OF` was accepted as a legal variable. Now system variables that take "enumeration" values must be assigned the full value. This affects some other variables that previously could be assigned using unambiguous prefixes of permissible values, such as `tx_isolation`. (Bug #34828)

- **Incompatible Change**: In binary installations of MySQL, the supplied `binary-configure` script would start and configure MySQL, even when command help was requested with the `--help` command-line option. The `--help` option, if provided, no longer starts and installs the server. (Bug #30954)

- **Incompatible Change**: Access privileges for several statements are more accurately checked:

  - `CHECK TABLE` requires some privilege for the table.
  - `CHECKSUM TABLE` requires `SELECT` for the table.
  - `CREATE TABLE ... LIKE` requires `SELECT` for the source table and `CREATE` for the destination table.
  - `SHOW COLUMNS` displays information only for those columns for which you have some privilege.
  - `SHOW CREATE TABLE` requires some privilege for the table (previously required `SELECT`).
  - `SHOW CREATE VIEW` requires `SHOW VIEW` and `SELECT` for the view.
  - `SHOW INDEX` requires some privilege for any column.
  - `SHOW OPEN TABLES` displays only tables for which you have some privilege on any column.

  (Bug #27145)

- **Important Change**: **Replication**: `MyISAM` transactions replicated to a transactional slave left the slave in an unstable condition. This was due to the fact that, when replicating from a nontransactional storage engine to a transactional engine with `autocommit` disabled, no `BEGIN` and `COMMIT` statements were written to the binary log; thus, on the slave, a never-ending transaction was started.

  The fix for this issue includes enforcing `autocommit` mode on the slave by replicating all `autocommit=1` statements from the master. (Bug #29288)

- **Important Change**: **Replication**: The `CHANGE MASTER TO` statement required the value for `RELAY_LOG_FILE` to be an absolute path, whereas the `MASTER_LOG_FILE` path could be relative.

  The inconsistent behavior is resolved by permitting relative paths for `RELAY_LOG_FILE`, and by using the same basename for `RELAY_LOG_FILE` as for `MASTER_LOG_FILE`. For more information, see Section 12.5.2.1, "`CHANGE MASTER TO` Syntax". (Bug #12190, Bug #11745232)

- **Important Change**: An option that requires a value, when specified in an option file without a value, was assigned the text of the next line in the file as the value. Now, if you fail to specify a required value in an option file, the server aborts with an error.

  This change does not effect how options are handled by the server when they are used on the command line. For example, starting the server using `mysqld_safe --relay-log --relay-log-index &` causes the server to create relay log files named `--relay-log-index.000001`, `--relay-log-index.000002`, and so on, because the `--relay-log` option expects an argument. (Bug #25192)

- **Partitioning**: An `ALTER TABLE ... ADD PARTITION` statement that caused `open_files_limit` to be exceeded led to a MySQL server crash. (Bug #46922)

  See also Bug #47343.

- **Partitioning**: When performing an `INSERT ... SELECT` into a partitioned table, `read_buffer_size` bytes of memory were allocated for every partition in the target table, resulting in consumption of large amounts of memory when the table had many partitions (more than 100).

  This fix changes the method used to estimate the buffer size required for each partition and limits the total buffer size to a maximum of approximately 10 times `read_buffer_size`. (Bug #45840)

- **Partitioning**: The cardinality of indexes on partitioned tables was calculated using the first partition in the table, which could result in suboptimal query execution plans being chosen. Now the partition having the most records is used instead, which should result in better use of indexes and thus improved performance of queries against partitioned tables in many if not most cases. (Bug #44059)

- **Partitioning**: Truncating a partitioned `MyISAM` table did not reset the `AUTO_INCREMENT` value. (Bug #35111)
- **Partitioning**: For partitioned tables with more than ten partitions, a full table scan was used in some cases when only a subset of the partitions were needed. (Bug #33730)
- **Replication**: When using statement-based or mixed-format replication, the database name was not written to the binary log when executing a `LOAD DATA INFILE` statement. This caused problems when the table being loaded belonged to a database other than the current database; data could be loaded into the wrong table (if a table having the same name existed in the current database) or replication could fail (if no table having that name existed in the current database). Now a table referenced in a `LOAD DATA INFILE` statement is always logged using its fully qualified name when the database to which it belongs is not the current database. (Bug #48297)
- **Replication**: When a session was closed on the master, temporary tables belonging to that session were logged with the wrong database names when either of the following conditions was true:

  1. The length of the name of the database to which the temporary table belonged was greater than the length of the current database name.
  2. The current database was not set.

  (Bug #48216)

  See also Bug #46861, Bug #48297.
- **Replication**: When using row-based replication, changes to nontransactional tables that occurred early in a transaction were not immediately flushed upon committing a statement. This behavior could break consistency since changes made to nontransactional tables become immediately visible to other connections. (Bug #47678)

  See also Bug #47287, Bug #46864, Bug #43929, Bug #11752675, Bug #46129.
- **Replication**: When `mysqlbinlog --verbose` was used to read a binary log that had been written using row-based format, the output for events that updated some but not all columns of tables was not correct. (Bug #47323)
- **Replication**: Performing `ALTER TABLE ... DISABLE KEYS` on a slave table caused row-based replication to fail. (Bug #47312)
- **Replication**: When using the row-based format to replicate a transaction involving both transactional and nontransactional engines, which contained a DML statement affecting multiple rows, the statement failed. If this transaction was followed by a `COMMIT`, the master and the slave could diverge, because the statement was correctly rolled back on the master, but was applied on the slave. (Bug #47287)

  See also Bug #46864.
- **Replication**: `BEGIN` statements were not included in the output of `mysqlbinlog`. (Bug #46998)
- **Replication**: A problem with the `BINLOG` statement in the output of `mysqlbinlog` could break replication; statements could be logged with the server ID stored within events by the `BINLOG` statement rather than the ID of the running server. With this fix, the server ID of the server executing the statements can no longer be overridden by the server ID stored in the binary log's `format description` statement. (Bug #46640)

  This regression was introduced by Bug #32407.
- **Replication**: When using row-based replication, `DROP TEMPORARY TABLE IF EXISTS` was written to the binary log if the table named in the statement did not exist, even though a `DROP TEMPORARY TABLE` statement should never be logged in row-based logging mode, whether the table exists or not. (Bug #46572)
- **Replication**: The internal function `get_master_version_and_clock()` (defined in `sql/slave.cc`) ignored errors and passed directly when queries failed, or when queries succeeded but the result retrieved was empty. Now this function tries to reconnect the master if a query fails due to transient network problems, and to fail otherwise. The I/O thread now prints a warning if the same system variables do not exist on master (in the event the master is a very old version of MySQL, compared to the slave.) (Bug #45214)
- **Replication**: Replicating `TEXT` or `VARCHAR` columns declared as `NULL` on the master but `NOT NULL` on the slave caused the slave to crash. (Bug #43789)

  See also Bug #38850, Bug #43783, Bug #43785, Bug #47741, Bug #48091.

- **Replication**: By default, all statements executed by the `mysql_upgrade` program on the master are written to the binary log, then replicated to the slave. In some cases, this can result in problems; for example, it attempted to alter log tables on replicated databases (this failed due to logging being enabled).

  As part of this fix, a `mysql_upgrade` option, `--write-binlog`, is added. Its inverse, `--skip-write-binlog`, can be used to disable binary logging while the upgrade is in progress. (Bug #43579)

- **Replication**: Two issues encountered on replication slaves during startup were fixed:

  1. A failure while allocating the master info structure caused the slave to crash.

  2. A failure during recovery caused the relay log file not to be properly initialized which led to a crash on the slave.

  (Bug #43075)

- **Replication**: When the logging format was set without binary logging being enabled, the server failed to start. Now in such cases, the server starts successfully, `binlog_format` is set, and a warning is logged instead of an error. (Bug #42928)

- **Replication**: On the master, if a binary log event is larger than `max_allowed_packet`, the error message `ER_MASTER_FATAL_ERROR_READING_BINLOG` is sent to a slave when it requests a dump from the master, thus leading the I/O thread to stop. On a slave, the I/O thread stops when receiving a packet larger than `max_allowed_packet`.

  In both cases, however, there was no `Last_IO_Error` reported, which made it difficult to determine why the slave had stopped in such cases. Now, `Last_IO_Error` is reported when `max_allowed_packet` is exceeded, and provides the reason for which the slave I/O thread stopped. (Bug #42914)

  See also Bug #14068, Bug #47200, Bug #47303.

- **Replication**: When using statement-based replication and the transaction isolation level was set to `READ COMMITTED` or a less strict level, `InnoDB` returned an error even if the statement in question was filtered out according to the `--binlog-do-db` or `--binlog-ignore-db` rules in effect at the time. (Bug #42829)

- **Replication**: When using row-based format, replication failed with the error `COULD NOT EXECUTE WRITE_ROWS EVENT ON TABLE ...; FIELD '...' DOESN'T HAVE A DEFAULT VALUE` when an `INSERT` was made on the master without specifying a value for a column having no default, even if strict server SQL mode was not in use and the statement would otherwise have succeeded on the master. Now the SQL mode is checked, and the statement is replicated unless strict mode is in effect. For more information, see Section 5.1.6, "Server SQL Modes". (Bug #38173)

  See also Bug #38262, Bug #43992.

- **Replication**: When `autocommit` was set equal to `1` after starting a transaction, the binary log did not commit the outstanding transaction. This happened because the binary log commit function saw only the values of the new settings, and decided that there was nothing to commit.

  This issue was first observed when using the `Falcon` storage engine, but it is possible that it affected other storage engines as well. (Bug #37221)

- **Replication**: `FLUSH LOGS` did not close and reopen the binary log index file. (Bug #34582)

  See also Bug #48738.

- **Replication**: An error message relating to permissions required for `SHOW SLAVE STATUS` was confusing. (Bug #34227)

- **Replication**: The `--base64-output` option for `mysqlbinlog` was not honored for all types of events. This interfered in some cases with performing point-in-time recovery. (Bug #32407)

  See also Bug #46640, Bug #34777.

- **Replication**: The value of `Slave_IO_running` in the output of `SHOW SLAVE STATUS` did not distinguish between all 3 possible states of the slave I/O thread (not running; running but not connected; connected). Now the value `Connecting` (rather than `No`) is shown when the slave I/O thread is running but the slave is not connected to a replication master.

  The server system variable `Slave_running` also reflects this change, and is now consistent with what is shown for `Slave_IO_running`. (Bug #30703, Bug #41613, Bug #51089)

- **Replication**: Queries written to the slow query log on the master were not written to the slow query log on the slave. (Bug #23300)

  See also Bug #48632.

- **Replication**: Valgrind revealed an issue with `mysqld` that was corrected: memory corruption in replication slaves when switching databases. (Bug #19022)

- **API**: The fix for Bug #24507 could lead in some cases to client application failures due to a race condition. Now the server waits for the “dummy” thread to return before exiting, thus making sure that only one thread can initialize the POSIX threads library. (Bug #42850)
- Certain `INTERVAL` expressions could cause a crash on 64-bit systems. (Bug #48739)
- Following a literal, the `COLLATE` clause was mishandled such that different results could be produced depending on whether an index was used. (Bug #48447)
- `SUM()` artificially increased the precision of a `DECIMAL` argument, which was truncated when a temporary table was created to hold the results. (Bug #48370)

  See also Bug #45261.
- `GRANT` and `REVOKE` crashed if a user name was specified as `CURRENT_USER()`. (Bug #48319)
- If an outer query was invalid, a subquery might not be set up. `EXPLAIN EXTENDED` did not expect this and caused a crash by trying to dereference improperly set up information. (Bug #48295)
- A query containing a view using temporary tables and multiple tables in the `FROM` clause and `PROCEDURE ANALYSE()` caused a server crash.

  As a result of this bug fix, `PROCEDURE ANALYSE()` is legal only in a top-level `SELECT`. (Bug #48293)

  See also Bug #46184.
- Error handling was missing for `SELECT` statements containing subqueries in the `WHERE` clause and that assigned a `SELECT` result to a user variable. The server could crash as a result. (Bug #48291)
- An assertion could fail if the optimizer used a `SPATIAL` index. (Bug #48258, Bug #47019)
- `InnoDB` mishandled memory-allocation failures in the `os_mem_alloc_large()` function. (Bug #48237)
- `WHERE` clauses with *`outer_value_list`* `NOT IN` *`subquery`* were handled incorrectly if the outer value list contained multiple items at least one of which could be `NULL`. (Bug #48177)
- Searches using a nondefault collation could return different results for a table depending on whether partitioning was used. (Bug #48161)
- A combination of `GROUP BY WITH ROLLUP`, `DISTINCT` and the `const` join type in a query caused a server crash when the optimizer used a temporary table to resolve `DISTINCT`. (Bug #48131)
- The subquery optimizer had a memory leak. (Bug #48060)
- Server shutdown failed on Windows. (Bug #48047)
- In some cases, using a null microsecond part in a `WHERE` condition (for example, `WHERE date_time_field <= 'YYYY-MM-DD HH:MM:SS.0000'`) could lead to incorrect results due to improper `DATETIME` comparison. (Bug #47963)
- A build configured using the `--without-server` option did not compile the yaSSL code, so if `--with-ssl` was also used, the build failed. (Bug #47957)
- When a query used a `DATE` or `DATETIME` value formatted using any separator characters other than hyphen (`'-'`) and a `>=` condition matching only the greatest value in an indexed column, the result was empty if an index range scan was employed. (Bug #47925)
- `mysys/mf_keycache.c` requires threading, but no test was made for thread support. (Bug #47923)
- For debug builds, an assertion could fail during the next statement executed for a temporary table after a multiple-table `UPDATE` involving that table modified an `AUTO_INCREMENT` column with a user-supplied value. (Bug #47919)
- The `mysys/mf_strip.c` file, which defines the `strip_sp()` function, has been removed from the MySQL source. The function was no longer used within the main build, and the supplied function was causing symbol errors on Windows builds. (Bug #47857)
- When building storage engines on Windows it was not possible to specify additional libraries within the `CMake` file required for the build. An `${engine}_LIBS` macro has been included in the files to support these additional storage-engine specific libraries. (Bug #47797)

- When building a pluggable storage engine on Windows, the engine name could be based on the directory name where the engine was located, rather than the configured storage engine name. (Bug #47795)
- During cleanup of a stored procedure's internal structures, the flag to ignore the errors for `INSERT IGNORE` or `UPDATE IGNORE` was not cleaned up, which could result in a server crash. (Bug #47788)
- If the first argument to `GeomFromWKB()` function was a geometry value, the function just returned its value. However, it failed to preserve the argument's `null_value` flag, which caused an unexpected `NULL` value to be returned to the caller, resulting in a server crash. (Bug #47780)
- `InnoDB` could crash when updating spatial values. (Bug #47777)
- The `pthread_cond_wait()` implementations for Windows could deadlock in some rare circumstances. (Bug #47768)
- The encoding of values for `SET system_variable = identifier` statements was incorrect, resulting in incorrect error messages. (Bug #47597)
- On Windows, when an idle named pipe connection was forcibly closed with a `KILL` statement or because the server was being shut down, the thread that was closing the connection would hang infinitely.

  As a result of the work done for this bug, the `net_read_timeout` and `net_write_timeout` system variables now apply to connections over all transports, not just to TCP/IP. (Bug #47571, Bug #31621)
- On Mac OS X or Windows, sending a `SIGHUP` signal to the server or an asynchronous flush (triggered by `flush_time`) caused the server to crash. (Bug #47525)
- Debug builds could not be compiled with the Sun Studio compiler. (Bug #47474)
- Queries of the form `SELECT SUM(DISTINCT varchar_key) FROM tbl_name` caused a server crash. (Bug #47421)
- A function call could end without throwing an error or setting the return value. For example, this could happen when an error occurred while calculating the return value. This is fixed by setting the value to `NULL` when an error occurs during evaluation of an expression. (Bug #47412)
- `mysqladmin debug` could crash on 64-bit systems. (Bug #47382)
- A simple `SELECT` with implicit grouping could return many rows rather than a single row if the query was ordered by the aggregated column in the select list. (Bug #47280)
- An assertion could be raised for `CREATE TABLE` if there was a pending `INSERT DELAYED` or `REPLACE DELAYED` for the same table. (Bug #47274)
- `InnoDB` raised errors in some cases in a manner not compatible with `SIGNAL` and `RESIGNAL`. (Bug #47233)
- A multiple-table `UPDATE` involving a natural join and a mergeable view raised an assertion. (Bug #47150)
- On FreeBSD, memory mapping for `MERGE` tables could fail if underlying tables were empty. (Bug #47139)
- Solaris binary packages now are compiled with `-g0` rather than `-g`. (Bug #47137)
- If an `InnoDB` table was created with the `AUTO_INCREMENT` table option to specify an initial auto-increment value, and an index was added in a separate operation later, the auto-increment value was lost (subsequent inserts began at 1 rather than the specified value). (Bug #47125)
- Incorrect handling of predicates involving `NULL` by the range optimizer could lead to an infinite loop during query execution. (Bug #47123)
- `EXPLAIN` caused a server crash for certain valid queries. (Bug #47106)
- Repair by sort or parallel repair of `MyISAM` tables might not fail over to repair with key cache. (Bug #47073)
- `InnoDB` did not compile on some Solaris systems. (Bug #47058)
- On Windows, when a failed I/O operation occurred with return code of `ERROR_WORKING_SET_QUOTA`, `InnoDB` intentionally crashed the server. Now `InnoDB` sleeps for 100ms and retries the failed operation. (Bug #47055)
- The `mysql_config` script contained a reference to `@innodb_system_libs@` that was not replaced with the corresponding library flags during the build process and ended up in the output of `mysql_config --libs`. (Bug #47007)
- The `configure` option `--without-server` did not work. (Bug #46980)

- `InnoDB` now ignores negative values supplied by a user for an `AUTO_INCREMENT` column when calculating the next value to store in the data dictionary. Setting `AUTO_INCREMENT` columns to negative values is undefined behavior and this change should bring the behavior of `InnoDB` closer to what users expect. (Bug #46965)
- Failed multiple-table `DELETE` statements could raise an assertion. (Bug #46958)
- When MySQL crashed (or a snapshot was taken that simulates a crash), it was possible that internal XA transactions (used to synchronize the binary log and `InnoDB`) could be left in a `PREPARED` state, whereas they should be rolled back. This occurred when the `server_id` value changed before the restart, because that value was used to construct XID values.

  Now the restriction is relaxed that the `server_id` value be consistent for XID values to be considered valid. The rollback phase should then be able to clean up all pending XA transactions. (Bug #46944)
- When creating a new instance on Windows using `mysqld-nt` and the `--install` parameter, the value of the service would be set incorrectly, resulting in a failure to start the configured service. (Bug #46917)
- The test suite was missing from RPM packages. (Bug #46834)
- For `InnoDB` tables, an unnecessary table rebuild for `ALTER TABLE` could sometimes occur for metadata-only changes. (Bug #46760)
- The server could crash for queries with the following elements: 1. An “impossible where” in the outermost `SELECT`; 2. An aggregate in the outermost `SELECT`; 3. A correlated subquery with a `WHERE` clause that includes an outer field reference as a top-level `WHERE` sargable predicate; (Bug #46749)
- `InnoDB` did not compile using `gcc` 4.1 on PowerPC systems. (Bug #46718)
- If `InnoDB` reached its limit on the number of concurrent transactions (1023), it wrote a descriptive message to the error log but returned a misleading error message to the client, or an assertion failure occurred. (Bug #46672)

  See also Bug #18828.
- A Valgrind error during index creation by `InnoDB` was corrected. (Bug #46657)
- Concurrent `INSERT INTO ... SELECT` statements for an `InnoDB` table could cause an `AUTO_INCREMENT` assertion failure. (Bug #46650)
- The Serbian locale name `'sr_YU'` is obsolete. It is still recognized for backward compatibility, but `'sr_RS'` now should be used instead. (Bug #46633)
- On Solaris and HP-UX systems with the environment set to the default `C` locale, MySQL client programs issued an `Unknown OS character set` error. (Bug #46619)
- `SHOW CREATE TRIGGER` for a `MERGE` table trigger caused an assertion failure. (Bug #46614)
- `DIV` operations that are out of range generated an error `Error (Code 1264): Out of range value` (correct), but also an error: `Error (Code 1041): Out of memory` (incorrect). (Bug #46606)
- If a transaction was rolled back inside `InnoDB` due to a deadlock or lock wait timeout, and a statement in the transaction had an `IGNORE` clause, the server could crash at the end of the statement or on shutdown. (Bug #46539)
- `TRUNCATE TABLE` for a table that was opened with `HANDLER` did not close the handler and left it in an inconsistent state that could lead to a server crash. Now `TRUNCATE TABLE` for a table closes all open handlers for the table. (Bug #46456)
- Trailing spaces were not ignored for user-defined collations that mapped spaces to a character other than 0x20. (Bug #46448)

  See also Bug #29468.
- The server crashed if a shutdown occurred while a connection was idle. This happened because of a `NULL` pointer dereference while logging to the error log. (Bug #46267)
- Dropping an `InnoDB` table that used an unknown collation (created on a different server, for example) caused a server crash. (Bug #46256)
- The GPL and commercial license headers had different sizes, so that error log, backtrace, core dump, and cluster trace file line numbers could be off by one if they were not checked against the version of the source used for the build. (For example, checking a GPL build backtrace against commercial sources.) (Bug #46216)
- A query containing a subquery in the `FROM` clause and `PROCEDURE ANALYSE()` caused a server crash. (Bug #46184)

  See also Bug #48293.

- After an error such as a table-full condition, `INSERT IGNORE` could cause an assertion failure for debug builds. (Bug #46075)
- On 64-bit systems, `--skip-innodb` did not skip `InnoDB` startup. (Bug #46043)
- `InnoDB` did not disallow creation of an index with the name `GEN_CLUST_INDEX`, which is used internally. (Bug #46000)
- `CREATE TABLE ... SELECT` could cause a server crash if no default database was selected. (Bug #45998)
- Configuring MySQL for DTrace support resulted in a build failure on Solaris if the directory for the `dtrace` executable was not in `PATH`. (Bug #45810)
- An infinite hang and 100% CPU usage occurred after a handler tried to open a merge table.

  If the command `mysqladmin shutdown` was executed during the hang, the debug server generated the following assert:

  ```
  mysqld: table.cc:407: void free_table_share(TABLE_SHARE*): Assertion `share->ref_count ==
  0' failed.
  090610 14:54:04 - mysqld got signal 6 ;
  ```

  (Bug #45781)
- During the build of the Red Hat IA64 MySQL server RPM, the system library link order was incorrect. This made the resulting Red Hat IA64 RPM depend on "libc.so.6.1(GLIBC_PRIVATE)(64bit)", thus preventing installation of the package. (Bug #45706)
- The `caseinfo` member of the `CHARSET_INFO` structure was not initialized for user-defined Unicode collations, leading to a server crash. (Bug #45645)
- Appending values to an `ENUM` or `SET` definition is a metadata change for which `ALTER TABLE` need not rebuild the table, but it was being rebuilt anyway. (Bug #45567)
- The `socket` system variable was unavailable on Windows. (Bug #45498)
- The combination of `MIN()` or `MAX()` in the select list with `WHERE` and `GROUP BY` clauses could lead to incorrect results. (Bug #45386)
- Truncation of `DECIMAL` values could lead to assertion failures; for example, when deducing the type of a table column from a literal `DECIMAL` value. (Bug #45261)

  See also Bug #48370.
- Client flags were incorrectly initialized for the embedded server, causing several tests in the `jp` test suite to fail. (Bug #45159)
- Concurrent execution of statements requiring a table-level lock and statements requiring a non-table-level write lock for a table could deadlock. (Bug #45143)
- For settings of `lower_case_table_names` greater than 0, some queries for `INFORMATION_SCHEMA` tables left entries with incorrect lettercase in the table definition cache. (Bug #44738)
- `mysqld_safe` could fail to find the `logger` program. (Bug #44736)
- Some Perl scripts in AIX packages contained an incorrect path to the `perl` executable. (Bug #44643)
- With `InnoDB`, renaming a table column and then creating an index on the renamed column caused a server crash to the `.frm` file and the `InnoDB` data directory going out of sync. Now `InnoDB` 1.0.5 returns an error instead: `ERROR 1034 (HY000): Incorrect key file for table 'tbl_name'; try to repair it`. To work around the problem, create another table with the same structure and copy the original table to it. (Bug #44571)
- For debug builds, executing a stored procedure as a prepared statement could sometimes cause an assertion failure. (Bug #44521)
- Using `mysql_stmt_execute()` to call a stored procedure could cause a server crash. (Bug #44495)
- `InnoDB` did not always disallow creating tables containing columns with names that match the names of internal columns, such as `DB_ROW_ID`, `DB_TRX_ID`, `DB_ROLL_PTR`, and `DB_MIX_ID`. (Bug #44369)
- An `InnoDB` error message incorrectly referred to the nonexistent `innodb_max_files_open` variable rather than to `innodb_open_files`. (Bug #44338)
- `SELECT ... WHERE ... IN (NULL, ...)` was executed using a full table scan, even if the same query without the `NULL` used an efficient range scan. (Bug #44139)

See also Bug #18360.

- `InnoDB` use of `SELECT MAX(`*`autoinc_column`*`)` could cause a crash when MySQL data dictionaries went out of sync. (Bug #44030)
- `LOAD DATA INFILE` statements were written to the binary log in such a way that parsing problems could occur when re-executing the statement from the log. (Bug #43746)
- Selecting from the process list in the embedded server caused a crash. (Bug #43733)

  See also Bug #47304.
- Attempts to enable `large_pages` with a shared memory segment larger than 4GB caused a server crash. (Bug #43606)
- For `ALTER TABLE`, renaming a `DATETIME` or `TIMESTAMP` column unnecessarily caused a table copy operation. (Bug #43508)
- The weekday names for the Romanian `lc_time_names` locale `'ro_RO'` were incorrect. Thanks to Andrei Boros for the patch to fix this bug. (Bug #43207)
- `XA START` could cause an assertion failure or server crash when it is called after a unilateral rollback issued by the Resource Manager (both in a regular transaction and after an XA transaction). (Bug #43171)
- Redefining a trigger could cause an assertion failure. (Bug #43054)
- The `FORCE INDEX FOR ORDER BY` index hint was ignored when join buffering was used. (Bug #43029)
- `DROP DATABASE` did not clear the message list. (Bug #43012, Bug #43138)
- The `NUM_FLAG` bit of the `MYSQL_FIELD.flags` member now is set for columns of type `MYSQL_TYPE_NEWDECIMAL`. (Bug #42980)
- Incorrect handling of range predicates combined with `OR` operators could yield incorrect results. (Bug #42846)
- Failure to treat `BIT` values as unsigned could lead to unpredictable results. (Bug #42803)
- For the embedded server on Windows, `InnoDB` crashed when `innodb_file_per_table` was enabled and a table name was in full path format. (Bug #42383)
- `SHOW ERRORS` returned an empty result set after an attempt to drop a nonexistent table. (Bug #42364)
- If the server was started with an option that had a missing or invalid value, a subsequent error that normally would cause the server to shut down could cause it to crash instead. (Bug #42244)
- Some queries with nested outer joins could lead to crashes or incorrect results because an internal data structure was handled improperly. (Bug #42116)
- The server used the wrong lock type (always `TL_READ` instead of `TL_READ_NO_INSERT` when appropriate) for tables used in subqueries of `UPDATE` statements. This led in some cases to replication failure because statements were written in the wrong order to the binary log. (Bug #42108)
- A Valgrind warning in `open_tables()` was corrected. (Bug #41759)
- In a replication scenario with `innodb_locks_unsafe_for_binlog` enabled on the slave, where rows were changed only on the slave (not through replication), in some rare cases, many messages of the following form were written to the slave error log: `InnoDB: Error: unlock row could not find a 4 mode lock on the record`. (Bug #41756)
- After renaming a user, granting that user privileges could result in the user having privileges additional to those granted. (Bug #41597)
- The `mysql-stress-test.pl` test script was missing from the `noinstall` packages on Windows. (Bug #41546)
- With a nonstandard `InnoDB` page size, some error messages became inaccurate.

  > **Note**
  >
  > Changing the page size is not a supported operation and there is no guarantee that `InnoDB` will function normally with a page size other than 16KB. Problems compiling or running InnoDB may occur. In particular, `ROW_FORMAT=COMPRESSED` in `InnoDB` assumes that the page size is at most 16KB and uses 14-bit pointers.

> A version of `InnoDB` built for one page size cannot use data files or log files from a version built for a different page size.

(Bug #41490)

- In some cases, the server did not recognize lettercase differences between `GRANT` attributes such as table name or user name. For example, a user was able to perform operations on a table with privileges of another user with the same user name but in a different lettercase.

  In consequence of this bug fix, the collation for the `Routine_name` column of the `mysql.proc` table is changed from `utf8_bin` to `utf8_general_ci`. (Bug #41049)

  See also Bug #48872.

- When a storage engine plugin failed to initialize before allocating a slot number, it would acidentally unplug the engine installed in slot 0. (Bug #41013)
- Optimized builds of `mysqld` crashed when built with Sun Studio on SPARC platforms. (Bug #40244)
- `CREATE TABLE` failed if a column name in a `FOREIGN KEY` clause was given in a lettercase different from the corresponding index definition. (Bug #39932)
- The `mysql_stmt_close()` C API function did not flush all pending data associated with the prepared statement. (Bug #39519)
- `INFORMATION_SCHEMA` access optimizations did not work properly in some cases. (Bug #39270)
- `ALTER TABLE` neglected to preserve `ROW_FORMAT` information from the original table, which could cause subsequent `ALTER TABLE` and `OPTIMIZE TABLE` statements to lose the row format for `InnoDB` tables. (Bug #39200)
- Simultaneous `ANALYZE TABLE` operations for an `InnoDB` tables could be subject to a race condition. (Bug #38996)
- `mysqlbinlog` option-processing code had a memory leak. (Bug #38468)
- The `ALTER ROUTINE` privilege incorrectly permitted `SHOW CREATE TABLE`. (Bug #38347)
- Setting the `general_log_file` or `slow_query_log_file` system variable to a nonconstant expression caused the variable to become unset. (Bug #38124)
- For certain `SELECT` statements using `ref` access, MySQL estimated an incorrect number of rows, which could lead to inefficient query plans. (Bug #38049)
- A workload consisting of `CREATE TABLE ... SELECT` and DML operations could cause deadlock. (Bug #37433)
- The MySQL client library mishandled `EINPROGRESS` errors for connections in nonblocking mode. This could lead to replication failures on hosts capable of resolving both IPv4 and IPv6 network addresses, when trying to resolve `localhost`. (Bug #37267)

  See also Bug #44344.

- Previously, `InnoDB` performed `REPLACE INTO T SELECT ... FROM S WHERE ...` by setting shared next-key locks on rows from `S`. Now `InnoDB` selects rows from `S` with shared locks or as a consistent read, as for `INSERT ... SELECT`. This reduces lock contention between sessions. (Bug #37232)
- Some warnings were being reported as errors. (Bug #36777)
- Privileges for `SHOW CREATE VIEW` were not being checked correctly. (Bug #35996)
- Different invocations of `CHECKSUM TABLE` could return different results for a table containing columns with spatial data types. (Bug #35570)
- Result set metadata for columns retrieved from `INFORMATION_SCHEMA` tables did not have the `db` or `org_table` members of the `MYSQL_FIELD` structure set. (Bug #35428)
- `SHOW CREATE EVENT` output did not include the `DEFINER` clause. (Bug #35297)
- For its warning count, the `mysql_info()` C API function could print the number of truncated data items rather than the number of warnings. (Bug #34898)
- Concurrent execution of `FLUSH TABLES` along with `SHOW FUNCTION STATUS` or `SHOW PROCEDURE STATUS` could

cause a server crash. (Bug #34895)

- Executing `SHOW MASTER LOGS` as a prepared statement without binary logging enabled caused a crash for debug builds. (Bug #34741)
- There were spurious warnings about `"Truncated incorrect DOUBLE value"` in queries with `MATCH ... AGAINST` and `>` or `<` with a constant (which was reported as an incorrect `DOUBLE` value) in the `WHERE` condition. (Bug #34374)
- A `COMMENT` longer than 64 characters caused `CREATE PROCEDURE` to fail. (Bug #34197)
- `mysql_real_connect()` did not check whether the `MYSQL` connection handler was already connected and connected again even if so. Now a `CR_ALREADY_CONNECTED` error occurs. (Bug #33831)
- `INSTALL PLUGIN` and `UNINSTALL PLUGIN` did not handle plugin identifiers consistently with respect to lettercase. (Bug #33731)
- The default values for the general query log and slow query log file are documented to be based on the server host name and located in the data directory. However, they were in fact being based on the basename and location of the process ID (PID) file. The name and location defaults for the PID file are based on the server host name and data directory, so if it was not assigned a different name explicitly, its defaults were used and the general query log and slow query log file defaults were as documented. But if the PID file was assigned a value with the `--pid-file` option, the defaults for the general query log and slow query log file were incorrect. This has been rectified so that the defaults for all three files are based on the server host name and data directory.

  A remaining problem is that the binary log and relay log `.NNNNNN` and `.index` basename defaults are based on the PID file basename, contrary to the documentation. This issue is to be addressed as Bug #45359. (Bug #33693)
- The `SHOW FUNCTION CODE` and `SHOW PROCEDURE CODE` statements are not present in nondebug builds, but attempting to use them resulted in a “syntax error” message. Now the error message indicates that the statements are disabled and that you must use a debug build. (Bug #33637)
- The `LAST_DAY()` and `MAKEDATE()` functions could return `NULL`, but the result metadata indicated `NOT NULL`. Thanks to Hiromichi Watari for the patch to fix this bug. (Bug #33629)
- Instance Manager (`mysqlmanager`) has been removed, but a reference to it still appeared in the `mysql.server` script. (Bug #33472)
- There was a race condition between the event scheduler and the server shutdown thread. (Bug #32771)
- When an `InnoDB` tablespace filled up, an error was logged to the client, but not to the error log. Also, the error message was misleading and did not indicate the real source of the problem. (Bug #31183)
- `ALTER TABLE` statements that added a column and added a nonpartial index on the column failed to add the index. (Bug #31031)
- For `const` tables that were optimized away, `EXPLAIN EXTENDED` displayed them in the `FROM` clause. Now they are not displayed. If all tables are optimized away, `FROM DUAL` is displayed. (Bug #30302)
- There were cases where string-to-number conversions would produce warnings for `CHAR` values but not for `VARCHAR` values. (Bug #28299)
- In `mysql`, using **Control+C** to kill the current query resulted in a `ERROR 1053 (08S01): Server shutdown in progress" message` if the query was waiting for a lock. (Bug #28141)
- When building MySQL on Windows from source, the `WITH_BERKELEY_STORAGE_ENGINE` option would fail to configure `BDB` support correctly. (Bug #27693)
- The default database is no longer changed to `NULL` (“no database”) if `DROP DATABASE` for that database failed. (Bug #26704)
- `DROP TABLE` for `INFORMATION_SCHEMA` tables produced an `Unknown table` error rather than the more appropriate `Access denied`. (Bug #24062)
- `SELECT COUNT(DISTINCT)` was slow compared with `SELECT DISTINCT`. Now the server can use loose index scan for certain forms of aggregate functions that use `DISTINCT`. See Section 7.13.10.1, “Loose Index Scan”. (Bug #21849, Bug #38213)
- Referring to a stored function qualified with the name of one database and tables in another database caused a “table doesn't exist” error. (Bug #18444)

- A `TABLE ... DOESN'T EXIST` error could occur for statements that called a function defined in another database. (Bug #17199)

D.2. MySQL Connector/ODBC (MyODBC) Change History

D.2.1. Changes in MySQL Connector/ODBC Version 5.1.x

D.2.1.1. Changes in MySQL Connector/ODBC 5.1.9 (Not released yet)

Bugs Fixed

- When executing the `SQLProcedureColumns()` ODBC function, the driver reported the following error:

  ```
  MySQL server does not provide the requested information
  ```

  (Bug #50400)

- When using MySQL Connector/ODBC to fetch data, if a `net_write_timeout` condition occurred, the operation returned the standard "end of data" status, rather than an error. (Bug #39878)

D.2.1.2. Changes in MySQL Connector/ODBC 5.1.8 (07 November 2010)

Functionality Added or Changed

- Documentation in `.CHM` and `.HLP` format has been removed from the distribution. (Bug #56232)

Bugs Fixed

- For some procedure and parameter combinations `SQLProcedureColumns()` did not work correctly. For example, it could not return records for an existing procedure with correct parameters supplied.

  Further, it returned incorrect data for column 7, `TYPE_NAME`. For example, it returned `VARCHAR(20)` instead of `VARCHAR`. (Bug #57182)

- The MySQL Connector/ODBC MSI installer did not set the `InstallLocation` value in the Microsoft Windows registry. (Bug #56978)

- In bulk upload mode, `SQLExecute` would return `SQL_SUCCESS`, even when the uploaded data contained errors, such as primary key duplication, and foreign key violation. (Bug #56804)

- `SQLDescribeCol` and `SQLColAttribute` could not be called before `SQLExecute`, if the query was parameterized and not all parameters were bound.

  Note, MSDN states that “For performance reasons, an application should not call `SQLColAttribute/SQLDescribeCol` before executing a statement.” However, it should still be possible to do so if performance reasons are not paramount. (Bug #56717)

- When `SQLNumResultCols()` was called between `SQLPrepare()` and `SQLExecute()` the driver ran `SET @@sql_select_limit=1`, which limited the resultset to just one row. (Bug #56677)

- After installing MySQL Connector/ODBC, the system DSN created could not be configured or deleted. An error dialog was displayed, showing the error message “Invalid attribute string”.

  In this case the problem was due to the fact that the driver could not parse the NULL-separated connection string. (Bug #56233)

- When used after a call to `SQLTables()`, `SQLRowCount()` did not return the correct value. (Bug #55870)

- When attempting to install the latest Connector/ODBC 5.1.6 on Windows using the MSI, with an existing 5.1.x version already installed, the following error was generated:

  ```
  Another version of this product is already installed.  Installation of this version
  cannot continue.  To configure or remove the existing version of this product, use
  Add/Remove Programs on the Control Panel.
  ```

Also, the version number displayed in the ODBC Data Source Administrator/Drivers tab did not get updated when removing or installing a new version of 5.1.x. (Bug #54314)

D.2.1.3. Changes in MySQL Connector/ODBC 5.1.7 (24 August 2010)

Functionality Added or Changed

- MySQL Connector/ODBC has been changed to support the `CLIENT_INTERACTIVE` flag. (Bug #48603)

Bugs Fixed

- `SQLColAttribute(SQL_DESC_PRECISION...)` function returned incorrect results for type identifiers that have a negative value:

```
#define SQL_LONGVARCHAR       (-1) returned 4294967295
#define SQL_BINARY            (-2) returned 4294967294
#define SQL_VARBINARY         (-3) returned 4294967293
#define SQL_LONGVARBINARY     (-4) returned 4294967292
#define SQL_BIGINT            (-5) returned 4294967291
#define SQL_TINYINT           (-6) returned 4294967290
#define SQL_BIT               (-7) returned 4294967289
```

  They were returned as 32-bit unsigned integer values. This only happened on 64-bit Linux. (Bug #55024)

- `SQLColAttribute` for `SQL_DESC_OCTET_LENGTH` returned length including terminating null byte. It should not have included the null byte. (Bug #54206)

- The `SQLColumns` function returned the incorrect transfer octet length into the column `BUFFER_LENGTH` for `DECIMAL` type. (Bug #53235)

- `SQLForeignKeys()` did not return the correct information. The list of foreign keys in other tables should not have included foreign keys that point to unique constraints in the specified table. (Bug #51422)

- In contrast to all other ODBC catalog functions `SQLTablePrivileges` required the user to have `SELECT` privilege on MySQL schemata, otherwise the function returned with an error:

```
SQL Error. Native Code: 1142, SQLState: HY000, Return Code: -1
[MySQL][ODBC 5.1 Driver][mysqld-5.0.67-community-nt]SELECT command denied to user
'repadmin'@'localhost' for table 'tables_priv'
[Error][SQL Error]Error executing SQLTablePrivileges for object cat: myrep, object Name:
xxxxxxxxxx
```

  (Bug #50195)

- MySQL Connector/ODBC manually added a `LIMIT` clause to the end of certain SQL statements, causing errors for statements that contained code that should be positioned after the `LIMIT` clause. (Bug #49726)

- If `NO_BACKSLASH_ESCAPES` mode was used on a server, escaping binary data led to server query parsing errors. (Bug #49029)

- Bulk upload operations did not work for queries that used parameters. (Bug #48310)

- Retrieval of the current catalog at the moment when a connection was not ready, such as when the connection had been broken or when not all pending results had been processed, resulted in the application crashing. (Bug #46910)

- Describing a view or table caused SQLPrepare to prefetch table data. For large tables this created an intolerable performance hit. (Bug #46411)

- If an application was invoked by the root user, `SQLDriverConnect()` was not able to use the username and password in the connection string to connect to the database. (Bug #45378)

- Calling `SQLColAttribute` on a date column did not set `SQL_DESC_DATETIME_INTERVAL_CODE`. `SQLColAttribute` returned `SQL_SUCCESS` but the integer passed in was not set to `SQL_CODE_DATE`. (Bug #44576)

- Conversions for many types were missing from the file `driver/info.c`. (Bug #43855)

- The `SQLTables()` function required approximately two to four minutes to return the list of 400 tables in a database. The `SHOW TABLE STATUS` query used by `SQLTables()` was extremely slow for InnoDB tables with a large number of rows because the query was calculating the approximate number of rows in each table. Further, the results could not be cached due to non-deterministic nature of the result set (the row count was re-calculated every time), impacting performance further. (Bug #43664)

- Executing `SQLForeignKeys` to get imported foreign keys for tables took an excessively long time. For example, getting imported foreign keys for 252 tables to determine parent/child dependencies took about 3 minutes and 14 seconds for the 5.1.5 driver, whereas it took 3 seconds for the 3.5x.x driver. (Bug #39562)

- `SQLDescribeCol` returned incorrect column definitions for `SQLTables` result. (Bug #37621)

- When opening `ADO.Recordset` from Microsoft Access 2003, a run-time error occurred:

  ```
  ErrNo: -2147467259 ErrMessage: Data provider or other service returned an E_FAIL status.
  ```

  (Bug #36996)

- `SQLPrimaryKeysW` returned mangled strings for table name, column name and primary key name. (Bug #36441)

- On Windows, the SOCKET parameter to the DSN was used as the named pipe name to connect to. This was not exposed in the Windows setup GUI. (Bug #34477)

- MySQL Connector/ODBC returned a value of zero for a column with a non-zero value. This happened when the column had a data type of `BIT`, and any numeric type was used in `SQLBindCol`. (Bug #32821)

- Option for handling bad dates was not available in the GUI. (Bug #30539)

D.2.1.4. Changes in MySQL Connector/ODBC 5.1.6 (09 November 2009)

Functionality Added or Changed

- In the MySQL Data Source Configuration dialog, an excessive number of tabs were required to navigate to selection of a database. MySQL Connector/ODBC has been changed to make the tab order more practical, thereby enabling faster configuration of a Data Source. (Bug #42905)

Bugs Fixed

- An error randomly occurred on Windows 2003 Servers (German language Version) serving classic ASP scripts on IIS6 MDAC version 2.8 SP2 on Windows 2003 SP2. The application connected to MySQL Server 5.0.44-log with a charset of UTF-8 Unicode (utf8). The MySQL server was running on Gentoo Linux.

  The script error occurred sporadically on the following line of code:

  ```
  SET my_conn = Server.CreateObject("ADODB.Connection")
  my_conn.Open ConnString  <- ERROR
  ```

  The connection was either a DSN or the explicit connection string:

  ```
  Driver={MySQL ODBC 5.1 Driver};SERVER=abc.abc.abc.abc;DATABASE=dbname;UID=uidname;PWD=pwdname;PORT=3306;OPTION=6710
  ```

  The error occurred on connections established using either a DNS or a connection string.

  When IISState and Debug Diagnostic Tool 1.0.0.152 was used to analyse the code, the following crash analysis was generated:

  ```
  MYODBC5!UTF16TOUTF32+6In 4640-1242788336.dmp the assembly instruction at
  myodbc5!utf16toutf32+6 in C:\Programme\MySQL\Connector ODBC 5.1\myodbc5.dll from MySQL AB
  has caused an access violation exception (0xC0000005) when trying to read from memory
  location 0x194dd000 on thread 33
  ```

  (Bug #44971)

- MySQL Connector/ODBC overwrote the query log. MySQL Connector/ODBC was changed to append the log, rather than overwrite it. (Bug #44965)

- MySQL Connector/ODBC failed to build with MySQL 5.1.30 due to incorrect use of the data type `bool`. (Bug #42120)

- Inserting a new record using `SQLSetPos` did not correspond to the database name specified in the `SELECT` statement when querying tables from databases other than the current one.

`SQLSetPos` attempted to do the `INSERT` in the current database, but finished with a `SQL_ERROR` result and “Table does not exist” message from MySQL Server. (Bug #41946)

- Calling `SQLDescribeCol()` with a NULL buffer and nonzero buffer length caused a crash. (Bug #41942)
- MySQL Connector/ODBC updated some fields with random values, rather than with `NULL`. (Bug #41256)
- When a column of type `DECIMAL` containing `NULL` was accessed, MySQL Connector/ODBC returned a 0 rather than a `NULL`. (Bug #41081)
- In Access 97, when linking a table containing a `LONGTEXT` or `TEXT` field to a MySQL Connector/ODBC DSN, the fields were shown as `TEXT(255)` in the table structure. Data was therefore truncated to 255 characters. (Bug #40932)
- Calling `SQLDriverConnect()` with a `NULL` pointer for the output buffer caused a crash if `SQL_DRIVER_NOPROMPT` was also specified:

  ```
  SQLDriverConnect(dbc, NULL, "DSN=myodbc5", SQL_NTS, NULL, 0, NULL, SQL_DRIVER_NOPROMPT)
  ```

  (Bug #40316)
- Setting the ADO `Recordset` decimal field value to 44.56 resulted in an incorrect value of 445600.0000 being stored when the record set was updated with the `Update` method. (Bug #39961)
- The `SQLTablesW` API gave incorrect results. For example, table name and table type were returned as `NULL` rather than as the correct values. (Bug #39957)
- MyODBC would crash when a character set was being used on the server that was not supported in the client, for example cp1251:

  ```
  [MySQL][ODBC 5.1 Driver][mysqld-5.0.27-community-nt]Restricted data type attribute violation
  ```

  The fix causes MyODBC to return an error message instead of crashing. (Bug #39831)
- Binding `SQL_C_BIT` to an `INTEGER` column did not work.

  The `sql_get_data()` function only worked correctly for `BOOLEAN` columns that corresponded to `SQL_C_BIT` buffers. (Bug #39644)
- When the `SQLTables` method was called with `NULL` passed as the `tablename` parameter, only one row in the `resultset`, with table name of `NULL` was returned, instead of all tables for the given database. (Bug #39561)
- The `SQLGetInfo()` function returned 0 for `SQL_CATALOG_USAGE` information. (Bug #39560)
- MyODBC Driver 5.1.5 was not able to connect if the connection string parameters contained spaces or tab symbols. For example, if the `SERVER` parameter was specified as “SERVER= localhost” instead of “SERVER=localhost” the following error message will be displayed:

  ```
  [MySQL][ODBC 5.1 Driver] Unknown MySQL server host ' localhost' (11001).
  ```

  (Bug #39085)
- The pointer passed to the `SQLDriverConnect` method to retrieve the output connection string length was one greater than it should have been due to the inclusion of the NULL terminator. (Bug #38949)
- Data-at-execution parameters were not supported during positioned update. This meant updating a long text field with a cursor update would erroneously set the value to null. This would lead to the error `Column 'column_name' cannot be null` while updating the database, even when `column_name` had been assigned a valid nonnull string. (Bug #37649)
- The `SQLDriverConnect` method truncated the `OutputConnectionString` parameter to 52 characters. (Bug #37278)
- The connection string option `Enable Auto-reconnect` did not work. When the connection failed, it could not be restored, and the errors generated were the same as if the option had not been selected. (Bug #37179)
- Insertion of data into a `LONGTEXT` table field did not work. If such an attempt was made the corresponding field would be found to be empty on examination, or contain random characters. (Bug #36071)
- No result record was returned for `SQLGetTypeInfo` for the `TIMESTAMP` data type. An application would receive the result `return code 100 (SQL_NO_DATA_FOUND)`. (Bug #30626)

- It was not possible to use MySQL Connector/ODBC to connect to a server using SSL. The following error was generated:

  ```
  Runtime error '-2147467259 (80004005)':
  [MySQL][ODBC 3.51 Driver]SSL connection error.
  ```

  (Bug #29955)

- When the `recordSet.Update` function was called to update an `adLongVarChar` field, the field was updated but the recordset was immediately lost. This happened with driver cursors, whether the cursor was opened in optimistic or pessimistic mode.

  When the next update was called the test code would exit with the following error:

  ```
  -2147467259 : Query-based update failed because the row to update could not be found.
  ```

  (Bug #26950)

- Microsoft Access was not able to read `BIGINT` values properly from a table with just two columns of type `BIGINT` and `VARCHAR`. `#DELETE` appeared instead of the correct values. (Bug #17679)

D.2.1.5. Changes in MySQL Connector/ODBC 5.1.5 (18 August 2008)

Bugs Fixed

- ODBC `TIMESTAMP` string format is not handled properly by the MyODBC driver. When passing a `TIMESTAMP` or `DATE` to MyODBC, in the ODBC format: {d <date>} or {ts <timestamp>}, the string that represents this is copied once into the SQL statement, and then added again, as an escaped string. (Bug #37342)
- The connector failed to prompt for additional information required to create a DSN-less connection from an application such as Microsoft Excel. (Bug #37254)
- `SQLDriverConnect` does not return `SQL_NO_DATA` on cancel. The ODBC documentation specifies that this method should return `SQL_NO_DATA` when the user cancels the dialog to connect. The connector, however, returns `SQL_ERROR`. (Bug #36293)
- Assigning a string longer than 67 characters to the `TableType` parameter resulted in a buffer overrun when the `SQLTables()` function was called. (Bug #36275)
- The ODBC connector randomly uses logon information stored in `odbc-profile`, or prompts the user for connection information and ignores any settings stored in `odbc-profile`. (Bug #36203)
- After having successfully established a connection, a crash occurs when calling `SQLProcedures()` followed by `SQLFreeStmt()`, using the ODBC C API. (Bug #36069)

D.2.1.6. Changes in MySQL Connector/ODBC 5.1.4 (15 April 2008)

Bugs Fixed

- Wrong result obtained when using `sum()` on a `decimal(8,2)` field type. (Bug #35920)
- The driver installer could not create a new DSN if many other drivers were already installed. (Bug #35776)
- The `SQLColAttribute()` function returned `SQL_TRUE` when querying the `SQL_DESC_FIXED_PREC_SCALE (SQL_COLUMN_MONEY)` attribute of a `DECIMAL` column. Previously, the correct value of `SQL_FALSE` was returned; this is now again the case. (Bug #35581)
- On Linux, `SQLGetDiagRec()` returned `SQL_SUCCESS` in cases when it should have returned `SQL_NO_DATA`. (Bug #33910)
- The driver crashes ODBC Administrator on attempting to add a new DSN. (Bug #32057)

D.2.1.7. Changes in MySQL Connector/ODBC 5.1.3 (26 March 2008)

Platform-Specific Notes

- **Important Change**: You must uninstall previous 5.1.x editions of MySQL Connector/ODBC before installing the new version.
- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- The installer for 64-bit Windows installs both the 32-bit and 64-bit driver. Please note that Microsoft does not yet supply a 64-bit bridge from ADO to ODBC.

Bugs Fixed

- **Important Change**: In previous versions, the SSL certificate would automatically be verified when used as part of the MySQL Connector/ODBC connection. The default mode is now to ignore the verificate of certificates. To enforce verification of the SSL certificate during connection, use the `SSLVERIFY` DSN parameter, setting the value to 1. (Bug #29955, Bug #34648)
- Inserting characters to a UTF8 table using surrogate pairs would fail and insert invalid data. (Bug #34672)
- Installation of MySQL Connector/ODBC would fail because it was unable to uninstall a previous installed version. The file being requested would match an older release version than any installed version of the connector. (Bug #34522)
- Using `SqlGetData` in combination with `SQL_C_WCHAR` would return overlapping data. (Bug #34429)
- Descriptor records were not cleared correctly when calling `SQLFreeStmt(SQL_UNBIND)`. (Bug #34271)
- The dropdown selection for databases on a server when creating a DSN was too small. The list size now automatically adjusts up to a maximum size of 20 potential databases. (Bug #33918)
- Microsoft Access would be unable to use `DBEngine.RegisterDatabase` to create a DSN using the MySQL Connector/ODBC driver. (Bug #33825)
- MySQL Connector/ODBC erroneously reported that it supported the `CAST()` and `CONVERT()` ODBC functions for parsing values in SQL statements, which could lead to bad SQL generation during a query. (Bug #33808)
- Using a linked table in Access 2003 where the table has a `BIGINT` column as the first column in the table, and is configured as the primary key, shows `#DELETED` for all rows of the table. (Bug #24535)
- Updating a `RecordSet` when the query involves a `BLOB` field would fail. (Bug #19065)

D.2.1.8. Changes in MySQL Connector/ODBC 5.1.2 (13 February 2008)

MySQL Connector/ODBC 5.1.2-beta, a new version of the ODBC driver for the MySQL database management system, has been released. This release is the second beta (feature-complete) release of the new 5.1 series and is suitable for use with any MySQL server version since MySQL 4.1, including MySQL 5.0, 5.1, and 6.0. (It will not work with 4.0 or earlier releases.)

Keep in mind that this is a beta release, and as with any other pre-production release, caution should be taken when installing on production level systems or systems with critical data.

Platform-Specific Notes

- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- The installer for 64-bit Windows installs both the 32-bit and 64-bit driver. Please note that Microsoft does not yet supply a 64-bit bridge from ADO to ODBC.
- Due to differences with the installation process used on Windows and potential registry corruption, it is recommended that uninstall any existing versions of MySQL Connector/ODBC 5.1.x before upgrading.

  See also Bug #34571.

Functionality Added or Changed

- Explicit descriptors are implemented. (Bug #32064)
- A full implementation of SQLForeignKeys based on the information available from INFORMATION_SCHEMA in 5.0 and later versions of the server has been implemented.
- Changed `SQL_ATTR_PARAMSET_SIZE` to return an error until support for it is implemented.
- Disabled `MYSQL_OPT_SSL_VERIFY_SERVER_CERT` when using an SSL connection.
- `SQLForeignKeys` uses `INFORMATION_SCHEMA` when it is available on the server, which enables more complete information to be returned.

Bugs Fixed

- The `SSLCIPHER` option would be incorrectly recorded within the SSL configuration on Windows. (Bug #33897)
- Within the GUI interface, when connecting to a MySQL server on a nonstandard port, the connection test within the GUI would fail. The issue was related to incorrect parsing of numeric values within the DSN when the option was not configured as the last parameter within the DSN. (Bug #33822)
- Specifying a nonexistent database name within the GUI dialog would result in an empty list, not an error. (Bug #33615)
- When deleting rows from a static cursor, the cursor position would be incorrectly reported. (Bug #33388)
- `SQLGetInfo()` reported characters for `SQL_SPECIAL_CHARACTERS` that were not encoded correctly. (Bug #33130)
- Retrieving data from a `BLOB` column would fail within `SQLGetData`when the target data type was `SQL_C_WCHAR` due to incorrect handling of the character buffer. (Bug #32684)
- Renaming an existing DSN entry would create a new entry with the new name without deleting the old entry. (Bug #31165)
- Reading a `TEXT` column that had been used to store UTF8 data would result in the wrong information being returned during a query. (Bug #28617)
- `SQLForeignKeys` would return an empty string for the schema columns instead of `NULL`. (Bug #19923)
- When accessing column data, `FLAG_COLUMN_SIZE_S32` did not limit the octet length or display size reported for fields, causing problems with Microsoft Visual FoxPro.

  The list of ODBC functions that could have caused failures in Microsoft software when retrieving the length of `LONGBLOB` or `LONGTEXT` columns includes:

  - `SQLColumns`
  - `SQLColAttribute`
  - `SQLColAttributes`
  - `SQLDescribeCol`
  - `SQLSpecialColumns` (theoretically can have the same problem)

  (Bug #12805, Bug #30890)
- Dynamic cursors on statements with parameters were not supported. (Bug #11846)
- Evaluating a simple numeric expression when using the OLEDB for ODBC provider and ADO would return an error, instead of the result. (Bug #10128)
- Adding or updating a row using `SQLSetPos()` on a result set with aliased columns would fail. (Bug #6157)

D.2.1.9. Changes in MySQL Connector/ODBC 5.1.1 (13 December 2007)

MySQL Connector/ODBC 5.1.1-beta, a new version of the ODBC driver for the MySQL database management system, has been released. This release is the first beta (feature-complete) release of the new 5.1 series and is suitable for use with any MySQL server version since MySQL 4.1, including MySQL 5.0, 5.1, and 6.0. (It will not work with 4.0 or earlier releases.)

Keep in mind that this is a beta release, and as with any other pre-production release, caution should be taken when installing on production level systems or systems with critical data.

Includes changes from Connector/ODBC 3.51.21 and 3.51.22.

Built using MySQL 5.0.52.

Platform-Specific Notes

- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- The installer for 64-bit Windows installs both the 32-bit and 64-bit driver. Please note that Microsoft does not yet supply a 64-bit bridge from ADO to ODBC.
- Due to differences with the installation process used on Windows and potential registry corruption, it is recommended that uninstall any existing versions of MySQL Connector/ODBC 5.1.x before upgrading.

  See also Bug #34571.

Functionality Added or Changed

- **Incompatible Change**: Replaced myodbc3i (now myodbc-installer) with MySQL Connector/ODBC 5.0 version.
- **Incompatible Change**: Removed monitor (myodbc3m) and dsn-editor (myodbc3c).
- **Incompatible Change**: Do not permit `SET NAMES` in initial statement and in executed statements.
- A wrapper for the `SQLGetPrivateProfileStringW()` function, which is required for Unicode support, has been created. This function is missing from the unixODBC driver manager. (Bug #32685)
- Added MSI installer for Windows 64-bit. (Bug #31510)
- Implemented support for `SQLCancel()`. (Bug #15601)
- Added support for `SQL_NUMERIC_STRUCT`. (Bug #3028, Bug #24920)
- Removed nonthreadsafe configuration of the driver. The driver is now always built against the threadsafe version of libmysql.
- Implemented native Windows setup library
- Replaced the internal library which handles creation and loading of DSN information. The new library, which was originally a part of MySQL Connector/ODBC 5.0, supports Unicode option values.
- The Windows installer now places files in a subdirectory of the `Program Files` directory instead of the Windows system directory.

Bugs Fixed

- The `SET NAMES` statement has been disabled because it causes problems in the ODBC driver when determining the current client character set. (Bug #32596)
- `SQLDescribeColW` returned UTF-8 column as `SQL_VARCHAR` instead of `SQL_WVARCHAR`. (Bug #32161)
- ADO was unable to open record set using dynamic cursor. (Bug #32014)
- ADO applications would not open a `RecordSet` that contained a `DECIMAL` field. (Bug #31720)
- Memory usage would increase considerably. (Bug #31115)
- SQL statements are limited to 64KB. (Bug #30983, Bug #30984)
- `SQLSetPos` with `SQL_DELETE` advances dynamic cursor incorrectly. (Bug #29765)
- Using an ODBC prepared statement with bound columns would produce an empty result set when called immediately after inserting a row into a table. (Bug #29239)
- ADO Not possible to update a client side cursor. (Bug #27961)

- Recordset `Update()` fails when using `adUseClient` cursor. (Bug #26985)
- MySQL Connector/ODBC would fail to connect to the server if the password contained certain characters, including the semicolon and other punctuation marks. (Bug #16178)
- Fixed `SQL_ATTR_PARAM_BIND_OFFSET`, and fixed row offsets to work with updatable cursors.
- `SQLSetConnectAttr()` did not clear previous errors, possibly confusing `SQLError()`.
- `SQLError()` incorrectly cleared the error information, making it unavailable from subsequent calls to `SQLGetDiagRec()`.
- NULL pointers passed to `SQLGetInfo()` could result in a crash.
- `SQL_ODBC_SQL_CONFORMANCE` was not handled by `SQLGetInfo()`.
- `SQLCopyDesc()` did not correctly copy all records.
- Diagnostics were not correctly cleared on connection and environment handles.

D.2.1.10. Changes in MySQL Connector/ODBC 5.1.0 (10 September 2007)

This release is the first of the new 5.1 series and is suitable for use with any MySQL server version since MySQL 4.1, including MySQL 5.0, 5.1, and 6.0. (It will not work with 4.0 or earlier releases.)

Keep in mind that this is a alpha release, and as with any other pre-production release, caution should be taken when installing on production level systems or systems with critical data. Not all of the features planned for the final Connector/ODBC 5.1 release are implemented.

Functionality is based on Connector/ODBC 3.51.20.

Platform-Specific Notes

- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- There are no installer packages for Microsoft Windows x64 Edition.
- Due to differences with the installation process used on Windows and potential registry corruption, it is recommended that uninstall any existing versions of MySQL Connector/ODBC 5.1.x before upgrading.

  See also Bug #34571.

Functionality Added or Changed

- Added support for Unicode functions (`SQLConnectW`, etc).
- Added descriptor support (`SQLGetDescField`, `SQLGetDescRec`, etc).
- Added support for `SQL_C_WCHAR`.

D.2.2. Changes in MySQL Connector/ODBC Version 5.0.x

D.2.2.1. Changes in MySQL Connector/ODBC 5.0.12 (Never released)

> **Note**
>
> Development on Connector/ODBC 5.0.x has ceased. New features and functionality will be incorporated into Connector/ODBC 5.1.

Bugs Fixed

- Inserting `NULL` values into a `DATETIME` column from Access reports an error. (Bug #27896)

- Tables with `TEXT` columns would be incorrectly identified, returning an `Unknown SQL type - 65535` error. (Bug #20127)

D.2.2.2. Changes in MySQL Connector/ODBC 5.0.11 (31 January 2007)

Functionality Added or Changed

- Added support for ODBC v2 statement options using attributes.
- Driver now builds and is partially tested under Linux with the iODBC driver manager.

Bugs Fixed

- Connection string parsing for DSN-less connections could fail to identify some parameters. (Bug #25316)
- Updates of `MEMO` or `TEXT` columns from within Microsoft Access would fail. (Bug #25263)
- Transaction support has been added and tested. (Bug #25045)
- Internal function, `my_setpos_delete_ignore()` could cause a crash. (Bug #22796)
- Fixed occasional mis-handling of the `SQL_NUMERIC_C` type.
- Fixed the binding of certain integer types.

D.2.2.3. Changes in MySQL Connector/ODBC 5.0.10 (14 December 2006)

Connector/ODBC 5.0.10 is the sixth BETA release.

Functionality Added or Changed

- Significant performance improvement when retrieving large text fields in pieces using `SQLGetData()` with a buffer smaller than the whole data. Mainly used in Access when fetching very large text fields. (Bug #24876)
- Added initial unicode support in data and metadata. (Bug #24837)
- Added initial support for removing braces when calling stored procedures and retrieving result sets from procedure calls. (Bug #24485)
- Added loose handling of retrieving some diagnostic data. (Bug #15782)
- Added wide-string type info for `SQLGetTypeInfo()`.

Bugs Fixed

- Editing DSN no longer crashes ODBC data source administrator. (Bug #24675)
- String query parameters are new escaped correctly. (Bug #19078)

D.2.2.4. Changes in MySQL Connector/ODBC 5.0.9 (22 November 2006)

Connector/ODBC 5.0.9 is the fifth BETA release.

This is an implementation and testing release, and is not designed for use within a production environment.

Functionality Added or Changed

- Added support for column binding as SQL_NUMERIC_STRUCT.
- Added recognition of `SQL_C_SHORT` and `SQL_C_TINYINT` as C types.

Bugs Fixed

- Fixed wildcard handling of and listing of catalogs and tables in `SQLTables`.
- Added limit of display size when requested using `SQLColAttribute`/`SQL_DESC_DISPLAY_SIZE`.
- Fixed buffer length return for SQLDriverConnect.
- ODBC v2 behavior in driver now supports ODBC v3 date/time types (since DriverManager maps them).
- Catch use of `SQL_ATTR_PARAMSET_SIZE` and report error until we fully support.
- Fixed statistics to fail if it couldn't be completed.
- Corrected retrieval multiple field types bit and blob/text.
- Fixed SQLGetData to clear the NULL indicator correctly during multiple calls.

D.2.2.5. Changes in MySQL Connector/ODBC 5.0.8 (17 November 2006)

Connector/ODBC 5.0.8 is the fourth BETA release.

This is an implementation and testing release, and is not designed for use within a production environment.

Functionality Added or Changed

- Also made `SQL_DESC_NAME` only fill in the name if there was a data pointer given, otherwise just the length.
- Fixed display size to be length if max length isn’t available.
- Made distinction between `CHAR`/`BINARY` (and VAR versions).
- Wildcards now support escaped chars and underscore matching (needed to link tables with underscores in access).

Bugs Fixed

- Fixed binding using `SQL_C_LONG`.
- Fixed using wrong pointer for `SQL_MAX_DRIVER_CONNECTIONS` in `SQLGetInfo`.
- Set default return to `SQL_SUCCESS` if nothing is done for `SQLSpecialColumns`.
- Fixed MDiagnostic to use correct v2/v3 error codes.
- Allow SQLDescribeCol to be called to retrieve the length of the column name, but not the name itself.
- Length now used when handling bind parameter (needed in particular for `SQL_WCHAR`) - this enables updating char data in MS Access.
- Updated retrieval of descriptor fields to use the right pointer types.
- Fixed handling of numeric pointers in SQLColAttribute.
- Fixed type returned for `MYSQL_TYPE_LONG` to `SQL_INTEGER` instead of `SQL_TINYINT`.
- Fix size return from `SQLDescribeCol`.
- Fixed string length to chars, not bytes, returned by SQLGetDiagRec.

D.2.2.6. Changes in MySQL Connector/ODBC 5.0.7 (08 November 2006)

Connector/ODBC 5.0.7 is the third BETA release.

This is an implementation and testing release, and is not designed for use within a production environment.

Functionality Added or Changed

- Added support for `SQLStatistics` to `MYODBCShell`.
- Improved trace/log.

Bugs Fixed

- SQLBindParameter now handles `SQL_C_DEFAULT`.
- Corrected incorrect column index within `SQLStatistics`. Many more tables can now be linked into MS Access.
- Fixed `SQLDescribeCol` returning column name length in bytes rather than chars.

D.2.2.7. Changes in MySQL Connector/ODBC 5.0.6 (03 November 2006)

Connector/ODBC 5.0.6 is the second BETA release.

This is an implementation and testing release, and is not designed for use within a production environment.

Features, Limitations, and Notes on this Release

- MySQL Connector/ODBC supports both `User` and `System` DSNs.
- Installation is provided in the form of a standard Microsoft System Installer (MSI).
- You no longer have to have MySQL Connector/ODBC 3.51 installed before installing this version.

Bugs Fixed

- You no longer have to have MySQL Connector/ODBC 3.51 installed before installing this version.
- MySQL Connector/ODBC supports both `User` and `System` DSNs.
- Installation is provided in the form of a standard Microsoft System Installer (MSI).

D.2.2.8. Changes in MySQL Connector/ODBC 5.0.5 (17 October 2006)

Connector/ODBC 5.0.5 is the first BETA release.

This is an implementation and testing release, and is not designed for use within a production environment.

You no longer have to have Connector/ODBC 3.51 installed before installing this version.

Bugs Fixed

- You no longer have to have MySQL Connector/ODBC 3.51 installed before installing this version.

D.2.2.9. Changes in Connector/ODBC 5.0.3 (Connector/ODBC 5.0 Alpha 3) (20 June 2006)

This is an implementation and testing release, and is not designed for use within a production environment.

Features, limitations and notes on this release:

- The following ODBC API functions have been added in this release:
  - `SQLBindParameter`
  - `SQLBindCol`

D.2.2.10. Changes in Connector/ODBC 5.0.2 (Never released)

Connector/ODBC 5.0.2 was an internal implementation and testing release.

D.2.2.11. Changes in Connector/ODBC 5.0.1 (Connector/ODBC 5.0 Alpha 2) (05 June 2006)

Features, limitations and notes on this release:

- Connector/ODBC 5.0 is Unicode aware.
- Connector/ODBC is currently limited to basic applications. ADO applications and Microsoft Office are not supported.
- Connector/ODBC must be used with a Driver Manager.
- The following ODBC API functions are implemented:
  - `SQLAllocHandle`
  - `SQLCloseCursor`
  - `SQLColAttribute`
  - `SQLColumns`
  - `SQLConnect`
  - `SQLCopyDesc`
  - `SQLDisconnect`
  - `SQLExecDirect`
  - `SQLExecute`
  - `SQLFetch`
  - `SQLFreeHandle`
  - `SQLFreeStmt`
  - `SQLGetConnectAttr`
  - `SQLGetData`
  - `SQLGetDescField`
  - `SQLGetDescRec`
  - `SQLGetDiagField`
  - `SQLGetDiagRec`
  - `SQLGetEnvAttr`
  - `SQLGetFunctions`
  - `SQLGetStmtAttr`
  - `SQLGetTypeInfo`
  - `SQLNumResultCols`
  - `SQLPrepare`
  - `SQLRowcount`
  - `SQLTables`

  The following ODBC API function are implemented, but not yet support all the available attributes/options:

  - `SQLSetConnectAttr`
  - `SQLSetDescField`

- `SQLSetDescRec`
- `SQLSetEnvAttr`
- `SQLSetStmtAttr`

D.2.3. Changes in MySQL Connector/ODBC Version 3.51.x

D.2.3.1. Changes in MySQL Connector/ODBC 3.51.28 (09 February 2011)

Bugs Fixed

- `SQLColAttribute(...SQL_DESC_CASE_SENSITIVE...)` returned `SQL_FALSE` for binary types and `SQL_TRUE` for the rest. It should have returned `SQL_TRUE` for binary types, and `SQL_FALSE` for the rest. (Bug #54212)
- `SQLColAttribute` for `SQL_DESC_OCTET_LENGTH` returned length including terminating null byte. It should not have included the null byte. (Bug #54206)
- When executing the `SQLProcedureColumns()` ODBC function, the driver reported the following error:

  ```
  MySQL server does not provide the requested information
  ```

  (Bug #50400)
- If `NO_BACKSLASH_ESCAPES` mode was used on a server, escaping binary data led to server query parsing errors. (Bug #49029)
- Inserting a new record using `SQLSetPos` did not correspond to the database name specified in the `SELECT` statement when querying tables from databases other than the current one.

  `SQLSetPos` attempted to do the `INSERT` in the current database, but finished with a `SQL_ERROR` result and “Table does not exist” message from MySQL Server. (Bug #41946)
- When using MySQL Connector/ODBC to fetch data, if a `net_write_timeout` condition occurred, the operation returned the standard "end of data" status, rather than an error. (Bug #39878)
- No result record was returned for `SQLGetTypeInfo` for the `TIMESTAMP` data type. An application would receive the result `return code 100 (SQL_NO_DATA_FOUND)`. (Bug #30626)
- Microsoft Access was not able to read `BIGINT` values properly from a table with just two columns of type `BIGINT` and `VARCHAR`. `#DELETE` appeared instead of the correct values. (Bug #17679)

D.2.3.2. Changes in MySQL Connector/ODBC 3.51.27 (20 November 2008)

Bugs Fixed

- The client program hung when the network connection to the server was interrupted. (Bug #40407)
- The connection string option `Enable Auto-reconnect` did not work. When the connection failed, it could not be restored, and the errors generated were the same as if the option had not been selected. (Bug #37179)
- It was not possible to use MySQL Connector/ODBC to connect to a server using SSL. The following error was generated:

  ```
  Runtime error '-2147467259 (80004005)':
  [MySQL][ODBC 3.51 Driver]SSL connection error.
  ```

  (Bug #29955)

D.2.3.3. Changes in MySQL Connector/ODBC 3.51.26 (07 July 2008)

Functionality Added or Changed

- There is a new connection option, `FLAG_NO_BINARY_RESULT`. When set this option disables charset 63 for columns with an empty `org_table`. (Bug #29402)

Bugs Fixed

- When an `ADOConnection` is created and attempts to open a schema with `ADOConnection.OpenSchema` an access violation occurs in `myodbc3.dll`. (Bug #30770)
- When `SHOW CREATE TABLE` was invoked and then the field values read, the result was truncated and unusable if the table had many rows and indexes. (Bug #24131)

D.2.3.4. Changes in MySQL Connector/ODBC 3.51.25 (11 April 2008)

Bugs Fixed

- The `SQLColAttribute()` function returned `SQL_TRUE` when querying the `SQL_DESC_FIXED_PREC_SCALE (SQL_COLUMN_MONEY)` attribute of a `DECIMAL` column. Previously, the correct value of `SQL_FALSE` was returned; this is now again the case. (Bug #35581)
- The driver crashes ODBC Administrator on attempting to add a new DSN. (Bug #32057)
- When accessing column data, `FLAG_COLUMN_SIZE_S32` did not limit the octet length or display size reported for fields, causing problems with Microsoft Visual FoxPro.

  The list of ODBC functions that could have caused failures in Microsoft software when retrieving the length of `LONGBLOB` or `LONGTEXT` columns includes:

  - `SQLColumns`
  - `SQLColAttribute`
  - `SQLColAttributes`
  - `SQLDescribeCol`
  - `SQLSpecialColumns` (theoretically can have the same problem)

  (Bug #12805, Bug #30890)

D.2.3.5. Changes in MySQL Connector/ODBC 3.51.24 (14 March 2008)

Bugs Fixed

- **Security Enhancement**: Accessing a parameter with the type of `SQL_C_CHAR`, but with a numeric type and a length of zero, the parameter marker would get stripped from the query. In addition, an SQL injection was possible if the parameter value had a nonzero length and was not numeric, the text would be inserted verbatim. (Bug #34575)
- **Important Change**: In previous versions, the SSL certificate would automatically be verified when used as part of the MySQL Connector/ODBC connection. The default mode is now to ignore the verificate of certificates. To enforce verification of the SSL certificate during connection, use the `SSLVERIFY` DSN parameter, setting the value to 1. (Bug #29955, Bug #34648)
- When using ADO, the count of parameters in a query would always return zero. (Bug #33298)
- Using tables with a single quote or other nonstandard characters in the table or column names through ODBC would fail. (Bug #32989)
- When using Crystal Reports, table and column names would be truncated to 21 characters, and truncated columns in tables where the truncated name was the duplicated would lead to only a single column being displayed. (Bug #32864)
- `SQLExtendedFetch()` and `SQLFetchScroll()` ignored the rowset size if the `Don't cache result` DSN option was set. (Bug #32420)
- When using the ODBC `SQL_TXN_READ_COMMITTED` option, 'dirty' records would be read from tables as if the option had not been applied. (Bug #31959)
- When creating a System DSN using the ODBC Administrator on Mac OS X, a User DSN would be created instead. The root

cause is a problem with the iODBC driver manager used on Mac OS X. The fix works around this issue.

> **Note**
>
> ODBC Administrator may still be unable to register a System DSN unless the `/Library/ODBC/odbc.ini` file has the correct permissions. You should ensure that the file is writable by the `admin` group.

(Bug #31495)

- Calling `SQLFetch` or `SQLFetchScroll` would return negative data lengths when using `SQL_C_WCHAR`. (Bug #31220)
- `SQLSetParam()` caused memory allocation errors due to driver manager's mapping of deprecated functions (buffer length -1). (Bug #29871)
- Static cursor was unable to be used through ADO when dynamic cursors were enabled. (Bug #27351)
- Using `connection.Execute` to create a record set based on a table without declaring the cmd option as `adCmdTable` will fail when communicating with versions of MySQL 5.0.37 and higher. The issue is related to the way that `SQLSTATE` is returned when ADO tries to confirm the existence of the target object. (Bug #27158)
- Updating a `RecordSet` when the query involves a `BLOB` field would fail. (Bug #19065)
- With some connections to MySQL databases using MySQL Connector/ODBC, the connection would mistakenly report 'user cancelled' for accesses to the database information. (Bug #16653)

D.2.3.6. Changes in MySQL Connector/ODBC 3.51.23 (09 January 2008)

Platform-Specific Notes

- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- There are no installer packages for Microsoft Windows x64 Edition.

Bugs Fixed

- MySQL Connector/ODBC would incorrectly return `SQL_SUCCESS` when checking for distributed transaction support. (Bug #32727)
- When using unixODBC or directly linked applications where the thread level is set to less than 3 (within `odbcinst.ini`), a thread synchronization issue would lead to an application crash. This was because `SQLAllocStmt()` and `SQLFreeStmt()` did not synchronize access to the list of statements associated with a connection. (Bug #32587)
- Cleaning up environment handles in multithread environments could result in a five (or more) second delay. (Bug #32366)
- Renaming an existing DSN entry would create a new entry with the new name without deleting the old entry. (Bug #31165)
- Setting the default database using the `DefaultDatabase` property of an ADO `Connection` object would fail with the error `Provider does not support this property`. The `SQLGetInfo()` returned the wrong value for `SQL_DATABASE_NAME` when no database was selected. (Bug #3780)

D.2.3.7. Changes in MySQL Connector/ODBC 3.51.22 (13 November 2007)

Functionality Added or Changed

- The workaround for this bug was removed due to the fixes in MySQL Server 5.0.48 and 5.1.21.

  This regression was introduced by Bug #10491.

Bugs Fixed

- The `English` locale would be used when formatting floating point values. The `C` locale is now used for these values. (Bug #32294)
- When accessing information about supported operations, the driver would return incorrect information about the support for `UNION`. (Bug #32253)
- Unsigned integer values greater than the maximum value of a signed integer would be handled incorrectly. (Bug #32171)
- The wrong result was returned by `SQLGetData()` when the data was an empty string and a zero-sized buffer was specified. (Bug #30958)
- Added the `FLAG_COLUMN_SIZE_S32` option to limit the reported column size to a signed 32-bit integer. This option is automatically enabled for ADO applications to provide a work around for a bug in ADO. (Bug #13776)

D.2.3.8. Changes in MySQL Connector/ODBC 3.51.21 (08 October 2007)

Bugs Fixed

- When using a rowset/cursor and add a new row with a number of fields, subsequent rows with fewer fields will include the original fields from the previous row in the final `INSERT` statement. (Bug #31246)
- Uninitiated memory could be used when C/ODBC internally calls `SQLGetFunctions()`. (Bug #31055)
- The wrong `SQL_DESC_LITERAL_PREFIX` would be returned for date/time types. (Bug #31009)
- The wrong `COLUMN_SIZE` would be returned by `SQLGetTypeInfo` for the TIME columns (`SQL_TYPE_TIME`). (Bug #30939)
- Clicking outside the character set selection box when configuring a new DSN could cause the wrong character set to be selected. (Bug #30568)
- Not specifying a user in the DSN dialog would raise a warning even though the parameter is optional. (Bug #30499)
- `SQLSetParam()` caused memory allocation errors due to driver manager's mapping of deprecated functions (buffer length -1). (Bug #29871)
- When using ADO, a column marked as `AUTO_INCREMENT` could incorrectly report that the column permitted `NULL` values. This was dur to an issue with `NULLABLE` and `IS_NULLABLE` return values from the call to `SQLColumns()`. (Bug #26108)
- MySQL Connector/ODBC would return the wrong the error code when the server disconnects the active connection because the configured `wait_timeout` has expired. Previously it would return `HY000`. MySQL Connector/ODBC now correctly returns an `SQLSTATE` of `08S01`. (Bug #3456)

D.2.3.9. Changes in MySQL Connector/ODBC 3.51.20 (10 September 2007)

Bugs Fixed

- Using `FLAG_NO_PROMPT` doesn't suppress the dialogs normally handled by `SQLDriverConnect`. (Bug #30840)
- The specified length of the user name and authentication parameters to `SQLConnect()` were not being honored. (Bug #30774)
- The wrong column size was returned for binary data. (Bug #30547)
- `SQLGetData()` will now always return `SQL_NO_DATA_FOUND` on second call when no data left, even if requested size is 0. (Bug #30520)
- `SQLGetConnectAttr()` did not reflect the connection state correctly. (Bug #14639)
- Removed check box in setup dialog for `FLAG_FIELD_LENGTH` (identified as `Don't Optimize Column Width` within the GUI dialog), which was removed from the driver in 3.51.18.

D.2.3.10. Changes in MySQL Connector/ODBC 3.51.19 (10 August 2007)

Connector/ODBC 3.51.19 fixes a specific issue with the 3.51.18 release. For a list of changes in the 3.51.18 release, see Section D.2.3.11, “Changes in MySQL Connector/ODBC 3.51.18 (08 August 2007)”.

Functionality Added or Changed

- Because of Bug #10491 in the server, character string results were sometimes incorrectly identified as `SQL_VARBINARY`. Until this server bug is corrected, the driver will identify all variable-length strings as `SQL_VARCHAR`.

D.2.3.11. Changes in MySQL Connector/ODBC 3.51.18 (08 August 2007)

Platform-Specific Notes

- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- Binary packages for Sun Solaris are now available as `PKG` packages.
- Binary packages as disk images with installers are now available for Mac OS X.
- A binary package without an installer is available for Microsoft Windows x64 Edition. There are no installer packages for Microsoft Windows x64 Edition.

Functionality Added or Changed

- **Incompatible Change**: The `FLAG_DEBUG` option was removed.
- When connecting to a specific database when using a DSN, the system tables from the `mysql` database are no longer also available. Previously, tables from the mysql database (catalog) were listed as `SYSTEM TABLES` by `SQLTables()` even when a different catalog was being queried. (Bug #28662)
- Installed for Mac OS X has been re-instated. The installer registers the driver at a system (not user) level and makes it possible to create both user and system DSNs using the MySQL Connector/ODBC driver. The installer also fixes the situation where the necessary drivers would bge installed local to the user, not globally. (Bug #15326, Bug #10444)
- MySQL Connector/ODBC now supports batched statements. To enable cached statement support, you must switch enable the batched statement option (`FLAG_MULTI_STATEMENTS`, 67108864, or **ALLOW MULTIPLE STATEMENTS** within a GUI configuration). Be aware that batched statements create an increased chance of SQL injection attacks and you must ensure that your application protects against this scenario. (Bug #7445)
- The `SQL_ATTR_ROW_BIND_OFFSET_PTR` is now supported for row bind offsets. (Bug #6741)
- The `TRACE` and `TRACEFILE` DSN options have been removed. Use the ODBC driver manager trace options instead.

Bugs Fixed

- When using a table with multiple `TIMESTAMP` columns, the final `TIMESTAMP` column within the table definition would not be updateable. Note that there is still a limitation in MySQL server regarding multiple `TIMESTAMP` columns. (Bug #30081)

  See also Bug #9927.
- Fixed an issue where the `myodbc3i` would update the user ODBC configuration file (`~/Library/ODBC/odbcinst.ini`) instead of the system `/Library/ODBC/odbcinst.ini`. This was caused because `myodbc3i` was not honoring the `s` and `u` modifiers for the `-d` command-line option. (Bug #29964)
- Getting table metadata (through the `SQLColumns()` would fail, returning a bad table definition to calling applications. (Bug #29888)
- `DATETIME` column types would return `FALSE` in place of `SQL_SUCCESS` when requesting the column type information. (Bug #28657)
- The `SQL_COLUMN_TYPE`, `SQL_COLUMN_DISPLAY` and `SQL_COLUMN_PRECISION` values would be returned incorrectly by `SQLColumns()`, `SQLDescribeCol()` and `SQLColAttribute()` when accessing character columns, especially those generated through `concat()`. The lengths returned should now conform to the ODBC specification. The `FLAG_FIELD_LENGTH` option no longer has any affect on the results returned. (Bug #27862)

- Obtaining the length of a column when using a character set for the connection of `utf8` would result in the length being returned incorrectly. (Bug #19345)
- The `SQLColumns()` function could return incorrect information about `TIMESTAMP` columns, indicating that the field was not nullable. (Bug #14414)
- The `SQLColumns()` function could return incorrect information about `AUTO_INCREMENT` columns, indicating that the field was not nullable. (Bug #14407)
- A binary package without an installer is available for Microsoft Windows x64 Edition. There are no installer packages for Microsoft Windows x64 Edition.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- `BIT(n)` columns are now treated as `SQL_BIT` data where `n = 1` and binary data where `n > 1`.
- The wrong value from `SQL_DESC_LITERAL_SUFFIX` was returned for binary fields.
- The `SQL_DATETIME_SUB` column in SQLColumns() was not correctly set for date and time types.
- The value for `SQL_DESC_FIXED_PREC_SCALE` was not returned correctly for values in MySQL 5.0 and later.
- The wrong value for `SQL_DESC_TYPE` was returned for date and time types.
- `SQLConnect()` and `SQLDriverConnect()` were rewritten to eliminate duplicate code and ensure all options were supported using both connection methods. `SQLDriverConnect()` now only requires the setup library to be present when the call requires it.
- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- Binary packages as disk images with installers are now available for Mac OS X.
- Binary packages for Sun Solaris are now available as `PKG` packages.
- The wrong value for `DECIMAL_DIGITS` in `SQLColumns()` was reported for `FLOAT` and `DOUBLE` fields, as well as the wrong value for the scale parameter to `SQLDescribeCol()`, and the `SQL_DESC_SCALE` attribute from `SQLColAttribute()`.
- The `SQL_DATA_TYPE` column in `SQLColumns()` results did not report the correct value for date and time types.

D.2.3.12. Changes in MySQL Connector/ODBC 3.51.17 (14 July 2007)

Platform-Specific Notes

- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- Binary packages for Sun Solaris are now available as `PKG` packages.
- Binary packages as disk images with installers are now available for Mac OS X.
- A binary package without an installer is available for Microsoft Windows x64 Edition. There are no installer packages for Microsoft Windows x64 Edition.

Functionality Added or Changed

- It is now possible to specify a different character set as part of the DSN or connection string. This must be used instead of the `SET NAMES` statement. You can also configure the character set value from the GUI configuration. (Bug #9498, Bug #6667)
- Fixed calling convention ptr and wrong free in `myodbc3i`, and fixed the null terminating (was only one, not two) when writing DSN to string.
- Dis-allow NULL ptr for null indicator when calling SQLGetData() if value is null. Now returns SQL_ERROR w/state 22002.

- The setup library has been split into its own RPM package, to enable installing the driver itself with no GUI dependencies.

Bugs Fixed

- `myodbc3i` did not correctly format driver info, which could cause the installation to fail. (Bug #29709)
- MySQL Connector/ODBC crashed with Crystal Reports due to a rproblem with `SQLProcedures()`. (Bug #28316)
- Fixed a problem where the GUI would crash when configuring or removing a System or User DSN. (Bug #27315)
- Fixed error handling of out-of-memory and bad connections in catalog functions. This might raise errors in code paths that had ignored them in the past. (Bug #26934)
- For a stored procedure that returns multiple result sets, MySQL Connector/ODBC returned only the first result set. (Bug #16817)
- Calling `SQLGetDiagField` with `RecNumber 0, DiagIdentifier NOT 0` returned `SQL_ERROR`, preventing access to diagnostic header fields. (Bug #16224)
- Added a new DSN option (`FLAG_ZERO_DATE_TO_MIN`) to retrieve `XXXX-00-00` dates as the minimum permitted ODBC date (`XXXX-01-01`). Added another option (`FLAG_MIN_DATE_TO_ZERO`) to mirror this but for bound parameters. `FLAG_MIN_DATE_TO_ZERO` only changes `0000-01-01` to `0000-00-00`. (Bug #13766)
- If there was more than one unique key on a table, the correct fields were not used in handling `SQLSetPos()`. (Bug #10563)
- When inserting a large `BLOB` field, MySQL Connector/ODBC would crash due to a memory allocation error. (Bug #10562)
- The driver was using `mysql_odbc_escape_string()`, which does not handle the `NO_BACKSLASH_ESCAPES` SQL mode. Now it uses `mysql_real_escape_string()`, which does. (Bug #9498)
- `SQLColumns()` did not handle many of its parameters correctly, which could lead to incorrect results. The table name argument was not handled as a pattern value, and most arguments were not escaped correctly when they contained nonalphanumeric characters. (Bug #8860)
- There are no binary packages for Microsoft Windows x64 Edition.
- There is no binary package for Mac OS X on 64-bit PowerPC because Apple does not currently provide a 64-bit PowerPC version of iODBC.
- Correctly return error if `SQLBindCol` is called with an invalid column.
- Fixed possible crash if `SQLBindCol()` was not called before `SQLSetPos()`.
- The Mac OS X binary packages are only provided as tarballs, there is no installer.
- The binary packages for Sun Solaris are only provided as tarballs, not the PKG format.
- The HP-UX 11.23 IA64 binary package does not include the GUI bits because of problems building Qt on that platform.

D.2.3.13. Changes in MySQL Connector/ODBC 3.51.16 (14 June 2007)

Functionality Added or Changed

- MySQL Connector/ODBC now supports using SSL for communication. This is not yet exposed in the setup GUI, but must be enabled through configuration files or the DSN. (Bug #12918)

Bugs Fixed

- Calls to SQLNativeSql() could cause stack corruption due to an incorrect pointer cast. (Bug #28758)
- Using cursors on results sets with multi-column keys could select the wrong value. (Bug #28255)
- `SQLForeignKeys` does not escape `_` and `%` in the table name arguments. (Bug #27723)
- When using stored procedures, making a `SELECT` or second stored procedure call after an initial stored procedure call, the second statement will fail. (Bug #27544)

- SQLTables() did not distinguish tables from views. (Bug #23031)
- Return values from `SQLTables()` may be truncated. (Bug #22797)
- Data in `TEXT` columns would fail to be read correctly. (Bug #16917)
- Specifying strings as parameters using the `adBSTR` or `adVarWChar` types, (`SQL_WVARCHAR` and `SQL_WLONGVARCHAR`) would be incorrectly quoted. (Bug #16235)
- SQL_WVARCHAR and SQL_WLONGVARCHAR parameters were not properly quoted and escaped. (Bug #16235)
- Using `BETWEEN` with date values, the wrong results could be returned. (Bug #15773)
- When using the `Don't Cache Results` (option value `1048576`) with Microsoft Access, the connection will fail using DAO/VisualBasic. (Bug #4657)

D.2.3.14. Changes in MySQL Connector/ODBC 3.51.15 (07 May 2007)

Bugs Fixed

- MySQL Connector/ODBC would incorrectly claim to support `SQLProcedureColumns` (by returning true when queried about `SQLPROCEDURECOLUMNS` with `SQLGetFunctions`), but this functionality is not supported. (Bug #27591)
- An incorrect transaction isolation level may not be returned when accessing the connection attributes. (Bug #27589)
- Adding a new DSN with the `myodbc3i` utility under AIX would fail. (Bug #27220)
- When inserting data using bulk statements (through `SQLBulkOperations`), the indicators for all rows within the insert would not updated correctly. (Bug #24306)
- Using `SQLProcedures` does not return the database name within the returned resultset. (Bug #23033)
- The `SQLTransact()` function did not support an empty connection handle. (Bug #21588)
- Using `SQLDriverConnect` instead of `SQLConnect` could cause later operations to fail. (Bug #7912)
- When using blobs and parameter replacement in a statement with `WHERE CURSOR OF`, the SQL is truncated. (Bug #5853)
- MySQL Connector/ODBC would return too many foreign key results when accessing tables with similar names. (Bug #4518)

D.2.3.15. Changes in MySQL Connector/ODBC 3.51.14 (08 March 2007)

Functionality Added or Changed

- Use of `SQL_ATTR_CONNECTION_TIMEOUT` on the server has now been disabled. If you attempt to set this attribute on your connection the `SQL_SUCCESS_WITH_INFO` will be returned, with an error number/string of `HYC00: Optional feature not supported`. (Bug #19823)
- Added auto is null option to MySQL Connector/ODBC option parameters. (Bug #10910)
- Added auto-reconnect option to MySQL Connector/ODBC option parameters.
- Added support for the `HENV` handlers in `SQLEndTran()`.

Bugs Fixed

- On 64-bit systems, some types would be incorrectly returned. (Bug #26024)
- When retrieving `TIME` columns, C/ODBC would incorrectly interpret the type of the string and could interpret it as a `DATE` type instead. (Bug #25846)
- MySQL Connector/ODBC may insert the wrong parameter values when using prepared statements under 64-bit Linux. (Bug #22446)
- Using MySQL Connector/ODBC, with `SQLBindCol` and binding the length to the return value from

`SQL_LEN_DATA_AT_EXEC` fails with a memory allocation error. (Bug #20547)

- Using `DataAdapter`, MySQL Connector/ODBC may continually consume memory when reading the same records within a loop (Windows Server 2003 SP1/SP2 only). (Bug #20459)
- When retrieving data from columns that have been compressed using `COMPRESS()`, the retrieved data would be truncated to 8KB. (Bug #20208)
- The ODBC driver name and version number were incorrectly reported by the driver. (Bug #19740)
- A string format exception would be raised when using iODBC, MySQL Connector/ODBC and the embedded MySQL server. (Bug #16535)
- The `SQLDriverConnect()` ODBC method did not work with recent MySQL Connector/ODBC releases. (Bug #12393)

D.2.3.16. Changes in MySQL Connector/ODBC 3.51.13 (Never released)

Connector/ODBC 3.51.13 was an internal implementation and testing release.

This section has no changelog entries.

D.2.3.17. Changes in MySQL Connector/ODBC 3.51.12 (11 February 2005)

Functionality Added or Changed

- N/A

Bugs Fixed

- Using stored procedures with ADO, where the `CommandType` has been set correctly to `adCmdStoredProc`, calls to stored procedures would fail. (Bug #15635)
- File DSNs could not be saved. (Bug #12019)
- `SQLColumns()` returned no information for tables that had a column named using a reserved word. (Bug #9539)

D.2.3.18. Changes in MySQL Connector/ODBC 3.51.11 (28 January 2005)

Bugs Fixed

- `mysql_list_dbcolumns()` and `insert_fields()` were retrieving all rows from a table. Fixed the queries generated by these functions to return no rows. (Bug #8198)
- `SQLGetTypoInfo()` returned `tinyblob` for `SQL_VARBINARY` and nothing for `SQL_BINARY`. Fixed to return `varbinary` for `SQL_VARBINARY`, `binary` for `SQL_BINARY`, and `longblob` for `SQL_LONGVARBINARY`. (Bug #8138)

D.3. MySQL Connector/Net Change History

D.3.1. Changes in MySQL Connector/Net Version 6.4.x

D.3.1.1. Changes in MySQL Connector/Net 6.4.4 (Not yet released)

This release fixes bugs since 6.4.3.

Bugs Fixed

- `MySqlDataReader.Close` was modified to use Default behavior when clearing remaining result sets. (Bug #61690, Bug #12723423)
- `MySqlScript` was modified to enable correct processing of the `DELIMITER` command when not followed by a new line. (Bug #61680, Bug #12732279)

- The ASP.NET membership provider was modified to create and query all related tables using lowercase names. (Bug #61108, Bug #12702009)
- On Model First changed column types generated in SQL scripts to produce more suitable `MySql` types. (Bug #59244, Bug #12707104)

D.3.1.2. Changes in MySQL Connector/Net 6.4.3 (05 July 2011)

This release fixes bugs since 6.4.2.

Bugs Fixed

- `SchemaDefinition-5.5.ssdl` was modified to treat `CHAR(36)` columns as a GUID. (Bug #61657, Bug #12708208)
- `SqlFragment.QuoteIdentifier` was modified to add MySQL quotes around identifiers. (Bug #61635, Bug #12707285)

D.3.1.3. Changes in MySQL Connector/Net 6.4.2 (29 June 2011)

This release fixes bugs since 6.4.1.

Bugs Fixed

- Modified `MySqlConnection.BeginTransaction` to throw a `NotSupportedException` for `Snapshot` isolation level. (Bug #61589, Bug #12698020)
- Modified `ProviderManifest.xml` to map `TIMESTAMP` database columns to the `DateTime` .NET type. (Bug #55351, Bug #12652602)
- Fixed Entity Framework provider `GROUP BY` clause generation by adding all group-by keys to the `SELECT` statement. (Bug #46742, Bug #12622129)

D.3.1.4. Changes in MySQL Connector/Net 6.4.1 (06 June 2011 Alpha)

First alpha release.

Functionality Added or Changed

- Calling a stored procedure with output parameters caused a marked performance decrease. (Bug #60366, Bug #12425959)
- Changed how the procedure schema collection is retrieved. If the connection string contains “`use procedure bodies=true`” then a `SELECT` is performed on the `mysql.proc` table directly, as this is up to 50 times faster than the current Information Schema implementation. If the connection string contains “`use procedure bodies=false`”, then the Information Schema collection is queried. (Bug #36694)

D.3.2. Changes in MySQL Connector/Net Version 6.3.x

D.3.2.1. Changes in MySQL Connector/Net 6.3.9 (Not yet released)

This release fixes bugs since 6.3.8.

Bugs Fixed

- On Model First changed column types generated in SQL scripts to produce more suitable `MySql` types. (Bug #59244, Bug #12707104)

D.3.2.2. Changes in MySQL Connector/Net 6.3.8 (Not yet released)

This release fixes bugs since 6.3.7.

Bugs Fixed

- `MySqlDataReader.Close` was modified to use Default behavior when clearing remaining result sets. (Bug #61690, Bug #12723423)
- `MySqlScript` was modified to enable correct processing of the `DELIMITER` command when not followed by a new line. (Bug #61680, Bug #12732279)
- `SchemaDefinition-5.5.ssdl` was modified to treat `CHAR(36)` columns as a GUID. (Bug #61657, Bug #12708208)
- `SqlFragment.QuoteIdentifier` was modified to add MySQL quotes around identifiers. (Bug #61635, Bug #12707285)
- Modified `MySqlConnection.BeginTransaction` to throw a `NotSupportedException` for `Snapshot` isolation level. (Bug #61589, Bug #12698020)
- The ASP.NET membership provider was modified to create and query all related tables using lowercase names. (Bug #61108, Bug #12702009)
- Modified `ProviderManifest.xml` to map `TIMESTAMP` database columns to the `DateTime` .NET type. (Bug #55351, Bug #12652602)

D.3.2.3. Changes in MySQL Connector/Net 6.3.7 (22 June 2011)

This release fixes bugs since 6.3.6.

Functionality Added or Changed

- Calling a stored procedure with output parameters caused a marked performance decrease. (Bug #60366, Bug #12425959)

Bugs Fixed

- MySQL Connector/Net 6.3.6 did not work with Visual Studio 2010. (Bug #60723, Bug #12394470)
- `MysqlDataReader.GetSchemaTable` returned incorrect values and types. (Bug #59989, Bug #11776346)
- All queries other than `INSERT` were executed individually instead of as a batch even though batching was enabled for the connection. (Bug #59616, Bug #11850286)
- MySQL Connector/Net generated an exception when executing a query consisting of ';', for example:

  ```
  mycmd(";",mycon)
  mycmd.executenonquery()
  ```

  The exception generated was:

  ```
  System.IndexOutOfRangeException: Index was outside the bounds of the array.
     at MySql.Data.MySqlClient.MySqlCommand.TrimSemicolons(String sql)
     at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
     at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
     at MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
  ```

  (Bug #59537, Bug #11766433)
- Setting `Membership.ApplicationName` had no effect. (Bug #59438, Bug #11770465)
- A `NullReferenceException` was thrown on disposal of a `TransactionScope` object. (Bug #59346, Bug #11766272)
- The setup wizard failed with the error “Setup Wizard ended prematurely because of an error”. This was because it assumed .NET Framework version 4.0 was located on the C: drive, when it was actually located on the E: drive. (Bug #59301)
- Fixed Entity Framework provider `GROUP BY` clause generation by adding all group-by keys to the `SELECT` statement. (Bug #46742, Bug #12622129)

D.3.2.4. Changes in MySQL Connector/Net 6.3.6 (03 January 2011)

This release fixes bugs since 6.3.5.

Functionality Added or Changed

- Changed how the procedure schema collection is retrieved. If the connection string contains "`use procedure bodies=true`" then a `SELECT` is performed on the `mysql.proc` table directly, as this is up to 50 times faster than the current Information Schema implementation. If the connection string contains "`use procedure bodies=false`", then the Information Schema collection is queried. (Bug #36694)

Bugs Fixed

- `MembershipProvider` did not generate hashes correctly if the algorithm was keyed. The Key of the algorithm should have been set if the `HashAlgorithm` was `KeyedHashAlgorithm`. (Bug #58906)
- Code introduced to fix bug #54863 proved problematic on .NET version 3.5 and above. (Bug #58853)
- The `MySqlTokenizer` contained unnecessary `Substring` and `Trim` calls:

  ```
  string token = sql.Substring(startIndex, stopIndex - startIndex).Trim();
  ```

  The variable `token` was not used anywhere in the code. (Bug #58757)
- `MySqlCommand.ExecuteReader(CommandBehavior)` threw a `NullReferenceException` when being called with `CommandBehavior.CloseConnection`, if the SQL statement contained a syntax error, or contained invalid data such as an invalid column name. (Bug #58652)
- `ReadFieldLength()` returned incorrect value for `BIGINT` autoincrement columns. (Bug #58373)
- When attempting to create an ADO.NET Entity Data Model, MySQL connections were not available. (Bug #58278)
- MySQL Connector/Net did not support the `utf8mb4` character set. When attempting to connect to `utf8mb4` tables or columns, an exception `KeyNotFoundException` was generated. (Bug #58244)
- Installation of MySQL Connector/Net 6.3.5 failed. The error reported was:

  ```
  MySQL Connector Net 6.3.5 Setup Wizard ended
  prematurely because of an error. Your system has not been modified.
  ```

  (Bug #57654)
- When the tracing driver was used and an SQL statement was longer than 300 characters, an ArgumentOutOfRangeExcpetion occurred if the statement also contained a quoted character, and the 300th character was in the middle of a quoted token. (Bug #57641)
- Calling the `Read()` method on a `DataReader` obtained from `MySqlHelper.ExecuteReader` generated the following exception:

  ```
  Unhandled Exception: MySql.Data.MySqlClient.MySqlException: Invalid attempt to R
  ead when reader is closed.
     at MySql.Data.MySqlClient.MySqlDataReader.Read()
     at MySqlTest.MainClass.Main(String[] args)
  ```

  (Bug #57501)
- Default values returned for text columns were not quoted. This meant that the `COLUMN_DEFAULT` field of the `GetSchema` columns collection did not return a valid SQL expression. (Bug #56509)
- When using MySQL Connector/Net on Mono 2.8 using .NET 4.0, attempting to connect to a MySQL database generated the following exception:

  ```
  Unhandled Exception: System.MissingMethodException: Method not found:
   'System.Data.Common.DbConnection.EnlistTransaction'.
    at (wrapper remoting-invoke-with-check)
   MySql.Data.MySqlClient.MySqlConnection:Open ()
  ```

  (Bug #56509)
- MySQL Connector/Net for .NET/Mono attempted to dynamically load the assembly `Mono.Posix.dll` when a Unix socket was used to connect to the server. This failed and the connector was not able to use a Unix socket unless the `Mono.Posix.dll` assembly was previously loaded by the program. (Bug #56410)
- The ADO.NET Entity Data Model could not add stored procedures from MySQL Server 5.0.45 but worked fine using MySQL Server 5.1. (Bug #55349)

- In the ADO.NET Entity Data Model Wizard, the time to update a model scaled abnormally as the number of entities increased. (Bug #48791, Bug #12596237)

D.3.2.5. Changes in MySQL Connector/Net 6.3.5 (12 October 2010)

This release fixes bugs since 6.3.4.

Bugs Fixed

- A typed dataset did not get the table name. (Bug #57894, Bug #11764989)
- Setting `MySqlCommand.CommandTimeout` to 0 had no effect. It should have resulted in an infinite timeout. (Bug #57265)
- When performing a row-by-row update, only the first row was updated and all other rows were ignored. (Bug #57092)
- MySQL Connector/Net experienced two problems as follows:

  1. A call to `System.Data.Objects.ObjectContext.DatabaseExists()` returned false, even if the database existed.
  2. A call to `System.Data.Objects.ObjectContext.CreateDatabase()` created a database but with a name other than the one specified in the connection string. It then failed to use it when EDM objects were processed.

  (Bug #56859)
- Setting the `Default Command Timeout` connection string option had no effect. (Bug #56806)
- When an output parameter was declared as type `MySqlDbType.Bit`, it failed to return with the correct value. (Bug #56756)
- `MySqlHelper.ExecuteReader` did not include an overload accepting `MySqlParameter` objects when using a `MySqlConnection`. However, `MySqlHelper` did include an overload for `MySqlParameter` objects when using a string object containing the connection string to the database. (Bug #56755)
- MySQL Connector/Net 6.1.3 (GA) would not install on a Windows Server 2008 (Web Edition) clean installation. There were two problems:

  - If .NET framework version 4.0 was not installed, installation failed because c:\windows\microsoft.net\v4.0.* did not exist.
  - If .NET 4.0 was subsequently installed, then the following error was generated:

    ```
    InstallFiles: File: MySql.Data.Entity.dll,  Directory: ,  Size: 229888
    MSI (s) (E0:AC) [15:20:26:196]: Assembly Error:The assembly is built by a runtime newer
    than the currently loaded runtime, and cannot be loaded.
    MSI (s) (E0:AC) [15:20:26:196]: Note: 1: 1935 2:  3: 0x8013101B 4: IStream 5: Commit 6:
    MSI (s) (E0:A0) [15:20:26:196]: Note: 1: 1304 2: MySql.Data.Entity.dll
    Error 1304. Error writing to file: MySql.Data.Entity.dll. Verify that you have access to
    that directory.
    ```

  (Bug #56580)

D.3.2.6. Changes in MySQL Connector/Net 6.3.4 (01 September 2010 GA)

First GA release. This release fixes bugs since 6.3.3.

Bugs Fixed

- The calculation of `lockAge` in the Session Provider sometimes generated a `System.Data.SqlTypes.SqlNullValueException`. (Bug #55701)
- Attempting to read `Double.MinValue` from a `DOUBLE` column in MySQL table generated the following exception:

  ```
  System.OverflowException : Value was either too large or too small for a Double.

  --OverflowException
  at System.Number.ParseDouble(String value, NumberStyles options, NumberFormatInfo
  numfmt)
  at MySql.Data.Types.MySqlDouble.MySql.Data.Types.IMySqlValue.ReadValue(MySqlPacket
  packet, Int64 length, Boolean nullVal)
  at MySql.Data.MySqlClient.NativeDriver.ReadColumnValue(Int32 index, MySqlField field,
  IMySqlValue valObject)
  at MySql.Data.MySqlClient.ResultSet.ReadColumnData(Boolean outputParms)
  at MySql.Data.MySqlClient.ResultSet.NextRow(CommandBehavior behavior)
  ```

```
at MySql.Data.MySqlClient.MySqlDataReader.Read()
```

(Bug #55644)

- Calling `MySqlDataAdapter.Update(DataTable)` resulted in an unacceptable performance hit when updating large amounts of data. (Bug #55609)
- If using MySQL Server 5.0.x it was not possible to alter stored routines in Visual Studio. If the stored routine was clicked, and the context sensitive menu option, Alter Routine, selected, the following error was generated:

  ```
  Unable to load object with error: Object reference not
  set to an instance of an object
  ```

  (Bug #55170)
- EventLog was not disposed in the SessionState provider. (Bug #52550)
- When attempting to carry out an operation such as:

  ```
  from p in db.Products where p.PostedDate>=DateTime.Now select p;
  ```

  Where `p.PostedDate` is a `DateTimeOffset`, and the underlying column type is a `TIMESTAMP`, the following exception was generated:

  ```
  MySqlException occurred
  Unable to serialize date/time value
  ```

  MySQL Connector/Net has now been changed so that all `TIMESTAMP` columns will be surfaced as `DateTime`. (Bug #52550)
- Stored procedure enumeration code generated an error if a procedure was used in a dataset that did not return any resultsets. (Bug #50671)
- The `INSERT` command was significantly slower with MySQL Connector/Net 6.x compared to 5.x, when compression was enabled. (Bug #48243)
- Opening a connection in the Visual Studio Server Explorer and choosing to alter an existing routine required another authentication at the server. (Bug #44715)

D.3.2.7. Changes in MySQL Connector/Net 6.3.3 (27 July 2010)

This release fixes bugs since 6.3.2.

Bugs Fixed

- `MySqlDataAdapter.Update()` generated concurrency violations for custom stored procedure driven update commands that used `UpdateRowSource.FirstReturnedRecord`. (Bug #54895)
- Several calls to `DataAdapter.Update()` with intervening changes to `DataTable` resulted in `ConcurrencyException` exceptions being generated. (Bug #54863)
- MySQL Connector/Net generated a null reference exception when `TransactionScope` was used by multiple threads. (Bug #54681)
- The icon for the MySQL Web Configuration Tool was not displayed in Visual Studio for Web Application Projects. (Bug #54571)
- The `MySqlHelper` object did not have an overloaded version of the `ExecuteReader` method that accepted a `MySqlConnection` object. (Bug #54570)
- If `MySqlDataAdapter` was used with an `INSERT` command where the `VALUES` clause contained an expression with parentheses in it, and set the `adapter.UpdateBatchSize` parameter to be greater than one, then the call to `adapter.Update` either generated an exception or failed to batch the commands, executing each insert individually. (Bug #54386)
- The method `MySql.Data.Common.QueryNormalizer.CollapseValueList` generated an `ArgumentOutOfRangeException`. (Bug #54152, Bug #53865)

- MySQL Connector/Net did not process `Thread.Abort()` correctly, and failed to cancel queries currently running on the server. (Bug #54012)
- MySQL Connector/Net 6.3.2 failed to install on Windows Vista. (Bug #53975)
- Garbage Collector disposal of a `MySqlConnection` object caused the following exception:

  ```
  System.IO.EndOfStreamException: Attempted to read past the end of the stream.
  MySql.Data.MySqlClient.MySqlStream.ReadFully(Stream stream, Byte[] buffer, Int32 offset,
  Int32 count)
  MySql.Data.MySqlClient.MySqlStream.LoadPacket()
  Outer Exception Reading from the stream has failed.
  ...
  ```

  (Bug #53457)
- MySQL Connector/Net did not throw an `EndOfStreamException` exception when `net_write_timeout` was exceeded. (Bug #53439)
- After a timeout exception, if an attempt was made to reuse a connection returned to the connection pool the following exception was generated:

  ```
  [MySqlException (0x80004005): There is already an open DataReader associated with this
  Connection which must be closed first.]
     MySql.Data.MySqlClient.MySqlCommand.CheckState() +278
     MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior) +43
     MySql.Data.MySqlClient.MySqlCommand.ExecuteReader() +6
     Controls.SimpleCommand.ExecuteReader(String SQL) in ...:323
     Albums.GetImagesByAlbum(SimpleCommand Cmd, Int32 iAlbum, String Order, String Limit)
  in ...:13
     Forecast.Page_Load(Object sender, EventArgs e) in ...:70
     System.Web.UI.Control.OnLoad(EventArgs e) +99
     System.Web.UI.Control.LoadRecursive() +50
     System.Web.UI.Page.ProcessRequestMain(Boolean includeStagesBeforeAsyncPoint, Boolean
  includeStagesAfterAsyncPoint) +627
  ```

  (Bug #53357)
- Membership schema creation failed if the default schema collation was not Latin1. (Bug #53174)
- The MySQL Connector/Net installation failed due to `machine.config` files not being present in configuration folders.

  MySQL Connector/Net has been changed to skip over configuration folders that do not contain a `machine.config` file. (Bug #52352)
- `CHAR(36)` columns were not recognized as GUIDs when used in views with entity models. (Bug #52085)
- When an application was subjected to increased concurrent load, MySQL Connector/Net generated the following error when calling stored procedures:

  ```
  A DataTable named \'Procedure Parameters\'
  already belongs to this DataSet.
  ```

  (Bug #49118)
- When the connection string option “Connection Reset = True” was used, a connection reset used the previously used encoding for the subsequent authentication operation. This failed, for example, if UCS2 was used to read the last column before the reset. (Bug #47153)
- When batching was used in `MySqlDataAdapter`, a connection was not opened automatically in `MySqlDataAdapter.Update()`. This resulted in an `InvalidOperationException` exception being generated, with the message text “connection must be valid and open”.

  MySQL Connector/Net has been changed to behave more like SQL Server: if the connection is closed, it is opened for the duration of update operation. (Bug #38411)
- Database name was emitted into typed datasets. This prevented users using the configured default database. (Bug #33870)

D.3.2.8. Changes in MySQL Connector/Net 6.3.2 (24 May 2010 beta)

First Beta release. This release fixes bugs since 6.3.1.

Functionality Added or Changed

- Procedure cacheing had a problem whereby if you created a procedure, dropped it, and recreated it with a different number of parameters an exception was generated.

  MySQL Connector/Net has been changed so that if the procedure is recreated with a different number of parameters, it will still be recognized. (Bug #52562)

- MySQL Connector/Net has been changed to include `MySqlDataReader.GetFieldType(string columnname)`. Further, `MySqlDataReader.GetOrdinal()` now includes the name of the column in the exception if the column is not found. (Bug #47467)

Bugs Fixed

- After an exception, the internal datareader, `MySqlCommand.Connection.Reader`, was not properly closed (it was not set to null). If another query was subsequently executed on that command object an exception was generated with the message “There is already an open DataReader associated with this Connection which must be closed first.” (Bug #55558)

- MySQL Connector/Net generated an exception when used to read a `TEXT` column containing more than 32767 bytes. (Bug #54040)

- In MySQL Connector/Net, the `MySqlConnection.Abort()` method contained a `try...catch` construct, with an empty `catch` block. This meant that any exception generated at this point would not be caught. (Bug #52769)

- The procedure cache affected the MySQL Connector/Net performance, reducing it by around 65%. This was due to unnecessary calls of `String.Format()`, related to debug logging. Even though the logging was disabled the string was still being formatted, resulting in impaired performance. (Bug #52475)

- If `FunctionsReturnString=true` was used in the connection string, the decimal separator (according to locale) was not interpreted. (Bug #52187)

- In MySQL Connector/Net, the `LoadCharsetMap()` function of the `CharSetMap` class set the following incorrect mapping:

  ```
  mapping.Add("latin1", new CharacterSet("latin1", 1));
  ```

  This meant that, for example, the Euro sign was not handled correctly.

  The correct mapping should have been:

  ```
  mapping.Add("latin1", new CharacterSet("windows-1252", 1));
  ```

  This is because MySQL's `latin1` character set is the same as the `windows-cp1252` character set and it extends the official ISO 8859-1 or IANA latin1. (Bug #51927)

- A non-terminated string in SQL threw a CLR exception rather than a syntax exception. (Bug #51788)

- When calling `ExecuteNonQuery` on a command object, the following exception occurred:

  ```
  Index and length must refer to a location within the string.
  Parameter name: length
  ```

  (Bug #51610)

- MySQL Connector/Net 6.3.1 failed to install. (Bug #51407, Bug #51604)

- When using table per type inheritance and listing the contents of the parent table, the result of the query was a list of child objects, even though there was no related child record with the same parent Id. (Bug #49850)

D.3.2.9. Changes in MySQL Connector/Net 6.3.1 (02 March 2010)

This release fixes bugs since 6.3.0.

Functionality Added or Changed

- Connector/Net was not compatible with Visual Studio wizards that used square brackets to delimit symbols.

  Connector/Net has been changed to include a new connection string option `Sql Server mode` that supports use of square brackets to delimit symbols. (Bug #35852)

Bugs Fixed

- Specifying a connection string where an option had no value generated an error, rather than the value being set to the default. For example, a connection string such as the following would result in an error:

  ```
  server=localhost;user=root;compress=;database=test;port=3306;password=123456;
  ```

  (Bug #51209)

- The method `Command.TrimSemicolons` used `StringBuilder`, and therefore allocated memory for the query even if it did not need to be trimmed. This led to excessive memory consumption when executing a number of large queries. (Bug #51149)

- `MySqlCommand.Parameters.Clear()` did not work. (Bug #50444)

- Binary Columns were not displayed in the Query Builder of Visual Studio. (Bug #50171)

- When the `UpdateBatchSize` property was set to a value greater than 1, only the first row was applied to the database. (Bug #50123)

- When trying to create stored procedures from an SQL script, a `MySqlException` was thrown when attempting to redefine the `DELIMITER`:

  ```
          MySql.Data.MySqlClient.MySqlException was unhandled
          Message="You have an error in your SQL syntax; check the manual that corresponds to your
          MySQL server version for the right syntax to use near 'DELIMITER' at line 1"
          Source="MySql.Data"
          ErrorCode=-2147467259
          Number=1064
          StackTrace:
          à MySql.Data.MySqlClient.MySqlStream.ReadPacket()
          à MySql.Data.MySqlClient.NativeDriver.ReadResult(UInt64& affectedRows, Int64&
          lastInsertId)
          à MySql.Data.MySqlClient.MySqlDataReader.GetResultSet()
          à MySql.Data.MySqlClient.MySqlDataReader.NextResult()
          à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
          à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
          à MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
        à MySql.Data.MySqlClient.MySqlScript.Execute()
  ```

  Note: The `MySqlScript` class has been fixed to support the delimiter statement as it is found in SQL scripts. (Bug #46429)

- A connection string set in `web.config` could not be reused after Visual Studio 2008 Professional was shut down. It continued working for the existing controls, but did not work for new controls added. (Bug #41629)

D.3.2.10. Changes in MySQL Connector/Net 6.3.0 (16 February 2010 alpha)

First alpha release of 6.3.

Functionality Added or Changed

- Nested transaction scopes were not supported. MySQL Connector/Net now implements nested transaction scopes. A per-thread stack of scopes is maintained, which is necessary to handle nested scopes with the `RequiresNew` or `Suppress` options. (Bug #45098)

- Support for MySQL Server 4.1 has been removed from MySQL Connector/Net starting with version 6.3.0. The connector will now throw an exception if you try to connect to a server of version less than 5.0.

Bugs Fixed

- When adding a data set in Visual Studio 2008, the following error was generated:

  ```
  Relations couldn't be addded. Column 'REFERENCED_TABLE_CATALOG' does not belong to table.
  ```

  This was due to a 'REFERENCED_TABLE_CATALOG' column not being included in the foreign keys collection. (Bug #48974)

- Attempting to execute a load data local infile on a file where the user did not have write permissions, or the file was open in an editor gave an access denied error. (Bug #48944)
- The method `MySqlDataReader.GetSchemaTable()` returned 0 in the `NumericPrecision` field for decimal and newdecimal columns. (Bug #48171)

D.3.3. Changes in MySQL Connector/Net Version 6.2.x

D.3.3.1. Changes in MySQL Connector/Net 6.2.6 (Not yet released)

This release fixes bugs since 6.2.5.

Bugs Fixed

- `MySqlScript` was modified to enable correct processing of the `DELIMITER` command when not followed by a new line. (Bug #61680, Bug #12732279)
- The ASP.NET membership provider was modified to create and query all related tables using lowercase names. (Bug #61108, Bug #12702009)
- On Model First changed column types generated in SQL scripts to produce more suitable `MySql` types. (Bug #59244, Bug #12707104)

D.3.3.2. Changes in MySQL Connector/Net 6.2.5 (05 July 2011)

This release fixes bugs since 6.2.4.

Bugs Fixed

- `SchemaDefinition-5.5.ssdl` was modified to treat `CHAR(36)` columns as a GUID. (Bug #61657, Bug #12708208)
- `SqlFragment.QuoteIdentifier` was modified to add MySQL quotes around identifiers. (Bug #61635, Bug #12707285)
- Modified `MySqlConnection.BeginTransaction` to throw a `NotSupportedException` for `Snapshot` isolation level. (Bug #61589, Bug #12698020)
- `MysqlDataReader.GetSchemaTable` returned incorrect values and types. (Bug #59989, Bug #11776346)
- All queries other than `INSERT` were executed individually instead of as a batch even though batching was enabled for the connection. (Bug #59616, Bug #11850286)
- MySQL Connector/Net generated an exception when executing a query consisting of ';', for example:

  ```
  mycmd(";",mycon)
  mycmd.executenonquery()
  ```

  The exception generated was:

  ```
  System.IndexOutOfRangeException: Index was outside the bounds of the array.
     at MySql.Data.MySqlClient.MySqlCommand.TrimSemicolons(String sql)
     at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
     at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
     at MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
  ```

  (Bug #59537, Bug #11766433)
- Setting `Membership.ApplicationName` had no effect. (Bug #59438, Bug #11770465)
- A `NullReferenceException` was thrown on disposal of a `TransactionScope` object. (Bug #59346, Bug #11766272)
- `MembershipProvider` did not generate hashes correctly if the algorithm was keyed. The Key of the algorithm should have been set if the `HashAlgorithm` was `KeyedHashAlgorithm`. (Bug #58906)
- Code introduced to fix bug #54863 proved problematic on .NET version 3.5 and above. (Bug #58853)
- The `MySqlTokenizer` contained unnecessary `Substring` and `Trim` calls:

```
string token = sql.Substring(startIndex, stopIndex - startIndex).Trim();
```

The variable `token` was not used anywhere in the code. (Bug #58757)

- `MySqlCommand.ExecuteReader(CommandBehavior)` threw a `NullReferenceException` when being called with `CommandBehavior.CloseConnection`, if the SQL statement contained a syntax error, or contained invalid data such as an invalid column name. (Bug #58652)
- `ReadFieldLength()` returned incorrect value for `BIGINT` autoincrement columns. (Bug #58373)
- MySQL Connector/Net did not support the `utf8mb4` character set. When attempting to connect to `utf8mb4` tables or columns, an exception `KeyNotFoundException` was generated. (Bug #58244)
- A typed dataset did not get the table name. (Bug #57894, Bug #11764989)
- Setting `MySqlCommand.CommandTimeout` to 0 had no effect. It should have resulted in an infinite timeout. (Bug #57265)
- When performing a row-by-row update, only the first row was updated and all other rows were ignored. (Bug #57092)
- Setting the `Default Command Timeout` connection string option had no effect. (Bug #56806)
- When an output parameter was declared as type `MySqlDbType.Bit`, it failed to return with the correct value. (Bug #56756)
- `MySqlHelper.ExecuteReader` did not include an overload accepting `MySqlParameter` objects when using a `MySqlConnection`. However, `MySqlHelper` did include an overload for `MySqlParameter` objects when using a string object containing the connection string to the database. (Bug #56755)
- Default values returned for text columns were not quoted. This meant that the `COLUMN_DEFAULT` field of the `GetSchema` columns collection did not return a valid SQL expression. (Bug #56509)
- MySQL Connector/Net for .NET/Mono attempted to dynamically load the assembly `Mono.Posix.dll` when a Unix socket was used to connect to the server. This failed and the connector was not able to use a Unix socket unless the `Mono.Posix.dll` assembly was previously loaded by the program. (Bug #56410)
- Modified `ProviderManifest.xml` to map `TIMESTAMP` database columns to the `DateTime` .NET type. (Bug #55351, Bug #12652602)
- The ADO.NET Entity Data Model could not add stored procedures from MySQL Server 5.0.45 but worked fine using MySQL Server 5.1. (Bug #55349)
- Fixed Entity Framework provider `GROUP BY` clause generation by adding all group-by keys to the `SELECT` statement. (Bug #46742, Bug #12622129)

D.3.3.3. Changes in MySQL Connector/Net 6.2.4 (30 August 2010)

This release fixes bugs since 6.2.3.

Functionality Added or Changed

- Procedure cacheing had a problem whereby if you created a procedure, dropped it, and recreated it with a different number of parameters an exception was generated.

  MySQL Connector/Net has been changed so that if the procedure is recreated with a different number of parameters, it will still be recognized. (Bug #52562)

Bugs Fixed

- The calculation of `lockAge` in the Session Provider sometimes generated a `System.Data.SqlTypes.SqlNullValueException`. (Bug #55701)
- Attempting to read `Double.MinValue` from a `DOUBLE` column in MySQL table generated the following exception:

```
System.OverflowException : Value was either too large or too small for a Double.

--OverflowException
at System.Number.ParseDouble(String value, NumberStyles options, NumberFormatInfo
numfmt)
at MySql.Data.Types.MySqlDouble.MySql.Data.Types.IMySqlValue.ReadValue(MySqlPacket
packet, Int64 length, Boolean nullVal)
at MySql.Data.MySqlClient.NativeDriver.ReadColumnValue(Int32 index, MySqlField field,
IMySqlValue valObject)
at MySql.Data.MySqlClient.ResultSet.ReadColumnData(Boolean outputParms)
at MySql.Data.MySqlClient.ResultSet.NextRow(CommandBehavior behavior)
at MySql.Data.MySqlClient.MySqlDataReader.Read()
```

(Bug #55644)

- After an exception, the internal datareader, `MySqlCommand.Connection.Reader`, was not properly closed (it was not set to null). If another query was subsequently executed on that command object an exception was generated with the message "There is already an open DataReader associated with this Connection which must be closed first." (Bug #55558)
- If using MySQL Server 5.0.x it was not possible to alter stored routines in Visual Studio. If the stored routine was clicked, and the context sensitive menu option, Alter Routine, selected, the following error was generated:

  ```
  Unable to load object with error: Object reference not
  set to an instance of an object
  ```

  (Bug #55170)
- `MySqlDataAdapter.Update()` generated concurrency violations for custom stored procedure driven update commands that used `UpdateRowSource.FirstReturnedRecord`. (Bug #54895)
- Several calls to `DataAdapter.Update()` with intervening changes to `DataTable` resulted in `ConcurrencyException` exceptions being generated. (Bug #54863)
- The icon for the MySQL Web Configuration Tool was not displayed in Visual Studio for Web Application Projects. (Bug #54571)
- The `MySqlHelper` object did not have an overloaded version of the `ExecuteReader` method that accepted a `MySqlConnection` object. (Bug #54570)
- If `MySqlDataAdapter` was used with an `INSERT` command where the `VALUES` clause contained an expression with parentheses in it, and set the `adapter.UpdateBatchSize` parameter to be greater than one, then the call to `adapter.Update` either generated an exception or failed to batch the commands, executing each insert individually. (Bug #54386)
- The method `MySql.Data.Common.QueryNormalizer.CollapseValueList` generated an `ArgumentOutOfRangeException`. (Bug #54152, Bug #53865)
- MySQL Connector/Net did not process `Thread.Abort()` correctly, and failed to cancel queries currently running on the server. (Bug #54012)
- Garbage Collector disposal of a `MySqlConnection` object caused the following exception:

  ```
  System.IO.EndOfStreamException: Attempted to read past the end of the stream.
  MySql.Data.MySqlClient.MySqlStream.ReadFully(Stream stream, Byte[] buffer, Int32 offset,
  Int32 count)
  MySql.Data.MySqlClient.MySqlStream.LoadPacket()
  Outer Exception Reading from the stream has failed.
  ...
  ```

  (Bug #53457)
- MySQL Connector/Net did not throw an `EndOfStreamException` exception when `net_write_timeout` was exceeded. (Bug #53439)
- After a timeout exception, if an attempt was made to reuse a connection returned to the connection pool the following exception was generated:

  ```
  [MySqlException (0x80004005): There is already an open DataReader associated with this
  Connection which must be closed first.]
     MySql.Data.MySqlClient.MySqlCommand.CheckState() +278
     MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior) +43
     MySql.Data.MySqlClient.MySqlCommand.ExecuteReader() +6
     Controls.SimpleCommand.ExecuteReader(String SQL) in ...:323
     Albums.GetImagesByAlbum(SimpleCommand Cmd, Int32 iAlbum, String Order, String Limit)
  in ...:13
     Forecast.Page_Load(Object sender, EventArgs e) in ...:70
     System.Web.UI.Control.OnLoad(EventArgs e) +99
     System.Web.UI.Control.LoadRecursive() +50
     System.Web.UI.Page.ProcessRequestMain(Boolean includeStagesBeforeAsyncPoint, Boolean
  includeStagesAfterAsyncPoint) +627
  ```

(Bug #53357)

- Membership schema creation failed if the default schema collation was not Latin1. (Bug #53174)
- In MySQL Connector/Net, the `MySqlConnection.Abort()` method contained a `try...catch` construct, with an empty `catch` block. This meant that any exception generated at this point would not be caught. (Bug #52769)
- EventLog was not disposed in the SessionState provider. (Bug #52550)
- The procedure cache affected the MySQL Connector/Net performance, reducing it by around 65%. This was due to unnecessary calls of `String.Format()`, related to debug logging. Even though the logging was disabled the string was still being formatted, resulting in impaired performance. (Bug #52475)
- If `FunctionsReturnString=true` was used in the connection string, the decimal separator (according to locale) was not interpreted. (Bug #52187)
- Periodically the session provider threw an `SqlNullValueException` exception. When this happened, the row within the `my_aspnet_Sessions` table had `locked` always set to '1'. The locked status never changed back to '0' and the user experienced the exception on every page, until their browser was closed and reopened (recreating a new sessionID), or the `locked` value was manually changed to '0'. (Bug #52175)
- `CHAR(36)` columns were not recognized as GUIDs when used in views with entity models. (Bug #52085)
- In MySQL Connector/Net, the `LoadCharsetMap()` function of the `CharSetMap` class set the following incorrect mapping:

  ```
  mapping.Add("latin1", new CharacterSet("latin1", 1));
  ```

  This meant that, for example, the Euro sign was not handled correctly.

  The correct mapping should have been:

  ```
  mapping.Add("latin1", new CharacterSet("windows-1252", 1));
  ```

  This is because MySQL's `latin1` character set is the same as the `windows-cp1252` character set and it extends the official ISO 8859-1 or IANA latin1. (Bug #51927)
- Stored procedure enumeration code generated an error if a procedure was used in a dataset that did not return any resultsets. (Bug #50671)
- When an application was subjected to increased concurrent load, MySQL Connector/Net generated the following error when calling stored procedures:

  ```
  A DataTable named \'Procedure Parameters\'
  already belongs to this DataSet.
  ```

  (Bug #49118)
- In the ADO.NET Entity Data Model Wizard, the time to update a model scaled abnormally as the number of entities increased. (Bug #48791, Bug #12596237)
- The `INSERT` command was significantly slower with MySQL Connector/Net 6.x compared to 5.x, when compression was enabled. (Bug #48243)
- When the connection string option “Connection Reset = True” was used, a connection reset used the previously used encoding for the subsequent authentication operation. This failed, for example, if UCS2 was used to read the last column before the reset. (Bug #47153)
- Opening a connection in the Visual Studio Server Explorer and choosing to alter an existing routine required another authentication at the server. (Bug #44715)
- When batching was used in `MySqlDataAdapter`, a connection was not opened automatically in `MySqlDataAdapter.Update()`. This resulted in an `InvalidOperationException` exception being generated, with the message text “connection must be valid and open”.

  MySQL Connector/Net has been changed to behave more like SQL Server: if the connection is closed, it is opened for the duration of update operation. (Bug #38411)

- Database name was emitted into typed datasets. This prevented users using the configured default database. (Bug #33870)

D.3.3.4. Changes in MySQL Connector/Net 6.2.3 (10 April 2010)

This release fixes bugs since 6.2.2.

Functionality Added or Changed

- MySQL Connector/Net has been changed to include `MySqlDataReader.GetFieldType(string columnname)`. Further, `MySqlDataReader.GetOrdinal()` now includes the name of the column in the exception if the column is not found. (Bug #47467)

Bugs Fixed

- A non-terminated string in SQL threw a CLR exception rather than a syntax exception. (Bug #51788)
- When calling `ExecuteNonQuery` on a command object, the following exception occurred:

  ```
  Index and length must refer to a location within the string.
  Parameter name: length
  ```

  (Bug #51610)
- Specifying a connection string where an option had no value generated an error, rather than the value being set to the default. For example, a connection string such as the following would result in an error:

  ```
  server=localhost;user=root;compress=;database=test;port=3306;password=123456;
  ```

  (Bug #51209)
- The method `Command.TrimSemicolons` used `StringBuilder`, and therefore allocated memory for the query even if it did not need to be trimmed. This led to excessive memory consumption when executing a number of large queries. (Bug #51149)
- `MySqlCommand.Parameters.Clear()` did not work. (Bug #50444)
- When the `MySqlScript.execute()` method was called, the following exception was generated:

  ```
  InvalidOperationException : The CommandText property has not been properly initialized.
  ```

  (Bug #50344)
- When using the Compact Framework the following exception occurred when attempting to connect to a MySQL Server:

  ```
  System.InvalidOperationException was unhandled
    Message="Timeouts are not supported on this stream."
  ```

  (Bug #50321)
- Binary Columns were not displayed in the Query Builder of Visual Studio. (Bug #50171)
- When the `UpdateBatchSize` property was set to a value greater than 1, only the first row was applied to the database. (Bug #50123)
- When using table per type inheritance and listing the contents of the parent table, the result of the query was a list of child objects, even though there was no related child record with the same parent Id. (Bug #49850)
- `MySqlDataReader.GetUInt64` returned an incorrect value when reading a `BIGINT UNSIGNED` column containing a value greater than 2147483647. (Bug #49794)
- A `FormatException` was generated when an empty string was returned from a stored function. (Bug #49642)
- When trying to create stored procedures from an SQL script, a `MySqlException` was thrown when attempting to redefine the `DELIMITER`:

  ```
          MySql.Data.MySqlClient.MySqlException was unhandled
          Message="You have an error in your SQL syntax; check the manual that corresponds to your
  ```

```
        MySQL server version for the right syntax to use near 'DELIMITER' at line 1"
        Source="MySql.Data"
        ErrorCode=-2147467259
        Number=1064
        StackTrace:
        à MySql.Data.MySqlClient.MySqlStream.ReadPacket()
        à MySql.Data.MySqlClient.NativeDriver.ReadResult(UInt64& affectedRows, Int64&
        lastInsertId)
        à MySql.Data.MySqlClient.MySqlDataReader.GetResultSet()
        à MySql.Data.MySqlClient.MySqlDataReader.NextResult()
        à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
        à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
        à MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
      à MySql.Data.MySqlClient.MySqlScript.Execute()
```

Note: The `MySqlScript` class has been fixed to support the delimiter statement as it is found in SQL scripts. (Bug #46429)

- Calling a User Defined Function using Entity SQL in the Entity Framework caused a `NullReferenceException`. (Bug #45277)
- A connection string set in `web.config` could not be reused after Visual Studio 2008 Professional was shut down. It continued working for the existing controls, but did not work for new controls added. (Bug #41629)

D.3.3.5. Changes in MySQL Connector/Net 6.2.2 (22 December 2009 GA)

First GA release of 6.2. This release fixes bugs since 6.2.1.

Bugs Fixed

- When adding a data set in Visual Studio 2008, the following error was generated:

  ```
  Relations couldn't be addded. Column 'REFERENCED_TABLE_CATALOG' does not belong to table.
  ```

  This was due to a 'REFERENCED_TABLE_CATALOG' column not being included in the foreign keys collection. (Bug #48974)
- Attempting to execute a load data local infile on a file where the user did not have write permissions, or the file was open in an editor gave an access denied error. (Bug #48944)
- The method `MySqlDataReader.GetSchemaTable()` returned 0 in the `NumericPrecision` field for decimal and newdecimal columns. (Bug #48171)
- MySQL Connector/Net generated an invalid operation exception during a transaction rollback:

  ```
  System.InvalidOperationException: Connection must be valid and open to rollback
  transaction
     at MySql.Data.MySqlClient.MySqlTransaction.Rollback()
     at MySql.Data.MySqlClient.MySqlConnection.CloseFully()
     at
  MySql.Data.MySqlClient.MySqlPromotableTransaction.System.Transactions.IPromotableSinglePhaseNotification.Rollback(S
  singlePhaseEnlistment)
  ...
  ```

  (Bug #35330)
- Connection objects were not garbage collected when not in use. (Bug #31996)

D.3.3.6. Changes in MySQL Connector/Net 6.2.1 (16 November 2009 beta)

This release fixes bugs since 6.2.0.

Functionality Added or Changed

- The `MySqlParameter` class now has a property named `PossibleValues`. This property is NULL unless the parameter is created by `MySqlCommandBuilder.DeriveParameters`. Further, it will be NULL unless the parameter is of type enum or set - in this case it will be a list of strings that are the possible values for the column. This feature is designed as an aid to the developer. (Bug #48586)
- Prior to MySQL Connector/Net 6.2, `MySqlCommand.CommandTimeout` included user processing time, that is processing time not related to direct use of the connector. Timeout was implemented through a .NET Timer, that triggered after `Com-`

`mandTimeout` seconds.

MySQL Connector/Net 6.2 introduced timeouts that are aligned with how Microsoft handles `SqlCommand.CommandTimeout`. This property is the cumulative timeout for all network reads and writes during command execution or processing of the results. A timeout can still occur in the `MySqlReader.Read` method after the first row is returned, and does not include user processing time, only IO operations.

Further details on this can be found in the relevant Microsoft documentation.

- Starting with MySQL Connector/Net 6.2, there is a background job that runs every three minutes and removes connections from pool that have been idle (unused) for more than three minutes. The pool cleanup frees resources on both client and server side. This is because on the client side every connection uses a socket, and on the server side every connection uses a socket and a thread.

  Prior to this change, connections were never removed from the pool, and the pool always contained the peak number of open connections. For example, a web application that peaked at 1000 concurrent database connections would consume 1000 threads and 1000 open sockets at the server, without ever freeing up those resources from the connection pool.

- MySQL Connector/Net now supports the processing of certificates when connecting to an SSL-enabled MySQL Server. For further information see the connection string option SSL Mode in the section Section 20.2.6, “Connector/Net Connection String Options Reference” and the tutorial Section 20.2.4.7, “Tutorial: Using SSL with MySQL Connector/Net”.

Bugs Fixed

- Cloning of `MySqlCommand` was not typesafe. To clone a `MySqlCommand` it was necessary to do:

  ```
          MySqlCommand clone = (MySqlCommand)((ICloneable)comm).Clone();
  ```

  MySQL Connector/Net was changed so that it was possible to do:

  ```
          MySqlCommand clone = comm.Clone();
  ```

  (Bug #48460)

- When used, the `Encrypt` connection string option caused a “Keyword not supported” exception to be generated.

  This option is in fact obsolete, and the option SSL Mode should be used instead. Although the `Encrypt` option has been fixed so that it does not generate an exception, it will be removed completely in version 6.4. (Bug #48290)

- When building the `MySql.Data` project with .NET Framework 3.5 installed, the following build output was displayed:

  ```
  Project file contains ToolsVersion="4.0", which is not supported by this version of
  MSBuild. Treating the project as if it had ToolsVersion="3.5".
  ```

  The project had been created using the .NET Framework 4.0, which was beta, instead of using the 3.5 framework. (Bug #48271)

- It was not possible to retrieve a value from a MySQL server table, if the value was larger than that supported by the .NET type `System.Decimal`.

  MySQL Connector/Net was changed to expose the `MySqlDecimal` type, along with the supporting method `GetMySqlDecimal`. (Bug #48100)

- An entity model created from a schema containing a table with a column of type `UNSIGNED BIGINT` and a view of the table did not behave correctly. When an entity was created and mapped to the view, the column that was of type `UNSIGNED BIGINT` was displayed as `BIGINT`. (Bug #47872)

- MySQL Connector/Net session support did not work with MySQL Server versions prior to 5.0, as the Session Provider used a call to `TIMESTAMPDIFF`, which was not available on servers prior to 5.0. (Bug #47219)

D.3.3.7. Changes in MySQL Connector/Net 6.2.0 (21 October 2009 alpha)

The first alpha release of 6.2.

Bugs Fixed

- When using a `BINARY(16)` column to represent a GUID and having specified “old guids = true” in the connection string, the values were returned correctly until a null value was encountered in that field. After the null value was encountered a format exception was thrown with the following message:

  ```
  Guid should contain 32 digits with 4 dashes (xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx).
  ```

  (Bug #47928)

- The Session Provider created invalid “session expires” on a random basis.

  This was due to the fact that the Session Provider was incorrectly reading from the root `web.config`, rather than from the application specific `web.config`. (Bug #47815)

- When loading the `MySQLClient-mono.sln` file included with the Connector/Net source into Mono Develop, the following error occurred:

  ```
  /home/tbedford/connector-net-src/6.1/MySQLClient-mono.sln(22):
  Unsupported or unrecognized project:
  '/home/tbedford/connector-net-src/6.1/Installer/Installer.wixproj'
  ```

  If the file was modified to remove this problem, then attempting to build the solution generated the following error:

  ```
  /home/tbedford/connector-net-src/6.1/MySql.Data/Provider/Source/Connection.cs(280,46):
  error CS0115: `MySql.Data.MySqlClient.MySqlConnection.DbProviderFactory' is marked as an
  override but no suitable property found to override
  ```

  (Bug #47048)

D.3.4. Changes in MySQL Connector/Net Version 6.1.x

D.3.4.1. Changes in MySQL Connector/Net 6.1.7 (Not released GA)

This release fixes bugs since 6.1.6.

Bugs Fixed

- `MySqlScript` was modified to enable correct processing of the `DELIMITER` command when not followed by a new line. (Bug #61680, Bug #12732279)
- `SchemaDefinition-5.5.ssdl` was modified to treat `CHAR(36)` columns as a GUID. (Bug #61657, Bug #12708208)
- `SqlFragment.QuoteIdentifier` was modified to add MySQL quotes around identifiers. (Bug #61635, Bug #12707285)
- The ASP.NET membership provider was modified to create and query all related tables using lowercase names. (Bug #61108, Bug #12702009)

D.3.4.2. Changes in MySQL Connector/Net 6.1.6 (Not released GA)

This release fixes bugs since 6.1.5.

Bugs Fixed

- Modified `MySqlConnection.BeginTransaction` to throw a `NotSupportedException` for `Snapshot` isolation level. (Bug #61589, Bug #12698020)
- `MysqlDataReader.GetSchemaTable` returned incorrect values and types. (Bug #59989, Bug #11776346)
- All queries other than `INSERT` were executed individually instead of as a batch even though batching was enabled for the connection. (Bug #59616, Bug #11850286)
- MySQL Connector/Net generated an exception when executing a query consisting of ';', for example:

  ```
  mycmd(";",mycon)
  mycmd.executenonquery()
  ```

The exception generated was:

```
System.IndexOutOfRangeException: Index was outside the bounds of the array.
   at MySql.Data.MySqlClient.MySqlCommand.TrimSemicolons(String sql)
   at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
   at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
   at MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
```

(Bug #59537, Bug #11766433)

- Setting `Membership.ApplicationName` had no effect. (Bug #59438, Bug #11770465)
- `MembershipProvider` did not generate hashes correctly if the algorithm was keyed. The Key of the algorithm should have been set if the `HashAlgorithm` was `KeyedHashAlgorithm`. (Bug #58906)
- Code introduced to fix bug #54863 proved problematic on .NET version 3.5 and above. (Bug #58853)
- The `MySqlTokenizer` contained unnecessary `Substring` and `Trim` calls:

  ```
  string token = sql.Substring(startIndex, stopIndex - startIndex).Trim();
  ```

  The variable `token` was not used anywhere in the code. (Bug #58757)
- `MySqlCommand.ExecuteReader(CommandBehavior)` threw a `NullReferenceException` when being called with `CommandBehavior.CloseConnection`, if the SQL statement contained a syntax error, or contained invalid data such as an invalid column name. (Bug #58652)
- `ReadFieldLength()` returned incorrect value for `BIGINT` autoincrement columns. (Bug #58373)
- MySQL Connector/Net did not support the `utf8mb4` character set. When attempting to connect to `utf8mb4` tables or columns, an exception `KeyNotFoundException` was generated. (Bug #58244)
- A typed dataset did not get the table name. (Bug #57894, Bug #11764989)
- Setting `MySqlCommand.CommandTimeout` to 0 had no effect. It should have resulted in an infinite timeout. (Bug #57265)
- When performing a row-by-row update, only the first row was updated and all other rows were ignored. (Bug #57092)
- Setting the `Default Command Timeout` connection string option had no effect. (Bug #56806)
- When an output parameter was declared as type `MySqlDbType.Bit`, it failed to return with the correct value. (Bug #56756)
- `MySqlHelper.ExecuteReader` did not include an overload accepting `MySqlParameter` objects when using a `MySqlConnection`. However, `MySqlHelper` did include an overload for `MySqlParameter` objects when using a string object containing the connection string to the database. (Bug #56755)
- Default values returned for text columns were not quoted. This meant that the `COLUMN_DEFAULT` field of the `GetSchema` columns collection did not return a valid SQL expression. (Bug #56509)
- MySQL Connector/Net for .NET/Mono attempted to dynamically load the assembly `Mono.Posix.dll` when a Unix socket was used to connect to the server. This failed and the connector was not able to use a Unix socket unless the `Mono.Posix.dll` assembly was previously loaded by the program. (Bug #56410)
- Modified `ProviderManifest.xml` to map `TIMESTAMP` database columns to the `DateTime` .NET type. (Bug #55351, Bug #12652602)
- The ADO.NET Entity Data Model could not add stored procedures from MySQL Server 5.0.45 but worked fine using MySQL Server 5.1. (Bug #55349)
- Fixed Entity Framework provider `GROUP BY` clause generation by adding all group-by keys to the `SELECT` statement. (Bug #46742, Bug #12622129)

D.3.4.3. Changes in MySQL Connector/Net 6.1.5 (30 August 2010 GA)

This release fixes bugs since 6.1.4.

Bugs Fixed

- The calculation of `lockAge` in the Session Provider sometimes generated a `System.Data.SqlTypes.SqlNullValueException`. (Bug #55701)
- Attempting to read `Double.MinValue` from a `DOUBLE` column in MySQL table generated the following exception:

  ```
  System.OverflowException : Value was either too large or too small for a Double.

  --OverflowException
  at System.Number.ParseDouble(String value, NumberStyles options, NumberFormatInfo
  numfmt)
  at MySql.Data.Types.MySqlDouble.MySql.Data.Types.IMySqlValue.ReadValue(MySqlPacket
  packet, Int64 length, Boolean nullVal)
  at MySql.Data.MySqlClient.NativeDriver.ReadColumnValue(Int32 index, MySqlField field,
  IMySqlValue valObject)
  at MySql.Data.MySqlClient.ResultSet.ReadColumnData(Boolean outputParms)
  at MySql.Data.MySqlClient.ResultSet.NextRow(CommandBehavior behavior)
  at MySql.Data.MySqlClient.MySqlDataReader.Read()
  ```

  (Bug #55644)
- If using MySQL Server 5.0.x it was not possible to alter stored routines in Visual Studio. If the stored routine was clicked, and the context sensitive menu option, Alter Routine, selected, the following error was generated:

  ```
  Unable to load object with error: Object reference not
  set to an instance of an object
  ```

  (Bug #55170)
- `MySqlDataAdapter.Update()` generated concurrency violations for custom stored procedure driven update commands that used `UpdateRowSource.FirstReturnedRecord`. (Bug #54895)
- Several calls to `DataAdapter.Update()` with intervening changes to `DataTable` resulted in `ConcurrencyException` exceptions being generated. (Bug #54863)
- The icon for the MySQL Web Configuration Tool was not displayed in Visual Studio for Web Application Projects. (Bug #54571)
- The `MySqlHelper` object did not have an overloaded version of the `ExecuteReader` method that accepted a `MySqlConnection` object. (Bug #54570)
- If `MySqlDataAdapter` was used with an `INSERT` command where the `VALUES` clause contained an expression with parentheses in it, and set the `adapter.UpdateBatchSize` parameter to be greater than one, then the call to `adapter.Update` either generated an exception or failed to batch the commands, executing each insert individually. (Bug #54386)
- The method `MySql.Data.Common.QueryNormalizer.CollapseValueList` generated an `ArgumentOutOfRangeException`. (Bug #54152, Bug #53865)
- Garbage Collector disposal of a `MySqlConnection` object caused the following exception:

  ```
  System.IO.EndOfStreamException: Attempted to read past the end of the stream.
  MySql.Data.MySqlClient.MySqlStream.ReadFully(Stream stream, Byte[] buffer, Int32 offset,
  Int32 count)
  MySql.Data.MySqlClient.MySqlStream.LoadPacket()
  Outer Exception Reading from the stream has failed.
  ...
  ```

  (Bug #53457)
- MySQL Connector/Net did not throw an `EndOfStreamException` exception when `net_write_timeout` was exceeded. (Bug #53439)
- After a timeout exception, if an attempt was made to reuse a connection returned to the connection pool the following exception was generated:

  ```
  [MySqlException (0x80004005): There is already an open DataReader associated with this
  Connection which must be closed first.]
     MySql.Data.MySqlClient.MySqlCommand.CheckState() +278
     MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior) +43
     MySql.Data.MySqlClient.MySqlCommand.ExecuteReader() +6
     Controls.SimpleCommand.ExecuteReader(String SQL) in ...:323
     Albums.GetImagesByAlbum(SimpleCommand Cmd, Int32 iAlbum, String Order, String Limit)
  in ...:13
     Forecast.Page_Load(Object sender, EventArgs e) in ...:70
     System.Web.UI.Control.OnLoad(EventArgs e) +99
     System.Web.UI.Control.LoadRecursive() +50
     System.Web.UI.Page.ProcessRequestMain(Boolean includeStagesBeforeAsyncPoint, Boolean
  includeStagesAfterAsyncPoint) +627
  ```

(Bug #53357)

- Membership schema creation failed if the default schema collation was not Latin1. (Bug #53174)
- EventLog was not disposed in the SessionState provider. (Bug #52550)
- `CHAR(36)` columns were not recognized as GUIDs when used in views with entity models. (Bug #52085)
- Stored procedure enumeration code generated an error if a procedure was used in a dataset that did not return any resultsets. (Bug #50671)
- When an application was subjected to increased concurrent load, MySQL Connector/Net generated the following error when calling stored procedures:

  ```
  A DataTable named \'Procedure Parameters\'
  already belongs to this DataSet.
  ```

  (Bug #49118)
- In the ADO.NET Entity Data Model Wizard, the time to update a model scaled abnormally as the number of entities increased. (Bug #48791, Bug #12596237)
- The `INSERT` command was significantly slower with MySQL Connector/Net 6.x compared to 5.x, when compression was enabled. (Bug #48243)
- When the connection string option “Connection Reset = True” was used, a connection reset used the previously used encoding for the subsequent authentication operation. This failed, for example, if UCS2 was used to read the last column before the reset. (Bug #47153)
- Opening a connection in the Visual Studio Server Explorer and choosing to alter an existing routine required another authentication at the server. (Bug #44715)
- When batching was used in `MySqlDataAdapter`, a connection was not opened automatically in `MySqlDataAdapter.Update()`. This resulted in an `InvalidOperationException` exception being generated, with the message text “connection must be valid and open”.

  MySQL Connector/Net has been changed to behave more like SQL Server: if the connection is closed, it is opened for the duration of update operation. (Bug #38411)
- Database name was emitted into typed datasets. This prevented users using the configured default database. (Bug #33870)

D.3.4.4. Changes in MySQL Connector/Net 6.1.4 (28 April 2010 GA)

This release fixes bugs since 6.1.3.

Functionality Added or Changed

- Procedure cacheing had a problem whereby if you created a procedure, dropped it, and recreated it with a different number of parameters an exception was generated.

  MySQL Connector/Net has been changed so that if the procedure is recreated with a different number of parameters, it will still be recognized. (Bug #52562)
- MySQL Connector/Net has been changed to include `MySqlDataReader.GetFieldType(string columnname)`. Further, `MySqlDataReader.GetOrdinal()` now includes the name of the column in the exception if the column is not found. (Bug #47467)

Bugs Fixed

- In MySQL Connector/Net, the `MySqlConnection.Abort()` method contained a `try...catch` construct, with an empty `catch` block. This meant that any exception generated at this point would not be caught. (Bug #52769)
- If `FunctionsReturnString=true` was used in the connection string, the decimal separator (according to locale) was not interpreted. (Bug #52187)

- In MySQL Connector/Net, the `LoadCharsetMap()` function of the `CharSetMap` class set the following incorrect mapping:

  ```
  mapping.Add("latin1", new CharacterSet("latin1", 1));
  ```

  This meant that, for example, the Euro sign was not handled correctly.

  The correct mapping should have been:

  ```
  mapping.Add("latin1", new CharacterSet("windows-1252", 1));
  ```

  This is because MySQL's `latin1` character set is the same as the `windows-cp1252` character set and it extends the official ISO 8859-1 or IANA latin1. (Bug #51927)

- A non-terminated string in SQL threw a CLR exception rather than a syntax exception. (Bug #51788)

- When calling `ExecuteNonQuery` on a command object, the following exception occurred:

  ```
  Index and length must refer to a location within the string.
  Parameter name: length
  ```

  (Bug #51610)

- The method `Command.TrimSemicolons` used `StringBuilder`, and therefore allocated memory for the query even if it did not need to be trimmed. This led to excessive memory consumption when executing a number of large queries. (Bug #51149)

- `MySqlCommand.Parameters.Clear()` did not work. (Bug #50444)

- When the `MySqlScript.execute()` method was called, the following exception was generated:

  ```
  InvalidOperationException : The CommandText property has not been properly initialized.
  ```

  (Bug #50344)

- Binary Columns were not displayed in the Query Builder of Visual Studio. (Bug #50171)

- When the `UpdateBatchSize` property was set to a value greater than 1, only the first row was applied to the database. (Bug #50123)

- When using table per type inheritance and listing the contents of the parent table, the result of the query was a list of child objects, even though there was no related child record with the same parent Id. (Bug #49850)

- `MySqlDataReader.GetUInt64` returned an incorrect value when reading a `BIGINT UNSIGNED` column containing a value greater than 2147483647. (Bug #49794)

- A `FormatException` was generated when an empty string was returned from a stored function. (Bug #49642)

- When adding a data set in Visual Studio 2008, the following error was generated:

  ```
  Relations couldn't be addded. Column 'REFERENCED_TABLE_CATALOG' does not belong to table.
  ```

  This was due to a 'REFERENCED_TABLE_CATALOG' column not being included in the foreign keys collection. (Bug #48974)

- Attempting to execute a load data local infile on a file where the user did not have write permissions, or the file was open in an editor gave an access denied error. (Bug #48944)

- The method `MySqlDataReader.GetSchemaTable()` returned 0 in the `NumericPrecision` field for decimal and newdecimal columns. (Bug #48171)

- When trying to create stored procedures from an SQL script, a `MySqlException` was thrown when attempting to redefine the `DELIMITER`:

  ```
          MySql.Data.MySqlClient.MySqlException was unhandled
          Message="You have an error in your SQL syntax; check the manual that corresponds to your
          MySQL server version for the right syntax to use near 'DELIMITER' at line 1"
          Source="MySql.Data"
          ErrorCode=-2147467259
          Number=1064
          StackTrace:
          à MySql.Data.MySqlClient.MySqlStream.ReadPacket()
  ```

```
        à MySql.Data.MySqlClient.NativeDriver.ReadResult(UInt64& affectedRows, Int64&
        lastInsertId)
        à MySql.Data.MySqlClient.MySqlDataReader.GetResultSet()
        à MySql.Data.MySqlClient.MySqlDataReader.NextResult()
        à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
        à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
        à MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
      à MySql.Data.MySqlClient.MySqlScript.Execute()
```

Note: The `MySqlScript` class has been fixed to support the delimiter statement as it is found in SQL scripts. (Bug #46429)

- Calling a User Defined Function using Entity SQL in the Entity Framework caused a `NullReferenceException`. (Bug #45277)

- A connection string set in `web.config` could not be reused after Visual Studio 2008 Professional was shut down. It continued working for the existing controls, but did not work for new controls added. (Bug #41629)

D.3.4.5. Changes in MySQL Connector/Net 6.1.3 (16 November 2009 GA)

This release fixes bugs since 6.1.2.

Bugs Fixed

- Cloning of `MySqlCommand` was not typesafe. To clone a `MySqlCommand` it was necessary to do:

  ```
          MySqlCommand clone = (MySqlCommand)((ICloneable)comm).Clone();
  ```

  MySQL Connector/Net was changed so that it was possible to do:

  ```
          MySqlCommand clone = comm.Clone();
  ```

  (Bug #48460)

- When building the `MySql.Data` project with .NET Framework 3.5 installed, the following build output was displayed:

  ```
  Project file contains ToolsVersion="4.0", which is not supported by this version of
  MSBuild. Treating the project as if it had ToolsVersion="3.5".
  ```

  The project had been created using the .NET Framework 4.0, which was beta, instead of using the 3.5 framework. (Bug #48271)

- If `MySqlConnection.GetSchema` was called for "Indexes" on a table named “b`a`d” as follows:

  ```
  DataTable schemaPrimaryKeys = connection.GetSchema(
    "Indexes",
    new string[] { null, schemaName, "b`a`d"});
  ```

  Then the following exception was generated:

  ```
  You have an error in your SQL syntax; check the manual that corresponds to
  your MySQL server version for the right syntax to use near 'a`d`' at line 1
  ```

  (Bug #48101)

- It was not possible to retrieve a value from a MySQL server table, if the value was larger than that supported by the .NET type `System.Decimal`.

  MySQL Connector/Net was changed to expose the `MySqlDecimal` type, along with the supporting method `GetMySqlDecimal`. (Bug #48100)

- For some character sets such as UTF-8, a `CHAR` column would sometimes be incorrectly interpreted as a `GUID` by MySQL Connector/Net.

  MySQL Connector/Net was changed so that a column would only be interpreted as a `GUID` if it had a character length of 36, as opposed to a byte length of 36. (Bug #47985)

- When using a `BINARY(16)` column to represent a GUID and having specified “old guids = true” in the connection string, the values were returned correctly until a null value was encountered in that field. After the null value was encountered a format exception was thrown with the following message:

```
Guid should contain 32 digits with 4 dashes (xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx).
```

(Bug #47928)

- An entity model created from a schema containing a table with a column of type `UNSIGNED BIGINT` and a view of the table did not behave correctly. When an entity was created and mapped to the view, the column that was of type `UNSIGNED BIGINT` was displayed as `BIGINT`. (Bug #47872)
- The Session Provider created invalid “session expires” on a random basis.

  This was due to the fact that the Session Provider was incorrectly reading from the root `web.config`, rather than from the application specific `web.config`. (Bug #47815)
- Attempting to build MySQL Connector/Net 6.1 `MySQL.Data` from source code on Windows failed with the following error:

  ```
  ...\clones\6.1\MySql.Data\Provider\Source\NativeDriver.cs(519,29): error CS0122:
  'MySql.Data.MySqlClient.MySqlPacket.MySqlPacket()' is inaccessible due to its protection level
  ```

  (Bug #47354)
- When tables were auto created for the Session State Provider they were set to use the MySQL Server's default collation, rather than the default collation set for the containing database. (Bug #47332)
- When loading the `MySQLClient-mono.sln` file included with the Connector/Net source into Mono Develop, the following error occurred:

  ```
  /home/tbedford/connector-net-src/6.1/MySQLClient-mono.sln(22):
  Unsupported or unrecognized project:
  '/home/tbedford/connector-net-src/6.1/Installer/Installer.wixproj'
  ```

  If the file was modified to remove this problem, then attempting to build the solution generated the following error:

  ```
  /home/tbedford/connector-net-src/6.1/MySql.Data/Provider/Source/Connection.cs(280,46):
  error CS0115: `MySql.Data.MySqlClient.MySqlConnection.DbProviderFactory' is marked as an
  override but no suitable property found to override
  ```

  (Bug #47048)

D.3.4.6. Changes in MySQL Connector/Net 6.1.2 (08 September 2009 GA)

This is the first GA release of 6.1. This release fixes bugs since 6.1.1.

Bugs Fixed

- The MySQL Connector/Net Session State Provider truncated session data to 64KB, due to its column types being set to `BLOB`. (Bug #47339)
- MySQL Connector/Net generated the following exception when using the Session State provider:

  ```
  You have an error in your SQL syntax; check the manual that corresponds to your MySQL
  server version for the right syntax to use near 'MINUTEWHERE SessionId =
  'dtmgga55x35oi255nrfrxe45' AND ApplicationId = 1 AND Loc' at line 1
  Description: An unhandled exception occurred during the execution of the current web
  request. Please review the stack trace for more information about the error and where it
  originated in the code.

  Exception Details: MySql.Data.MySqlClient.MySqlException: You have an error in your SQL
  syntax; check the manual that corresponds to your MySQL server version for the right
  syntax to use near 'MINUTEWHERE SessionId = 'dtmgga55x35oi255nrfrxe45' AND ApplicationId =
  1 AND Loc' at line 1
  ```

  (Bug #46939)
- If an error occurred during connection to a MySQL Server, deserializing the error message from the packet buffer caused a `NullReferenceException` to be thrown. When the method `MySqlPacket::ReadString()` attempted to retrieve the error message, the following line of code threw the exception:

  ```
          string s = encoding.GetString(bits, (int)buffer.Position, end - (int)buffer.Position);
  ```

This was due to the fact that the encoding field had not been initialized correctly. (Bug #46844)

- Input parameters were missing from Stored Procedures when using them with ADO.NET Data Entities. (Bug #44985)
- MySQL Connector/Net did not time out correctly. The command timeout was set to 30 secs, but MySQL Connector/Net hung for several hours. (Bug #43761)

D.3.4.7. Changes in MySQL Connector/Net 6.1.1 (20 August 2009 beta)

This is the first Beta release of 6.1.

Bugs Fixed

- In the `MySqlDataReader` class the `GetSByte` function returned a `byte` value instead of an `sbyte` value. (Bug #46620)
- The MySQL Connector/Net Profile Provider, `MySql.Web.Profile.MySQLProfileProvider`, generated an error when running on Mono. When an attempt was made to save a string in `Profile.Name` the string was not saved to the `my_aspnet_Profiles` table. If an attempt was made to force the save with `Profile.Save()` the following error was generated:

```
Server Error in '/mono' Application

--------------------------------------------------------------------------------

The requested feature is not implemented.
Description: HTTP 500. Error processing request.

Stack Trace:

System.NotImplementedException: The requested feature is not implemented.
at MySql.Data.MySqlClient.MySqlConnection.EnlistTransaction
(System.Transactions.Transaction transaction) [0x00000]
at MySql.Data.MySqlClient.MySqlConnection.Open () [0x00000]
at MySql.Web.Profile.MySQLProfileProvider.SetPropertyValues
(System.Configuration.SettingsContext context,
System.Configuration.SettingsPropertyValueCollection collection) [0x00000]


--------------------------------------------------------------------------------
Version information: Mono Version: 2.0.50727.1433; ASP.NET Version: 2.0.50727.1433
```

  (Bug #46375)

- An exception was generated when using `TIMESTAMP` columns with the Entity Framework. (Bug #46311)
- MySQL Connector/Net sometimes hung, without generating an exception. This happened if a read from a stream failed returning a 0, causing the code in `LoadPacket()` to enter an infinite loop. (Bug #46308)
- When using MySQL Connector/Net 6.0.4 and a MySQL Server 4.1 an exception was generated when trying to execute:

```
connection.GetSchema("Columns", ...);
```

  The exception generated was:

```
'connection.GetSchema("Columns")' threw an exception of type
'System.ArgumentException'System.Data.DataTable {System.ArgumentException}
base{"Input string was not in a correct format.Couldn't store <'Select'> in
NUMERIC_PRECISION Column.  Expected type is UInt64."}System.Exception
{System.ArgumentException}
```

  (Bug #46270)

- The MySQL Connector/Net method `StoredProcedure.GetParameters(string)` ignored the programmer's setting of the `UseProcedureBodies` option. This broke any application for which the application's parameter names did not match the parameter names in the Stored Procedure, resulting in an `ArgumentException` with the message “Parameter 'foo' not found in the collection.” and the following stack trace:

```
MySql.Data.dll!MySql.Data.MySqlClient.MySqlParameterCollection.GetParameterFlexible(stri
ng parameterName = "pStart", bool throwOnNotFound = true) Line 459C#
```

```
    MySql.Data.dll!MySql.Data.MySqlClient.StoredProcedure.Resolve() Line 157 + 0x25
    bytesC#
    MySql.Data.dll!MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(System.Data.CommandBeha
    vior behavior = SequentialAccess) Line 405 + 0xb bytesC#
    MySql.Data.dll!MySql.Data.MySqlClient.MySqlCommand.ExecuteDbDataReader(System.Data.Comma
    ndBehavior behavior = SequentialAccess) Line 884 + 0xb bytesC#
    System.Data.dll!System.Data.Common.DbCommand.System.Data.IDbCommand.ExecuteReader(System
    .Data.CommandBehavior behavior) + 0xb bytes
    System.Data.dll!System.Data.Common.DbDataAdapter.FillInternal(System.Data.DataSet
    dataset = {System.Data.DataSet}, System.Data.DataTable[] datatables = null, int
    startRecord = 0, int maxRecords = 0, string srcTable = "Table", System.Data.IDbCommand
    command = {MySql.Data.MySqlClient.MySqlCommand}, System.Data.CommandBehavior behavior) +
    0x83 bytes
    System.Data.dll!System.Data.Common.DbDataAdapter.Fill(System.Data.DataSet dataSet, int
    startRecord, int maxRecords, string srcTable, System.Data.IDbCommand command,
    System.Data.CommandBehavior behavior) + 0x120 bytes
    System.Data.dll!System.Data.Common.DbDataAdapter.Fill(System.Data.DataSet dataSet) +
    0x5f bytes
```

(Bug #46213)

- Conversion of MySQL `TINYINT(1)` to `boolean` failed. (Bug #46205, Bug #46359, Bug #41953)

- When populating a MySQL database table in Visual Studio using the Table Editor, if a `VARCHAR(10)` column was changed to a `VARCHAR(20)` column an exception was generated:

```
    SystemArgumentException: DataGridViewComboBoxCell value is not valid.
   To replace this default dialog please handle the DataError Event.
```

  (Bug #46100)

- The Entity Framework provider was not calling `DBSortExpression` correctly when the `Skip` and `Take` methods were used, such as in the following statement:

```
    TestModel.tblquarantine.OrderByDescending(q => q.MsgDate).Skip(100).Take(100).ToList();
```

  This resulted in the data being unsorted. (Bug #45723)

- The MySQL Connector/Net 6.0.4 installer failed with an error. The error message generated was:

```
    There is a problem with this Windows Installer package. A DLL required for this
    install to complete could not be run. Contact your support personnel or package vendor.
```

  When OK was clicked to acknowledge the error the installer exited. (Bug #45474)

- Calling the Entity Framework `SaveChanges()` method of any MySQL ORM Entity with a column type `TIME`, generated an error message:

```
Unknown PrimitiveKind Time
```

  (Bug #45457)

- Insert into two tables failed when using the Entity Framework. The exception generated was:

```
    The value given is not an instance of type 'Edm.Int32'
```

  (Bug #45077)

- Errors occurred when using the Entity Framework with cultures that used a comma as the decimal separator. This was because the formatting for `SINGLE`, `DOUBLE` and `DECIMAL` values was not handled correctly. (Bug #44455)

- When attempting to connect to MySQL using the Compact Framework version of MySQL Connector/Net, an `IndexOutOfRangeException` exception was generated on trying to open the connection. (Bug #43736)

- When reading data, such as with a `MySqlDataAdapter` on a `MySqlConnection`, MySQL Connector/Net could potentially enter an infinite loop in `CompressedStream.ReadNextpacket()` if compression was enabled. (Bug #43678)

- An error occurred when building MySQL Connector/Net from source code checked out from the public SVN repository. This happened on Linux using Mono and Nant. The Mono JIT compiler version was 1.2.6.0. The Nant version was 0.85.

When an attempt was made to build (for example) the MySQL Connector/Net 5.2 branch using the command:

```
        $ nant -buildfile:Client.build
```

The following error occurred:

```
        BUILD FAILED

        Error loading buildfile.
        Encoding name 'Windows-1252' not supported.
        Parameter name: name
```

(Bug #42411)

- MySQL Connector/Net CHM documentation stated that MySQL Server 3.23 was supported. (Bug #42110)
- In the case of long network inactivity, especially when connection pooling was used, connections were sometimes dropped, for example, by firewalls.

  Note: The bugfix introduced a new `keepalive` parameter, which prevents disconnects by sending an empty TCP packet after a specified timeout. (Bug #40684)
- Calling a Stored Procedure with an output parameter through MySQL Connector/Net resulted in a memory leak. Calling the same Stored Procedure without an output parameter did not result in a memory leak. (Bug #36027)

D.3.4.8. Changes in MySQL Connector/Net 6.1.0 (15 July 2009 alpha)

This is the first Alpha release of 6.1.

Functionality Added or Changed

- Changed GUID type - The backend representation of a guid type has been changed to be CHAR(36). This is so you can use the server UUID() function to populate a GUID table. UUID generates a 36 character string. Developers of older applications can add `old guids=true` to the connection string and the old BINARY(16) type will be used instead.
- Support for native output parameters - This is supported when connected to a server that supports native output parameters. This includes servers as of 5.5.3 and 6.0.8.
- Session State Provider - This enables you to store the state of your website in a MySQL server.
- Website Configuration Dialog - This is a new wizard that is activated by clicking a button on the toolbar at the top of the Visual Studio Solution Explorer. It works in conjunction with the ASP.Net administration pages, making it easier to activate and set advanced options for the different MySQL web providers included.

D.3.5. Changes in MySQL Connector/Net Version 6.0.x

D.3.5.1. Changes in MySQL Connector/Net 6.0.8 (Not released)

Fixes bugs since 6.0.7.

Bugs Fixed

- `MysqlDataReader.GetSchemaTable` returned incorrect values and types. (Bug #59989, Bug #11776346)
- All queries other than `INSERT` were executed individually instead of as a batch even though batching was enabled for the connection. (Bug #59616, Bug #11850286)
- MySQL Connector/Net generated an exception when executing a query consisting of ';', for example:

```
mycmd(";",mycon)
mycmd.executenonquery()
```

The exception generated was:

```
System.IndexOutOfRangeException: Index was outside the bounds of the array.
   at MySql.Data.MySqlClient.MySqlCommand.TrimSemicolons(String sql)
   at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
   at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
   at MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
```

(Bug #59537, Bug #11766433)

- Setting `Membership.ApplicationName` had no effect. (Bug #59438, Bug #11770465)
- `MembershipProvider` did not generate hashes correctly if the algorithm was keyed. The Key of the algorithm should have been set if the `HashAlgorithm` was `KeyedHashAlgorithm`. (Bug #58906)
- Code introduced to fix bug #54863 proved problematic on .NET version 3.5 and above. (Bug #58853)
- The `MySqlTokenizer` contained unnecessary `Substring` and `Trim` calls:

  ```
  string token = sql.Substring(startIndex, stopIndex - startIndex).Trim();
  ```

  The variable `token` was not used anywhere in the code. (Bug #58757)
- `MySqlCommand.ExecuteReader(CommandBehavior)` threw a `NullReferenceException` when being called with `CommandBehavior.CloseConnection`, if the SQL statement contained a syntax error, or contained invalid data such as an invalid column name. (Bug #58652)
- `ReadFieldLength()` returned incorrect value for `BIGINT` autoincrement columns. (Bug #58373)
- MySQL Connector/Net did not support the `utf8mb4` character set. When attempting to connect to `utf8mb4` tables or columns, an exception `KeyNotFoundException` was generated. (Bug #58244)
- A typed dataset did not get the table name. (Bug #57894, Bug #11764989)
- Setting `MySqlCommand.CommandTimeout` to 0 had no effect. It should have resulted in an infinite timeout. (Bug #57265)
- When performing a row-by-row update, only the first row was updated and all other rows were ignored. (Bug #57092)
- Setting the `Default Command Timeout` connection string option had no effect. (Bug #56806)
- When an output parameter was declared as type `MySqlDbType.Bit`, it failed to return with the correct value. (Bug #56756)
- Default values returned for text columns were not quoted. This meant that the `COLUMN_DEFAULT` field of the `GetSchema` columns collection did not return a valid SQL expression. (Bug #56509)
- MySQL Connector/Net for .NET/Mono attempted to dynamically load the assembly `Mono.Posix.dll` when a Unix socket was used to connect to the server. This failed and the connector was not able to use a Unix socket unless the `Mono.Posix.dll` assembly was previously loaded by the program. (Bug #56410)
- The ADO.NET Entity Data Model could not add stored procedures from MySQL Server 5.0.45 but worked fine using MySQL Server 5.1. (Bug #55349)

D.3.5.2. Changes in MySQL Connector/Net 6.0.7 (30 August 2010)

Fixes bugs since 6.0.6.

Bugs Fixed

- Attempting to read `Double.MinValue` from a `DOUBLE` column in MySQL table generated the following exception:

  ```
  System.OverflowException : Value was either too large or too small for a Double.

  --OverflowException
  at System.Number.ParseDouble(String value, NumberStyles options, NumberFormatInfo
  numfmt)
  at MySql.Data.Types.MySqlDouble.MySql.Data.Types.IMySqlValue.ReadValue(MySqlPacket
  packet, Int64 length, Boolean nullVal)
  at MySql.Data.MySqlClient.NativeDriver.ReadColumnValue(Int32 index, MySqlField field,
  IMySqlValue valObject)
  at MySql.Data.MySqlClient.ResultSet.ReadColumnData(Boolean outputParms)
  at MySql.Data.MySqlClient.ResultSet.NextRow(CommandBehavior behavior)
  at MySql.Data.MySqlClient.MySqlDataReader.Read()
  ```

(Bug #55644)

- `MySqlDataAdapter.Update()` generated concurrency violations for custom stored procedure driven update commands that used `UpdateRowSource.FirstReturnedRecord`. (Bug #54895)

- Several calls to `DataAdapter.Update()` with intervening changes to `DataTable` resulted in `ConcurrencyException` exceptions being generated. (Bug #54863)

- The `MySqlHelper` object did not have an overloaded version of the `ExecuteReader` method that accepted a `MySqlConnection` object. (Bug #54570)

- If `MySqlDataAdapter` was used with an `INSERT` command where the `VALUES` clause contained an expression with parentheses in it, and set the `adapter.UpdateBatchSize` parameter to be greater than one, then the call to `adapter.Update` either generated an exception or failed to batch the commands, executing each insert individually. (Bug #54386)

- The method `MySql.Data.Common.QueryNormalizer.CollapseValueList` generated an `ArgumentOutOfRangeException`. (Bug #54152, Bug #53865)

- Garbage Collector disposal of a `MySqlConnection` object caused the following exception:

```
System.IO.EndOfStreamException: Attempted to read past the end of the stream.
MySql.Data.MySqlClient.MySqlStream.ReadFully(Stream stream, Byte[] buffer, Int32 offset,
Int32 count)
MySql.Data.MySqlClient.MySqlStream.LoadPacket()
Outer Exception Reading from the stream has failed.
...
```

  (Bug #53457)

- After a timeout exception, if an attempt was made to reuse a connection returned to the connection pool the following exception was generated:

```
[MySqlException (0x80004005): There is already an open DataReader associated with this
Connection which must be closed first.]
   MySql.Data.MySqlClient.MySqlCommand.CheckState() +278
   MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior) +43
   MySql.Data.MySqlClient.MySqlCommand.ExecuteReader() +6
   Controls.SimpleCommand.ExecuteReader(String SQL) in ...:323
   Albums.GetImagesByAlbum(SimpleCommand Cmd, Int32 iAlbum, String Order, String Limit)
in ...:13
   Forecast.Page_Load(Object sender, EventArgs e) in ...:70
   System.Web.UI.Control.OnLoad(EventArgs e) +99
   System.Web.UI.Control.LoadRecursive() +50
   System.Web.UI.Page.ProcessRequestMain(Boolean includeStagesBeforeAsyncPoint, Boolean
includeStagesAfterAsyncPoint) +627
```

  (Bug #53357)

- Membership schema creation failed if the default schema collation was not Latin1. (Bug #53174)

- EventLog was not disposed in the SessionState provider. (Bug #52550)

- Stored procedure enumeration code generated an error if a procedure was used in a dataset that did not return any resultsets. (Bug #50671)

- When an application was subjected to increased concurrent load, MySQL Connector/Net generated the following error when calling stored procedures:

```
A DataTable named \'Procedure Parameters\'
already belongs to this DataSet.
```

  (Bug #49118)

- In the ADO.NET Entity Data Model Wizard, the time to update a model scaled abnormally as the number of entities increased. (Bug #48791, Bug #12596237)

- The `INSERT` command was significantly slower with MySQL Connector/Net 6.x compared to 5.x, when compression was enabled. (Bug #48243)

- When the connection string option “Connection Reset = True” was used, a connection reset used the previously used encoding for the subsequent authentication operation. This failed, for example, if UCS2 was used to read the last column before the reset. (Bug #47153)

- Opening a connection in the Visual Studio Server Explorer and choosing to alter an existing routine required another authentication at the server. (Bug #44715)
- When batching was used in `MySqlDataAdapter`, a connection was not opened automatically in `MySqlDataAdapter.Update()`. This resulted in an `InvalidOperationException` exception being generated, with the message text “connection must be valid and open”.

  MySQL Connector/Net has been changed to behave more like SQL Server: if the connection is closed, it is opened for the duration of update operation. (Bug #38411)
- Database name was emitted into typed datasets. This prevented users using the configured default database. (Bug #33870)

D.3.5.3. Changes in MySQL Connector/Net 6.0.6 (28 April 2010)

Fixes bugs since 6.0.5.

Functionality Added or Changed

- Procedure cacheing had a problem whereby if you created a procedure, dropped it, and recreated it with a different number of parameters an exception was generated.

  MySQL Connector/Net has been changed so that if the procedure is recreated with a different number of parameters, it will still be recognized. (Bug #52562)
- MySQL Connector/Net has been changed to include `MySqlDataReader.GetFieldType(string columnname)`. Further, `MySqlDataReader.GetOrdinal()` now includes the name of the column in the exception if the column is not found. (Bug #47467)

Bugs Fixed

- If using MySQL Server 5.0.x it was not possible to alter stored routines in Visual Studio. If the stored routine was clicked, and the context sensitive menu option, Alter Routine, selected, the following error was generated:

  ```
  Unable to load object with error: Object reference not
  set to an instance of an object
  ```

  (Bug #55170)
- In MySQL Connector/Net, the `MySqlConnection.Abort()` method contained a `try...catch` construct, with an empty `catch` block. This meant that any exception generated at this point would not be caught. (Bug #52769)
- If `FunctionsReturnString=true` was used in the connection string, the decimal separator (according to locale) was not interpreted. (Bug #52187)
- In MySQL Connector/Net, the `LoadCharsetMap()` function of the `CharSetMap` class set the following incorrect mapping:

  ```
  mapping.Add("latin1", new CharacterSet("latin1", 1));
  ```

  This meant that, for example, the Euro sign was not handled correctly.

  The correct mapping should have been:

  ```
  mapping.Add("latin1", new CharacterSet("windows-1252", 1));
  ```

  This is because MySQL's `latin1` character set is the same as the `windows-cp1252` character set and it extends the official ISO 8859-1 or IANA latin1. (Bug #51927)
- A non-terminated string in SQL threw a CLR exception rather than a syntax exception. (Bug #51788)
- When calling `ExecuteNonQuery` on a command object, the following exception occurred:

  ```
  Index and length must refer to a location within the string.
  Parameter name: length
  ```

  (Bug #51610)

- The method `Command.TrimSemicolons` used `StringBuilder`, and therefore allocated memory for the query even if it did not need to be trimmed. This led to excessive memory consumption when executing a number of large queries. (Bug #51149)

- `MySqlCommand.Parameters.Clear()` did not work. (Bug #50444)

- When the `MySqlScript.execute()` method was called, the following exception was generated:

  ```
  InvalidOperationException : The CommandText property has not been properly initialized.
  ```

  (Bug #50344)

- Binary Columns were not displayed in the Query Builder of Visual Studio. (Bug #50171)

- When the `UpdateBatchSize` property was set to a value greater than 1, only the first row was applied to the database. (Bug #50123)

- When using table per type inheritance and listing the contents of the parent table, the result of the query was a list of child objects, even though there was no related child record with the same parent Id. (Bug #49850)

- `MySqlDataReader.GetUInt64` returned an incorrect value when reading a `BIGINT UNSIGNED` column containing a value greater than 2147483647. (Bug #49794)

- A `FormatException` was generated when an empty string was returned from a stored function. (Bug #49642)

- When adding a data set in Visual Studio 2008, the following error was generated:

  ```
  Relations couldn't be addded. Column 'REFERENCED_TABLE_CATALOG' does not belong to table.
  ```

  This was due to a 'REFERENCED_TABLE_CATALOG' column not being included in the foreign keys collection. (Bug #48974)

- Attempting to execute a load data local infile on a file where the user did not have write permissions, or the file was open in an editor gave an access denied error. (Bug #48944)

- The method `MySqlDataReader.GetSchemaTable()` returned 0 in the `NumericPrecision` field for decimal and newdecimal columns. (Bug #48171)

- When trying to create stored procedures from an SQL script, a `MySqlException` was thrown when attempting to redefine the `DELIMITER`:

  ```
          MySql.Data.MySqlClient.MySqlException was unhandled
          Message="You have an error in your SQL syntax; check the manual that corresponds to your
          MySQL server version for the right syntax to use near 'DELIMITER' at line 1"
          Source="MySql.Data"
          ErrorCode=-2147467259
          Number=1064
          StackTrace:
          à MySql.Data.MySqlClient.MySqlStream.ReadPacket()
          à MySql.Data.MySqlClient.NativeDriver.ReadResult(UInt64& affectedRows, Int64&
          lastInsertId)
          à MySql.Data.MySqlClient.MySqlDataReader.GetResultSet()
          à MySql.Data.MySqlClient.MySqlDataReader.NextResult()
          à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
          à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
          à MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
        à MySql.Data.MySqlClient.MySqlScript.Execute()
  ```

  Note: The `MySqlScript` class has been fixed to support the delimiter statement as it is found in SQL scripts. (Bug #46429)

- Calling a User Defined Function using Entity SQL in the Entity Framework caused a `NullReferenceException`. (Bug #45277)

- A connection string set in `web.config` could not be reused after Visual Studio 2008 Professional was shut down. It continued working for the existing controls, but did not work for new controls added. (Bug #41629)

D.3.5.4. Changes in MySQL Connector/Net 6.0.5 (12 November 2009)

This is a new release, fixing recently discovered bugs.

Bugs Fixed

- Cloning of `MySqlCommand` was not typesafe. To clone a `MySqlCommand` it was necessary to do:

  ```
          MySqlCommand clone = (MySqlCommand)((ICloneable)comm).Clone();
  ```

  MySQL Connector/Net was changed so that it was possible to do:

  ```
          MySqlCommand clone = comm.Clone();
  ```

  (Bug #48460)

- If `MySqlConnection.GetSchema` was called for "Indexes" on a table named “b`a`d” as follows:

  ```
  DataTable schemaPrimaryKeys = connection.GetSchema(
    "Indexes",
    new string[] { null, schemaName, "b`a`d"});
  ```

  Then the following exception was generated:

  ```
  You have an error in your SQL syntax; check the manual that corresponds to
  your MySQL server version for the right syntax to use near 'a`d`' at line 1
  ```

  (Bug #48101)

- It was not possible to retrieve a value from a MySQL server table, if the value was larger than that supported by the .NET type `System.Decimal`.

  MySQL Connector/Net was changed to expose the `MySqlDecimal` type, along with the supporting method `GetMySqlDecimal`. (Bug #48100)

- An entity model created from a schema containing a table with a column of type `UNSIGNED BIGINT` and a view of the table did not behave correctly. When an entity was created and mapped to the view, the column that was of type `UNSIGNED BIGINT` was displayed as `BIGINT`. (Bug #47872)

- When loading the `MySQLClient-mono.sln` file included with the Connector/Net source into Mono Develop, the following error occurred:

  ```
  /home/tbedford/connector-net-src/6.1/MySQLClient-mono.sln(22):
  Unsupported or unrecognized project:
  '/home/tbedford/connector-net-src/6.1/Installer/Installer.wixproj'
  ```

  If the file was modified to remove this problem, then attempting to build the solution generated the following error:

  ```
  /home/tbedford/connector-net-src/6.1/MySql.Data/Provider/Source/Connection.cs(280,46):
  error CS0115: `MySql.Data.MySqlClient.MySqlConnection.DbProviderFactory' is marked as an
  override but no suitable property found to override
  ```

  (Bug #47048)

- If an error occurred during connection to a MySQL Server, deserializing the error message from the packet buffer caused a `NullReferenceException` to be thrown. When the method `MySqlPacket::ReadString()` attempted to retrieve the error message, the following line of code threw the exception:

  ```
          string s = encoding.GetString(bits, (int)buffer.Position, end - (int)buffer.Position);
  ```

  This was due to the fact that the encoding field had not been initialized correctly. (Bug #46844)

- In the `MySqlDataReader` class the `GetSByte` function returned a `byte` value instead of an `sbyte` value. (Bug #46620)

- The MySQL Connector/Net Profile Provider, `MySql.Web.Profile.MySQLProfileProvider`, generated an error when running on Mono. When an attempt was made to save a string in `Profile.Name` the string was not saved to the `my_aspnet_Profiles` table. If an attempt was made to force the save with `Profile.Save()` the following error was generated:

  ```
          Server Error in '/mono' Application

          --------------------------------------------------------------------------------

          The requested feature is not implemented.
          Description: HTTP 500. Error processing request.
  ```

```
Stack Trace:

System.NotImplementedException: The requested feature is not implemented.
at MySql.Data.MySqlClient.MySqlConnection.EnlistTransaction
(System.Transactions.Transaction transaction) [0x00000]
at MySql.Data.MySqlClient.MySqlConnection.Open () [0x00000]
at MySql.Web.Profile.MySQLProfileProvider.SetPropertyValues
(System.Configuration.SettingsContext context,
System.Configuration.SettingsPropertyValueCollection collection) [0x00000]


--------------------------------------------------------------------------------
Version information: Mono Version: 2.0.50727.1433; ASP.NET Version: 2.0.50727.1433
```

(Bug #46375)

- An exception was generated when using `TIMESTAMP` columns with the Entity Framework. (Bug #46311)
- MySQL Connector/Net sometimes hung, without generating an exception. This happened if a read from a stream failed returning a 0, causing the code in `LoadPacket()` to enter an infinite loop. (Bug #46308)
- When using MySQL Connector/Net 6.0.4 and a MySQL Server 4.1 an exception was generated when trying to execute:

  ```
  connection.GetSchema("Columns", ...);
  ```

  The exception generated was:

  ```
  'connection.GetSchema("Columns")' threw an exception of type
  'System.ArgumentException'System.Data.DataTable {System.ArgumentException}
  base{"Input string was not in a correct format.Couldn't store <'Select'> in
  NUMERIC_PRECISION Column.  Expected type is UInt64."}System.Exception
  {System.ArgumentException}
  ```

  (Bug #46270)

- The MySQL Connector/Net method `StoredProcedure.GetParameters(string)` ignored the programmer's setting of the `UseProcedureBodies` option. This broke any application for which the application's parameter names did not match the parameter names in the Stored Procedure, resulting in an `ArgumentException` with the message “Parameter 'foo' not found in the collection.” and the following stack trace:

  ```
  MySql.Data.dll!MySql.Data.MySqlClient.MySqlParameterCollection.GetParameterFlexible(stri
  ng parameterName = "pStart", bool throwOnNotFound = true) Line 459C#
  MySql.Data.dll!MySql.Data.MySqlClient.StoredProcedure.Resolve() Line 157 + 0x25
  bytesC#
  MySql.Data.dll!MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(System.Data.CommandBeha
  vior behavior = SequentialAccess) Line 405 + 0xb bytesC#
  MySql.Data.dll!MySql.Data.MySqlClient.MySqlCommand.ExecuteDbDataReader(System.Data.Comma
  ndBehavior behavior = SequentialAccess) Line 884 + 0xb bytesC#
  System.Data.dll!System.Data.Common.DbCommand.System.Data.IDbCommand.ExecuteReader(System
  .Data.CommandBehavior behavior) + 0xb bytes
  System.Data.dll!System.Data.Common.DbDataAdapter.FillInternal(System.Data.DataSet
  dataset = {System.Data.DataSet}, System.Data.DataTable[] datatables = null, int
  startRecord = 0, int maxRecords = 0, string srcTable = "Table", System.Data.IDbCommand
  command = {MySql.Data.MySqlClient.MySqlCommand}, System.Data.CommandBehavior behavior) +
  0x83 bytes
  System.Data.dll!System.Data.Common.DbDataAdapter.Fill(System.Data.DataSet dataSet, int
  startRecord, int maxRecords, string srcTable, System.Data.IDbCommand command,
  System.Data.CommandBehavior behavior) + 0x120 bytes
  System.Data.dll!System.Data.Common.DbDataAdapter.Fill(System.Data.DataSet dataSet) +
  0x5f bytes
  ```

  (Bug #46213)

- Conversion of MySQL `TINYINT(1)` to `boolean` failed. (Bug #46205, Bug #46359, Bug #41953)
- When populating a MySQL database table in Visual Studio using the Table Editor, if a `VARCHAR(10)` column was changed to a `VARCHAR(20)` column an exception was generated:

  ```
    SystemArgumentException: DataGridViewComboBoxCell value is not valid.
  To replace this default dialog please handle the DataError Event.
  ```

  (Bug #46100)

- In MySQL Connector/Net 6.0.4 using `GetProcData` generated an error because the `parameters` data table was only created if MySQL Server was at least version 6.0.6, or if the `UseProcedureBodies` connection string option was set to true.

Also the `DeriveParameters` command generated a null reference exception. This was because the `parameters` data table, which was null, was used in a `for each` loop. (Bug #45952)

- The Entity Framework provider was not calling `DBSortExpression` correctly when the `Skip` and `Take` methods were used, such as in the following statement:

  ```
          TestModel.tblquarantine.OrderByDescending(q => q.MsgDate).Skip(100).Take(100).ToList();
  ```

  This resulted in the data being unsorted. (Bug #45723)

- The `EscapeString` code carried out escaping by calling `string.Replace` multiple times. This resulted in a performance bottleneck, as for every line a new string was allocated and another was disposed of by the garbage collector. (Bug #45699)

- Adding the `Allow Batch=False` option to the connection string caused MySQL Connector/Net to generate the error:

  ```
  You have an error in your SQL syntax; check the manual that corresponds to your MySQL
        server version for the right syntax to use near 'SET character_set_results=NULL' at line 1
  ```

  (Bug #45502)

- The MySQL Connector/Net 6.0.4 installer failed with an error. The error message generated was:

  ```
          There is a problem with this Windows Installer package. A DLL required for this
          install to complete could not be run. Contact your support personnel or package vendor.
  ```

  When OK was clicked to acknowledge the error the installer exited. (Bug #45474)

- A MySQL Connector/Net test program that connected to MySQL Server using the connection string option `compress=true` crashed, but only when running on Mono. The program worked as expected when running on Microsoft Windows.

  This was due to a bug in Mono. MySQL Connector/Net was modified to avoid using `WeakReferences` in the `Compressed` stream class, which was causing the crash. (Bug #45463)

- Calling the Entity Framework `SaveChanges()` method of any MySQL ORM Entity with a column type `TIME`, generated an error message:

  ```
  Unknown PrimitiveKind Time
  ```

  (Bug #45457)

- Insert into two tables failed when using the Entity Framework. The exception generated was:

  ```
          The value given is not an instance of type 'Edm.Int32'
  ```

  (Bug #45077)

- Input parameters were missing from Stored Procedures when using them with ADO.NET Data Entities. (Bug #44985)

- Errors occurred when using the Entity Framework with cultures that used a comma as the decimal separator. This was because the formatting for `SINGLE`, `DOUBLE` and `DECIMAL` values was not handled correctly. (Bug #44455)

- When attempting to connect to MySQL using the Compact Framework version of MySQL Connector/Net, an `IndexOutOfRangeException` exception was generated on trying to open the connection. (Bug #43736)

- When reading data, such as with a `MySqlDataAdapter` on a `MySqlConnection`, MySQL Connector/Net could potentially enter an infinite loop in `CompressedStream.ReadNextpacket()` if compression was enabled. (Bug #43678)

- An error occurred when building MySQL Connector/Net from source code checked out from the public SVN repository. This happened on Linux using Mono and Nant. The Mono JIT compiler version was 1.2.6.0. The Nant version was 0.85.

  When an attempt was made to build (for example) the MySQL Connector/Net 5.2 branch using the command:

  ```
          $ nant -buildfile:Client.build
  ```

  The following error occurred:

```
        BUILD FAILED

        Error loading buildfile.
        Encoding name 'Windows-1252' not supported.
        Parameter name: name
```

(Bug #42411)

- After a Reference to "C:\Program Files\MySQL\MySQL Connector Net 5.2.4\Compact Framework\MySql.Data.CF.dll" was added to a Windows Mobile 5.0 project, the project then failed to build, generating a Microsoft Visual C# compiler error.

  The error generated was:

  ```
  Error 2 The type 'System.Runtime.CompilerServices.CompilerGeneratedAttribute'
        has no constructors defined MysqlTest
        Error 3 Internal Compiler Error (0xc0000005 at address 5A7E3714):
        likely culprit is 'COMPILE'.
  ```

  (Bug #42261)

- MySQL Connector/Net CHM documentation stated that MySQL Server 3.23 was supported. (Bug #42110)

- In the case of long network inactivity, especially when connection pooling was used, connections were sometimes dropped, for example, by firewalls.

  Note: The bugfix introduced a new `keepalive` parameter, which prevents disconnects by sending an empty TCP packet after a specified timeout. (Bug #40684)

- MySQL Connector/Net generated the following exception:

  ```
  System.NullReferenceException: Object reference not set to an instance of an object.
        bei MySql.Data.MySqlClient.MySqlCommand.TimeoutExpired(Object commandObject)
        bei System.Threading._TimerCallback.TimerCallback_Context(Object state)
        bei System.Threading.ExecutionContext.runTryCode(Object userData)
        bei
        System.Runtime.CompilerServices.RuntimeHelpers.ExecuteCodeWithGuaranteedCleanup(TryCode
        code, CleanupCode backoutCode, Object userData)
        bei System.Threading.ExecutionContext.RunInternal(ExecutionContext executionContext,
        ContextCallback callback, Object state)
        bei System.Threading.ExecutionContext.Run(ExecutionContext executionContext,
        ContextCallback callback, Object state)
        bei System.Threading._TimerCallback.PerformTimerCallback(Object state)
  ```

  (Bug #40005)

- Calling a Stored Procedure with an output parameter through MySQL Connector/Net resulted in a memory leak. Calling the same Stored Procedure without an output parameter did not result in a memory leak. (Bug #36027)

- Using a `DataAdapter` with a linked `MySqlCommandBuilder` the following exception was thrown when trying to call `da.Update(DataRow[] rows)`:

  ```
  Connection must be valid and open
  ```

  (Bug #34657)

D.3.5.5. Changes in MySQL Connector/Net 6.0.4 (16 June 2009)

This is the first post-GA release, fixing recently discovered bugs.

Bugs Fixed

- If a certain socket exception occurred when trying to establish a MySQL database connection, MySQL Connector/Net displayed an exception message that appeared to be unrelated to the underlying problem. This masked the problem and made diagnosing problems more difficult.

  For example, if, when establishing a database connection using TCP/IP, Windows on the local machine allocated an ephemeral port that conflicted with a socket address still in use, then Windows/.NET would throw a socket exception with the following error text:

  ```
  Only one usage of each socket address (protocol/network address/port) is normally
        permitted IP ADDRESS/PORT.
  ```

However, MySQL Connector/Net masked this socket exception and displayed an exception with the following text:

```
Unable to connect to any of the specified MySQL hosts.
```

(Bug #45021)

- A SQL query string containing an escaped backslash caused an exception to be generated:

  ```
  Index and length must refer to a location within the string.
        Parameter name: length
        at System.String.InternalSubStringWithChecks(Int32 startIndex, Int32 length, Boolean
        fAlwaysCopy)
        at MySql.Data.MySqlClient.MySqlTokenizer.NextParameter()
        at MySql.Data.MySqlClient.Statement.InternalBindParameters(String sql,
        MySqlParameterCollection parameters, MySqlPacket packet)
        at MySql.Data.MySqlClient.Statement.BindParameters()
        at MySql.Data.MySqlClient.PreparableStatement.Execute()
        at MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior be□havior)
        at MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
  ```

  (Bug #44960)

- The Microsoft Visual Studio solution file `MySQL-VS2005.sln` was invalid. Several projects could not be loaded and thus it was not possible to build MySQL Connector/Net from source. (Bug #44822)

- The Data Set editor generated an error when attempts were made to modify insert, update or delete commands:

  ```
  Error in WHERE clause near '@'.
        Unable to parse query text.
  ```

  (Bug #44512)

- The DataReader in MySQL Connector/Net 6.0.3 considered a BINARY(16) field as a GUID with a length of 16. (Bug #44507)

- When creating a new DataSet the following error was generated:

  ```
  Failed to open a connection to database.
        Cannot load type with name 'MySQL.Data.VisualStudio.StoredProcedureColumnEnumerator'
  ```

  (Bug #44460)

- The MySQL Connector/Net MySQLRoleProvider reported that there were no roles, even when roles existed. (Bug #44414)

- MySQL Connector/Net was missing the capability to validate the server's certificate when using encryption. This made it possible to conduct a man-in-the-middle attack against the connection, which defeated the security provided by SSL. (Bug #38700)

D.3.5.6. Changes in MySQL Connector/Net 6.0.3 (28 April 2009)

First GA release.

Functionality Added or Changed

- The `MySqlTokenizer` failed to split fieldnames from values if they were not separated by a space. This also happened if the string contained certain characters. As a result `MySqlCommand.ExecuteNonQuery` raised an index out of range exception.

  The resulting errors are illustrated by the following examples. Note, the example statements do not have delimiting spaces around the `=` operator.

  ```
  INSERT INTO anytable SET Text='test--test';
  ```

  The tokenizer incorrectly interpreted the value as containing a comment.

  ```
  UPDATE anytable SET Project='123-456',Text='Can you explain this ?',Duration=15 WHERE
        ID=4711;'
  ```

  A `MySqlException` was generated, as the `?` in the value was interpreted by the tokenizer as a parameter sign. The error message generated was:

  ```
  Fatal error encountered during command execution.
        EXCEPTION: MySqlException - Parameter '?'' must be defined.
  ```

(Bug #44318)

Bugs Fixed

- `MySQL.Data` was not displayed as a Reference inside Microsoft Visual Studio 2008 Professional.

  When a new C# project was created in Microsoft Visual Studio 2008 Professional, `MySQL.Data` was not displayed when REFERENCES, ADD REFERENCE was selected. (Bug #44141)

- Column types for `SchemaProvider` and `ISSchemaProvider` did not match.

  When the source code in `SchemaProvider.cs` and `ISSchemaProvider.cs` were compared it was apparent that they were not using the same column types. The base provider used SQL such as `SHOW CREATE TABLE`, while `ISSchemaProvider` used the schema information tables. Column types used by the base class were `INT64` and the column types used by `ISSchemaProvider` were `UNSIGNED`. (Bug #44123)

D.3.5.7. Changes in MySQL Connector/Net 6.0.2 (07 April 2009 beta)

This is a new development release, fixing recently discovered bugs.

Bugs Fixed

- MySQL Connector/Net 6.0.1 did not load in Microsoft Visual Studio 2008 and Visual Studio 2005 Pro.

  The following error message was generated:

  ```
  .NET Framework Data Provider for MySQL: The data provider object factory service was not
        found.
  ```

  (Bug #44064)

D.3.5.8. Changes in MySQL Connector/Net 6.0.1 (02 April 2009 beta)

This is a new Beta development release, fixing recently discovered bugs.

Bugs Fixed

- An insert and update error was generated by the decimal data type in the Entity Framework, when a German collation was used. (Bug #43574)
- Generating an Entity Data Model (EDM) schema with a table containing columns with data types `MEDIUMTEXT` and `LONGTEXT` generated a runtime error message “Max value too long or too short for Int32”. (Bug #43480)

D.3.5.9. Changes in MySQL Connector/Net 6.0.0 (02 March 2009 alpha)

This is a new Alpha development release.

Bugs Fixed

- A null reference exception was generated when `MySqlConnection.ClearPool(connection)` was called. (Bug #42801)

D.3.6. Changes in MySQL Connector/Net Version 5.3.x

D.3.6.1. Changes in MySQL Connector/Net 5.3.0 (Not released)

Bugs Fixed

- The Web Provider did not work at all on a remote host, and did not create a database when using `autogenerates-`

`chema="true"`. (Bug #39072)

- The MySQL Connector/Net installer program ended prematurely without reporting the specific error. (Bug #39019)
- When called with an incorrect password the `MembershipProvider.GetPassword()` method threw a `MySQLException` instead of a `MembershipPasswordException` . (Bug #38939)
- Possible overflow in `MySqlPacket.ReadLong()`. (Bug #36997)
- The `TokenizeSql` method was adding query overhead and causing high CPU utilization for larger queries. (Bug #36836)

D.3.7. Changes in MySQL Connector/Net Version 5.2.x

D.3.7.1. Changes in MySQL Connector/Net 5.2.8 (Not released)

Bugs Fixed

- If `MySqlConnection.GetSchema` was called for "Indexes" on a table named “b`a`d” as follows:

  ```
  DataTable schemaPrimaryKeys = connection.GetSchema(
    "Indexes",
    new string[] { null, schemaName, "b`a`d"});
  ```

  Then the following exception was generated:

  ```
  You have an error in your SQL syntax; check the manual that corresponds to
  your MySQL server version for the right syntax to use near 'a`d`' at line 1
  ```

  (Bug #48101)
- When the connection string option “Connection Reset = True” was used, a connection reset used the previously used encoding for the subsequent authentication operation. This failed, for example, if UCS2 was used to read the last column before the reset. (Bug #47153)
- In the `MySqlDataReader` class the `GetSByte` function returned a `byte` value instead of an `sbyte` value. (Bug #46620)
- When trying to create stored procedures from an SQL script, a `MySqlException` was thrown when attempting to redefine the `DELIMITER`:

  ```
      MySql.Data.MySqlClient.MySqlException was unhandled
      Message="You have an error in your SQL syntax; check the manual that corresponds to your
      MySQL server version for the right syntax to use near 'DELIMITER' at line 1"
      Source="MySql.Data"
      ErrorCode=-2147467259
      Number=1064
      StackTrace:
      à MySql.Data.MySqlClient.MySqlStream.ReadPacket()
      à MySql.Data.MySqlClient.NativeDriver.ReadResult(UInt64& affectedRows, Int64&
      lastInsertId)
      à MySql.Data.MySqlClient.MySqlDataReader.GetResultSet()
      à MySql.Data.MySqlClient.MySqlDataReader.NextResult()
      à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(CommandBehavior behavior)
      à MySql.Data.MySqlClient.MySqlCommand.ExecuteReader()
      à MySql.Data.MySqlClient.MySqlCommand.ExecuteNonQuery()
     à MySql.Data.MySqlClient.MySqlScript.Execute()
  ```

  Note: The `MySqlScript` class has been fixed to support the delimiter statement as it is found in SQL scripts. (Bug #46429)
- The MySQL Connector/Net Profile Provider, `MySql.Web.Profile.MySQLProfileProvider`, generated an error when running on Mono. When an attempt was made to save a string in `Profile.Name` the string was not saved to the `my_aspnet_Profiles` table. If an attempt was made to force the save with `Profile.Save()` the following error was generated:

  ```
      Server Error in '/mono' Application

      --------------------------------------------------------------------------------

      The requested feature is not implemented.
      Description: HTTP 500. Error processing request.

      Stack Trace:

      System.NotImplementedException: The requested feature is not implemented.
      at MySql.Data.MySqlClient.MySqlConnection.EnlistTransaction
      (System.Transactions.Transaction transaction) [0x00000]
  ```

```
        at MySql.Data.MySqlClient.MySqlConnection.Open () [0x00000]
        at MySql.Web.Profile.MySQLProfileProvider.SetPropertyValues
        (System.Configuration.SettingsContext context,
        System.Configuration.SettingsPropertyValueCollection collection) [0x00000]


        --------------------------------------------------------------------------------
        Version information: Mono Version: 2.0.50727.1433; ASP.NET Version: 2.0.50727.1433
```

(Bug #46375)

- When using MySQL Connector/Net 6.0.4 and a MySQL Server 4.1 an exception was generated when trying to execute:

  ```
  connection.GetSchema("Columns", ...);
  ```

  The exception generated was:

  ```
  'connection.GetSchema("Columns")' threw an exception of type
  'System.ArgumentException'System.Data.DataTable {System.ArgumentException}
  base{"Input string was not in a correct format.Couldn't store <'Select'> in
  NUMERIC_PRECISION Column.  Expected type is UInt64."}System.Exception
  {System.ArgumentException}
  ```

  (Bug #46270)

- The MySQL Connector/Net method `StoredProcedure.GetParameters(string)` ignored the programmer's setting of the `UseProcedureBodies` option. This broke any application for which the application's parameter names did not match the parameter names in the Stored Procedure, resulting in an `ArgumentException` with the message “Parameter 'foo' not found in the collection.” and the following stack trace:

  ```
  MySql.Data.dll!MySql.Data.MySqlClient.MySqlParameterCollection.GetParameterFlexible(stri
  ng parameterName = "pStart", bool throwOnNotFound = true) Line 459C#
  MySql.Data.dll!MySql.Data.MySqlClient.StoredProcedure.Resolve() Line 157 + 0x25
  bytesC#
  MySql.Data.dll!MySql.Data.MySqlClient.MySqlCommand.ExecuteReader(System.Data.CommandBeha
  vior behavior = SequentialAccess) Line 405 + 0xb bytesC#
  MySql.Data.dll!MySql.Data.MySqlClient.MySqlCommand.ExecuteDbDataReader(System.Data.Comma
  ndBehavior behavior = SequentialAccess) Line 884 + 0xb bytesC#
  System.Data.dll!System.Data.Common.DbCommand.System.Data.IDbCommand.ExecuteReader(System
  .Data.CommandBehavior behavior) + 0xb bytes
  System.Data.dll!System.Data.Common.DbDataAdapter.FillInternal(System.Data.DataSet
  dataset = {System.Data.DataSet}, System.Data.DataTable[] datatables = null, int
  startRecord = 0, int maxRecords = 0, string srcTable = "Table", System.Data.IDbCommand
  command = {MySql.Data.MySqlClient.MySqlCommand}, System.Data.CommandBehavior behavior) +
  0x83 bytes
  System.Data.dll!System.Data.Common.DbDataAdapter.Fill(System.Data.DataSet dataSet, int
  startRecord, int maxRecords, string srcTable, System.Data.IDbCommand command,
  System.Data.CommandBehavior behavior) + 0x120 bytes
  System.Data.dll!System.Data.Common.DbDataAdapter.Fill(System.Data.DataSet dataSet) +
  0x5f bytes
  ```

  (Bug #46213)

- Conversion of MySQL `TINYINT(1)` to `boolean` failed. (Bug #46205, Bug #46359, Bug #41953)

- If the application slept for longer than the specified `net_write_timeout`, and then resumed `Read` operations on a connection, then the application failed silently. (Bug #45978)

- When reading data, such as with a `MySqlDataAdapter` on a `MySqlConnection`, MySQL Connector/Net could potentially enter an infinite loop in `CompressedStream.ReadNextpacket()` if compression was enabled. (Bug #43678)

- An error occurred when building MySQL Connector/Net from source code checked out from the public SVN repository. This happened on Linux using Mono and Nant. The Mono JIT compiler version was 1.2.6.0. The Nant version was 0.85.

  When an attempt was made to build (for example) the MySQL Connector/Net 5.2 branch using the command:

  ```
  $ nant -buildfile:Client.build
  ```

  The following error occurred:

  ```
  BUILD FAILED

  Error loading buildfile.
  ```

```
        Encoding name 'Windows-1252' not supported.
        Parameter name: name
```

(Bug #42411)

- MySQL Connector/Net CHM documentation stated that MySQL Server 3.23 was supported. (Bug #42110)
- Using a `DataAdapter` with a linked `MySqlCommandBuilder` the following exception was thrown when trying to call `da.Update(DataRow[] rows)`:

  ```
  Connection must be valid and open
  ```

  (Bug #34657)

D.3.7.2. Changes in MySQL Connector/Net 5.2.7 (15 July 2009)

Bugs Fixed

- The `EscapeString` code carried out escaping by calling `string.Replace` multiple times. This resulted in a performance bottleneck, as for every line a new string was allocated and another was disposed of by the garbage collector. (Bug #45699)
- A MySQL Connector/Net test program that connected to MySQL Server using the connection string option `compress=true` crashed, but only when running on Mono. The program worked as expected when running on Microsoft Windows.

  This was due to a bug in Mono. MySQL Connector/Net was modified to avoid using `WeakReferences` in the `Compressed` stream class, which was causing the crash. (Bug #45463)
- If a certain socket exception occurred when trying to establish a MySQL database connection, MySQL Connector/Net displayed an exception message that appeared to be unrelated to the underlying problem. This masked the problem and made diagnosing problems more difficult.

  For example, if, when establishing a database connection using TCP/IP, Windows on the local machine allocated an ephemeral port that conflicted with a socket address still in use, then Windows/.NET would throw a socket exception with the following error text:

  ```
  Only one usage of each socket address (protocol/network address/port) is normally
        permitted IP ADDRESS/PORT.
  ```

  However, MySQL Connector/Net masked this socket exception and displayed an exception with the following text:

  ```
  Unable to connect to any of the specified MySQL hosts.
  ```

  (Bug #45021)
- The Microsoft Visual Studio solution file `MySQL-VS2005.sln` was invalid. Several projects could not be loaded and thus it was not possible to build MySQL Connector/Net from source. (Bug #44822)
- The MySQL Connector/Net MySQLRoleProvider reported that there were no roles, even when roles existed. (Bug #44414)
- After a Reference to "C:\Program Files\MySQL\MySQL Connector Net 5.2.4\Compact Framework\MySql.Data.CF.dll" was added to a Windows Mobile 5.0 project, the project then failed to build, generating a Microsoft Visual C# compiler error.

  The error generated was:

  ```
  Error 2 The type 'System.Runtime.CompilerServices.CompilerGeneratedAttribute'
        has no constructors defined MysqlTest
        Error 3 Internal Compiler Error (0xc0000005 at address 5A7E3714):
        likely culprit is 'COMPILE'.
  ```

  (Bug #42261)
- MySQL Connector/Net generated the following exception:

  ```
  System.NullReferenceException: Object reference not set to an instance of an object.
        bei MySql.Data.MySqlClient.MySqlCommand.TimeoutExpired(Object commandObject)
        bei System.Threading._TimerCallback.TimerCallback_Context(Object state)
        bei System.Threading.ExecutionContext.runTryCode(Object userData)
        bei
  ```

```
      System.Runtime.CompilerServices.RuntimeHelpers.ExecuteCodeWithGuaranteedCleanup(TryCode
      code, CleanupCode backoutCode, Object userData)
      bei System.Threading.ExecutionContext.RunInternal(ExecutionContext executionContext,
      ContextCallback callback, Object state)
      bei System.Threading.ExecutionContext.Run(ExecutionContext executionContext,
      ContextCallback callback, Object state)
      bei System.Threading._TimerCallback.PerformTimerCallback(Object state)
```

(Bug #40005)

- When a TableAdapter was created on a DataSet, it was not possible to use a stored procedure with variables. The following error was generated:

  ```
  The method or operation is not implemented
  ```

  (Bug #39409)

D.3.7.3. Changes in MySQL Connector/Net 5.2.6 (28 April 2009)

Functionality Added or Changed

- A new connection string option has been added: `use affected rows`. When `true` the connection will report changed rows instead of found rows. (Bug #44194)

Bugs Fixed

- Calling `GetSchema()` on `Indexes` or `IndexColumns` failed where index or column names were restricted.

  In `SchemaProvider.cs`, methods `GetIndexes()` and `GetIndexColumns()` passed their restrictions directly to `GetTables()`. This only worked if the restrictions were no more specific than `schemaName` and `tableName`. If `IndexName` was given, this was passed to `GetTables()` where it was treated as `TableType`. As a result no tables were returned, unless the index name happened to be `BASE TABLE` or `VIEW`. This meant that both methods failed to return any rows. (Bug #43991)

- `GetSchema("MetaDataCollections")` should have returned a table with a column named “NumberOfRestrictions” not “NumberOfRestriction”.

  This can be confirmed by referencing the Microsoft Documentation. (Bug #43990)

- Requests sent to the MySQL Connector/Net role provider to remove a user from a role failed. The query log showed the query was correctly executed within a transaction which was immediately rolled back. The rollback was caused by a missing call to the `Complete` method of the transaction. (Bug #43553)

- When using `MySqlBulkLoader.Load()`, the text file is opened by `NativeDriver.SendFileToServer`. If it encountered a problem opening the file as a stream, an exception was generated and caught. An attempt to clean up resources was then made in the `finally{}` clause by calling `fs.Close()`, but since the stream was never successfully opened, this was an attempt to execute a method of a null reference. (Bug #43332)

- A null reference exception was generated when `MySqlConnection.ClearPool(connection)` was called. (Bug #42801)

- `MySQLMembershipProvider.ValidateUser` only used the `userId` to validate. However, it should also use the `applicationId` to perform the validation correctly.

  The generated query was, for example:

  ```
  SELECT Password, PasswordKey, PasswordFormat, IsApproved, Islockedout
        FROM my_aspnet_Membership WHERE userId=13
  ```

  Note that `applicationId` is not used. (Bug #42574)

- There was an error in the `ProfileProvider` class in the `private ProfileInfoCollection GetProfiles()` function. The column of the final table was named “lastUpdatdDate” ('e' is missing) instead of the correct “lastUpdatedDate”. (Bug #41654)

- The `GetGuid()` method of `MySqlDataReader` did not treat `BINARY(16)` column data as a GUID. When operating on such a column a `FormatException` exception was generated. (Bug #41452)

- When ASP.NET membership was configured to not require password question and answer using `requiresQuestionAndAnswer="false"`, a `SqlNullValueException` was generated when using `MembershipUser.ResetPassword()` to reset the user password. (Bug #41408)
- If a `Stored Procedure` contained spaces in its parameter list, and was then called from MySQL Connector/Net, an exception was generated. However, the same `Stored Procedure` called from the MySQL Query Analyzer or the MySQL Client worked correctly.

  The exception generated was:

  ```
          Parameter '0' not found in the collection.
  ```

  (Bug #41034)
- The `DATETIME` format contained an erroneous space. (Bug #41021)
- When `MySql.Web.Profile.MySQLProfileProvider` was configured, it was not possible to assign a name other than the default name `MySQLProfileProvider`.

  If the name `SCC_MySQLProfileProvider` was assigned, an exception was generated when attempting to use `Page.Context.Profile['custom prop']`.

  The exception generated was:

  ```
  The profile default provider was not found.
  ```

  Note that the exception stated: 'the profile **default provider**...', even though a different name was explicitly requested. (Bug #40871)
- When `ExecuteNonQuery` was called with a command type of `Stored Procedure` it worked for one user but resulted in a hang for another user with the same database permissions.

  However, if `CALL` was used in the command text and `ExecuteNonQuery` was used with a command type of `Text`, the call worked for both users. (Bug #40139)

D.3.7.4. Changes in MySQL Connector/Net 5.2.5 (19 November 2008)

Bugs Fixed

- Visual Studio 2008 displayed the following error three times on start-up:

  ```
          "Package Load Failure

          Package 'MySql.Data.VisualStudio.MySqlDataProviderPackage, MySql.VisualStudio,
          Version=5.2.4, Culture=neutral, PublicKeyToken=null' has failed to load properly (GUID =
          {79A115C9-B133-4891-9E7B-242509DAD272}).  Please contact the package vendor for
          assistance.  Application restart is recommended, due to possible environment corruption.
          Would you like to disable loading the package in the future?  You may use
          'devenve/resetskippkgs' to re-enable package loading."
  ```

  (Bug #40726)

D.3.7.5. Changes in MySQL Connector/Net 5.2.4 (13 November 2008)

Bugs Fixed

- `MySqlDataReader` did not feature a `GetSByte` method. (Bug #40571)
- When working with stored procedures MySQL Connector/Net generated an exception `Unknown "table parameters" in information_schema`. (Bug #40382)
- `GetDefaultCollation` and `GetMaxLength` were not thread safe. These functions called the database to get a set of parameters and cached them in two static dictionaries in the function `InitCollections`. However, if many threads called them they would try to insert the same keys in the collections resulting in duplicate key exceptions. (Bug #40231)
- If connection pooling was not set explicitly in the connection string, MySQL Connector/Net added “;Pooling=False” to the end

of the connection string when `MySqlCommand.ExecuteReader()` was called.

If connection pooling was explicitly set in the connection string, when `MySqlConnection.Open()` was called it converted “Pooling=True” to “pooling=True”.

If `MySqlCommand.ExecuteReader()` was subsequently called, it concatenated “;Pooling=False” to the end of the connection string. The resulting connection string was thus terminated with “pooling=True;Pooling=False”. This disabled connection pooling completely. (Bug #40091)

- The connection string option `Functions Return String` did not set the correct encoding for the result string. Even though the connection string option `Functions Return String=true;` is set, the result of `SELECT DES_DECRYPT()` contained “??” instead of the correct national character symbols. (Bug #40076)
- If, when using the `MySqlTransaction` transaction object, an exception was thrown, the transaction object was not disposed of and the transaction was not rolled back. (Bug #39817)
- After the `ConnectionString` property was initialized using the public setter of `DbConnectionStringBuilder`, the `GetConnectionString` method of `MySqlConnectionStringBuilder` incorrectly returned `null` when `true` was assigned to the `includePass` parameter. (Bug #39728)
- When using `ProfileProvider`, attempting to update a previously saved property failed. (Bug #39330)
- Reading a negative time value greater than -01:00:00 returned the absolute value of the original time value. (Bug #39294)
- Inserting a negative time value (negative `TimeSpan`) into a `Time` column through the use of `MySqlParameter` caused `MySqlException` to be thrown. (Bug #39275)
- When a data connection was created in the server explorer of Visual Studio 2008 Team, an error was generated when trying to expand stored procedures that had parameters.

  Also, if **TableAdapter** was right-clicked and then Add, Query, Use Existing Stored Procedures selected, if you then attempted to select a stored procedure, the window would close and no error message would be displayed. (Bug #39252)
- The Web Provider did not work at all on a remote host, and did not create a database when using `autogenerateschema="true"`. (Bug #39072)
- MySQL Connector/Net called hashed password methods not supported in Mono 2.0 Preview 2. (Bug #38895)

D.3.7.6. Changes in MySQL Connector/Net 5.2.3 (19 August 2008)

Functionality Added or Changed

- Error string was returned after a 28000 second `wait_timeout`. This has been changed to generate a `ConnectionState.Closed` event. (Bug #38119)
- Changed how the procedure schema collection is retrieved. If `use procedure bodies=true` then the `mysql.proc` table is selected directly as this is up to 50 times faster than the current `information_schema` implementation. If `use procedure bodies=false`, then the `information_schema` collection is queried. (Bug #36694)
- String escaping functionality has been moved from the `MySqlString` class to the `MySqlHelper` class, where it can be accessed by the `EscapeString` method. (Bug #36205)

Bugs Fixed

- The `GetOrdinal()` method failed to return the ordinal if the column name string contained an accent. (Bug #38721)
- MySQL Connector/Net uninstaller did not clean up all installed files. (Bug #38534)
- There was a short circuit evaluation error in the `MySqlCommand.CheckState()` method. When the statement `connection == null` was true a `NullReferenceException` was thrown and not the expected `InvalidOperationException`. (Bug #38276)
- The provider did not silently create the user if the user did not exist. (Bug #38243)
- Executing a command that resulted in a fatal exception did not close the connection. (Bug #37991)
- When a prepared insert query is run that contains an `UNSIGNED TINYINT` in the parameter list, the complete query and data

that should be inserted is corrupted and no error is thrown. (Bug #37968)

- In a .NET application MySQL Connector/Net modifies the connection string so that it contains several occurrences of the same option with different values. This is illustrated by the example that follows.

  The original connection string:

  ```
          host=localhost;database=test;uid=*****;pwd=*****;
        connect timeout=25; auto enlist=false;pooling=false;
  ```

  The connection string after closing `MySqlDataReader`:

  ```
          host=localhost;database=test;uid=*****;pwd=*****;
          connect timeout=25;auto enlist=false;pooling=false;
          Allow User Variables=True;Allow User Variables=False;
        Allow User Variables=True;Allow User Variables=False;
  ```

  (Bug #37955)

- Unnecessary network traffic was generated for the normal case where the web provider schema was up to date. (Bug #37469)
- `MySqlReader.GetOrdinal()` performance enhancements break existing functionality. (Bug #37239)
- The `autogenerateschema` option produced tables with incorrect collations. (Bug #36444)
- `GetSchema` did not work correctly when querying for a collection, if using a non-English locale. (Bug #35459)
- When reading back a stored double or single value using the .NET provider, the value had less precision than the one stored. (Bug #33322)
- Using the MySQL Visual Studio plugin and a MySQL 4.1 server, certain field types (`ENUM`) would not be identified correctly. Also, when looking for tables, the plugin would list all tables matching a wildcard pattern of the database name supplied in the connection string, instead of only tables within the specified database. (Bug #30603)

D.3.7.7. Changes in MySQL Connector/Net 5.2.2 (12 May 2008)

Bugs Fixed

- Product documentation incorrectly stated '?' is the preferred parameter marker. (Bug #37349)
- An incorrect value for a bit field would returned in a multi-row query if a preceding value for the field returned `NULL`. (Bug #36313)
- Tables with `GEOMETRY` field types would return an unknown data type exception. (Bug #36081)
- When using the `MySQLProfileProvider`, setting profile details and then reading back saved data would result in the default values being returned instead of the updated values. (Bug #36000)
- When creating a connection, setting the `ConnectionString` property of `MySqlConnection` to `NULL` would throw an exception. (Bug #35619)
- The `DbCommandBuilder.QuoteIdentifer` method was not implemented. (Bug #35492)
- When using encrypted passwords, the `GetPassword()` function would return the wrong string. (Bug #35336)
- An error would be raised when calling `GetPassword()` with a `NULL` value. (Bug #35332)
- When retrieving data where a field has been identified as containing a GUID value, the incorrect value would be returned when a previous row contained a `NULL` value for that field. (Bug #35041)
- Using the `TableAdapter Wizard` would fail when generating commands that used stored procedures due to the change in supported parameter characters. (Bug #34941)
- When creating a new stored procedures, the new parameter code which permits the use of the `@` symbol would interfere with the specification of a `DEFINER`. (Bug #34940)
- When using `SqlDataSource` to open a connection, the connection would not automatically be closed when access had completed. (Bug #34460)

- There was a high level of contention in the connection pooling code that could lead to delays when opening connections and submitting queries. The connection pooling code has been modified to try and limit the effects of the contention issue. (Bug #34001)
- Using the `TableAdaptor` wizard in combination with a suitable `SELECT` statement, only the associated `INSERT` statement would also be created, rather than the required `DELETE` and `UPDATE` statements. (Bug #31338)
- Fixed problem in datagrid code related to creating a new table. This problem may have been introduced with .NET 2.0 SP1.
- Fixed profile provider that would throw an exception if you were updating a profile that already existed.

D.3.7.8. Changes in MySQL Connector/Net 5.2.1 (27 February 2008)

Bugs Fixed

- When using the provider to generate or update users and passwords, the password checking algorithm would not validate the password strength or requirements correctly. (Bug #34792)
- When executing statements that used stored procedures and functions, the new parameter code could fail to identify the correct parameter format. (Bug #34699)
- The installer would fail to the DDEX provider binary if the Visual Studio 2005 component was not selected. The result would lead to MySQL Connector/Net not loading properly when using the interface to a MySQL server within Visual Studio. (Bug #34674)
- A number of issues were identified in the case, connection and schema areas of the code for `MembershipProvider`, `RoleProvider`, `ProfileProvider`. (Bug #34495)
- When using web providers, the MySQL Connector/Net would check the schema and cache the application id, even when the connection string had been set. The effect would be to break the membership provider list. (Bug #34451)
- Attempting to use an isolation level other than the default with a transaction scope would use the default isolation level. (Bug #34448)
- When altering a stored procedure within Visual Studio, the parameters to the procedure could be lost. (Bug #34359)
- A race condition could occur within the procedure cache resulting the cache contents overflowing beyond the configured cache size. (Bug #34338)
- Fixed problem with Visual Studio 2008 integration that caused pop-up menus on server explorer nodes to not function
- The provider code has been updated to fix a number of outstanding issues.

D.3.7.9. Changes in MySQL Connector/Net 5.2.0 (11 February 2008)

Functionality Added or Changed

- Performing `GetValue()` on a field `TINYINT(1)` returned a `BOOLEAN`. While not a bug, this caused problems in software that expected an `INT` to be returned. A new connection string option `Treat Tiny As Boolean` has been added with a default value of `true`. If set to `false` the provider will treat `TINYINT(1)` as `INT`. (Bug #34052)
- Added support for `DbDataAdapter` `UpdateBatchSize`. Batching is fully supported including collapsing inserts down into the multi-value form if possible.
- DDEX provider now works under Visual Studio 2008 beta 2.
- Added ClearPool and ClearAllPools features.

Bugs Fixed

- Some speed improvements have been implemented in the `TokenizeSql` process used to identify elements of SQL statements. (Bug #34220)
- When accessing tables from different databases within the same `TransactionScope`, the same user/password combination would be used for each database connection. MySQL Connector/Net does not handle multiple connections within the same

transaction scope. An error is now returned if you attempt this process, instead of using the incorrect authorization information. (Bug #34204)

- The status of connections reported through the state change handler was not being updated correctly. (Bug #34082)
- Incorporated some connection string cache optimizations sent to us by Maxim Mass. (Bug #34000)
- In an open connection where the server had disconnected unexpectedly, the status information of the connection would not be updated properly. (Bug #33909)
- Data cached from the connection string could return invalid information because the internal routines were not using case-sensitive semantics. This lead to updated connection string options not being recognized if they were of a different case than the existing cached values. (Bug #31433)
- Column name metadata was not using the character set as defined within the connection string being used. (Bug #31185)
- Memory usage could increase and decrease significantly when updating or inserting a large number of rows. (Bug #31090)
- Commands executed from within the state change handeler would fail with a `NULL` exception. (Bug #30964)
- When running a stored procedure multiple times on the same connection, the memory usage could increase indefinitely. (Bug #30116)
- Using compression in the MySQL connection with MySQL Connector/Net would be slower than using native (uncompressed) communication. (Bug #27865)
- The `MySqlDbType.Datetime` has been replaced with `MySqlDbType.DateTime`. The old format has been obsoleted. (Bug #26344)

D.3.8. Changes in MySQL Connector/Net Version 5.1.x

D.3.8.1. Changes in MySQL Connector/Net 5.1.8 (Not released)

Bugs Fixed

- Calling `GetSchema()` on `Indexes` or `IndexColumns` failed where index or column names were restricted.

  In `SchemaProvider.cs`, methods `GetIndexes()` and `GetIndexColumns()` passed their restrictions directly to `GetTables()`. This only worked if the restrictions were no more specific than `schemaName` and `tableName`. If `IndexName` was given, this was passed to `GetTables()` where it was treated as `TableType`. As a result no tables were returned, unless the index name happened to be `BASE TABLE` or `VIEW`. This meant that both methods failed to return any rows. (Bug #43991)
- The `DATETIME` format contained an erroneous space. (Bug #41021)
- If connection pooling was not set explicitly in the connection string, MySQL Connector/Net added “;Pooling=False” to the end of the connection string when `MySqlCommand.ExecuteReader()` was called.

  If connection pooling was explicitly set in the connection string, when `MySqlConnection.Open()` was called it converted “Pooling=True” to “pooling=True”.

  If `MySqlCommand.ExecuteReader()` was subsequently called, it concatenated “;Pooling=False” to the end of the connection string. The resulting connection string was thus terminated with “pooling=True;Pooling=False”. This disabled connection pooling completely. (Bug #40091)
- MySQL Connector/Net generated the following exception:

  ```
  System.NullReferenceException: Object reference not set to an instance of an object.
        bei MySql.Data.MySqlClient.MySqlCommand.TimeoutExpired(Object commandObject)
        bei System.Threading._TimerCallback.TimerCallback_Context(Object state)
        bei System.Threading.ExecutionContext.runTryCode(Object userData)
        bei
        System.Runtime.CompilerServices.RuntimeHelpers.ExecuteCodeWithGuaranteedCleanup(TryCode
        code, CleanupCode backoutCode, Object userData)
        bei System.Threading.ExecutionContext.RunInternal(ExecutionContext executionContext,
        ContextCallback callback, Object state)
        bei System.Threading.ExecutionContext.Run(ExecutionContext executionContext,
        ContextCallback callback, Object state)
        bei System.Threading._TimerCallback.PerformTimerCallback(Object state)
  ```

  (Bug #40005)

- If, when using the `MySqlTransaction` transaction object, an exception was thrown, the transaction object was not disposed of and the transaction was not rolled back. (Bug #39817)
- When a prepared insert query is run that contains an `UNSIGNED TINYINT` in the parameter list, the complete query and data that should be inserted is corrupted and no error is thrown. (Bug #37968)
- Calling `MySqlDataAdapter.FillSchema` on a `SELECT` statement that referred to a table that did not exist left the connection in a bad state. After this call, all `SELECT` statements returned an empty result set. If the `SELECT` statement referred to a table that did exist then everything worked as expected. (Bug #30518)

D.3.8.2. Changes in MySQL Connector/Net 5.1.7 (21 August 2008)

Bugs Fixed

- There was a short circuit evaluation error in the `MySqlCommand.CheckState()` method. When the statement `connection == null` was true a `NullReferenceException` was thrown and not the expected `InvalidOperationException`. (Bug #38276)
- Executing a command that resulted in a fatal exception did not close the connection. (Bug #37991)
- In a .NET application MySQL Connector/Net modifies the connection string so that it contains several occurrences of the same option with different values. This is illustrated by the example that follows.

  The original connection string:

  ```
          host=localhost;database=test;uid=*****;pwd=*****;
        connect timeout=25; auto enlist=false;pooling=false;
  ```

  The connection string after closing `MySqlDataReader`:

  ```
          host=localhost;database=test;uid=*****;pwd=*****;
          connect timeout=25;auto enlist=false;pooling=false;
          Allow User Variables=True;Allow User Variables=False;
        Allow User Variables=True;Allow User Variables=False;
  ```

  (Bug #37955)
- As `MySqlDbType.DateTime` is not available in `VB.Net` the warning THE DATETIME ENUM VALUE IS OBSOLETE was always shown during compilation. (Bug #37406)
- An unknown `MySqlErrorCode` was encountered when opening a connection with an incorrect password. (Bug #37398)
- Documentation incorrectly stated that “the DataColumn class in .NET 1.0 and 1.1 does not permit columns with type of UInt16, UInt32, or UInt64 to be autoincrement columns”. (Bug #37350)
- `SemaphoreFullException` is generated when application is closed. (Bug #36688)
- `GetSchema` did not work correctly when querying for a collection, if using a non-English locale. (Bug #35459)
- When reading back a stored double or single value using the .NET provider, the value had less precision than the one stored. (Bug #33322)
- Using the MySQL Visual Studio plugin and a MySQL 4.1 server, certain field types (`ENUM`) would not be identified correctly. Also, when looking for tables, the plugin would list all tables matching a wildcard pattern of the database name supplied in the connection string, instead of only tables within the specified database. (Bug #30603)

D.3.8.3. Changes in MySQL Connector/Net 5.1.6 (12 May 2008)

Bugs Fixed

- When creating a connection pool, specifying an invalid IP address will cause the entire application to crash, instead of providing an exception. (Bug #36432)
- An incorrect value for a bit field would returned in a multi-row query if a preceding value for the field returned `NULL`. (Bug #36313)
- The `MembershipProvider` will raise an exception when the connection string is configured with `enablePasswordRe-`

`trival = true` and `RequireQuestionAndAnswer = false`. (Bug #36159)

- When calling `GetNumberOfUsersOnline` an exception is raised on the submitted query due to a missing parameter. (Bug #36157)
- Tables with `GEOMETRY` field types would return an unknown data type exception. (Bug #36081)
- When creating a connection, setting the `ConnectionString` property of `MySqlConnection` to `NULL` would throw an exception. (Bug #35619)
- The `DbCommandBuilder.QuoteIdentifer` method was not implemented. (Bug #35492)
- When using `SqlDataSource` to open a connection, the connection would not automatically be closed when access had completed. (Bug #34460)
- Attempting to use an isolation level other than the default with a transaction scope would use the default isolation level. (Bug #34448)
- When altering a stored procedure within Visual Studio, the parameters to the procedure could be lost. (Bug #34359)
- A race condition could occur within the procedure cache resulting the cache contents overflowing beyond the configured cache size. (Bug #34338)
- Using the `TableAdaptor` wizard in combination with a suitable `SELECT` statement, only the associated `INSERT` statement would also be created, rather than the required `DELETE` and `UPDATE` statements. (Bug #31338)

D.3.8.4. Changes in MySQL Connector/Net 5.1.5 (Not released)

Functionality Added or Changed

- Performing `GetValue()` on a field `TINYINT(1)` returned a `BOOLEAN`. While not a bug, this caused problems in software that expected an `INT` to be returned. A new connection string option `Treat Tiny As Boolean` has been added with a default value of `true`. If set to `false` the provider will treat `TINYINT(1)` as `INT`. (Bug #34052)

Bugs Fixed

- Some speed improvements have been implemented in the `TokenizeSql` process used to identify elements of SQL statements. (Bug #34220)
- When accessing tables from different databases within the same `TransactionScope`, the same user/password combination would be used for each database connection. MySQL Connector/Net does not handle multiple connections within the same transaction scope. An error is now returned if you attempt this process, instead of using the incorrect authorization information. (Bug #34204)
- The status of connections reported through the state change handler was not being updated correctly. (Bug #34082)
- Incorporated some connection string cache optimizations sent to us by Maxim Mass. (Bug #34000)
- In an open connection where the server had disconnected unexpectedly, the status information of the connection would not be updated properly. (Bug #33909)
- MySQL Connector/Net would fail to compile properly with `nant`. (Bug #33508)
- Problem with membership provider would mean that `FindUserByEmail` would fail with a `MySqlException` because it was trying to add a second parameter with the same name as the first. (Bug #33347)
- Using compression in the MySQL connection with MySQL Connector/Net would be slower than using native (uncompressed) communication. (Bug #27865)

D.3.8.5. Changes in MySQL Connector/Net 5.1.4 (20 November 2007)

Bugs Fixed

- Setting the size of a string parameter after the value could cause an exception. (Bug #32094)

- Creation of parameter objects with noninput direction using a constructor would fail. This was cause by some old legacy code preventing their use. (Bug #32093)
- A date string could be returned incorrectly by `MySqlDateTime.ToString()` when the date returned by MySQL was `0000-00-00 00:00:00`. (Bug #32010)
- A syntax error in a set of batch statements could leave the data adapter in a state that appears hung. (Bug #31930)
- Installing over a failed uninstall of a previous version could result in multiple clients being registered in the `machine.config`. This would prevent certain aspects of the MySQL connection within Visual Studio to work properly. (Bug #31731)
- MySQL Connector/Net would incorrectly report success when enlisting in a distributed transaction, although distributed transactions are not supported. (Bug #31703)
- Data cached from the connection string could return invalid information because the internal routines were not using case-sensitive semantics. This lead to updated connection string options not being recognized if they were of a different case than the existing cached values. (Bug #31433)
- Trying to use a connection that was not open could return an ambiguous and misleading error message. (Bug #31262)
- Column name metadata was not using the character set as defined within the connection string being used. (Bug #31185)
- Memory usage could increase and decrease significantly when updating or inserting a large number of rows. (Bug #31090)
- Commands executed from within the state change handeler would fail with a `NULL` exception. (Bug #30964)
- Extracting data through XML functions within a query returns the data as `System.Byte[]`. This was due to MySQL Connector/Net incorrectly identifying `BLOB` fields as binary, rather than text. (Bug #30233)
- When running a stored procedure multiple times on the same connection, the memory usage could increase indefinitely. (Bug #30116)
- Column types with only 1-bit (such as `BOOLEAN` and `TINYINT(1)` were not returned as boolean fields. (Bug #27959)
- When accessing certain statements, the command would timeout before the command completed. Because this cannot always be controlled through the individual command timeout options, a `default command timeout` has been added to the connection string options. (Bug #27958)
- The server error code was not updated in the `Data[]` hash, which prevented `DbProviderFactory` users from accessing the server error code. (Bug #27436)
- The `MySqlDbType.Datetime` has been replaced with `MySqlDbType.DateTime`. The old format has been obsoleted. (Bug #26344)
- Changing the connection string of a connection to one that changes the parameter marker after the connection had been assigned to a command but before the connection is opened could cause parameters to not be found. (Bug #13991)

D.3.8.6. Changes in MySQL Connector/Net 5.1.3 (21 September 2007 beta)

This is a new Beta development release, fixing recently discovered bugs.

Bugs Fixed

- An incorrect `ConstraintException` could be raised on an `INSERT` when adding rows to a table with a multiple-column unique key index. (Bug #30204)
- A `DATE` field would be updated with a date/time value, causing a `MySqlDataAdapter.Update()` exception. (Bug #30077)
- The Saudi Hijri calendar was not supported. (Bug #29931)
- Calling `SHOW CREATE PROCEDURE` for routines with a hyphen in the catalog name produced a syntax error. (Bug #29526)
- Connecting to a MySQL server earlier than version 4.1 would raise a `NullException`. (Bug #29476)
- The availability of a MySQL server would not be reset when using pooled connections (`pooling=true`). This would lead to the server being reported as unavailable, even if the server become available while the application was still running. (Bug #29409)

- A `FormatException` error would be raised if a parameter had not been found, instead of `Resources.ParameterMustBeDefined`. (Bug #29312)
- An exception would be thrown when using the Manage Role functionality within the web administrator to assign a role to a user. (Bug #29236)
- Using the membership/role providers when `validationKey` or `decryptionKey` parameters are set to `AutoGenerate`, an exception would be raised when accessing the corresponding values. (Bug #29235)
- Certain operations would not check the `UsageAdvisor` setting, causing log messages from the Usage Advisor even when it was disabled. (Bug #29124)
- Using the same connection string multiple times would result in `Database=dbname` appearing multiple times in the resulting string. (Bug #29123)
- *Visual Studio Plugin*: Adding a new query based on a stored procedure that uses the `SELECT` statement would terminate the query/TableAdapter wizard. (Bug #29098)
- Using `TransactionScope` would cause an `InvalidOperationException`. (Bug #28709)

D.3.8.7. Changes in MySQL Connector/Net 5.1.2 (18 June 2007)

This is a new Beta development release, fixing recently discovered bugs.

Bugs Fixed

- Log messages would be truncated to 300 bytes. (Bug #28706)
- Creating a user would fail due to the application name being set incorrectly. (Bug #28648)
- *Visual Studio Plugin*: Adding a new query based on a stored procedure that used a `UPDATE`, `INSERT` or `DELETE` statement would terminate the query/TableAdapter wizard. (Bug #28536)
- *Visual Studio Plugin*: Query Builder would fail to show `TINYTEXT` columns, and any columns listed after a `TINYTEXT` column correctly. (Bug #28437)
- Accessing the results from a large query when using data compression in the connection would fail to return all the data. (Bug #28204)
- *Visual Studio Plugin*: Update commands would not be generated correctly when using the TableAdapter wizard. (Bug #26347)

D.3.8.8. Changes in MySQL Connector/Net 5.1.1 (23 May 2007)

Bugs Fixed

- Running the statement `SHOW PROCESSLIST` would return columns as byte arrays instead of native columns. (Bug #28448)
- Installation of the MySQL Connector/Net on Windows would fail if VisualStudio had not already been installed. (Bug #28260)
- MySQL Connector/Net would look for the wrong table when executing `User.IsRole().` (Bug #28251)
- Building a connection string within a tight loop would show slow performance. (Bug #28167)
- The `UNSIGNED` flag for parameters in a stored procedure would be ignored when using `MySqlCommandBuilder` to obtain the parameter information. (Bug #27679)
- Using `MySQLDataAdapter.FillSchema()` on a stored procedure would raise an exception: `Invalid attempt to access a field before calling Read()`. (Bug #27668)
- `DATETIME` fields from versions of MySQL bgefore 4.1 would be incorrectly parsed, resulting in a exception. (Bug #23342)
- Fixed password property on `MySqlConnectionStringBuilder` to use `PasswordPropertyText` attribute. This causes dots to show instead of actual password text.

D.3.8.9. Changes in MySQL Connector/Net 5.1.0 (01 May 2007)

Functionality Added or Changed

- Now compiles for .NET CF 2.0.
- Rewrote stored procedure parsing code using a new SQL tokenizer. Really nasty procedures including nested comments are now supported.
- GetSchema will now report objects relative to the currently selected database. What this means is that passing in null as a database restriction will report objects on the currently selected database only.
- Added Membership and Role provider contributed by Sean Wright (thanks!).

D.3.9. Changes in MySQL Connector/Net Version 5.0.x

D.3.9.1. Changes in MySQL Connector/Net 5.0.10 (Not released)

Bugs Fixed

- If, when using the `MySqlTransaction` transaction object, an exception was thrown, the transaction object was not disposed of and the transaction was not rolled back. (Bug #39817)
- Executing a command that resulted in a fatal exception did not close the connection. (Bug #37991)
- When a prepared insert query is run that contains an `UNSIGNED TINYINT` in the parameter list, the complete query and data that should be inserted is corrupted and no error is thrown. (Bug #37968)
- In a .NET application MySQL Connector/Net modifies the connection string so that it contains several occurrences of the same option with different values. This is illustrated by the example that follows.

  The original connection string:

  ```
    host=localhost;database=test;uid=*****;pwd=*****;
  connect timeout=25; auto enlist=false;pooling=false;
  ```

  The connection string after closing `MySqlDataReader`:

  ```
    host=localhost;database=test;uid=*****;pwd=*****;
    connect timeout=25;auto enlist=false;pooling=false;
    Allow User Variables=True;Allow User Variables=False;
  Allow User Variables=True;Allow User Variables=False;
  ```

  (Bug #37955)
- When creating a connection pool, specifying an invalid IP address will cause the entire application to crash, instead of providing an exception. (Bug #36432)
- `GetSchema` did not work correctly when querying for a collection, if using a non-English locale. (Bug #35459)
- When reading back a stored double or single value using the .NET provider, the value had less precision than the one stored. (Bug #33322)

D.3.9.2. Changes in MySQL Connector/Net 5.0.9 (Not released)

Bugs Fixed

- The `DbCommandBuilder.QuoteIdentifer` method was not implemented. (Bug #35492)
- Setting the size of a string parameter after the value could cause an exception. (Bug #32094)
- Creation of parameter objects with noninput direction using a constructor would fail. This was cause by some old legacy code preventing their use. (Bug #32093)
- A date string could be returned incorrectly by `MySqlDateTime.ToString()` when the date returned by MySQL was `0000-00-00 00:00:00`. (Bug #32010)
- A syntax error in a set of batch statements could leave the data adapter in a state that appears hung. (Bug #31930)

- Installing over a failed uninstall of a previous version could result in multiple clients being registered in the `machine.config`. This would prevent certain aspects of the MySQL connection within Visual Studio to work properly. (Bug #31731)
- Data cached from the connection string could return invalid information because the internal routines were not using case-sensitive semantics. This lead to updated connection string options not being recognized if they were of a different case than the existing cached values. (Bug #31433)
- Column name metadata was not using the character set as defined within the connection string being used. (Bug #31185)
- Memory usage could increase and decrease significantly when updating or inserting a large number of rows. (Bug #31090)
- Commands executed from within the state change handeler would fail with a `NULL` exception. (Bug #30964)
- When running a stored procedure multiple times on the same connection, the memory usage could increase indefinitely. (Bug #30116)
- The server error code was not updated in the `Data[]` hash, which prevented `DbProviderFactory` users from accessing the server error code. (Bug #27436)
- Changing the connection string of a connection to one that changes the parameter marker after the connection had been assigned to a command but before the connection is opened could cause parameters to not be found. (Bug #13991)

D.3.9.3. Changes in MySQL Connector/Net 5.0.8 (21 August 2007)

> **Note**
>
> This version introduces a new installer technology.

Bugs Fixed

- Extracting data through XML functions within a query returns the data as `System.Byte[]`. This was due to MySQL Connector/Net incorrectly identifying `BLOB` fields as binary, rather than text. (Bug #30233)
- An incorrect `ConstraintException` could be raised on an `INSERT` when adding rows to a table with a multiple-column unique key index. (Bug #30204)
- A `DATE` field would be updated with a date/time value, causing a `MySqlDataAdapter.Update()` exception. (Bug #30077)
- Fixed bug where MySQL Connector/Net was hand building some date time patterns rather than using the patterns provided under CultureInfo. This caused problems with some calendars that do not support the same ranges as Gregorian.. (Bug #29931)
- Calling `SHOW CREATE PROCEDURE` for routines with a hyphen in the catalog name produced a syntax error. (Bug #29526)
- The availability of a MySQL server would not be reset when using pooled connections (`pooling=true`). This would lead to the server being reported as unavailable, even if the server become available while the application was still running. (Bug #29409)
- A `FormatException` error would be raised if a parameter had not been found, instead of `Resources.ParameterMustBeDefined`. (Bug #29312)
- Certain operations would not check the `UsageAdvisor` setting, causing log messages from the Usage Advisor even when it was disabled. (Bug #29124)
- Using the same connection string multiple times would result in `Database=`*`dbname`* appearing multiple times in the resulting string. (Bug #29123)
- Log messages would be truncated to 300 bytes. (Bug #28706)
- Accessing the results from a large query when using data compression in the connection will fail to return all the data. (Bug #28204)
- Fixed problem where `MySqlConnection.BeginTransaction` checked the drivers status var before checking if the connection was open. The result was that the driver could report an invalid condition on a previously opened connection.
- Fixed problem where we were not closing prepared statement handles when commands are disposed. This could lead to using up all prepared statement handles on the server.

- Fixed the database schema collection so that it works on servers that are not properly respecting the `lower_case_table_names` setting.
- Fixed problem where any attempt to not read all the records returned from a select where each row of the select is greater than 1024 bytes would hang the driver.
- Fixed problem where a command timing out just after it actually finished would cause an exception to be thrown on the command timeout thread which would then be seen as an unhandled exception.
- Fixed some serious issues with command timeout and cancel that could present as exceptions about thread ownership. The issue was that not all queries cancel the same. Some produce resultsets while others don't. ExecuteReader had to be changed to check for this.

D.3.9.4. Changes in MySQL Connector/Net 5.0.7 (18 May 2007)

Bugs Fixed

- Running the statement `SHOW PROCESSLIST` would return columns as byte arrays instead of native columns. (Bug #28448)
- Building a connection string within a tight loop would show slow performance. (Bug #28167)
- Using logging (with the `logging=true` parameter to the connection string) would not generate a log file. (Bug #27765)
- The `UNSIGNED` flag for parameters in a stored procedure would be ignored when using `MySqlCommandBuilder` to obtain the parameter information. (Bug #27679)
- Using `MySQLDataAdapter.FillSchema()` on a stored procedure would raise an exception: `Invalid attempt to access a field before calling Read()`. (Bug #27668)
- If you close an open connection with an active transaction, the transaction is not automatically rolled back. (Bug #27289)
- When cloning an open `MySqlClient.MySqlConnection` with the `Persist Security Info=False` option set, the cloned connection is not usable because the security information has not been cloned. (Bug #27269)
- Enlisting a null transaction would affect the current connection object, such that further enlistment operations to the transaction are not possible. (Bug #26754)
- Attempting to change the `Connection Protocol` property within a `PropertyGrid` control would raise an exception. (Bug #26472)
- The `characterset` property would not be identified during a connection (also affected Visual Studion Plugin). (Bug #26147, Bug #27240)
- The `CreateFormat` column of the `DataTypes` collection did not contain a format specification for creating a new column type. (Bug #25947)
- `DATETIME` fields from versions of MySQL bgefore 4.1 would be incorrectly parsed, resulting in a exception. (Bug #23342)

D.3.9.5. Changes in MySQL Connector/Net 5.0.6 (22 March 2007)

Bugs Fixed

- Publisher listed in "Add/Remove Programs" is not consistent with other MySQL products. (Bug #27253)
- `DESCRIBE ....` SQL statement returns byte arrays rather than data on MySQL versions older than 4.1.15. (Bug #27221)
- `cmd.Parameters.RemoveAt("Id")` will cause an error if the last item is requested. (Bug #27187)
- `MySqlParameterCollection` and parameters added with `Insert` method can not be retrieved later using `ParameterName`. (Bug #27135)
- Exception thrown when using large values in `UInt64` parameters. (Bug #27093)
- MySQL Visual Studio Plugin 1.1.2 does not work with MySQL Connector/Net 5.0.5. (Bug #26960)

D.3.9.6. Changes in MySQL Connector/Net 5.0.5 (07 March 2007)

Functionality Added or Changed

- Reverted behavior that required parameter names to start with the parameter marker. We apologize for this back and forth but we mistakenly changed the behavior to not match what `SqlClient` supports. We now support using either syntax for adding parameters however we also respond exactly like `SqlClient` in that if you ask for the index of a parameter using a syntax different from when you added the parameter, the result will be -1.
- Assembly now properly appears in the Visual Studio 2005 Add/Remove Reference dialog.
- Fixed problem that prevented use of `SchemaOnly` or `SingleRow` command behaviors with stored procedures or prepared statements.
- Added `MySqlParameterCollection.AddWithValue` and marked the `Add(name, value)` method as obsolete.
- Return parameters created with DeriveParameters now have the name `RETURN_VALUE`.
- Fixed problem with parameter name hashing where the hashes were not getting updated when parameters were removed from the collection.
- Fixed problem with calling stored functions when a return parameter was not given.
- Added `Use Procedure Bodies` connection string option to enable calling procedures without using procedure metadata.

Bugs Fixed

- `MySqlConnection.GetSchema` fails with `NullReferenceException` for Foreign Keys. (Bug #26660)
- MySQL Connector/Net would fail to install under Windows Vista. (Bug #26430)
- Opening a connection would be slow due to host name lookup. (Bug #26152)
- Incorrect values/formats would be applied when the `OldSyntax` connection string option was used. (Bug #25950)
- Registry would be incorrectly populated with installation locations. (Bug #25928)
- Times with negative values would be returned incorrectly. (Bug #25912)
- Returned data types of a `DataTypes` collection do not contain the right correct CLR data type. (Bug #25907)
- `GetSchema` and `DataTypes` would throw an exception due to an incorrect table name. (Bug #25906)
- `MySqlConnection` throws an exception when connecting to MySQL v4.1.7. (Bug #25726)
- `SELECT` did not work correctly when using a `WHERE` clause containing a UTF-8 string. (Bug #25651)
- When closing and then re-opening a connection to a database, the character set specification is lost. (Bug #25614)
- Filling a table schema through a stored procedure triggers a runtime error. (Bug #25609)
- `BINARY` and `VARBINARY` columns would be returned as a string, not binary, data type. (Bug #25605)
- A critical `ConnectionPool` error would result in repeated `System.NullReferenceException`. (Bug #25603)
- The `UpdateRowSource.FirstReturnedRecord` method does not work. (Bug #25569)
- When connecting to a MySQL Server earlier than version 4.1, the connection would hang when reading data. (Bug #25458)
- Using `ExecuteScalar()` with more than one query, where one query fails, will hang the connection. (Bug #25443)
- When a `MySqlConversionException` is raised on a remote object, the client application would receive a `SerializationException` instead. (Bug #24957)
- When connecting to a server, the return code from the connection could be zero, even though the host name was incorrect. (Bug #24802)
- High CPU utilization would be experienced when there is no idle connection waiting when using pooled connections through `MySqlPool.GetConnection`. (Bug #24373)
- MySQL Connector/Net would not compile properly when used with Mono 1.2. (Bug #24263)

- Applications would crash when calling with `CommandType` set to `StoredProcedure`.

D.3.9.7. Changes in MySQL Connector/Net 5.0.4 (Not released)

This is a new Beta development release, fixing recently discovered bugs.

This section has no changelog entries.

D.3.9.8. Changes in MySQL Connector/Net 5.0.3 (05 January 2007)

Functionality Added or Changed

- Usage Advisor has been implemented. The Usage Advisor checks your queries and will report if you are using the connection inefficiently.
- PerfMon hooks have been added to monitor the stored procedure cache hits and misses.
- The `MySqlCommand` object now supports asynchronous query methods. This is implemented useg the `BeginExecuteNonQuery` and `EndExecuteNonQuery` methods.
- Metadata from storaed procedures and stored function execution are cached.
- The `CommandBuilder.DeriveParameters` function has been updated to the procedure cache.
- The `ViewColumns` `GetSchema` collection has been updated.
- Improved speed and performance by re-architecting certain sections of the code.
- Support for the embedded server and client library have been removed from this release. Support will be added back to a later release.
- The ShapZipLib library has been replaced with the deflate support provided within .NET 2.0.
- SSL support has been updated.

Bugs Fixed

- Additional text added to error message (Bug #25178)
- An exception would be raised, or the process would hang, if `SELECT` privileges on a database were not granted and a stored procedure was used. (Bug #25033)
- When adding parameter objects to a command object, if the parameter direction is set to `ReturnValue` before the parameter is added to the command object then when the command is executed it throws an error. (Bug #25013)
- Using `Driver.IsTooOld()` would return the wrong value. (Bug #24661)
- When using a `DbNull.Value` as the value for a parameter value, and then later setting a specific value type, the command would fail with an exception because the wrong type was implied from the `DbNull.Value`. (Bug #24565)
- Stored procedure executions are not thread safe. (Bug #23905)
- Deleting a connection to a disconnected server when using the Visual Studio Plugin would cause an assertion failure. (Bug #23687)
- Nested transactions (which are unsupported)do not raise an error or warning. (Bug #22400)

D.3.9.9. Changes in MySQL Connector/Net 5.0.2 (06 November 2006)

Functionality Added or Changed

- An `Ignore Prepare` option has been added to the connection string options. If enabled, prepared statements will be disabled application-wide. The default for this option is true.
- Implemented a stored procedure cache. By default, the connector caches the metadata for the last 25 procedures that are seen.

You can change the numbver of procedures that are cacheds by using the `procedure cache` connection string.

- **Important change:** Due to a number of issues with the use of server-side prepared statements, MySQL Connector/Net 5.0.2 has disabled their use by default. The disabling of server-side prepared statements does not affect the operation of the connector in any way.

  To enable server-side prepared statements you must add the following configuration property to your connector string properties:

  ```
  ignore prepare=false
  ```

  The default value of this property is true.

Bugs Fixed

- One system where IPv6 was enabled, MySQL Connector/Net would incorrectly resolve host names. (Bug #23758)
- Column names with accented characters were not parsed properly causing malformed column names in result sets. (Bug #23657)
- An exception would be thrown when calling `GetSchemaTable` and `fields` was null. (Bug #23538)
- A `System.FormatException` exception would be raised when invoking a stored procedure with an `ENUM` input parameter. (Bug #23268)
- During installation, an antivirus error message would be raised (indicating a malicious script problem). (Bug #23245)
- Creating a connection through the Server Explorer when using the Visual Studio Plugin would fail. The installer for the Visual Studio Plugin has been updated to ensure that MySQL Connector/Net 5.0.2 must be installed. (Bug #23071)
- Using Windows Vista (RC2) as a nonprivileged user would raise a `Registry key 'Global' access denied`. (Bug #22882)
- Within Mono, using the `PreparedStatement` interface could result in an error due to a `BitArray` copying error. (Bug #18186)
- MySQL Connector/Net did not work as a data source for the `SqlDataSource` object used by ASP.NET 2.0. (Bug #16126)

D.3.9.10. Changes in MySQL Connector/Net 5.0.1 (01 October 2006)

Bugs Fixed

- MySQL Connector/Net on a Turkish operating system, may fail to execute certain SQL statements correctly. (Bug #22452)
- Starting a transaction on a connection created by `MySql.Data.MySqlClient.MySqlClientFactory`, using `BeginTransaction` without specifying an isolation level, causes the SQL statement to fail with a syntax error. (Bug #22042)
- The `MySqlexception` class is now derived from the `DbException` class. (Bug #21874)
- The `#` would not be accepted within column/table names, even though it was valid. (Bug #21521)
- You can now install the MySQL Connector/Net MSI package from the command line using the `/passive`, `/quiet`, `/q` options. (Bug #19994)
- Submitting an empty string to a command object through `prepare` raises an `System.IndexOutOfRangeException`, rather than a MySQL Connector/Net exception. (Bug #18391)
- Incorrect field/data lengths could be returned for `VARCHAR` UTF8 columns. (Bug #14592)
- Using `ExecuteScalar` with a datetime field, where the value of the field is "0000-00-00 00:00:00", a `MySqlConversionException` exception would be raised. (Bug #11991)
- An `MySql.Data.Types.MySqlConversionException` would be raised when trying to update a row that contained a date field, where the date field contained a zero value (0000-00-00 00:00:00). (Bug #9619)
- Executing multiple queries as part of a transaction returns `There is already an openDataReader associated with this Connection which must be closed first`. (Bug #7248)

D.3.9.11. Changes in MySQL Connector/Net 5.0.0 (08 August 2006)

Functionality Added or Changed

- Replaced use of ICSharpCode with .NET 2.0 internal deflate support.
- Refactored test suite to test all protocols in a single pass.
- Added usage advisor warnings for requesting column values by the wrong type.
- Reimplemented PacketReader/PacketWriter support into `MySqlStream` class.
- Reworked connection string classes to be simpler and faster.
- Added procedure metadata caching.
- Added internal implemention of SHA1 so we don't have to distribute the OpenNetCF on mobile devices.
- Implemented `MySqlClientFactory` class.
- Added perfmon hooks for stored procedure cache hits and misses.
- Implemented classes and interfaces for ADO.Net 2.0 support.
- Added Async query methods.
- Implemented Usage Advisor.
- Completely refactored how column values are handled to avoid boxing in some cases.
- Implemented `MySqlConnectionBuilder` class.

Bugs Fixed

- CommandText: Question mark in comment line is being parsed as a parameter. (Bug #6214)

D.3.10. Changes in MySQL Connector/Net Version 1.0.x

D.3.10.1. Changes in MySQL Connector/Net 1.0.11 (Not released)

Bugs Fixed

- Attempting to utilize MySQL Connector .Net version 1.0.10 throws a fatal exception under Mono when pooling is enabled. (Bug #33682)
- Setting the size of a string parameter after the value could cause an exception. (Bug #32094)
- Creation of parameter objects with noninput direction using a constructor would fail. This was cause by some old legacy code preventing their use. (Bug #32093)
- Memory usage could increase and decrease significantly when updating or inserting a large number of rows. (Bug #31090)
- Commands executed from within the state change handeler would fail with a `NULL` exception. (Bug #30964)
- Extracting data through XML functions within a query returns the data as `System.Byte[]`. This was due to MySQL Connector/Net incorrectly identifying `BLOB` fields as binary, rather than text. (Bug #30233)
- Using compression in the MySQL connection with MySQL Connector/Net would be slower than using native (uncompressed) communication. (Bug #27865)
- Changing the connection string of a connection to one that changes the parameter marker after the connection had been assigned to a command but before the connection is opened could cause parameters to not be found. (Bug #13991)

D.3.10.2. Changes in MySQL Connector/Net 1.0.10 (24 August 2007)

Bugs Fixed

- An incorrect `ConstraintException` could be raised on an `INSERT` when adding rows to a table with a multiple-column unique key index. (Bug #30204)
- The availability of a MySQL server would not be reset when using pooled connections (`pooling=true`). This would lead to the server being reported as unavailable, even if the server become available while the application was still running. (Bug #29409)
- Publisher listed in "Add/Remove Programs" is not consistent with other MySQL products. (Bug #27253)
- `MySqlParameterCollection` and parameters added with `Insert` method can not be retrieved later using `ParameterName`. (Bug #27135)
- `BINARY` and `VARBINARY` columns would be returned as a string, not binary, data type. (Bug #25605)
- A critical `ConnectionPool` error would result in repeated `System.NullReferenceException`. (Bug #25603)
- When a `MySqlConversionException` is raised on a remote object, the client application would receive a `SerializationException` instead. (Bug #24957)
- High CPU utilization would be experienced when there is no idle connection waiting when using pooled connections through `MySqlPool.GetConnection`. (Bug #24373)

D.3.10.3. Changes in MySQL Connector/Net 1.0.9 (02 February 2007)

Functionality Added or Changed

- The ICSharpCode ZipLib is no longer used by the Connector, and is no longer distributed with it.
- **Important change:** Binaries for .NET 1.0 are no longer supplied with this release. If you need support for .NET 1.0, you must build from source.
- Improved `CommandBuilder.DeriveParameters` to first try and use the procedure cache before querying for the stored procedure metadata. Return parameters created with `DeriveParameters` now have the name `RETURN_VALUE`.
- An `Ignore Prepare` option has been added to the connection string options. If enabled, prepared statements will be disabled application-wide. The default for this option is true.
- Implemented a stored procedure cache. By default, the connector caches the metadata for the last 25 procedures that are seen. You can change the numbver of procedures that are cacheds by using the `procedure cache` connection string.
- **Important change:** Due to a number of issues with the use of server-side prepared statements, MySQL Connector/Net 5.0.2 has disabled their use by default. The disabling of server-side prepared statements does not affect the operation of the connector in any way.

  To enable server-side prepared statements you must add the following configuration property to your connector string properties:

  ```
  ignore prepare=false
  ```

  The default value of this property is true.

Bugs Fixed

- Times with negative values would be returned incorrectly. (Bug #25912)
- `MySqlConnection` throws a `NullReferenceException` and `ArgumentNullException` when connecting to MySQL v4.1.7. (Bug #25726)
- `SELECT` did not work correctly when using a `WHERE` clause containing a UTF-8 string. (Bug #25651)
- When closing and then re-opening a connection to a database, the character set specification is lost. (Bug #25614)
- Trying to fill a table schema through a stored procedure triggers a runtime error. (Bug #25609)

- Using `ExecuteScalar()` with more than one query, where one query fails, will hang the connection. (Bug #25443)
- Additional text added to error message. (Bug #25178)
- When adding parameter objects to a command object, if the parameter direction is set to `ReturnValue` before the parameter is added to the command object then when the command is executed it throws an error. (Bug #25013)
- When connecting to a server, the return code from the connection could be zero, even though the host name was incorrect. (Bug #24802)
- Using `Driver.IsTooOld()` would return the wrong value. (Bug #24661)
- When using a `DbNull.Value` as the value for a parameter value, and then later setting a specific value type, the command would fail with an exception because the wrong type was implied from the `DbNull.Value`. (Bug #24565)
- Stored procedure executions are not thread safe. (Bug #23905)
- The `CommandBuilder` would mistakenly add insert parameters for a table column with auto incrementation enabled. (Bug #23862)
- One system where IPv6 was enabled, MySQL Connector/Net would incorrectly resolve host names. (Bug #23758)
- An `System.OverflowException` would be raised when accessing a varchar field over 255 bytes. (Bug #23749)
- Nested transactions do not raise an error or warning. (Bug #22400)
- Within Mono, using the `PreparedStatement` interface could result in an error due to a `BitArray` copying error. (Bug #18186)

D.3.10.4. Changes in MySQL Connector/Net 1.0.8 (20 October 2006)

Functionality Added or Changed

- Stored procedures are now cached.
- The method for retrieving stored procedure metadata has been changed so that users without `SELECT` privileges on the `mysql.proc` table can use a stored procedure.

Bugs Fixed

- MySQL Connector/Net on a Turkish operating system, may fail to execute certain SQL statements correctly. (Bug #22452)
- The `#` would not be accepted within column/table names, even though it was valid. (Bug #21521)
- Calling `Close` on a connection after calling a stored procedure would trigger a `NullReferenceException`. (Bug #20581)
- You can now install the MySQL Connector/Net MSI package from the command line using the `/passive`, `/quiet`, `/q` options. (Bug #19994)
- The DiscoverParameters function would fail when a stored procedure used a `NUMERIC` parameter type. (Bug #19515)
- When running a query that included a date comparison, a DateReader error would be raised. (Bug #19481)
- `IDataRecord.GetString` would raise `NullPointerException` for null values in returned rows. Method now throws `SqlNullValueException`. (Bug #19294)
- Parameter substitution in queries where the order of parameters and table fields did not match would substitute incorrect values. (Bug #19261)
- Submitting an empty string to a command object through `prepare` raises an `System.IndexOutOfRangeException`, rather than a MySQL Connector/Net exception. (Bug #18391)
- An exception would be raised when using an output parameter to a `System.String` value. (Bug #17814)
- CHAR type added to MySqlDbType. (Bug #17749)
- A `SELECT` query on a table with a date with a value of `'0000-00-00'` would hang the application. (Bug #17736)

- The CommandBuilder ignored Unsigned flag at Parameter creation. (Bug #17375)
- When working with multiple threads, character set initialization would generate errors. (Bug #17106)
- When using an unsigned 64-bit integer in a stored procedure, the unsigned bit would be lost stored. (Bug #16934)
- `DataReader` would show the value of the previous row (or last row with nonnull data) if the current row contained a `datetime` field with a null value. (Bug #16884)
- Unsigned data types were not properly supported. (Bug #16788)
- The connection string parser did not permit single or double quotation marks in the password. (Bug #16659)
- The `MySqlDateTime` class did not contain constructors. (Bug #15112)
- Called `MySqlCommandBuilder.DeriveParameters` for a stored procedure that has no paramers would cause an application crash. (Bug #15077)
- Incorrect field/data lengths could be returned for `VARCHAR` UTF8 columns. (Bug #14592)
- Using `ExecuteScalar` with a datetime field, where the value of the field is "0000-00-00 00:00:00", a `MySqlConversionException` exception would be raised. (Bug #11991)
- An `MySql.Data.Types.MySqlConversionException` would be raised when trying to update a row that contained a date field, where the date field contained a zero value (0000-00-00 00:00:00). (Bug #9619)
- When using `MySqlDataAdapter`, connections to a MySQL server may remain open and active, even though the use of the connection has been completed and the data received. (Bug #8131)
- Executing multiple queries as part of a transaction returns `There is already an openDataReader associated with this Connection which must be closed first`. (Bug #7248)

D.3.10.5. Changes in MySQL Connector/Net 1.0.7 (21 November 2005)

Bugs Fixed

- Unsigned `tinyint` (NET byte) would lead to and incorrectly determined parameter type from the parameter value. (Bug #18570)
- A `#42000Query was empty` exception occurred when executing a query built with `MySqlCommandBuilder`, if the query string ended with a semicolon. (Bug #14631)
- The parameter collection object's `Add()` method added parameters to the list without first checking to see whether they already existed. Now it updates the value of the existing parameter object if it exists. (Bug #13927)
- Added support for the `cp932` character set. (Bug #13806)
- Calling a stored procedure where a parameter contained special characters (such as `'@'`) would produce an exception. Note that `ANSI_QUOTES` had to be enabled to make this possible. (Bug #13753)
- The `Ping()` method did not update the `State` property of the `Connection` object. (Bug #13658)
- Implemented the `MySqlCommandBuilder.DeriveParameters` method that is used to discover the parameters for a stored procedure. (Bug #13632)
- A statement that contained multiple references to the same parameter could not be prepared. (Bug #13541)

D.3.10.6. Changes in MySQL Connector/Net 1.0.6 (03 October 2005)

Bugs Fixed

- MySQL Connector/Net 1.0.5 could not connect on Mono. (Bug #13345)
- Serializing a parameter failed if the first value passed in was `NULL`. (Bug #13276)
- Field names that contained the following characters caused errors: `()%<>/` (Bug #13036)

- The `nant` build sequence had problems. (Bug #12978)
- The MySQL Connector/Net 1.0.5 installer would not install alongside MySQL Connector/Net 1.0.4. (Bug #12835)

D.3.10.7. Changes in MySQL Connector/Net 1.0.5 (29 August 2005)

Bugs Fixed

- MySQL Connector/Net could not connect to MySQL 4.1.14. (Bug #12771)
- With multiple hosts in the connection string, MySQL Connector/Net would not connect to the last host in the list. (Bug #12628)
- The `ConnectionString` property could not be set when a `MySqlConnection` object was added with the designer. (Bug #12551, Bug #8724)
- The `cp1250` character set was not supported. (Bug #11621)
- A call to a stored procedure caused an exception if the stored procedure had no parameters. (Bug #11542)
- Certain malformed queries would trigger a `Connection must be valid and open` error message. (Bug #11490)
- Trying to use a stored procedure when `Connection.Database` was not populated generated an exception. (Bug #11450)
- MySQL Connector/Net interpreted the new decimal data type as a byte array. (Bug #11294)
- Added support to call a stored function from MySQL Connector/Net. (Bug #10644)
- Connection could fail when .NET thread pool had no available worker threads. (Bug #10637)
- Calling `MySqlConnection.clone` when a connection string had not yet been set on the original connection would generate an error. (Bug #10281)
- Decimal parameters caused syntax errors. (Bug #10152, Bug #11550, Bug #10486)
- Parameters were not recognized when they were separated by linefeeds. (Bug #9722)
- The `MySqlCommandBuilder` class could not handle queries that referenced tables in a database other than the default database. (Bug #8382)
- Trying to read a `TIMESTAMP` column generated an exception. (Bug #7951)
- MySQL Connector/Net could not work properly with certain regional settings. (WL#8228)

D.3.10.8. Changes in MySQL Connector/Net 1.0.4 (20 January 2005)

Bugs Fixed

- `MySqlReader.GetInt32` throws exception if column is unsigned. (Bug #7755)
- Quote character \222 not quoted in `EscapeString`. (Bug #7724)
- GetBytes is working no more. (Bug #7704)
- `MySqlDataReader.GetString(index)` returns non-Null value when field is `Null`. (Bug #7612)
- Clone method bug in `MySqlCommand`. (Bug #7478)
- Problem with Multiple resultsets. (Bug #7436)
- `MySqlAdapter.Fill` method throws error message `Non-negative number required`. (Bug #7345)
- `MySqlCommand.Connection` returns an IDbConnection. (Bug #7258)
- Calling prepare causing exception. (Bug #7243)
- Fixed problem with shared memory connections.
- Added or filled out several more topics in the API reference documentation.

- Fixed another small problem with prepared statements.
- Fixed problem that causes named pipes to not work with some blob functionality.

D.3.10.9. Changes in MySQL Connector/Net 1.0.3 (12 October 2004 gamma)

Bugs Fixed

- Invalid query string when using inout parameters (Bug #7133)
- Inserting `DateTime` causes `System.InvalidCastException` to be thrown. (Bug #7132)
- `MySqlDateTime` in Datatables sorting by Text, not Date. (Bug #7032)
- Exception stack trace lost when re-throwing exceptions. (Bug #6983)
- Errors in parsing stored procedure parameters. (Bug #6902)
- InvalidCast when using `DATE_ADD`-function. (Bug #6879)
- Int64 Support in `MySqlCommand` Parameters. (Bug #6863)
- Test suite fails with MySQL 4.0 because of case sensitivity of table names. (Bug #6831)
- `MySqlDataReader.GetChar(int i)` throws `IndexOutOfRange` exception. (Bug #6770)
- Integer "out" parameter from stored procedure returned as string. (Bug #6668)
- An Open Connection has been Closed by the Host System. (Bug #6634)
- Fixed Invalid character set index: 200. (Bug #6547)
- Connections now do not have to give a database on the connection string.
- Installer now includes options to install into GAC and create START MENU items.
- Fixed major problem with detecting null values when using prepared statements.
- Fixed problem where multiple resultsets having different numbers of columns would cause a problem.
- Added `ServerThread` property to `MySqlConnection` to expose server thread id.
- Added Ping method to `MySqlConnection`.
- Changed the name of the test suite to `MySql.Data.Tests.dll`.
- Now `SHOW COLLATION` is used upon connection to retrieve the full list of charset ids.
- Made MySQL the default named pipe name.

D.3.10.10. Changes in MySQL Connector/Net 1.0.2 (15 November 2004 gamma)

Bugs Fixed

- Fixed Objects not being disposed (Bug #6649)
- Fixed Charset-map for UCS-2 (Bug #6541)
- Fixed Zero date "0000-00-00" is returned wrong when filling Dataset (Bug #6429)
- Fixed double type handling in MySqlParameter(string parameterName, object value). (Bug #6428)
- Fixed Installation directory ignored using custom installation (Bug #6329)
- Fixed #HY000 Illegal mix of collations (latin1_swedish_ci,IMPLICIT) and (utf8_general_ (Bug #6322)
- Added the TableEditor CS and VB sample

- Added charset connection string option
- Fixed problem with MySqlBinary where string values could not be used to update extended text columns
- Provider is now using character set specified by server as default
- Updated the installer to include the new samples
- Fixed problem where setting command text leaves the command in a prepared state
- Fixed Long inserts take very long time (Bu #5453)
- Fixed problem where calling stored procedures might cause an "Illegal mix of collations" problem.

D.3.10.11. Changes in MySQL Connector/Net 1.0.1 (27 October 2004 beta)

Bugs Fixed

- Fixed IndexOutOfBounds when reading `BLOB` with `DataReader` with `GetString(index)`. (Bug #6230)
- Fixed GetBoolean returns wrong values (Bug #6227)
- Fixed Method TokenizeSql() uses only a limited set of valid characters for parameters (Bug #6217)
- Fixed NET Connector source missing resx files (Bug #6216)
- Fixed System.OverflowException when using `YEAR` data type. (Bug #6036)
- Fixed MySqlDateTime sets IsZero property on all subseq.records after first zero found (Bug #6006)
- Fixed serializing of floating point parameters (double, numeric, single, decimal) (Bug #5900)
- Fixed missing Reference in DbType setter (Bug #5897)
- Fixed Parsing the ';' char (Bug #5876)
- Fixed DBNull Values causing problems with retrieving/updating queries. (Bug #5798)
- IsNullable error (Bug #5796)
- Fixed problem where MySqlParameterCollection.Add() would throw unclear exception when given a null value (Bug #5621)
- Fixed constructor initialize problems in MySqlCommand() (Bug #5613)
- Possible bug in MySqlParameter(string, object) constructor (Bug #5602)
- Fixed Yet Another "object reference not set to an instance of an object" (Bug #5496)
- Cannot run a stored procedure populating mysqlcommand.parameters (Bug #5474)
- Setting `DbType` threw a `NullReferenceException`. (Bug #5469)
- Calling `GetChars` on a `LONGTEXT` column threw an exception. (Bug #5458)
- `MySqlCommand` saw instances of `"?"` as parameters in string literals. (Bug #5392)
- `DataReader` reported all rows as `NULL` if one row was `NULL`. (Bug #5388)
- Fixed Can't display Chinese correctly (Bug #5288)
- Fixed MySqlDataReader and 'show tables from ...' behavior (Bug #5256)
- Fixed problem in PacketReader where it could try to allocate the wrong buffer size in EnsureCapacity
- Fixed problem where using old syntax while using the interfaces caused problems
- Added test case for resetting the command text on a prepared command
- Fixed problem where connection lifetime on the connect string was not being respected

- Field buffers being reused to decrease memory allocations and increase speed
- Added Aggregate function test (wasn't really a bug)
- Using PacketWriter instead of Packet for writing to streams
- Implemented SequentialAccess
- Fixed problem with ConnectionInternal where a key might be added more than once
- Fixed Russian character support as well
- Fixed problem where connector was not issuing a CMD_QUIT before closing the socket
- Fixed problem where Min Pool Size was not being respected
- Refactored compression code into CompressedStream to clean up NativeDriver
- CP1252 is now used for Latin1 only when the server is 4.1.2 and later
- Virtualized driver subsystem so future releases could easily support client or embedded server support

D.3.10.12. Changes in MySQL Connector/Net 1.0.0 (01 September 2004)

Bugs Fixed

- Thai encoding not correctly supported. (Bug #3889)
- Bumped version number to 1.0.0 for beta 1 release.
- Removed all of the XML comment warnings.
- Added `COPYING.rtf` file for use in installer.
- Updated many of the test cases.
- Fixed problem with using compression.
- Removed some last references to ByteFX.

D.3.11. Changes in MySQL Connector/Net Version 0.9.0 (30 August 2004)

- Added test fixture for prepared statements.
- All type classes now implement a `SerializeBinary` method for sending their data to a `PacketWriter`.
- Added `PacketWriter` class that will enable future low-memory large object handling.
- Fixed many small bugs in running prepared statements and stored procedures.
- Changed command so that an exception will not be thrown in executing a stored procedure with parameters in old syntax mode.
- `SingleRow` behavior now working right even with limit.
- `GetBytes` now only works on binary columns.
- Logger now truncates long SQL commands so blob columns do not blow out our log.
- Host and database now have a default value of "" unless otherwise set.
- Connection Timeout seems to be ignored. (Bug #5214)
- Added test case for bug# 5051: GetSchema not working correctly.
- Fixed problem where `GetSchema` would return false for `IsUnique` when the column is key.
- `MySqlDataReader GetXXX` methods now using the field level `MySqlValue` object and not performing conversions.

- `DataReader` returning `NULL` for time column. (Bug #5097)
- Added test case for `LOAD DATA LOCAL INFILE`.
- Added replacetext custom nant task.
- Added `CommandBuilderTest` fixture.
- Added Last One Wins feature to `CommandBuilder`.
- Fixed persist security info case problem.
- Fixed `GetBool` so that 1, true, "true", and "yes" all count as true.
- Make parameter mark configurable.
- Added the "old syntax" connection string parameter to enable use of @ parameter marker.
- `MySqlCommandBuilder`. (Bug #4658)
- `ByteFX.MySqlClient` caches passwords if `Persist Security Info` is false. (Bug #4864)
- Updated license banner in all source files to include FLOSS exception.
- Added new .Types namespace and implementations for most current MySql types.
- Added `MySqlField41` as a subclass of `MySqlField`.
- Changed many classes to now use the new .Types types.
- Changed type `enum int` to `Int32`, `short` to `Int16`, and `bigint` to `Int64`.
- Added dummy types `UInt16`, `UInt32`, and `UInt64` to allow an unsigned parameter to be made.
- Connections are now reset when they are pulled from the connection pool.
- Refactored auth code in driver so it can be used for both auth and reset.
- Added `UserReset` test in `PoolingTests.cs`.
- Connections are now reset using `COM_CHANGE_USER` when pulled from the pool.
- Implemented `SingleResultSet` behavior.
- Implemented support of unicode.
- Added char set mappings for utf-8 and ucs-2.
- Time fields overflow using bytefx .net mysql driver (Bug #4520)
- Modified time test in data type test fixture to check for time spans where hours > 24.
- Wrong string with backslash escaping in `ByteFx.Data.MySqlClient.MySqlParameter`. (Bug #4505)
- Added code to Parameter test case TestQuoting to test for backslashes.
- `MySqlCommandBuilder` fails with multi-word column names. (Bug #4486)
- Fixed bug in `TokenizeSql` where underscore would terminate character capture in parameter name.
- Added test case for spaces in column names.
- `MySqlDataReader.GetBytes` do not work correctly. (Bug #4324)
- Added `GetBytes()` test case to `DataReader` test fixture.
- Now reading all server variables in `InternalConnection.Configure` into `Hashtable`.
- Now using `string[]` for index map in `CharSetMap`.
- Added CRInSQL test case for carriage returns in SQL.

- Setting maxPacketSize to default value in `Driver.ctor`.
- Setting `MySqlDbType` on a parameter doesn't set generic type. (Bug #4442)
- Removed obsolete data types `Long` and `LongLong`.
- Overflow exception thrown when using "use pipe" on connection string. (Bug #4071)
- Changed "use pipe" keyword to "pipe name" or just "pipe".
- Enable reading multiple resultsets from a single query.
- Added flags attribute to `ServerStatusFlags` enum.
- Changed name of `ServerStatus` enum to `ServerStatusFlags`.
- Inserted data row doesn't update properly.
- Error processing show create table. (Bug #4074)
- Change `Packet.ReadLenInteger` to `ReadPackedLong` and added `packet.ReadPackedInteger` that always reads integers packed with 2,3,4.
- Added `syntax.cs` test fixture to test various SQL syntax bugs.
- Improper handling of time values. Now time value of 00:00:00 is not treated as null. (Bug #4149)
- Moved all test suite files into `TestSuite` folder.
- Fixed bug where null column would move the result packet pointer backward.
- Added new nant build script.
- Clear tablename so it will be regen'ed properly during the next `GenerateSchema`. (Bug #3917)
- `GetValues` was always returning zero and was also always trying to copy all fields rather than respecting the size of the array passed in. (Bug #3915)
- Implemented shared memory access protocol.
- Implemented prepared statements for MySQL 4.1.
- Implemented stored procedures for MySQL 5.0.
- Renamed `MySqlInternalConnection` to `InternalConnection`.
- SQL is now parsed as chars, fixes problems with other languages.
- Added logging and allow batch connection string options.
- `RowUpdating` event not set when setting the `DataAdapter` property. (Bug #3888)
- Fixed bug in char set mapping.
- Implemented 4.1 authentication.
- Improved open/auth code in driver.
- Improved how connection bits are set during connection.
- Database name is now passed to server during initial handshake.
- Changed namespace for client to `MySql.Data.MySqlClient`.
- Changed assembly name of client to `MySql.Data.dll`.
- Changed license text in all source files to GPL.
- Added the `MySqlClient.build` Nant file.
- Removed the mono batch files.

- Moved some of the unused files into notused folder so nant build file can use wildcards.
- Implemented shared memory access.
- Major revamp in code structure.
- Prepared statements now working for MySql 4.1.1 and later.
- Finished implementing auth for 4.0, 4.1.0, and 4.1.1.
- Changed namespace from `MySQL.Data.MySQLClient` back to `MySql.Data.MySqlClient`.
- Fixed bug in `CharSetMapping` where it was trying to use text names as ints.
- Changed namespace to `MySQL.Data.MySQLClient`.
- Integrated auth changes from UC2004.
- Fixed bug where calling any of the GetXXX methods on a datareader before or after reading data would not throw the appropriate exception (thanks Luca Morelli).
- Added `TimeSpan` code in parameter.cs to properly serialize a timespan object to mysql time format (thanks Gianluca Colombo).
- Added `TimeStamp` to parameter serialization code. Prevented `DataAdapter` updates from working right (thanks Michael King).
- Fixed a misspelling in `MySqlHelper.cs` (thanks Patrick Kristiansen).

D.3.12. Changes in MySQL Connector/Net Version 0.76

- Driver now using charset number given in handshake to create encoding.
- Changed command editor to point to `MySqlClient.Design`.
- Fixed bug in `Version.isAtLeast`.
- Changed `DBConnectionString` to support changes done to `MySqlConnectionString`.
- Removed `SqlCommandEditor` and `DataAdapterPreviewDialog`.
- Using new long return values in many places.
- Integrated new `CompressedStream` class.
- Changed `ConnectionString` and added attributes to permit it to be used in `MySqlClient.Design`.
- Changed `packet.cs` to support newer lengths in `ReadLenInteger`.
- Changed other classes to use new properties and fields of `MySqlConnectionString`.
- `ConnectionInternal` is now using PING to see whether the server is available.
- Moved toolbox bitmaps into resource folder.
- Changed `field.cs` to permit values to come directly from row buffer.
- Changed to use the new driver.Send syntax.
- Using a new packet queueing system.
- Started work handling the "broken" compression packet handling.
- Fixed bug in `StreamCreator` where failure to connect to a host would continue to loop infinitely (thanks Kevin Casella).
- Improved connectstring handling.
- Moved designers into Pro product.
- Removed some old commented out code from `command.cs`.

- Fixed a problem with compression.
- Fixed connection object where an exception throw prior to the connection opening would not leave the connection in the connecting state (thanks Chris Cline).
- Added GUID support.
- Fixed sequence out of order bug (thanks Mark Reay).

D.3.13. Changes in MySQL Connector/Net Version 0.75

- Enum values now supported as parameter values (thanks Philipp Sumi).
- Year data type now supported.
- Fixed compression.
- Fixed bug where a parameter with a `TimeSpan` as the value would not serialize properly.
- Fixed bug where default constructor would not set default connection string values.
- Added some XML comments to some members.
- Work to fix/improve compression handling.
- Improved `ConnectionString` handling so that it better matches the standard set by `SqlClient`.
- A `MySqlException` is now thrown if a user name is not included in the connection string.
- Localhost is now used as the default if not specified on the connection string.
- An exception is now thrown if an attempt is made to set the connection string while the connection is open.
- Small changes to `ConnectionString` docs.
- Removed `MultiHostStream` and `MySqlStream`. Replaced it with `Common/StreamCreator`.
- Added support for Use Pipe connection string value.
- Added Platform class for easier access to platform utility functions.
- Fixed small pooling bug where new connection was not getting created after `IsAlive` fails.
- Added `Platform.cs` and `StreamCreator.cs`.
- Fixed `Field.cs` to properly handle 4.1 style timestamps.
- Changed `Common.Version` to `Common.DBVersion` to avoid name conflict.
- Fixed `field.cs` so that text columns return the right field type.
- Added `MySqlError` class to provide some reference for error codes (thanks Geert Veenstra).

D.3.14. Changes in MySQL Connector/Net Version 0.74

- Added Unix socket support (thanks Mohammad DAMT).
- Only calling `Thread.Sleep` when no data is available.
- Improved escaping of quote characters in parameter data.
- Removed misleading comments from `parameter.cs`.
- Fixed pooling bug.
- Fixed `ConnectionString` editor dialog (thanks marco p (pomarc)).

- `UserId` now supported in connection strings (thanks Jeff Neeley).
- Attempting to create a parameter that is not input throws an exception (thanks Ryan Gregg).
- Added much documentation.
- Checked in new `MultiHostStream` capability. Big thanks to Dan Guisinger for this. he originally submitted the code and idea of supporting multiple machines on the connect string.
- Added a lot of documentation.
- Fixed speed issue with 0.73.
- Changed to Thread.Sleep(0) in MySqlDataStream to help optimize the case where it doesn't need to wait (thanks Todd German).
- Prepopulating the idlepools to `MinPoolSize`.
- Fixed `MySqlPool` deadlock condition as well as stupid bug where CreateNewPooledConnection was not ever adding new connections to the pool. Also fixed `MySqlStream.ReadBytes` and `ReadByte` to not use `TicksPerSecond` which does not appear to always be right. (thanks Matthew J. Peddlesden)
- Fix for precision and scale (thanks Matthew J. Peddlesden).
- Added `Thread.Sleep(1)` to stream reading methods to be more cpu friendly (thanks Sean McGinnis).
- Fixed problem where `ExecuteReader` would sometime return null (thanks Lloyd Dupont).
- Fixed major bug with null field handling (thanks Naucki).
- Enclosed queries for `max_allowed_packet` and `characterset` inside try catch (and set defaults).
- Fixed problem where socket was not getting closed properly (thanks Steve!).
- Fixed problem where `ExecuteNonQuery` was not always returning the right value.
- Fixed `InternalConnection` to not use `@@session.max_allowed_packet` but use `@@max_allowed_packet`. (Thanks Miguel)
- Added many new XML doc lines.
- Fixed SQL parsing to not send empty queries (thanks Rory).
- Fixed problem where the reader was not unpeeking the packet on close.
- Fixed problem where user variables were not being handled (thanks Sami Vaaraniemi).
- Fixed loop checking in the MySqlPool (thanks Steve M. Brown)
- Fixed `ParameterCollection.Add` method to match `SqlClient` (thanks Joshua Mouch).
- Fixed `ConnectionString` parsing to handle no and yes for boolean and not lowercase values (thanks Naucki).
- Added `InternalConnection` class, changes to pooling.
- Implemented Persist Security Info.
- Added `security.cs` and `version.cs` to project
- Fixed `DateTime` handling in `Parameter.cs` (thanks Burkhard Perkens-Golomb).
- Fixed parameter serialization where some types would throw a cast exception.
- Fixed `DataReader` to convert all returned values to prevent casting errors (thanks Keith Murray).
- Added code to `Command.ExecuteReader` to return null if the initial SQL statement throws an exception (thanks Burkhard Perkens-Golomb).
- Fixed `ExecuteScalar` bug introduced with restructure.
- Restructure to permit `LOCAL DATA INFILE` and better sequencing of packets.

- Fixed several bugs related to restructure.
- Early work done to support more secure passwords in MySQL 4.1. Old passwords in 4.1 not supported yet.
- Parameters appearing after system parameters are now handled correctly (Adam M. (adammil)).
- Strings can now be assigned directly to blob fields (Adam M.).
- Fixed float parameters (thanks Pent).
- Improved Parameter constructor and `ParameterCollection.Add` methods to better match SqlClient (thanks Joshua Mouch).
- Corrected `Connection.CreateCommand` to return a `MySqlCommand` type.
- Fixed connection string designer dialog box problem (thanks Abraham Guyt).
- Fixed problem with sending commands not always reading the response packet (thanks Joshua Mouch).
- Fixed parameter serialization where some blobs types were not being handled (thanks Sean McGinnis).
- Removed spurious `MessageBox.show` from `DataReader` code (thanks Joshua Mouch).
- Fixed a nasty bug in the split SQL code (thanks everyone!).

D.3.15. Changes in MySQL Connector/Net Version 0.71

- Fixed bug in `MySqlStream` where too much data could attempt to be read (thanks Peter Belbin)
- Implemented `HasRows` (thanks Nash Pherson).
- Fixed bug where tables with more than 252 columns cause an exception (thanks Joshua Kessler).
- Fixed bug where SQL statements ending in ; would cause a problem (thanks Shane Krueger).
- Fixed bug in driver where error messages were getting truncated by 1 character (thanks Shane Krueger).
- Made `MySqlException` serializable (thanks Mathias Hasselmann).

D.3.16. Changes in MySQL Connector/Net Version 0.70

- Updated some of the character code pages to be more accurate.
- Fixed problem where readers could be opened on connections that had readers open.
- Moved test to separate assembly `MySqlClientTests`.
- Fixed stupid problem in driver with sequence out of order (Thanks Peter Belbin).
- Added some pipe tests.
- Increased default max pool size to 50.
- Compiles with Mono 0-24.
- Fixed connection and data reader dispose problems.
- Added `String` data type handling to parameter serialization.
- Fixed sequence problem in driver that occurred after thrown exception (thanks Burkhard Perkens-Golomb).
- Added support for `CommandBehavior.SingleRow` to `DataReader`.
- Fixed command SQL processing so quotation marks are better handled (thanks Theo Spears).
- Fixed parsing of double, single, and decimal values to account for non-English separators. You still have to use the right syntax if you using hard coded SQL, but if you use parameters the code will convert floating point types to use '.' appropriately internal

both into the server and out.

- Added `MySqlStream` class to simplify timeouts and driver coding.
- Fixed `DataReader` so that it is closed properly when the associated connection is closed. [thanks smishra]
- Made client more SqlClient compliant so that DataReaders have to be closed before the connection can be used to run another command.
- Improved `DBNull.Value` handling in the fields.
- Added several unit tests.
- Fixed `MySqlException` base class.
- Improved driver coding
- Fixed bug where NextResult was returning false on the last resultset.
- Added more tests for MySQL.
- Improved casting problems by equating unsigned 32bit values to Int64 and unsigned 16bit values to Int32, and so forth.
- Added new constructor for `MySqlParameter` for (name, type, size, srccol)
- Fixed bug in `MySqlDataReader` where it didn't check for null fieldlist before returning field count.
- Started adding `MySqlClient` unit tests (added `MySqlClient/Tests` folder and some test cases).
- Fixed some things in Connection String handling.
- Moved `INIT_DB` to `MySqlPool`. I may move it again, this is in preparation of the conference.
- Fixed bug inside `CommandBuilder` that prevented inserts from happening properly.
- Reworked some of the internals so that all three execute methods of Command worked properly.
- Fixed many small bugs found during benchmarking.
- The first cut of `CoonectionPooling` is working. "min pool size" and "max pool size" are respected.
- Work to enable multiple resultsets to be returned.
- Character sets are handled much more intelligently now. The driver queries MySQL at startup for the default character set. That character set is then used for conversions if that code page can be loaded. If not, then the default code page for the current OS is used.
- Added code to save the inferred type in the name,value constructor of `Parameter`.
- Also, inferred type if value of null parameter is changed using `Value` property.
- Converted all files to use proper Camel case. MySQL is now MySql in all files. PgSQL is now PgSql.
- Added attribute to PgSql code to prevent designer from trying to show.
- Added `MySQLDbType` property to Parameter object and added proper conversion code to convert from `DbType` to `MySQLDbType`).
- Removed unused `ObjectToString` method from `MySQLParameter.cs`.
- Fixed `Add(..)` method in `ParameterCollection` so that it doesn't use `Add(name, value)` instead.
- Fixed `IndexOf` and `Contains` in `ParameterCollection` to be aware that parameter names are now stored without @.
- Fixed `Command.ConvertSQLToBytes` so it only permits characters that can be in MySQL variable names.
- Fixed `DataReader` and `Field` so that blob fields read their data from `Field.cs` and `GetBytes` works right.
- Added simple query builder editor to `CommandText` property of `MySQLCommand`.
- Fixed `CommandBuilder` and `Parameter` serialization to account for Parameters not storing @ in their names.

- Removed `MySQLFieldType` enum from Field.cs. Now using `MySQLDbType` enum.
- Added `Designer` attribute to several classes to prevent designer view when using VS.Net.
- Fixed Initial catalog typo in `ConnectionString` designer.
- Removed 3 parameter constructor for `MySQLParameter` that conflicted with (name, type, value).
- Changed `MySQLParameter` so `paramName` is now stored without leading @ (this fixed null inserts when using designer).
- Changed `TypeConverter` for `MySQLParameter` to use the constructor with all properties.

D.3.17. Changes in MySQL Connector/Net Version 0.68

- Fixed sequence issue in driver.
- Added `DbParametersEditor` to make parameter editing more like `SqlClient`.
- Fixed `Command` class so that parameters can be edited using the designer
- Update connection string designer to support `Use Compression` flag.
- Fixed string encoding so that European characters will work correctly.
- Creating base classes to aid in building new data providers.
- Added support for UID key in connection string.
- Field, parameter, command now using DBNull.Value instead of null.
- `CommandBuilder` using `DBNull.Value`.
- `CommandBuilder` now builds insert command correctly when an auto_insert field is not present.
- Field now uses typeof keyword to return `System.Types` (performance).

D.3.18. Changes in MySQL Connector/Net Version 0.65

- `MySQLCommandBuilder` now implemented.
- Transaction support now implemented (not all table types support this).
- `GetSchemaTable` fixed to not use xsd (for Mono).
- Driver is now Mono-compatible.
- TIME data type now supported.
- More work to improve Timestamp data type handling.
- Changed signatures of all classes to match corresponding `SqlClient` classes.

D.3.19. Changes in MySQL Connector/Net Version 0.60

- Protocol compression using SharpZipLib (www.icsharpcode.net).
- Named pipes on Windows now working properly.
- Work done to improve `Timestamp` data type handling.
- Implemented `IEnumerable` on `DataReader` so `DataGrid` would work.

D.3.20. Changes in MySQL Connector/Net Version 0.50

- Speed increased dramatically by removing bugging network sync code.
- Driver no longer buffers rows of data (more ADO.Net compliant).
- Conversion bugs related to `TIMESTAMP` and `DATETIME` fields fixed.

D.4. MySQL Visual Studio Plugin Change History

> **Note**
>
> As of Connector/Net 5.1.2 (14 June 2007), the Visual Studion Plugin is part of the main Connector/Net package. For the change history for the Visual Studio Plugin, see Section D.3, “MySQL Connector/Net Change History”.

D.4.1. Changes in MySQL Visual Studio Plugin 1.0.3 (Not yet released)

Bugs Fixed

- Running queries based on a stored procedure would cause the data set designer to terminate. (Bugs #26364)
- DataSet wizard would show all tables instead of only the tables available within the selected database. (Bugs #26348)

D.4.2. Changes in MySQL Visual Studio Plugin 1.0.2 (Not yet released)

Bugs Fixed

- The Add Connection dialog of the Server Explorer would freeze when accessing databases with capitalized characters in their name. (Bug #24875)
- Creating a connection through the Server Explorer when using the Visual Studio Plugin would fail. The installer for the Visual Studio Plugin has been updated to ensure that Connector/Net 5.0.2 must be installed. (Bug #23071)

D.4.3. Changes in MySQL Visual Studio Plugin 1.0.1 (04 October 2006)

This is a bug fix release to resolve an incompatibility issue with Connector/Net 5.0.1.

It is critical that this release only be used with Connector/Net 5.0.1. After installing Connector/Net 5.0.1, you will need to make a small change in your machine.config file. This file should be located at `%win%\Microsoft.Net\Framework\v2.0.50727\CONFIG\machine.config` (`%win%` should be the location of your Windows folder). Near the bottom of the file you will see a line like this:

```
<add name="MySQL Data Provider" invariant="MySql.Data.MySqlClient"
description=".Net Framework Data Provider for MySQL"
type="MySql.Data.MySqlClient.MySqlClientFactory, MySql.Data"/>
```

It needs to be changed to be like this:

```
<add name="MySQL Data Provider" invariant="MySql.Data.MySqlClient"
description=".Net Framework Data Provider for MySQL"
type="MySql.Data.MySqlClient.MySqlClientFactory, MySql.Data,
Version=5.0.1.0, Culture=neutral, PublicKeyToken=c5687fc88969c44d"/>
```

This section has no changelog entries.

D.4.4. Changes in MySQL Visual Studio Plugin 1.0.0 (04 October 2006)

Bugs Fixed

- Ability to work with MySQL objects (tables, views, stored procedures, etc) from within Server Explorer.
- DDEX (Data Designer Extensibility) compatibility.

D.5. MySQL Connector/J Change History

D.5.1. Changes in MySQL Connector/J 5.1.x

D.5.1.1. Changes in MySQL Connector/J 5.1.17 (07 July 2011)

Fixes bugs found since release 5.1.16.

Bugs Fixed

- `LIKE` was not optimized in then server when run against `INFORMATION_SCHEMA` tables and no wildcards were used. Databases/tables with `'_'` or `'%'` in their names (escaped or not) are handled by this code path, although slower, since it is rare to find these characters in table names in SQL. If there is a `'_'` or `'%'` in the string, `LIKE` takes care of that; otherwise, `'='` is now used instead. The only exception is the `information_schema` database, which is handled separately. The patch covers both `getTables()` and `getColumns()`. (Bug #61332)
- The first call to a stored procedure failed with “No Database Selected”. The workaround introduced in `DatabaseMetaData.getCallStmtParameterTypes` to fix the server bug where `SHOW CREATE PROCEDURE` was not respecting lowercase table names was misbehaving when the connection was not attached to a database and on case-insensitive operating systems. (Bug #61150)
- There was a concurrency bottleneck in Java's character set encoding/decoding when converting bytes to/from `String` values.

  > **Important**
  >
  > No longer use `String.getBytes(...)`, or `new String(byte[]...)`. Use the `StringUtils` method instead.

  (Bug #61105)

D.5.1.2. Changes in MySQL Connector/J 5.1.16 (Not released)

Fixes bugs found since release 5.1.15.

Bugs Fixed

- When auto-reconnect was used with `cacheServerConfiguration`, errors could occur when the host changed (in an HA setup, for example). (Bug #12325877)

D.5.1.3. Changes in MySQL Connector/J 5.1.15 (09 February 2011)

Fixes bugs found since release 5.1.14.

Bugs Fixed

- Optional logging class `com.mysql.jdbc.log.Log4JLogger` was not included in the source/binary package for 5.1.14.

  5.1.15 will ship with an SLF4J logger (which can then be plugged into Log4J). Unfortunately, it is not possible to ship a direct Log4J integration because the GPL is not compatible with Log4J's license. (Bug #59511, Bug #11766408)
- The hard-coded list of reserved words in Connector/J was not updated to reflect the list of reserved words in MySQL Server 5.5. (Bug #59224)
- MySqlProcedure accepted null arguments as parameters, however the JDBC meta data did not indicate that. (Bug #38367, Bug #11749186)
- Using Connector/J to connect from a z/OS machine to a MySQL Server failed when the database name to connect to was included in the connection URL. This was because the name was sent in z/OS default platform encoding, but the MySQL Server expected Latin1.

  It should be noted that when connecting from systems that do not use Latin1 as the default platform encoding, the following connection string options can be useful: `passwordCharacterEncoding=ASCII` and `characterEncoding=ASCII`. (Bug #18086, Bug #11745647)

D.5.1.4. Changes in MySQL Connector/J 5.1.14 (6th December 2010)

Fixes bugs found since release 5.1.13.

Functionality Added or Changed

- Connector/J's load-balancing functionality only allowed the following events to trigger failover:

  - Transaction commit/rollback

  - CommunicationExceptions

  - Matches to user-defined Exceptions using the loadBalanceSQLStateFailover, loadBalanceSQLExceptionSubclassFailover or loadBalanceExceptionChecker property.

  This meant that connections where auto-commit was enabled were not balanced, except for Exceptions, and this was problematic in the case of distribution of read-only work across slaves in a replication deployment.

  The ability to load-balance while auto-commit is enabled has now been added to Connector/J. This introduces two new properties:

  1. loadBalanceAutoCommitStatementThreshold - defines the number of matching statements which will trigger the driver to (potentially) swap physical server connections. The default value (0) retains the previously-established behavior that connections with auto-commit enabled are never balanced.

  2. loadBalanceAutoCommitStatementRegex - the regular expression against which statements must match. The default value (blank) matches all statements.

  Load-balancing will be done after the statement is executed, before control is returned to the application. If rebalancing fails, the driver will silently swallow the resulting Exception (as the statement itself completed successfully). (Bug #55723)

Bugs Fixed

- Connection failover left slave/secondary in read-only mode. Failover attempts between two read-write masters did not properly set `this.currentConn.setReadOnly(false)`. (Bug #58706)

- Connector/J mapped both 3-byte and 4-byte UTF8 encodings to the same Java UTF8 encoding.

  To use 3-byte UTF8 with Connector/J set `characterEncoding=utf8` and set `useUnicode=true` in the connection string.

  To use 4-byte UTF8 with Connector/J configure the MySQL server with `character_set_server=utf8mb4`. Connector/J will then use that setting as long as `characterEncoding` has not been set in the connection string. This is equivalent to autodetection of the character set. (Bug #58232)

- The `CallableStatementRegression` test suite failed with a Null Pointer Exception because the `OUT` parameter in the `I__S.PARAMETERS` table had no name, that is `COLUMN_NAME` had the value `NULL`. (Bug #58232)

- `DatabaseMetaData.supportsMultipleResultSets()` was hard-coded to return `false`, even though Connector/J supports multiple result sets. (Bug #57380)

- Using the `useOldUTF8Behavior` parameter failed to set the connection character set to `latin1` as required.

  In versions prior to 5.1.3, the handshake was done using `latin1`, and while there was logic in place to explicitly set the character set after the handshake was complete, this was bypassed when `useOldUTF8Behavior` was true. This was not a problem until 5.1.3, when the handshake was modified to use `utf8`, but the logic continued to allow the character set configured during that handshake process to be retained for later use. As a result, `useOldUTF8Behavior` effectively failed. (Bug #57262)

- Invoking a stored procedure containing output parameters by its full name, where the procedure was located in another database, generated the following exception:

  ```
  Parameter index of 1 is out of range (1, 0)
  ```

  (Bug #57022)

- When a JDBC client disconnected from a remote server using `Connection.close()`, the TCP connection remained in the `TIME_WAIT` state on the server side, rather than on the client side. (Bug #56979)

- Leaving Trust/ClientCertStoreType properties unset caused an exception to be thrown when connecting with `useSSL=true`, as no default was used. (Bug #56955)

- When load-balanced connections swap servers, certain session state was copied from the previously active connection to the newly-selected connection. State synchronized included:

    - Auto-commit state

    - Transaction isolation state

    - Current schema/catalog

    However, the read-only state was not synchronized, which caused problems if a write was attempted on a read-only connection. (Bug #56706)

- When using Connector/J configured for failover (jdbc:mysql://host1,host2,... URLs), the non-primary servers re-balanced when the transactions on the master were committed or rolled-back. (Bug #56429)

- An unhandled Null Pointer Exception (NPE) was generated in `DatabaseMetaData.java` when calling an incorrectly cased function name where no permission to access `mysql.proc` was available.

    In addition to catching potential NPEs, a guard against calling JDBC functions with `db_name.proc_name` notation was also added. (Bug #56305)

- Attempting to use JDBC4 functions on `Connection` objects resulted in errors being generated:

    ```
    Exception in thread "main" java.lang.AbstractMethodError:
    com.mysql.jdbc.LoadBalancedMySQLConnection.createBlob()Ljava/sql/Blob;
       at sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
       at sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:39)
       at
    sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:25)
       at java.lang.reflect.Method.invoke(Method.java:597)
       at
    com.mysql.jdbc.LoadBalancingConnectionProxy.invoke(LoadBalancingConnectionProxy.java:476)
       at $Proxy0.createBlob(Unknown Source)
    ```

    (Bug #56099)

D.5.1.5. Changes in MySQL Connector/J 5.1.13 (24 June 2010)

Fixes bugs found since release 5.1.12.

Functionality Added or Changed

- Connector/J did not support `utf8mb4` for servers 5.5.2 and newer.

    Connector/J now auto-detects servers configured with `character_set_server=utf8mb4` or treats the Java encoding `utf-8` passed using `characterEncoding=...` as `utf8mb4` in the `SET NAMES=` calls it makes when establishing the connection. (Bug #54175)

Bugs Fixed

- The method `unSafeStatementInterceptors()` contained an erroneous line of code, which resulted in the interceptor being called, but the result being thrown away. (Bug #53041)

- There was a performance regression of roughly 25% between r906 and r907, which appeared to be caused by pushing the Proxy down to the I/O layer. (Bug #52534)

- Logic in implementations of `LoadBalancingConnectionProxy` and `LoadBalanceStrategy` behaved differently as to which `SQLException`s trigger failover to a new host. The former looked at the first two characters of the SQLState:

    ```
    if (sqlState.startsWith("08"))
    ...
    ```

    The latter used a different test:

    ```
    if (sqlEx instanceof CommunicationsException
      || "08S01".equals(sqlEx.getSQLState())) {
    ...
    ```

This meant it was possible for a new `Connection` object to throw an `Exception` when the first selected host was unavailable. This happened because `MySqlIO.createNewIO()` could throw an `SQLException` with a `SQLState` of "08001", which did not trigger the "try another host" logic in the `LoadBalanceStrategy` implementations, so an `Exception` was thrown after having only attempted connecting to a single host. (Bug #52231)

- In the file `DatabaseMetadata.java`, the function `private void getCallStmtParameterTypes` failed if the parameter was defined over more than one line by using the '\n' character. (Bug #52167)

- The catalog parameter, `PARAM_CAT`, was not correctly processed when calling for metadata with `getMetaData()` on stored procedures. This was because `PARAM_CAT` was hardcoded in the code to `NULL`. In the case where `nullcatalogmeanscurrent` was `true`, which is its default value, a crash did not occur, but the metadata returned was for the stored procedures from the catalog currently attached to. If, however, `nullcatalogmeanscurrent` was set to `false` then a crash resulted.

  Connector/J has been changed so that when `NULL` is passed as `PARAM_CAT` it will not crash when `nullcatalogmeanscurrent` is `false`, but rather iterate all catalogs in search of stored procedures. This means that `PARAM_CAT` is no longer hardcoded to `NULL` (see Bug #51904). (Bug #51912)

- A load balanced `Connection` object with multiple open underlying physical connections rebalanced on `commit()`, `rollback()`, or on a communication exception, without validating the existing connection. This caused a problem when there was no pinging of the physical connections, using queries starting with "/* ping */", to ensure they remained active. This meant that calls to `Connection.commit()` could throw a `SQLException`. This did not occur when the transaction was actually committed; it occurred when the new connection was chosen and the driver attempted to set the auto-commit or transaction isolation state on the newly chosen physical connection. (Bug #51783)

- The `rollback()` method could fail to rethrow a `SQLException` if the server became unavailable during a rollback. The errant code only rethrew when `ignoreNonTxTables` was true and the exception did not have the error code 1196, `SQLError.ER_WARNING_NOT_COMPLETE_ROLLBACK`. (Bug #51776)

- When the `allowMultiQueries` connection string option was set to `true`, a call to `Statement.executeBatch()` scanned the query for escape codes, even though `setEscapeProcessing(false)` had been called previously. (Bug #51704)

- When a `StatementInterceptor` was used and an alternate `ResultSet` was returned from `preProcess()`, the original statement was still executed. (Bug #51666)

- Objects created by `ConnectionImpl`, such as prepared statements, hold a reference to the `ConnectionImpl` that created them. However, when the load balancer picked a new connection, it did not update the reference contained in, for example, the `PreparedStatement`. This resulted in inserts and updates being directed to invalid connections, while commits were directed to the new connection. This resulted in silent data loss. (Bug #51643)

- `jdbc:mysql:loadbalance://` would connect to the same host, even though `loadBalanceStrategy` was set to a value of `random`, and multiple hosts were specified. (Bug #51266)

- An unexpected exception when trying to register `OUT` parameters in `CallableStatement`.

  Sometimes Connector/J was not able to register `OUT` parameters for `CallableStatements`. (Bug #43576)

D.5.1.6. Changes in MySQL Connector/J 5.1.12 (18 February 2010)

Fixes bugs found since release 5.1.11.

Bugs Fixed

- The catalog parameter was ignored in the `DatabaseMetaData.getProcedure()` method. It returned all procedures in all databases. (Bug #51022)

- A call to `DatabaseMetaData.getDriverVersion()` returned the revision as `mysql-connector-java-5.1.11 ( Revision: ${svn.Revision} )`. The variable `${svn.Revision}` was not replaced by the SVN revision number. (Bug #50288)

D.5.1.7. Changes in MySQL Connector/J 5.1.11 (21 January 2010)

Fixes bugs found since release 5.1.10.

Functionality Added or Changed

- Replication connections, those with URLs that start with jdbc:mysql:replication, now use a jdbc:mysql:loadbalance connection for the slave pool. This means that it is possible to set load balancing properties such as `loadBalanceBlacklistTimeout` and `loadBalanceStrategy` to choose a mechanism for balancing the load, and failover or fault tolerance strategy for the slave pool. (Bug #49537)

Bugs Fixed

- `NullPointerException` sometimes occurred in `invalidateCurrentConnection()` for load-balanced connections. (Bug #50288)
- The `deleteRow` method caused a full table scan, when using an updatable cursor and a multibyte character set. (Bug #49745)
- For pooled connections, Connector/J did not process the session variable `time_zone` when set using the URL, resulting in incorrect timestamp values being stored. (Bug #49700)
- The `ExceptionInterceptor` class did not provide a `Connection` context. (Bug #49607)
- Ping left closed connections in the liveConnections map, causing subsequent Exceptions when that connection was used. (Bug #48605)
- Using `MysqlConnectionPoolDataSource` with a load-balanced URL generated exceptions of type `ClassCastException`:

  ```
  ClassCastException in MysqlConnectionPoolDataSource
  Caused by: java.lang.ClassCastException: $Proxy0
     at
  com.mysql.jdbc.jdbc2.optional.MysqlConnectionPoolDataSource.getPooledConnection(MysqlConne
  ctionPoolDataSource.java:80)
  ```

  ```
  java.lang.ClassCastException: $Proxy2
   at com.mysql.jdbc.jdbc2.optional.StatementWrapper.executeQuery(StatementWrapper.java:744)
  ```

  (Bug #48486)
- The implementation for load-balanced `Connection` used a proxy, which delegated method calls, including `equals()` and `hashCode()`, to underlying `Connection` objects. This meant that successive calls to `hashCode()` on the same object potentially returned different values, if the proxy state had changed such that it was utilizing a different underlying connection. (Bug #48442)
- The batch rewrite functionality attempted to identify the start of the `VALUES` list by looking for “VALUES ” (with trailing space). However, valid MySQL syntax permits `VALUES` to be followed by whitespace or an opening parenthesis:

  ```
  INSERT INTO tbl VALUES
  (1);

  INSERT INTO tbl VALUES(1);
  ```

  Queries written with the above formats did not therefore gain the performance benefits of the batch rewrite. (Bug #48172)
- A PermGen memory leaked was caused by the Connector/J statement cancellation timer (`java.util.Timer`). When the application was unloaded the cancellation timer did not terminate, preventing the ClassLoader from being garbage collected. (Bug #36565)
- With the connection string option `noDatetimeStringSync` set to `true`, and server-side prepared statements enabled, the following exception was generated if an attempt was made to obtain, using `ResultSet.getString()`, a datetime value containing all zero components:

  ```
  java.sql.SQLException: Value '0000-00-00' can not be represented as java.sql.Date
  ```

  (Bug #32525)

D.5.1.8. Changes in MySQL Connector/J 5.1.10 (23 September 2009)

Fixes bugs found since release 5.1.9.

Bugs Fixed

- The `DriverManager.getConnection()` method ignored a non-standard port if it was specified in the JDBC connection string. Connector/J always used the standard port 3306 for connection creation. For example, if the string was `jdbc:mysql://localhost:6777`, Connector/J would attempt to connect to port 3306, rather than 6777. (Bug #47494)

D.5.1.9. Changes in MySQL Connector/J 5.1.9 (21 September 2009)

Bugs Fixed

- In the class `com.mysql.jdbc.jdbc2.optional.SuspendableXAConnection`, which is used when `pinGlobalTxToPhysicalConnection=true`, there is a static map (XIDS_TO_PHYSICAL_CONNECTIONS) that tracks the Xid with the XAConnection, however this map was not populated. The effect was that the `SuspendableXAConnection` was never pinned to the real XA connection. Instead it created new connections on calls to `start`, `end`, `resume`, and `prepare`. (Bug #46925)

- When using the ON DUPLICATE KEY UPDATE functionality together with the rewriteBatchedStatements option set to true, an exception was generated when trying to execute the prepared statement:

  ```
  INSERT INTO config_table (modified,id_) VALUES (?,?) ON DUPLICATE KEY UPDATE modified=?
  ```

  The exception generated was:

  ```
  java.sql.SQLException: Parameter index out of range (3 > number of parameters, which is
  2).
          at com.sag.etl.job.processors.JdbcInsertProcessor.flush(JdbcInsertProcessor.java:135)
  ......
  Caused by: java.sql.SQLException: Parameter index out of range (3 > number of parameters,
  which is 2).
          at com.mysql.jdbc.SQLError.createSQLException(SQLError.java:1055)
          at com.mysql.jdbc.SQLError.createSQLException(SQLError.java:956)
          at com.mysql.jdbc.SQLError.createSQLException(SQLError.java:926)
          at com.mysql.jdbc.PreparedStatement.checkBounds(PreparedStatement.java:3657)
          at com.mysql.jdbc.PreparedStatement.setInternal(PreparedStatement.java:3641)
          at
  com.mysql.jdbc.PreparedStatement.setBytesNoEscapeNoQuotes(PreparedStatement.java:3391)
          at
  com.mysql.jdbc.PreparedStatement.setOneBatchedParameterSet(PreparedStatement.java:4203)
          at com.mysql.jdbc.PreparedStatement.executeBatchedInserts(PreparedStatement.java:1759)
          at com.mysql.jdbc.PreparedStatement.executeBatch(PreparedStatement.java:1441)
          at com.sag.etl.job.processors.JdbcInsertProcessor.flush(JdbcInsertProcessor.java:131)
          ... 16 more
  ```

  (Bug #46788)

- When Connector/J encountered an error condition that caused it to create a `CommunicationsException`, it tried to build a friendly error message that helped diagnose what was wrong. However, if there had been no network packets received from the server, the error message contained the following incorrect text:

  ```
  The last packet successfully received from the server was 1,249,932,468,916 milliseconds
  ago.  The last packet sent successfully to the server was 0 milliseconds ago.
  ```

  (Bug #46637)

- The `getSuperTypes` method returned a result set with incorrect names for the first two columns. The name of the first column in the result set was expected to be `TYPE_CAT` and that of the second column `TYPE_SCHEM`. The method however returned the names as `TABLE_CAT` and `TABLE_SCHEM` for first and second column respectively. (Bug #44508)

- SQLException for data truncation error gave the error code as 0 instead of 1265. (Bug #44324)

- Calling `ResultSet.deleteRow()` on a table with a primary key of type `BINARY(8)` silently failed to delete the row, but only in some repeatable cases. The generated `DELETE` statement generated corrupted part of the primary key data. Specifically, one of the bytes was changed from 0x90 to 0x9D, although the corruption appeared to be different depending on whether the application was run on Windows or Linux. (Bug #43759)

- Accessing result set columns by name after the result set had been closed resulted in a NullPointerException instead of a SQLException. (Bug #41484)

- `QueryTimeout` did not work for batch statements waiting on a locked table.

  When a batch statement was issued to the server and was forced to wait because of a locked table, Connector/J only terminated the first statement in the batch when the timeout was exceeded, leaving the rest hanging. (Bug #34555)

- The `parseURL` method in class `com.mysql.jdbc.Driver` did not work as expected. When given a URL such as “jdbc:mysql://www.mysql.com:12345/my_database” to parse, the property `PORT_PROPERTY_KEY` was found to be `null` and the `HOST_PROPERTY_KEY` property was found to be “www.mysql.com:12345”.

  > **Note**
  >
  > Connector/J has been fixed so that it will now always fill in the `PORT` property (using 3306 if not specified), and the `HOST` property (using `localhost` if not specified) when `parseURL()` is called. The driver also parses a list of hosts into `HOST.n` and `PORT.n` properties as well as adding a property `NUM_HOSTS` for the number of hosts it has found. If a list of hosts is passed to the driver, `HOST` and `PORT` will be set to the values given by `HOST.1` and `PORT.1` respectively. This change has centralized and cleaned up a large section of code used to generate lists of hosts, both for load-balanced and fault tolerant connections and their tests.

  (Bug #32216)

- Attempting to delete rows using `ResultSet.deleteRow()` did not delete rows correctly. (Bug #27431)

- The `setDate` method silently ignored the Calendar parameter. The code was implemented as follows:

  ```
  public void setDate(int parameterIndex, java.sql.Date x, Calendar cal) throws SQLException {
     setDate(parameterIndex, x);
  }
  ```

  From reviewing the code it was apparent that the Calendar parameter `cal` was ignored. (Bug #23584)

D.5.1.10. Changes in MySQL Connector/J 5.1.8 (16 July 2009)

Bugs Fixed

- The reported milliseconds since the last server packets were received/sent was incorrect by a factor of 1000. For example, the following method call:

  ```
  SQLError.createLinkFailureMessageBasedOnHeuristics(
  (ConnectionImpl) this.conn,
  System.currentTimeMillis() - 1000,
  System.currentTimeMillis() - 2000,
  e,
  false);
  ```

  returned the following string:

  ```
  The last packet successfully received from the server
  was 2 milliseconds ago. The last packet sent successfully to the
  server was 1 milliseconds ago.
  ```

  (Bug #45419)

- Calling `Connection.serverPrepareStatement()` variants that do not take result set type or concurrency arguments returned statements that produced result sets with incorrect defaults, namely `TYPE_SCROLL_SENSITIVE`. (Bug #45171)

- The result set returned by `getIndexInfo()` did not have the format defined in the JDBC API specifications. The fourth column, `DATA_TYPE`, of the result set should be of type `BOOLEAN`. Connector/J however returns `CHAR`. (Bug #44869)

- The result set returned by `getTypeInfo()` did not have the format defined in the JDBC API specifications. The second column, `DATA_TYPE`, of the result set should be of type `INTEGER`. Connector/J however returns `SMALLINT`. (Bug #44868)

- The `DEFERRABILITY` column in database metadata result sets was expected to be of type `SHORT`. However, Connector/J returned it as `INTEGER`.

  This affected the following methods: `getImportedKeys()`, `getExportedKeys()`, `getCrossReference()`. (Bug #44867)

- The result set returned by `getColumns()` did not have the format defined in the JDBC API specifications. The fifth column, `DATA_TYPE`, of the result set should be of type `INTEGER`. Connector/J however returns `SMALLINT`. (Bug #44865)

- The result set returned by `getVersionColumns()` did not have the format defined in the JDBC API specifications. The third column, `DATA_TYPE`, of the result set should be of type `INTEGER`. Connector/J however returns `SMALLINT`. (Bug #44863)

- The result set returned by `getBestRowIdentifier()` did not have the format defined in the JDBC API specifications. The third column, `DATA_TYPE`, of the result set should be of type `INTEGER`. Connector/J however returns `SMALLINT`. (Bug #44862)

- Connector/J contains logic to generate a message text specifically for streaming result sets when there are `CommunicationsException` exceptions generated. However, this code was never reached.

  In the `CommunicationsException` code:

  ```
  private boolean streamingResultSetInPlay = false;

  public CommunicationsException(ConnectionImpl conn, long lastPacketSentTimeMs,
  long lastPacketReceivedTimeMs, Exception underlyingException) {

  this.exceptionMessage = SQLError.createLinkFailureMessageBasedOnHeuristics(conn,
        lastPacketSentTimeMs, lastPacketReceivedTimeMs, underlyingException,
        this.streamingResultSetInPlay);
  ```

  `streamingResultSetInPlay` was always false, which in the following code in `SQLError.createLinkFailureMessageBasedOnHeuristics()` never being executed:

  ```
  if (streamingResultSetInPlay) {
      exceptionMessageBuf.append(
      Messages.getString("CommunicationsException.ClientWasStreaming")); //$NON-NLS-1$
  } else {
  ...
  ```

  (Bug #44588)

- The `SQLError.createLinkFailureMessageBasedOnHeuristics()` method created a message text for communication link failures. When certain conditions were met, this message included both “last packet sent” and “last packet received” information, but when those conditions were not met, only “last packet sent” information was provided.

  Information about when the last packet was successfully received should be provided in all cases. (Bug #44587)

- `Statement.getGeneratedKeys()` retained result set instances until the statement was closed. This caused memory leaks for long-lived statements, or statements used in tight loops. (Bug #44056)

- Using `useInformationSchema` with `DatabaseMetaData.getExportedKeys()` generated the following exception:

  ```
  com.mysql.jdbc.exceptions.MySQLIntegrityConstraintViolationException: Column
  'REFERENCED_TABLE_NAME' in where clause is ambiguous
  ...
  at com.mysql.jdbc.PreparedStatement.executeInternal(PreparedStatement.java:1772)
  at com.mysql.jdbc.PreparedStatement.executeQuery(PreparedStatement.java:1923)
  at
  com.mysql.jdbc.DatabaseMetaDataUsingInfoSchema.executeMetadataQuery(
  DatabaseMetaDataUsingInfoSchema.java:50)
  at
  com.mysql.jdbc.DatabaseMetaDataUsingInfoSchema.getExportedKeys(
  DatabaseMetaDataUsingInfoSchema.java:603)
  ```

  (Bug #43714)

- `LoadBalancingConnectionProxy.doPing()` did not have blacklist awareness.

  `LoadBalancingConnectionProxy` implemented `doPing()` to ping all underlying connections, but it threw any exceptions it encountered during this process.

  With the global blacklist enabled, it catches these exceptions, adds the host to the global blacklist, and only throws an exception if all hosts are down. (Bug #43421)

- The method `Statement.getGeneratedKeys()` did not return values for `UNSIGNED BIGINTS` with values greater than `Long.MAX_VALUE`.

  Unfortunately, because the server does not tell clients what TYPE the auto increment value is, the driver cannot consistently return BigIntegers for the result set returned from `getGeneratedKeys()`, it will only return them if the value is greater than `Long.MAX_VALUE`. If your application needs this consistency, it will need to check the class of the return value from `.getObject()` on the ResultSet returned by `Statement.getGeneratedKeys()` and if it is not a BigInteger, create one based on the `java.lang.Long` that is returned. (Bug #43196)

- When the MySQL Server was upgraded from 4.0 to 5.0, the Connector/J application then failed to connect to the server. This was because authentication failed when the application ran from EBCDIC platforms such as z/OS. (Bug #43071)

- When connecting with `traceProtocol=true`, no trace data was generated for the server greeting or login request. (Bug #43070)
- Connector/J generated an unhandled `StringIndexOutOfBoundsException`:

  ```
  java.lang.StringIndexOutOfBoundsException: String index out of range: -1
  at java.lang.String.substring(String.java:1938)
  at com.mysql.jdbc.EscapeProcessor.processTimeToken(EscapeProcessor.java:353)
  at com.mysql.jdbc.EscapeProcessor.escapeSQL(EscapeProcessor.java:257)
  at com.mysql.jdbc.StatementImpl.executeUpdate(StatementImpl.java:1546)
  at com.mysql.jdbc.StatementImpl.executeUpdate(StatementImpl.java:1524)
  ```

  (Bug #42253)
- A `ConcurrentModificationException` was generated in `LoadBalancingConnectionProxy`:

  ```
  java.util.ConcurrentModificationException
   at java.util.HashMap$HashIterator.nextEntry(Unknown Source)
   at java.util.HashMap$KeyIterator.next(Unknown Source)
   at
  com.mysql.jdbc.LoadBalancingConnectionProxy.getGlobalBlacklist(LoadBalancingConnectionProxy.java:520)
   at com.mysql.jdbc.RandomBalanceStrategy.pickConnection(RandomBalanceStrategy.java:55)
   at
  com.mysql.jdbc.LoadBalancingConnectionProxy.pickNewConnection(LoadBalancingConnectionProxy.java:414)
   at
  com.mysql.jdbc.LoadBalancingConnectionProxy.invoke(LoadBalancingConnectionProxy.java:390)
  ```

  (Bug #42055)
- SQL injection was possible when using a string containing U+00A5 in a client-side prepared statement, and the character set being used was SJIS/Windows-31J. (Bug #41730)
- If there was an apostrophe in a comment in a statement that was being sent through Connector/J, the apostrophe was still recognized as a quote and put the state machine in `EscapeTokenizer` into the `inQuotes` state. This led to further parse errors.

  For example, consider the following statement:

  ```
  String sql = "-- Customer's zip code will be fixed\n" +
    "update address set zip_code = 99999\n" +
    "where not regexp '^[0-9]{5}([[.-.]])?([0-9]{4})?$'";
  ```

  When passed through Connector/J, the `EscapeTokenizer` did not recognize that the first apostrophe was in a comment and thus set `inQuotes` to true. When that happened, the quote count was incorrect and thus the regular expression did not appear to be in quotation marks. With the parser not detecting that the regular expression was in quotation marks, the curly braces were recognized as escape sequences and were removed from the regular expression, breaking it. The server thus received SQL such as:

  ```
  -- Customer's zip code will be fixed
  update address set zip_code = '99999'
  where not regexp '^[0-9]([[.-.]])?([0-9])?$'
  ```

  (Bug #41566)
- MySQL Connector/J 5.1.7 was slower than previous versions when the `rewriteBatchedStatements` option was set to `true`.

  > **Note**
  >
  > The performance regression in `indexOfIgnoreCaseRespectMarker()`has been fixed. It has also been made possible for the driver to rewrite `INSERT` statements with `ON DUPLICATE KEY UPDATE` clauses in them, as long as the `UPDATE` clause contains no reference to `LAST_INSERT_ID()`, as that would cause the driver to return bogus values for `getGeneratedKeys()` invocations. This has resulted in improved performance over version 5.1.7.

  (Bug #41532)
- When accessing a result set column by name using `ResultSetImpl.findColumn()` an exception was generated:

  ```
  java.lang.NullPointerException
  at com.mysql.jdbc.ResultSetImpl.findColumn(ResultSetImpl.java:1103)
  at com.mysql.jdbc.ResultSetImpl.getShort(ResultSetImpl.java:5415)
  at org.apache.commons.dbcp.DelegatingResultSet.getShort(DelegatingResultSet.java:219)
  at com.zimbra.cs.db.DbVolume.constructVolume(DbVolume.java:297)
  at com.zimbra.cs.db.DbVolume.get(DbVolume.java:197)
  at com.zimbra.cs.db.DbVolume.create(DbVolume.java:95)
  at com.zimbra.cs.store.Volume.create(Volume.java:227)
  at com.zimbra.cs.store.Volume.create(Volume.java:189)
  at com.zimbra.cs.service.admin.CreateVolume.handle(CreateVolume.java:48)
  ```

```
at com.zimbra.soap.SoapEngine.dispatchRequest(SoapEngine.java:428)
at com.zimbra.soap.SoapEngine.dispatch(SoapEngine.java:285)
```

(Bug #41484)

- The `RETURN_GENERATED_KEYS` flag was being ignored. For example, in the following code the `RETURN_GENERATED_KEYS` flag was ignored:

  ```
  PreparedStatement ps = connection.prepareStatement("INSERT INTO table
    values(?,?)",PreparedStatement.RETURN_GENERATED_KEYS);
  ```

  (Bug #41448)

- When using Connector/J 5.1.7 to connect to MySQL Server 4.1.18 the following error message was generated:

  ```
  Thu Dec 11 17:38:21 PST 2008 WARN: Invalid value {1} for server variable named {0},
  falling back to sane default of {2}
  ```

  This occurred with MySQL Server version that did not support `auto_increment_increment`. The error message should not have been generated. (Bug #41416)

- When `DatabaseMetaData.getProcedureColumns()` was called, the value for `LENGTH` was always returned as 65535, regardless of the column type (fixed or variable) or the actual length of the column.

  However, if you obtained the `PRECISION` value, this was correct for both fixed and variable length columns. (Bug #41269)

- `PreparedStatement.addBatch()` did not check for all parameters being set, which led to inconsistent behavior in `executeBatch()`, especially when rewriting batched statements into multi-value `INSERT`s. (Bug #41161)

- Error message strings contained variable values that were not expanded. For example:

  ```
  Mon Nov 17 11:43:18 JST 2008 WARN: Invalid value {1} for server variable named {0},
  falling back to sane default of {2}
  ```

  (Bug #40772)

- When using `rewriteBatchedStatements=true` with:

  ```
  INSERT INTO table_name_values (...) VALUES (...)
  ```

  Query rewriting failed because “values” at the end of the table name was mistaken for the reserved keyword. The error generated was as follows:

  ```
  testBug40439(testsuite.simple.TestBug40439)java.sql.BatchUpdateException: You have an
  error in your SQL syntax; check the manual that corresponds to your MySQL server version
  for the right syntax to use near 'values (2,'toto',2),(id,data, ordr) values
  (3,'toto',3),(id,data, ordr) values (' at line 1
  at com.mysql.jdbc.PreparedStatement.executeBatchedInserts(PreparedStatement.java:1495)
  at com.mysql.jdbc.PreparedStatement.executeBatch(PreparedStatement.java:1097)
  at testsuite.simple.TestBug40439.testBug40439(TestBug40439.java:42)
  at sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
  at sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:39)
  at sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:25)
  at testsuite.simple.TestBug40439.main(TestBug40439.java:57)
  ```

  (Bug #40439)

- A statement interceptor received the incorrect parameters when used with a batched statement. (Bug #39426)

- Using Connector/J 5.1.6 the method `ResultSet.getObject` returned a `BYTE[]` for following:

  ```
  SELECT TRIM(rowid) FROM tbl
  ```

  Where `rowid` had a type of `INT(11) PRIMARY KEY AUTO_INCREMENT`.

  The expected return type was one of `CHAR`, `VARCHAR`, `CLOB`, however, a `BYTE[]` was returned.

  Further, adding `functionsNeverReturnBlobs=true` to the connection string did not have any effect on the return type. (Bug #38387)

D.5.1.11. Changes in MySQL Connector/J 5.1.7 (21 October 2008)

Functionality Added or Changed

- When statements include `ON DUPLICATE UPDATE`, and `rewriteBatchedStatements` is set to true, batched statements are not rewritten into the form `INSERT INTO table VALUES (), (), ()`, instead the statements are executed sequentially.

Bugs Fixed

- `Statement.getGeneratedKeys()` returned two keys when using `ON DUPLICATE KEY UPDATE` and the row was updated, not inserted. (Bug #42309)
- When using the replication driver with `autoReconnect=true`, Connector/J checks in `PreparedStatement.execute` (also called by `CallableStatement.execute`) to determine if the first character of the statement is an “S”, in an attempt to block all statements that are not read-only-safe, for example non-`SELECT` statements. However, this also blocked `CALL`s to stored procedures, even if the stored procedures were defined as `SQL READ DATA` or `NO SQL`. (Bug #40031)
- With large result sets `ResultSet.findColumn` became a performance bottleneck. (Bug #39962)
- Connector/J ignored the value of the MySQL Server variable `auto_increment_increment`. (Bug #39956)
- Connector/J failed to parse `TIMESTAMP` strings for nanos correctly. (Bug #39911)
- When the `LoadBalancingConnectionProxy` handles a `SQLException` with SQL state starting with “08”, it calls `invalidateCurrentConnection`, which in turn removes that `Connection` from `liveConnections` and the `connectionsToHostsMap`, but it did not add the host to the new global blacklist, if the global blacklist was enabled.

  There was also the possibility of a `NullPointerException` when trying to update stats, where `connectionsToHostsMap.get(this.currentConn)` was called:

  ```
  int hostIndex = ((Integer) this.hostsToListIndexMap.get(this.connectionsToHostsMap.get(this.currentConn))).intValue
  ```

  This could happen if a client tried to issue a rollback after catching a `SQLException` caused by a connection failure. (Bug #39784)
- When configuring the Java Replication Driver the last slave specified was never used. (Bug #39611)
- When an `INSERT ON DUPLICATE KEY UPDATE` was performed, and the key already existed, the `affected-rows` value was returned as 1 instead of 0. (Bug #39352)
- When using the random load balancing strategy and starting with two servers that were both unavailable, an `IndexOutOfBoundsException` was generated when removing a server from the `whiteList`. (Bug #38782)
- Connector/J threw the following exception when using a read-only connection:

  ```
  java.sql.SQLException: Connection is read-only. Queries leading to data
  modification are not allowed.
  ```

  (Bug #38747)
- Connector/J was unable to connect when using a non-`latin1` password. (Bug #37570)
- The `useOldAliasMetadataBehavior` connection property was ignored. (Bug #35753)
- Incorrect result is returned from `isAfterLast()` in streaming `ResultSet` when using `setFetchSize(Integer.MIN_VALUE)`. (Bug #35170)
- When `getGeneratedKeys()` was called on a statement that had not been created with `RETURN_GENERATED_KEYS`, no exception was thrown, and batched executions then returned erroneous values. (Bug #34185)
- The `loadBalance` `bestResponseTime` blacklists did not have a global state. (Bug #33861)

D.5.1.12. Changes in MySQL Connector/J 5.1.6 (07 March 2008)

Functionality Added or Changed

- Multiple result sets were not supported when using streaming mode to return data. Both normal statements and the resul sets from stored procedures now return multiple results sets, with the exception of result sets using registered `OUTPUT` parameters. (Bug #33678)
- XAConnections and datasources have been updated to the JDBC-4.0 standard.
- The profiler event handling has been made extensible using the `profilerEventHandler` connection property.
- Add the `verifyServerCertificate` property. If set to "false" the driver will not verify the server's certificate when `useSSL` is set to "true"

  When using this feature, the keystore parameters should be specified by the `clientCertificateKeyStore*` properties, rather than system properties, as the JSSE doesn't it straightforward to have a nonverifying trust store and the "default" key store.

Bugs Fixed

- `DatabaseMetaData.getColumns()` returns incorrect `COLUMN_SIZE` value for `SET` column. (Bug #36830)
- When trying to read `Time` values like “00:00:00” with `ResultSet.getTime(int)` an exception is thrown. (Bug #36051)
- JDBC connection URL parameters is ignored when using `MysqlConnectionPoolDataSource`. (Bug #35810)
- When `useServerPrepStmts=true` and slow query logging is enabled, the connector throws a `NullPointerException` when it encounters a slow query. (Bug #35666)
- When using the keyword “loadbalance” in the connection string and trying to perform load balancing between two databases, the driver appears to hang. (Bug #35660)
- JDBC data type getter method was changed to accept only column name, whereas previously it accepted column label. (Bug #35610)
- Prepared statements from pooled connections caused a `NullPointerException` when `closed()` under JDBC-4.0. (Bug #35489)
- In calling a stored function returning a `bigint`, an exception is encountered beginning:

  ```
  java.sql.SQLException: java.lang.NumberFormatException: For input string:
  ```

  followed by the text of the stored function starting after the argument list. (Bug #35199)
- The JDBC driver uses a different method for evaluating column names in `resultsetmetadata.getColumnName()` and when looking for a column in `resultset.getObject(columnName)`. This causes Hibernate to fail in queries where the two methods yield different results, for example in queries that use alias names:

  ```
  SELECT column AS aliasName from table
  ```

  (Bug #35150)
- `MysqlConnectionPoolDataSource` does not support `ReplicationConnection`. Notice that we implemented `com.mysql.jdbc.Connection` for `ReplicationConnection`, however, only accessors from ConnectionProperties are implemented (not the mutators), and they return values from the currently active connection. All other methods from `com.mysql.jdbc.Connection` are implemented, and operate on the currently active connection, with the exception of `resetServerState()` and `changeUser()`. (Bug #34937)
- `ResultSet.getTimestamp()` returns incorrect values for month/day of `TIMESTAMP`s when using server-side prepared statements (not enabled by default). (Bug #34913)
- `RowDataStatic` doesn't always set the metadata in `ResultSetRow`, which can lead to failures when unpacking `DATE`, `TIME`, `DATETIME` and `TIMESTAMP` types when using absolute, relative, and previous result set navigation methods. (Bug #34762)
- When calling `isValid()` on an active connection, if the timeout is nonzero then the `Connection` is invalidated even if the `Connection` is valid. (Bug #34703)
- It was not possible to truncate a `BLOB` using `Blog.truncate()` when using 0 as an argument. (Bug #34677)
- When using a cursor fetch for a statement, the internal prepared statement could cause a memory leak until the connection was closed. The internal prepared statement is now deleted when the corresponding result set is closed. (Bug #34518)

- When retrieving the column type name of a geometry field, the driver would return `UNKNOWN` instead of `GEOMETRY`. (Bug #34194)
- Statements with batched values do not return correct values for `getGeneratedKeys()` when `rewriteBatchedStatements` is set to `true`, and the statement has an `ON DUPLICATE KEY UPDATE` clause. (Bug #34093)
- The internal class `ResultSetInternalMethods` referenced the nonpublic class `com.mysql.jdbc.CachedResultSetMetaData`. (Bug #33823)
- A `NullPointerException` could be raised when using client-side prepared statements and enabled the prepared statement cache using the `cachePrepStmts`. (Bug #33734)
- Using server side cursors and cursor fetch, the table metadata information would return the data type name instead of the column name. (Bug #33594)
- `ResultSet.getTimestamp()` would throw a `NullPointerException` instead of a `SQLException` when called on an empty `ResultSet`. (Bug #33162)
- Load balancing connection using best response time would incorrectly "stick" to hosts that were down when the connection was first created.

  We solve this problem with a black list that is used during the picking of new hosts. If the black list ends up including all configured hosts, the driver will retry for a configurable number of times (the `retriesAllDown` configuration property, with a default of 120 times), sleeping 250ms between attempts to pick a new connection.

  We've also went ahead and made the balancing strategy extensible. To create a new strategy, implement the interface `com.mysql.jdbc.BalanceStrategy` (which also includes our standard "extension" interface), and tell the driver to use it by passing in the class name using the `loadBalanceStrategy` configuration property. (Bug #32877)
- During a Daylight Savings Time (DST) switchover, there was no way to store two timestamp/datetime values , as the hours end up being the same when sent as the literal that MySQL requires.

  Note that to get this scenario to work with MySQL (since it doesn't support per-value timezones), you need to configure your server (or session) to be in UTC, and tell the driver not to use the legacy date/time code by setting `useLegacyDatetimeCode` to "false". This will cause the driver to always convert to/from the server and client timezone consistently.

  This bug fix also fixes Bug #15604, by adding entirely new date/time handling code that can be switched on by `useLegacyDatetimeCode` being set to "false" as a JDBC configuration property. For Connector/J 5.1.x, the default is "true", in trunk and beyond it will be "false" (that is, the old date/time handling code will be deprecated) (Bug #32577, Bug #15604)
- When unpacking rows directly, we don't hand off error message packets to the internal method which decodes them correctly, so no exception is raised, and the driver than hangs trying to read rows that aren't there. This tends to happen when calling stored procedures, as normal SELECTs won't have an error in this spot in the protocol unless an I/O error occurs. (Bug #32246)
- When using a connection from `ConnectionPoolDataSource`, some `Connection.prepareStatement()` methods would return null instead of the prepared statement. (Bug #32101)
- Using `CallableStatement.setNull()` on a stored function would throw an `ArrayIndexOutOfBounds` exception when setting the last parameter to null. (Bug #31823)
- `MysqlValidConnectionChecker` doesn't properly handle connections created using `ReplicationConnection`. (Bug #31790)
- Retrieving the server version information for an active connection could return invalid information if the default character encoding on the host was not ASCII compatible. (Bug #31192)
- Further fixes have been made to this bug in the event that a node is nonresponsive. Connector/J will now try a different random node instead of waiting for the node to recover before continuing. (Bug #31053)
- `ResultSet` returned by `Statement.getGeneratedKeys()` is not closed automatically when statement that created it is closed. (Bug #30508)
- `DatabaseMetadata.getColumns()` doesn't return the correct column names if the connection character isn't UTF-8. A bug in MySQL server compounded the issue, but was fixed within the MySQL 5.0 release cycle. The fix includes changes to all the sections of the code that access the server metadata. (Bug #20491)
- Fixed `ResultSetMetadata.getColumnName()` for result sets returned from `Statement.getGeneratedKeys()` - it was returning null instead of "GENERATED_KEY" as in 5.0.x.

D.5.1.13. Changes in MySQL Connector/J 5.1.5 (09 October 2007)

New Features, Compared to the 5.0 Series of Connector/J

- Support for JDBC-4.0 `NCHAR`, `NVARCHAR` and `NCLOB` types.
- JDBC-4.0 support for setting per-connection client information (which can be viewed in the comments section of a query using `SHOW PROCESSLIST` on a MySQL server, or can be extended to support custom persistence of the information using a public interface).
- Support for JDBC-4.0 XML processing using JAXP interfaces to DOM, SAX and StAX.
- JDBC-4.0 standardized unwrapping to interfaces that include vendor extensions.

Functionality Added or Changed

- Added `autoSlowLog` configuration property, overrides `slowQueryThreshold*` properties, driver determines slow queries by those that are slower than 5 * stddev of the mean query time (outside the 96% percentile).

Bugs Fixed

- When a connection is in read-only mode, queries that are wrapped in parentheses were incorrectly identified DML statements. (Bug #28256)
- When calling `setTimestamp` on a prepared statement, the timezone information stored in the calendar object was ignored. This resulted in the incorrect `DATETIME` information being stored. The following example illustrates this:

  ```
  Timestamp t = new Timestamp( cal.getTimeInMillis() );
  ps.setTimestamp( N, t, cal );
  ```

  (Bug #15604)

D.5.1.14. Changes in MySQL Connector/J 5.1.4 (Not Released)

Only released internally.

This section has no changelog entries.

D.5.1.15. Changes in MySQL Connector/J 5.1.3 (10 September 2007)

New Features, Compared to the 5.0 Series of Connector/J

- Support for JDBC-4.0 `NCHAR`, `NVARCHAR` and `NCLOB` types.
- JDBC-4.0 support for setting per-connection client information (which can be viewed in the comments section of a query using `SHOW PROCESSLIST` on a MySQL server, or can be extended to support custom persistence of the information using a public interface).
- Support for JDBC-4.0 XML processing using JAXP interfaces to DOM, SAX and StAX.
- JDBC-4.0 standardized unwrapping to interfaces that include vendor extensions.

Functionality Added or Changed

- Connector/J now connects using an initial character set of `utf-8` solely for the purpose of authentication to permit user names or database names in any character set to be used in the JDBC connection URL. (Bug #29853)
- Added two configuration parameters:
    - `blobsAreStrings`: Should the driver always treat BLOBs as Strings. Added specifically to work around dubious metadata returned by the server for `GROUP BY` clauses. Defaults to false.
    - `functionsNeverReturnBlobs`: Should the driver always treat data from functions returning `BLOBs` as Strings. Added specifically to work around dubious metadata returned by the server for `GROUP BY` clauses. Defaults to false.

- Setting `rewriteBatchedStatements` to `true` now causes CallableStatements with batched arguments to be re-written in the form "CALL (...); CALL (...); ..." to send the batch in as few client/server round trips as possible.

- The driver now picks appropriate internal row representation (whole row in one buffer, or individual byte[]s for each column value) depending on heuristics, including whether or not the row has `BLOB` or `TEXT` types and the overall row-size. The threshold for row size that will cause the driver to use a buffer rather than individual byte[]s is configured by the configuration property `largeRowSizeThreshold`, which has a default value of 2KB.

- The data (and how it is stored) for `ResultSet` rows are now behind an interface which enables us (in some cases) to allocate less memory per row, in that for "streaming" result sets, we re-use the packet used to read rows, since only one row at a time is ever active.

- Added experimental support for statement "interceptors" through the `com.mysql.jdbc.StatementInterceptor` interface, examples are in `com/mysql/jdbc/interceptors`. Implement this interface to be placed "in between" query execution, so that it can be influenced (currently experimental).

- The driver will automatically adjust the server session variable `net_write_timeout` when it determines its been asked for a "streaming" result, and resets it to the previous value when the result set has been consumed. (The configuration property is named `netTimeoutForStreamingResults`, with a unit of seconds, the value '0' means the driver will not try and adjust this value).

- JDBC-4.0 ease-of-development features including auto-registration with the `DriverManager` through the service provider mechanism, standardized Connection validity checks and categorized `SQLExceptions` based on recoverability/retry-ability and class of the underlying error.

- `Statement.setQueryTimeout()`s now affect the entire batch for batched statements, rather than the individual statements that make up the batch.

- Errors encountered during `Statement`/`PreparedStatement`/`CallableStatement.executeBatch()` when `rewriteBatchStatements` has been set to `true` now return `BatchUpdateExceptions` according to the setting of `continueBatchOnError`.

  If `continueBatchOnError` is set to `true`, the update counts for the "chunk" that were sent as one unit will all be set to `EXECUTE_FAILED`, but the driver will attempt to process the remainder of the batch. You can determine which "chunk" failed by looking at the update counts returned in the `BatchUpdateException`.

  If `continueBatchOnError` is set to "false", the update counts returned will contain all updates up-to and including the failed "chunk", with all counts for the failed "chunk" set to `EXECUTE_FAILED`.

  Since MySQL doesn't return multiple error codes for multiple-statements, or for multi-value `INSERT`/`REPLACE`, it is the application's responsibility to handle determining which item(s) in the "chunk" actually failed.

- New methods on com.mysql.jdbc.Statement: `setLocalInfileInputStream()` and `getLocalInfileInputStream()`:

  - `setLocalInfileInputStream()` sets an `InputStream` instance that will be used to send data to the MySQL server for a `LOAD DATA LOCAL INFILE` statement rather than a `FileInputStream` or `URLInputStream` that represents the path given as an argument to the statement.

    This stream will be read to completion upon execution of a `LOAD DATA LOCAL INFILE` statement, and will automatically be closed by the driver, so it needs to be reset before each call to `execute*()` that would cause the MySQL server to request data to fulfill the request for `LOAD DATA LOCAL INFILE`.

    If this value is set to `NULL`, the driver will revert to using a `FileInputStream` or `URLInputStream` as required.

  - `getLocalInfileInputStream()` returns the `InputStream` instance that will be used to send data in response to a `LOAD DATA LOCAL INFILE` statement.

    This method returns `NULL` if no such stream has been set using `setLocalInfileInputStream()`.

- Setting `useBlobToStoreUTF8OutsideBMP` to `true` tells the driver to treat `[MEDIUM/LONG]BLOB` columns as `[LONG]VARCHAR` columns holding text encoded in UTF-8 that has characters outside the BMP (4-byte encodings), which MySQL server can't handle natively.

  Set `utf8OutsideBmpExcludedColumnNamePattern` to a regex so that column names matching the given regex will still be treated as `BLOBs` The regex must follow the patterns used for the `java.util.regex`package. The default is to exclude no columns, and include all columns.

  Set `utf8OutsideBmpIncludedColumnNamePattern` to specify exclusion rules to utf8OutsideBmpExcludedColumnNamePattern". The regex must follow the patterns used for the `java.util.regex` package.

Bugs Fixed

- `setObject(int, Object, int, int)` delegate in PreparedStatementWrapper delegates to wrong method. (Bug #30892)
- NPE with null column values when `padCharsWithSpace` is set to true. (Bug #30851)
- Collation on `VARBINARY` column types would be misidentified. A fix has been added, but this fix only works for MySQL server versions 5.0.25 and newer, since earlier versions didn't consistently return correct metadata for functions, and thus results from subqueries and functions were indistinguishable from each other, leading to type-related bugs. (Bug #30664)
- An `ArithmeticException` or `NullPointerException` would be raised when the batch had zero members and `rewriteBatchedStatements=true` when `addBatch()` was never called, or `executeBatch()` was called immediately after `clearBatch()`. (Bug #30550)
- Closing a load-balanced connection would cause a `ClassCastException`. (Bug #29852)
- Connection checker for JBoss didn't use same method parameters using reflection, causing connections to always seem "bad". (Bug #29106)
- `DatabaseMetaData.getTypeInfo()` for the types `DECIMAL` and `NUMERIC` will return a precision of 254 for server versions older than 5.0.3, 64 for versions 5.0.3 to 5.0.5 and 65 for versions newer than 5.0.5. (Bug #28972)
- `CallableStatement.executeBatch()` doesn't work when connection property `noAccessToProcedureBodies` has been set to `true`.

  The fix involves changing the behavior of `noAccessToProcedureBodies`,in that the driver will now report all paramters as `IN` paramters but permit callers to call registerOutParameter() on them without throwing an exception. (Bug #28689)
- `DatabaseMetaData.getColumns()` doesn't contain `SCOPE_*` or `IS_AUTOINCREMENT` columns. (Bug #27915)
- Schema objects with identifiers other than the connection character aren't retrieved correctly in `ResultSetMetadata`. (Bug #27867)
- `Connection.getServerCharacterEncoding()` doesn't work for servers with version >= 4.1. (Bug #27182)
- The automated SVN revisions in `DBMD.getDriverVersion()`. The SVN revision of the directory is now inserted into the version information during the build. (Bug #21116)
- Specifying a "validation query" in your connection pool that starts with "/* ping */" _exactly_ will cause the driver to instead send a ping to the server and return a fake result set (much lighter weight), and when using a ReplicationConnection or a LoadBalancedConnection, will send the ping across all active connections.

D.5.1.16. Changes in MySQL Connector/J 5.1.2 (29 June 2007)

This is a new Beta development release, fixing recently discovered bugs.

Functionality Added or Changed

- Setting the configuration property `rewriteBatchedStatements` to `true` will now cause the driver to rewrite batched prepared statements with more than 3 parameter sets in a batch into multi-statements (separated by ";") if they are not plain (that is, without `SELECT` or `ON DUPLICATE KEY UPDATE` clauses) `INSERT` or `REPLACE` statements.

D.5.1.17. Changes in MySQL Connector/J 5.1.1 (22 June 2007)

This is a new Alpha development release, adding new features and fixing recently discovered bugs.

Functionality Added or Changed

- **Incompatible Change**: Pulled vendor-extension methods of `Connection` implementation out into an interface to support `java.sql.Wrapper` functionality from `ConnectionPoolDataSource`. The vendor extensions are javadoc'd in the `com.mysql.jdbc.Connection` interface.

  For those looking further into the driver implementation, it is not an API that is used for pluggability of implementations inside our driver (which is why there are still references to `ConnectionImpl` throughout the code).

We've also added server and client `prepareStatement()` methods that cover all of the variants in the JDBC API.

`Connection.serverPrepare(String)` has been re-named to `Connection.serverPrepareStatement()` for consistency with `Connection.clientPrepareStatement()`.

- Row navigation now causes any streams/readers open on the result set to be closed, as in some cases we're reading directly from a shared network packet and it will be overwritten by the "next" row.
- Made it possible to retrieve prepared statement parameter bindings (to be used in `StatementInterceptors`, primarily).
- Externalized the descriptions of connection properties.
- The data (and how it is stored) for `ResultSet` rows are now behind an interface which enables us (in some cases) to allocate less memory per row, in that for "streaming" result sets, we re-use the packet used to read rows, since only one row at a time is ever active.
- Similar to `Connection`, we pulled out vendor extensions to `Statement` into an interface named `com.mysql.Statement`, and moved the `Statement` class into `com.mysql.StatementImpl`. The two methods (javadoc'd in `com.mysql.Statement` are `enableStreamingResults()`, which already existed, and `disableStreamingResults()` which sets the statement instance back to the fetch size and result set type it had before `enableStreamingResults()` was called.
- Driver now picks appropriate internal row representation (whole row in one buffer, or individual byte[]s for each column value) depending on heuristics, including whether or not the row has `BLOB` or `TEXT` types and the overall row-size. The threshold for row size that will cause the driver to use a buffer rather than individual byte[]s is configured by the configuration property `largeRowSizeThreshold`, which has a default value of 2KB.
- Added experimental support for statement "interceptors" through the `com.mysql.jdbc.StatementInterceptor` interface, examples are in `com/mysql/jdbc/interceptors`.

  Implement this interface to be placed "in between" query execution, so that you can influence it. (currently experimental).

  `StatementInterceptors` are "chainable" when configured by the user, the results returned by the "current" interceptor will be passed on to the next on in the chain, from left-to-right order, as specified by the user in the JDBC configuration property `statementInterceptors`.
- See the sources (fully javadoc'd) for `com.mysql.jdbc.StatementInterceptor` for more details until we iron out the API and get it documented in the manual.
- Setting `rewriteBatchedStatements` to `true` now causes `CallableStatements` with batched arguments to be rewritten in the form `CALL (...); CALL (...); ...` to send the batch in as few client/server round trips as possible.

D.5.1.18. Changes in MySQL Connector/J 5.1.0 (11 April 2007)

This is the first public alpha release of the current Connector/J 5.1 development branch, providing an insight to upcoming features. Although some of these are still under development, this release includes the following new features and changes (in comparison to the current Connector/J 5.0 production release):

Important change: Due to a number of issues with the use of server-side prepared statements, Connector/J 5.0.5 has disabled their use by default. The disabling of server-side prepared statements does not affect the operation of the connector in any way.

To enable server-side prepared statements you must add the following configuration property to your connector string:

```
useServerPrepStmts=true
```

The default value of this property is `false` (that is, Connector/J does not use server-side prepared statements).

> **Note**
>
> The disabling of server-side prepared statements does not affect the operation of the connector. However, if you use the `useTimezone=true` connection option and use client-side prepared statements (instead of server-side prepared statements) you should also set `useSSPSCompatibleTimezoneShift=true`.

Functionality Added or Changed

- Refactored `CommunicationsException` into a JDBC-3.0 version, and a JDBC-4.0 version (which extends `SQLRecoverableException`, now that it exists).

> **Note**
>
> This change means that if you were catching `com.mysql.jdbc.CommunicationsException` in your applications instead of looking at the SQLState class of `08`, and are moving to Java 6 (or newer), you need to change your imports to that exception to be `com.mysql.jdbc.exceptions.jdbc4.CommunicationsException`, as the old class will not be instantiated for communications link-related errors under Java 6.

- Added support for JDBC-4.0 categorized `SQLExceptions`.
- Added support for JDBC-4.0's `NCLOB`, and `NCHAR`/`NVARCHAR` types.
- `com.mysql.jdbc.java6.javac`: Full path to your Java-6 `javac` executable
- Added support for JDBC-4.0's SQLXML interfaces.
- Re-worked Ant buildfile to build JDBC-4.0 classes separately, as well as support building under Eclipse (since Eclipse can't mix/match JDKs).

  To build, you must set `JAVA_HOME` to J2SDK-1.4.2 or Java-5, and set the following properties on your Ant command line:

  - `com.mysql.jdbc.java6.javac`: Full path to your Java-6 `javac` executable
  - `com.mysql.jdbc.java6.rtjar`: Full path to your Java-6 `rt.jar` file
- New feature—driver will automatically adjust session variable `net_write_timeout` when it determines it has been asked for a "streaming" result, and resets it to the previous value when the result set has been consumed. (configuration property is named `netTimeoutForStreamingResults` value and has a unit of seconds, the value `0` means the driver will not try and adjust this value).
- Added support for JDBC-4.0's client information. The backend storage of information provided using `Connection.setClientInfo()` and retrieved by `Connection.getClientInfo()` is pluggable by any class that implements the `com.mysql.jdbc.JDBC4ClientInfoProvider` interface and has a no-args constructor.

  The implementation used by the driver is configured using the `clientInfoProvider` configuration property (with a default of value of `com.mysql.jdbc.JDBC4CommentClientInfoProvider`, an implementation which lists the client information as a comment prepended to every query sent to the server).

  This functionality is only available when using Java-6 or newer.
- `com.mysql.jdbc.java6.rtjar`: Full path to your Java-6 `rt.jar` file
- Added support for JDBC-4.0's `Wrapper` interface.

D.5.2. Changes in MySQL Connector/J 5.0.x

D.5.2.1. Changes in MySQL Connector/J 5.0.8 (09 October 2007)

Functionality Added or Changed

- `blobsAreStrings`: Should the driver always treat BLOBs as Strings. Added specifically to work around dubious metadata returned by the server for `GROUP BY` clauses. Defaults to false.
- Added two configuration parameters:
  - `blobsAreStrings`: Should the driver always treat BLOBs as Strings. Added specifically to work around dubious metadata returned by the server for `GROUP BY` clauses. Defaults to false.
  - `functionsNeverReturnBlobs`: Should the driver always treat data from functions returning `BLOBs` as Strings. Added specifically to work around dubious metadata returned by the server for `GROUP BY` clauses. Defaults to false.
- `functionsNeverReturnBlobs`: Should the driver always treat data from functions returning `BLOBs` as Strings. Added specifically to work around dubious metadata returned by the server for `GROUP BY` clauses. Defaults to false.
- XAConnections now start in auto-commit mode (as per JDBC-4.0 specification clarification).
- Driver will now fall back to sane defaults for `max_allowed_packet` and `net_buffer_length` if the server reports them incorrectly (and will log this situation at `WARN` level, since it is actually an error condition).

Bugs Fixed

- Connections established using URLs of the form `jdbc:mysql:loadbalance://` weren't doing failover if they tried to connect to a MySQL server that was down. The driver now attempts connections to the next "best" (depending on the load balance strategy in use) server, and continues to attempt connecting to the next "best" server every 250 milliseconds until one is found that is up and running or 5 minutes has passed.

  If the driver gives up, it will throw the last-received `SQLException`. (Bug #31053)

- `setObject(int, Object, int, int)` delegate in PreparedStatementWrapper delegates to wrong method. (Bug #30892)

- NPE with null column values when `padCharsWithSpace` is set to true. (Bug #30851)

- Collation on `VARBINARY` column types would be misidentified. A fix has been added, but this fix only works for MySQL server versions 5.0.25 and newer, since earlier versions didn't consistently return correct metadata for functions, and thus results from subqueries and functions were indistinguishable from each other, leading to type-related bugs. (Bug #30664)

- An `ArithmeticException` or `NullPointerException` would be raised when the batch had zero members and `rewriteBatchedStatements=true` when `addBatch()` was never called, or `executeBatch()` was called immediately after `clearBatch()`. (Bug #30550)

- Closing a load-balanced connection would cause a `ClassCastException`. (Bug #29852)

- Connection checker for JBoss didn't use same method parameters using reflection, causing connections to always seem "bad". (Bug #29106)

- `DatabaseMetaData.getTypeInfo()` for the types `DECIMAL` and `NUMERIC` will return a precision of 254 for server versions older than 5.0.3, 64 for versions 5.0.3 to 5.0.5 and 65 for versions newer than 5.0.5. (Bug #28972)

- `CallableStatement.executeBatch()` doesn't work when connection property `noAccessToProcedureBodies` has been set to `true`.

  The fix involves changing the behavior of `noAccessToProcedureBodies`,in that the driver will now report all paramters as `IN` paramters but permit callers to call registerOutParameter() on them without throwing an exception. (Bug #28689)

- When a connection is in read-only mode, queries that are wrapped in parentheses were incorrectly identified DML statements. (Bug #28256)

- `UNSIGNED` types not reported using `DBMD.getTypeInfo()`, and capitalization of type names is not consistent between `DBMD.getColumns()`, `RSMD.getColumnTypeName()` and `DBMD.getTypeInfo()`.

  This fix also ensures that the precision of `UNSIGNED MEDIUMINT` and `UNSIGNED BIGINT` is reported correctly using `DBMD.getColumns()`. (Bug #27916)

- `DatabaseMetaData.getColumns()` doesn't contain `SCOPE_*` or `IS_AUTOINCREMENT` columns. (Bug #27915)

- Schema objects with identifiers other than the connection character aren't retrieved correctly in `ResultSetMetadata`. (Bug #27867)

- Cached metadata with `PreparedStatement.execute()` throws `NullPointerException`. (Bug #27412)

- `Connection.getServerCharacterEncoding()` doesn't work for servers with version >= 4.1. (Bug #27182)

- The automated SVN revisions in `DBMD.getDriverVersion()`. The SVN revision of the directory is now inserted into the version information during the build. (Bug #21116)

- Specifying a "validation query" in your connection pool that starts with "/* ping */" _exactly_ will cause the driver to instead send a ping to the server and return a fake result set (much lighter weight), and when using a ReplicationConnection or a LoadBalancedConnection, will send the ping across all active connections.

D.5.2.2. Changes in MySQL Connector/J 5.0.7 (20 July 2007)

Functionality Added or Changed

- The driver will now automatically set `useServerPrepStmts` to `true` when `useCursorFetch` has been set to `true`, since the feature requires server-side prepared statements to function.

- `tcpKeepAlive` - Should the driver set SO_KEEPALIVE (default `true`)?
- Give more information in EOFExceptions thrown out of MysqlIO (how many bytes the driver expected to read, how many it actually read, say that communications with the server were unexpectedly lost).
- Driver detects when it is running in a ColdFusion MX server (tested with version 7), and uses the configuration bundle `coldFusion`, which sets `useDynamicCharsetInfo` to `false` (see previous entry), and sets `useLocalSessionState` and autoReconnect to `true`.
- `tcpNoDelay` - Should the driver set SO_TCP_NODELAY (disabling the Nagle Algorithm, default `true`)?
- Added configuration property `slowQueryThresholdNanos` - if `useNanosForElapsedTime` is set to `true`, and this property is set to a nonzero value the driver will use this threshold (in nanosecond units) to determine if a query was slow, instead of using millisecond units.
- `tcpRcvBuf` - Should the driver set SO_RCV_BUF to the given value? The default value of '0', means use the platform default value for this property.
- Setting `useDynamicCharsetInfo` to `false` now causes driver to use static lookups for collations as well (makes ResultSetMetadata.isCaseSensitive() much more efficient, which leads to performance increase for ColdFusion, which calls this method for every column on every table it sees, it appears).
- Added configuration properties to enable tuning of TCP/IP socket parameters:
  - `tcpNoDelay` - Should the driver set SO_TCP_NODELAY (disabling the Nagle Algorithm, default `true`)?
  - `tcpKeepAlive` - Should the driver set SO_KEEPALIVE (default `true`)?
  - `tcpRcvBuf` - Should the driver set SO_RCV_BUF to the given value? The default value of '0', means use the platform default value for this property.
  - `tcpSndBuf` - Should the driver set SO_SND_BUF to the given value? The default value of '0', means use the platform default value for this property.
  - `tcpTrafficClass` - Should the driver set traffic class or type-of-service fields? See the documentation for java.net.Socket.setTrafficClass() for more information.
- Setting the configuration parameter `useCursorFetch` to `true` for MySQL-5.0+ enables the use of cursors that enable Connector/J to save memory by fetching result set rows in chunks (where the chunk size is set by calling setFetchSize() on a Statement or ResultSet) by using fully-materialized cursors on the server.
- `tcpSndBuf` - Should the driver set SO_SND_BUF to the given value? The default value of '0', means use the platform default value for this property.
- `tcpTrafficClass` - Should the driver set traffic class or type-of-service fields? See the documentation for java.net.Socket.setTrafficClass() for more information.
- Added new debugging functionality - Setting configuration property `includeInnodbStatusInDeadlockExceptions` to `true` will cause the driver to append the output of `SHOW ENGINE INNODB STATUS` to deadlock-related exceptions, which will enumerate the current locks held inside InnoDB.
- Added configuration property `useNanosForElapsedTime` - for profiling/debugging functionality that measures elapsed time, should the driver try to use nanoseconds resolution if available (requires JDK >= 1.5)?

  > **Note**
  >
  > If `useNanosForElapsedTime` is set to `true`, and this property is set to "0" (or left default), then elapsed times will still be measured in nanoseconds (if possible), but the slow query threshold will be converted from milliseconds to nanoseconds, and thus have an upper bound of approximately 2000 milliseconds (as that threshold is represented as an integer, not a long).

Bugs Fixed

- Don't send any file data in response to LOAD DATA LOCAL INFILE if the feature is disabled at the client side. This is to prevent a malicious server or man-in-the-middle from asking the client for data that the client is not expecting. Thanks to Jan Kneschke for discovering the exploit and Andrey "Poohie" Hristov, Konstantin Osipov and Sergei Golubchik for discussions about implications and possible fixes. (Bug #29605)
- Parser in client-side prepared statements runs to end of statement, rather than end-of-line for '#' comments. Also added support

for '--' single-line comments. (Bug #28956)

- Parser in client-side prepared statements eats character following '/' if it is not a multi-line comment. (Bug #28851)
- PreparedStatement.getMetaData() for statements containing leading one-line comments is not returned correctly.

  As part of this fix, we also overhauled detection of DML for `executeQuery()` and `SELECT`s for `executeUpdate()` in plain and prepared statements to be aware of the same types of comments. (Bug #28469)

D.5.2.3. Changes in MySQL Connector/J 5.0.6 (15 May 2007)

Functionality Added or Changed

- Added an experimental load-balanced connection designed for use with SQL nodes in a MySQL Cluster/NDB environment (This is not for master-slave replication. For that, we suggest you look at `ReplicationConnection` or `lbpool`).

  If the JDBC URL starts with `jdbc:mysql:loadbalance://host-1,host-2,...host-n`, the driver will create an implementation of `java.sql.Connection` that load balances requests across a series of MySQL JDBC connections to the given hosts, where the balancing takes place after transaction commit.

  Therefore, for this to work (at all), you must use transactions, even if only reading data.

  Physical connections to the given hosts will not be created until needed.

  The driver will invalidate connections that it detects have had communication errors when processing a request. A new connection to the problematic host will be attempted the next time it is selected by the load balancing algorithm.

  There are two choices for load balancing algorithms, which may be specified by the `loadBalanceStrategy` JDBC URL configuration property:

  - `random`: The driver will pick a random host for each request. This tends to work better than round-robin, as the randomness will somewhat account for spreading loads where requests vary in response time, while round-robin can sometimes lead to overloaded nodes if there are variations in response times across the workload.
  - `bestResponseTime`: The driver will route the request to the host that had the best response time for the previous transaction.
- `bestResponseTime`: The driver will route the request to the host that had the best response time for the previous transaction.
- Added configuration property `padCharsWithSpace` (defaults to `false`). If set to `true`, and a result set column has the `CHAR` type and the value does not fill the amount of characters specified in the DDL for the column, the driver will pad the remaining characters with space (for ANSI compliance).
- When `useLocalSessionState` is set to `true` and connected to a MySQL-5.0 or later server, the JDBC driver will now determine whether an actual `commit` or `rollback` statement needs to be sent to the database when `Connection.commit()` or `Connection.rollback()` is called.

  This is especially helpful for high-load situations with connection pools that always call `Connection.rollback()` on connection check-in/check-out because it avoids a round-trip to the server.
- Added configuration property `useDynamicCharsetInfo`. If set to `false` (the default), the driver will use a per-connection cache of character set information queried from the server when necessary, or when set to `true`, use a built-in static mapping that is more efficient, but isn't aware of custom character sets or character sets implemented after the release of the JDBC driver.

  > **Note**
  >
  > This only affects the `padCharsWithSpace` configuration property and the `ResultSetMetaData.getColumnDisplayWidth()` method.
- New configuration property, `enableQueryTimeouts` (default `true`).

  When enabled, query timeouts set with `Statement.setQueryTimeout()` use a shared `java.util.Timer` instance for scheduling. Even if the timeout doesn't expire before the query is processed, there will be memory used by the `TimerTask` for the given timeout which won't be reclaimed until the time the timeout would have expired if it hadn't been cancelled by the driver. High-load environments might want to consider disabling this functionality. (this configuration property is part of the `maxPerformance` configuration bundle).

- Give better error message when "streaming" result sets, and the connection gets clobbered because of exceeding `net_write_timeout` on the server.

- `random`: The driver will pick a random host for each request. This tends to work better than round-robin, as the randomness will somewhat account for spreading loads where requests vary in response time, while round-robin can sometimes lead to overloaded nodes if there are variations in response times across the workload.

- `com.mysql.jdbc.[NonRegistering]Driver` now understands URLs of the format `jdbc:mysql:replication://` and `jdbc:mysql:loadbalance://` which will create a ReplicationConnection (exactly like when using `[NonRegistering]ReplicationDriver`) and an experimental load-balanced connection designed for use with SQL nodes in a MySQL Cluster/NDB environment, respectively.

  In an effort to simplify things, we're working on deprecating multiple drivers, and instead specifying different core behavior based upon JDBC URL prefixes, so watch for `[NonRegistering]ReplicationDriver` to eventually disappear, to be replaced with `com.mysql.jdbc[NonRegistering]Driver` with the new URL prefix.

- Fixed issue where a failed-over connection would let an application call `setReadOnly(false)`, when that call should be ignored until the connection is reconnected to a writable master unless `failoverReadOnly` had been set to `false`.

- Driver will now use `INSERT INTO ... VALUES (DEFAULT)`form of statement for updatable result sets for `ResultSet.insertRow()`, rather than pre-populating the insert row with values from `DatabaseMetaData.getColumns()`(which results in a `SHOW FULL COLUMNS` on the server for every result set). If an application requires access to the default values before `insertRow()` has been called, the JDBC URL should be configured with `populateInsertRowWithDefaultValues` set to `true`.

  This fix specifically targets performance issues with ColdFusion and the fact that it seems to ask for updatable result sets no matter what the application does with them.

- More intelligent initial packet sizes for the "shared" packets are used (512 bytes, rather than 16K), and initial packets used during handshake are now sized appropriately as to not require reallocation.

Bugs Fixed

- More useful error messages are generated when the driver thinks a result set is not updatable. (Thanks to Ashley Martens for the patch). (Bug #28085)

- `Connection.getTransactionIsolation()` uses "`SHOW VARIABLES LIKE`" which is very inefficient on MySQL-5.0+ servers. (Bug #27655)

- Fixed issue where calling `getGeneratedKeys()` on a prepared statement after calling `execute()` didn't always return the generated keys (`executeUpdate()` worked fine however). (Bug #27655)

- `CALL /* ... */ some_proc()` doesn't work. As a side effect of this fix, you can now use `/* */` and `#` comments when preparing statements using client-side prepared statement emulation.

  If the comments happen to contain parameter markers (`?`), they will be treated as belonging to the comment (that is, not recognized) rather than being a parameter of the statement.

  > **Note**
  >
  > The statement when sent to the server will contain the comments as-is, they're not stripped during the process of preparing the `PreparedStatement` or `CallableStatement`.

  (Bug #27400)

- `ResultSet.get*()` with a column index < 1 returns misleading error message. (Bug #27317)

- Using `ResultSet.get*()` with a column index less than 1 returns a misleading error message. (Bug #27317)

- Comments in DDL of stored procedures/functions confuse procedure parser, and thus metadata about them can not be created, leading to inability to retrieve said metadata, or execute procedures that have certain comments in them. (Bug #26959)

- Fast date/time parsing doesn't take into account `00:00:00` as a legal value. (Bug #26789)

- `PreparedStatement` is not closed in `BlobFromLocator.getBytes()`. (Bug #26592)

- When the configuration property `useCursorFetch` was set to `true`, sometimes server would return new, more exact metadata during the execution of the server-side prepared statement that enables this functionality, which the driver ignored (using the original metadata returned during `prepare()`), causing corrupt reading of data due to type mismatch when the actual rows were returned. (Bug #26173)

- `CallableStatements` with `OUT/INOUT` parameters that are "binary" (`BLOB`, `BIT`, `(VAR)BINARY`, `JAVA_OBJECT`) have extra 7 bytes. (Bug #25715)
- Whitespace surrounding storage/size specifiers in stored procedure parameters declaration causes `NumberFormatException` to be thrown when calling stored procedure on JDK-1.5 or newer, as the Number classes in JDK-1.5+ are whitespace intolerant. (Bug #25624)
- Client options not sent correctly when using SSL, leading to stored procedures not being able to return results. Thanks to Don Cohen for the bug report, testcase and patch. (Bug #25545)
- `Statement.setMaxRows()` is not effective on result sets materialized from cursors. (Bug #25517)
- `BIT(> 1)` is returned as `java.lang.String` from `ResultSet.getObject()` rather than `byte[]`. (Bug #25328)

D.5.2.4. Changes in MySQL Connector/J 5.0.5 (02 March 2007)

Functionality Added or Changed

- Usage Advisor will now issue warnings for result sets with large numbers of rows. You can configure the trigger value by using the `resultSetSizeThreshold` parameter, which has a default value of 100.
- The `rewriteBatchedStatements` feature can now be used with server-side prepared statements.
- **Important change:** Due to a number of issues with the use of server-side prepared statements, Connector/J 5.0.5 has disabled their use by default. The disabling of server-side prepared statements does not affect the operation of the connector in any way.

  To enable server-side prepared statements you must add the following configuration property to your connector string:

  ```
  useServerPrepStmts=true
  ```

  The default value of this property is `false` (that is, Connector/J does not use server-side prepared statements).
- Improved speed of `datetime` parsing for ResultSets that come from plain or nonserver-side prepared statements. You can enable old implementation with `useFastDateParsing=false` as a configuration parameter.
- Usage Advisor now detects empty results sets and does not report on columns not referenced in those empty sets.
- Fixed logging of XA commands sent to server, it is now configurable using `logXaCommands` property (defaults to `false`).
- Added configuration property `localSocketAddress`, which is the host name or IP address given to explicitly configure the interface that the driver will bind the client side of the TCP/IP connection to when connecting.
- We've added a new configuration option `treatUtilDateAsTimestamp`, which is `false` by default, as (1) We already had specific behavior to treat java.util.Date as a java.sql.Timestamp because it is useful to many folks, and (2) that behavior will very likely be required for drivers JDBC-post-4.0.

Bugs Fixed

- Connection property `socketFactory` wasn't exposed using correctly named mutator/accessor, causing data source implementations that use JavaBean naming conventions to set properties to fail to set the property (and in the case of SJAS, fail silently when trying to set this parameter). (Bug #26326)
- A query execution which timed out did not always throw a `MySQLTimeoutException`. (Bug #25836)
- Storing a `java.util.Date` object in a `BLOB` column would not be serialized correctly during `setObject`. (Bug #25787)
- Timer instance used for `Statement.setQueryTimeout()` created per-connection, rather than per-VM, causing memory leak. (Bug #25514)
- `EscapeProcessor` gets confused by multiple backslashes. We now push the responsibility of syntax errors back on to the server for most escape sequences. (Bug #25399)
- `INOUT` parameters in `CallableStatements` get doubly-escaped. (Bug #25379)
- When using the `rewriteBatchedStatements` connection option with `PreparedState.executeBatch()` an in-

ternal memory leak would occur. (Bug #25073)

- Fixed issue where field-level for metadata from `DatabaseMetaData` when using `INFORMATION_SCHEMA` didn't have references to current connections, sometimes leading to Null Pointer Exceptions (NPEs) when introspecting them using `ResultSetMetaData`. (Bug #25073)

- `StringUtils.indexOfIgnoreCaseRespectQuotes()` isn't case-insensitive on the first character of the target. This bug also affected `rewriteBatchedStatements` functionality when prepared statements did not use uppercase for the `VALUES` clause. (Bug #25047)

- Client-side prepared statement parser gets confused by in-line comments `/*...*/` and therefore cannot rewrite batch statements or reliably detect the type of statements when they are used. (Bug #25025)

- Results sets from `UPDATE` statements that are part of multi-statement queries would cause an `SQLException` error, "Result is from UPDATE". (Bug #25009)

- Specifying `US-ASCII` as the character set in a connection to a MySQL 4.1 or newer server does not map correctly. (Bug #24840)

- Using `DatabaseMetaData.getSQLKeywords()` does not return a all of the of the reserved keywords for the current MySQL version. Current implementation returns the list of reserved words for MySQL 5.1, and does not distinguish between versions. (Bug #24794)

- Calling `Statement.cancel()` could result in a Null Pointer Exception (NPE). (Bug #24721)

- Using `setFetchSize()` breaks prepared `SHOW` and other commands. (Bug #24360)

- Calendars and timezones are now lazily instantiated when required. (Bug #24351)

- Using `DATETIME` columns would result in time shifts when `useServerPrepStmts` was true. This occurred due to different behavior when using client-side compared to server-side prepared statements and the `useJDBCCompliantTimezoneShift` option. This is now fixed if moving from server-side prepared statements to client-side prepared statements by setting `useSSPSCompatibleTimezoneShift` to `true`, as the driver can't tell if this is a new deployment that never used server-side prepared statements, or if it is an existing deployment that is switching to client-side prepared statements from server-side prepared statements. (Bug #24344)

- Connector/J now returns a better error message when server doesn't return enough information to determine stored procedure/function parameter types. (Bug #24065)

- A connection error would occur when connecting to a MySQL server with certain character sets. Some collations/character sets reported as "unknown" (specifically `cias` variants of existing character sets), and inability to override the detected server character set. (Bug #23645)

- Inconsistency between `getSchemas` and `INFORMATION_SCHEMA`. (Bug #23304)

- `DatabaseMetaData.getSchemas()` doesn't return a `TABLE_CATALOG` column. (Bug #23303)

- When using a JDBC connection URL that is malformed, the `NonRegisteringDriver.getPropertyInfo` method will throw a Null Pointer Exception (NPE). (Bug #22628)

- Some exceptions thrown out of `StandardSocketFactory` were needlessly wrapped, obscuring their true cause, especially when using socket timeouts. (Bug #21480)

- When using a server-side prepared statement the driver would send timestamps to the server using nanoseconds instead of milliseconds. (Bug #21438)

- When using server-side prepared statements and timestamp columns, value would be incorrectly populated (with nanoseconds, not microseconds). (Bug #21438)

- `ParameterMetaData` throws `NullPointerException` when prepared SQL has a syntax error. Added `generateSimpleParameterMetadata` configuration property, which when set to `true` will generate metadata reflecting `VARCHAR` for every parameter (the default is `false`, which will cause an exception to be thrown if no parameter metadata for the statement is actually available). (Bug #21267)

- Fixed an issue where `XADataSources` couldn't be bound into JNDI, as the `DataSourceFactory` didn't know how to create instances of them.

Other Changes

- Avoid static synchronized code in JVM class libraries for dealing with default timezones.
- Performance enhancement of initial character set configuration, driver will only send commands required to configure connection character set session variables if the current values on the server do not match what is required.
- Re-worked stored procedure parameter parser to be more robust. Driver no longer requires `BEGIN` in stored procedure definition, but does have requirement that if a stored function begins with a label directly after the "returns" clause, that the label is not a quoted identifier.
- Throw exceptions encountered during timeout to thread calling `Statement.execute*()`, rather than `RuntimeException`.
- Changed cached result set metadata (when using `cacheResultSetMetadata=true`) to be cached per-connection rather than per-statement as previously implemented.
- Reverted back to internal character conversion routines for single-byte character sets, as the ones internal to the JVM are using much more CPU time than our internal implementation.
- When extracting foreign key information from `SHOW CREATE TABLE` in `DatabaseMetaData`, ignore exceptions relating to tables being missing (which could happen for cross-reference or imported-key requests, as the list of tables is generated first, then iterated).
- Fixed some Null Pointer Exceptions (NPEs) when cached metadata was used with `UpdatableResultSets`.
- Take `localSocketAddress` property into account when creating instances of `CommunicationsException` when the underlying exception is a `java.net.BindException`, so that a friendlier error message is given with a little internal diagnostics.
- Fixed cases where `ServerPreparedStatements` weren't using cached metadata when `cacheResultSetMetadata=true` was used.
- Use a `java.util.TreeMap` to map column names to ordinal indexes for `ResultSet.findColumn()` instead of a HashMap. This enables us to have case-insensitive lookups (required by the JDBC specification) without resorting to the many transient object instances needed to support this requirement with a normal `HashMap` with either case-adjusted keys, or case-insensitive keys. (In the worst case scenario for lookups of a 1000 column result set, TreeMaps are about half as fast wall-clock time as a HashMap, however in normal applications their use gives many orders of magnitude reduction in transient object instance creation which pays off later for CPU usage in garbage collection).
- When using cached metadata, skip field-level metadata packets coming from the server, rather than reading them and discarding them without creating `com.mysql.jdbc.Field` instances.

D.5.2.5. Changes in MySQL Connector/J 5.0.4 (20 October 2006)

Bugs Fixed

- DBMD.getColumns() does not return expected COLUMN_SIZE for the SET type, now returns length of largest possible set disregarding whitespace or the "," delimitters to be consistent with the ODBC driver. (Bug #22613)
- Added new _ci collations to CharsetMapping - utf8_unicode_ci not working. (Bug #22456)
- Driver was using milliseconds for Statement.setQueryTimeout() when specification says argument is to be in seconds. (Bug #22359)
- Workaround for server crash when calling stored procedures using a server-side prepared statement (driver now detects prepare(stored procedure) and substitutes client-side prepared statement). (Bug #22297)
- Driver issues truncation on write exception when it shouldn't (due to sending big decimal incorrectly to server with server-side prepared statement). (Bug #22290)
- Newlines causing whitespace to span confuse procedure parser when getting parameter metadata for stored procedures. (Bug #22024)
- When using information_schema for metadata, COLUMN_SIZE for getColumns() is not clamped to range of java.lang.Integer as is the case when not using information_schema, thus leading to a truncation exception that isn't present when not using information_schema. (Bug #21544)
- Column names don't match metadata in cases where server doesn't return original column names (column functions) thus breaking compatibility with applications that expect 1-to-1 mappings between `findColumn()` and `rsmd.getColumnName()`, usually manifests itself as "Can't find column ('')" exceptions. (Bug #21379)

- Driver now sends numeric 1 or 0 for client-prepared statement `setBoolean()` calls instead of '1' or '0'.
- Fixed configuration property `jdbcCompliantTruncation` was not being used for reads of result set values.
- DatabaseMetaData correctly reports `true` for `supportsCatalog*()` methods.
- Driver now supports `{call sp}` (without "()" if procedure has no arguments).

D.5.2.6. Changes in MySQL Connector/J 5.0.3 (26 July 2006 beta)

Functionality Added or Changed

- Added configuration option `noAccessToProcedureBodies` which will cause the driver to create basic parameter metadata for `CallableStatements` when the user does not have access to procedure bodies using `SHOW CREATE PROCEDURE` or selecting from `mysql.proc` instead of throwing an exception. The default value for this option is `false`

Bugs Fixed

- Fixed `Statement.cancel()` causes `NullPointerException` if underlying connection has been closed due to server failure. (Bug #20650)
- If the connection to the server has been closed due to a server failure, then the cleanup process will call `Statement.cancel()`, triggering a `NullPointerException`, even though there is no active connection. (Bug #20650)

D.5.2.7. Changes in MySQL Connector/J 5.0.2 (11 July 2006)

Bugs Fixed

- `MysqlXaConnection.recover(int flags)` now permits combinations of `XAResource.TMSTARTRSCAN` and `TMENDRSCAN`. To simulate the “scanning” nature of the interface, we return all prepared XIDs for `TMSTARTRSCAN`, and no new XIDs for calls with `TMNOFLAGS`, or `TMENDRSCAN` when not in combination with `TMSTARTRSCAN`. This change was made for API compliance, as well as integration with IBM WebSphere's transaction manager. (Bug #20242)
- Fixed `MysqlValidConnectionChecker` for JBoss doesn't work with `MySQLXADataSources`. (Bug #20242)
- Added connection/datasource property `pinGlobalTxToPhysicalConnection` (defaults to `false`). When set to `true`, when using `XAConnections`, the driver ensures that operations on a given XID are always routed to the same physical connection. This enables the `XAConnection` to support `XA START ... JOIN` after `XA END` has been called, and is also a workaround for transaction managers that don't maintain thread affinity for a global transaction (most either always maintain thread affinity, or have it as a configuration option). (Bug #20242)
- Better caching of character set converters (per-connection) to remove a bottleneck for multibyte character sets. (Bug #20242)
- Fixed `ConnectionProperties` (and thus some subclasses) are not serializable, even though some J2EE containers expect them to be. (Bug #19169)
- Fixed driver fails on non-ASCII platforms. The driver was assuming that the platform character set would be a superset of MySQL's `latin1` when doing the handshake for authentication, and when reading error messages. We now use Cp1252 for all strings sent to the server during the handshake phase, and a hard-coded mapping of the `language` system variable to the character set that is used for error messages. (Bug #18086)
- Fixed can't use `XAConnection` for local transactions when no global transaction is in progress. (Bug #17401)

D.5.2.8. Changes in MySQL Connector/J 5.0.1 (Not Released)

Not released due to a packaging error

This section has no changelog entries.

D.5.2.9. Changes in MySQL Connector/J 5.0.0 (22 December 2005)

Bugs Fixed

- Added support for Connector/MXJ integration using url subprotocol `jdbc:mysql:mxj://....`. (Bug #14729)
- Idle timeouts cause `XAConnections` to whine about rolling themselves back. (Bug #14729)
- When fix for Bug #14562 was merged from 3.1.12, added functionality for `CallableStatement`'s parameter metadata to return correct information for `.getParameterClassName()`. (Bug #14729)
- Added service-provider entry to `META-INF/services/java.sql.Driver` for JDBC-4.0 support. (Bug #14729)
- Fuller synchronization of `Connection` to avoid deadlocks when using multithreaded frameworks that multithread a single connection (usually not recommended, but the JDBC spec permits it anyways), part of fix to Bug #14972). (Bug #14729)
- Moved all `SQLException` constructor usage to a factory in `SQLError` (ground-work for JDBC-4.0 `SQLState`-based exception classes). (Bug #14729)
- Removed Java5-specific calls to `BigDecimal` constructor (when result set value is `''`, `(int)0` was being used as an argument indirectly using method return value. This signature doesn't exist prior to Java5.) (Bug #14729)
- Implementation of `Statement.cancel()` and `Statement.setQueryTimeout()`. Both require MySQL-5.0.0 or newer server, require a separate connection to issue the `KILL QUERY` statement, and in the case of `setQueryTimeout()` creates an additional thread to handle the timeout functionality.

  Note: Failures to cancel the statement for `setQueryTimeout()` may manifest themselves as `RuntimeExceptions` rather than failing silently, as there is currently no way to unblock the thread that is executing the query being cancelled due to timeout expiration and have it throw the exception instead. (Bug #14729)
- Return "[VAR]BINARY" for `RSMD.getColumnTypeName()` when that is actually the type, and it can be distinguished (MySQL-4.1 and newer). (Bug #14729)
- Attempt detection of the MySQL type `BINARY` (it is an alias, so this isn't always reliable), and use the `java.sql.Types.BINARY` type mapping for it.
- Added unit tests for `XADatasource`, as well as friendlier exceptions for XA failures compared to the "stock" `XAException` (which has no messages).
- If the connection `useTimezone` is set to `true`, then also respect time zone conversions in escape-processed string literals (for example, `"{ts ...}"` and `"{t ...}"`).
- Do not permit `.setAutoCommit(true)`, or `.commit()` or `.rollback()` on an XA-managed connection as per the JDBC specification.
- `XADataSource` implemented (ported from 3.2 branch which won't be released as a product). Use `com.mysql.jdbc.jdbc2.optional.MysqlXADataSource` as your datasource class name in your application server to utilize XA transactions in MySQL-5.0.10 and newer.
- Moved `-bin-g.jar` file into separate `debug` subdirectory to avoid confusion.
- Return original column name for `RSMD.getColumnName()` if the column was aliased, alias name for `.getColumnLabel()` (if aliased), and original table name for `.getTableName()`. Note this only works for MySQL-4.1 and newer, as older servers don't make this information available to clients.
- Setting `useJDBCCompliantTimezoneShift=true` (it is not the default) causes the driver to use GMT for *all* `TIMESTAMP`/`DATETIME` time zones, and the current VM time zone for any other type that refers to time zones. This feature can not be used when `useTimezone=true` to convert between server and client time zones.
- `PreparedStatement.setString()` didn't work correctly when `sql_mode` on server contained `NO_BACKSLASH_ESCAPES` and no characters that needed escaping were present in the string.
- Add one level of indirection of internal representation of `CallableStatement` parameter metadata to avoid class not found issues on JDK-1.3 for `ParameterMetadata` interface (which doesn't exist prior to JDBC-3.0).

D.5.3. Changes in MySQL Connector/J 3.1.x

D.5.3.1. Changes in MySQL Connector/J 3.1.15 (Not yet released)

Important change: Due to a number of issues with the use of server-side prepared statements, Connector/J 5.0.5 has disabled their use by default. The disabling of server-side prepared statements does not affect the operation of the connector in any way.

To enable server-side prepared statements you must add the following configuration property to your connector string:

```
useServerPrepStmts=true
```

The default value of this property is `false` (that is, Connector/J does not use server-side prepared statements).

Bugs Fixed

- Specifying `US-ASCII` as the character set in a connection to a MySQL 4.1 or newer server does not map correctly. (Bug #24840)

D.5.3.2. Changes in MySQL Connector/J 3.1.14 (19 October 2006)

Bugs Fixed

- Check and store value for continueBatchOnError property in constructor of Statements, rather than when executing batches, so that Connections closed out from underneath statements don't cause NullPointerExceptions when it is required to check this property. (Bug #22290)
- Driver now sends numeric 1 or 0 for client-prepared statement setBoolean() calls instead of '1' or '0'. (Bug #22290)
- Fixed bug where driver would not advance to next host if roundRobinLoadBalance=true and the last host in the list is down. (Bug #22290)
- Driver issues truncation on write exception when it shouldn't (due to sending big decimal incorrectly to server with server-side prepared statement). (Bug #22290)
- Fixed bug when calling stored functions, where parameters weren't numbered correctly (first parameter is now the return value, subsequent parameters if specified start at index "2"). (Bug #22290)
- Removed logger autodetection altogether, must now specify logger explicitly if you want to use a logger other than one that logs to STDERR. (Bug #21207)
- DDriver throws NPE when tracing prepared statements that have been closed (in asSQL()). (Bug #21207)
- ResultSet.getSomeInteger() doesn't work for BIT(>1). (Bug #21062)
- Escape of quotation marks in client-side prepared statements parsing not respected. Patch covers more than bug report, including NO_BACKSLASH_ESCAPES being set, and stacked quote characters forms of escaping (that is, '' or ""). (Bug #20888)
- Fixed can't pool server-side prepared statements, exception raised when re-using them. (Bug #20687)
- Fixed Updatable result set that contains a BIT column fails when server-side prepared statements are used. (Bug #20485)
- Fixed updatable result set throws ClassCastException when there is row data and moveToInsertRow() is called. (Bug #20479)
- Fixed ResultSet.getShort() for UNSIGNED TINYINT returns incorrect values when using server-side prepared statements. (Bug #20306)
- ReplicationDriver does not always round-robin load balance depending on URL used for slaves list. (Bug #19993)
- Fixed calling toString() on ResultSetMetaData for driver-generated (that is, from DatabaseMetaData method calls, or from getGeneratedKeys()) result sets would raise a NullPointerException. (Bug #19993)
- Connection fails to localhost when using timeout and IPv6 is configured. (Bug #19726)
- ResultSet.getFloatFromString() can't retrieve values near Float.MIN/MAX_VALUE. (Bug #18880)
- `DatabaseMetaData.getTables()` or `getColumns()` with a bad catalog parameter threw an exception rather than return an empty result set (as required by the specification). (Bug #18258)
- Fixed memory leak with profileSQL=true. (Bug #16987)
- Fixed NullPointerException in MysqlDataSourceFactory due to Reference containing RefAddrs with null content. (Bug #16791)

D.5.3.3. Changes in MySQL Connector/J 3.1.13 (26 May 2006)

Bugs Fixed

- `Fixed PreparedStatement.setObject(int, Object, int)` doesn't respect scale of BigDecimals. (Bug #19615)
- Fixed `ResultSet.wasNull()` returns incorrect value when extracting native string from server-side prepared statement generated result set. (Bug #19282)
- Fixed invalid classname returned for `ResultSetMetaData.getColumnClassName()` for `BIGINT type`. (Bug #19282)
- Fixed case where driver wasn't reading server status correctly when fetching server-side prepared statement rows, which in some cases could cause warning counts to be off, or multiple result sets to not be read off the wire. (Bug #19282)
- Fixed data truncation and `getWarnings()` only returns last warning in set. (Bug #18740)
- Fixed aliased column names where length of name > 251 are corrupted. (Bug #18554)
- Improved performance of retrieving `BigDecimal`, `Time`, `Timestamp` and `Date` values from server-side prepared statements by creating fewer short-lived instances of `Strings` when the native type is not an exact match for the requested type. (Bug #18496)
- Added performance feature, re-writing of batched executes for `Statement.executeBatch()` (for all DML statements) and `PreparedStatement.executeBatch()` (for INSERTs with VALUE clauses only). Enable by using "rewriteBatchedStatements=true" in your JDBC URL. (Bug #18041)
- Fixed issue where server-side prepared statements don't cause truncation exceptions to be thrown when truncation happens. (Bug #18041)
- Fixed `CallableStatement.registerOutParameter()` not working when some parameters pre-populated. Still waiting for feedback from JDBC experts group to determine what correct parameter count from `getMetaData()` should be, however. (Bug #17898)
- Fixed calling `clearParameters()` on a closed prepared statement causes NPE. (Bug #17587)
- Map "latin1" on MySQL server to CP1252 for MySQL > 4.1.0. (Bug #17587)
- Added additional accessor and mutator methods on ConnectionProperties so that DataSource users can use same naming as regular URL properties. (Bug #17587)
- Fixed `ResultSet.wasNull()` not always reset correctly for booleans when done using conversion for server-side prepared statements. (Bug #17450)
- Fixed `Statement.getGeneratedKeys()` throws `NullPointerException` when no query has been processed. (Bug #17099)
- Fixed updatable result set doesn't return `AUTO_INCREMENT` values for `insertRow()` when multiple column primary keys are used. (the driver was checking for the existence of single-column primary keys and an autoincrement value > 0 instead of a straightforward `isAutoIncrement()` check). (Bug #16841)
- `DBMD.getColumns()` returns wrong type for `BIT`. (Bug #15854)
- `lib-nodist` directory missing from package breaks out-of-box build. (Bug #15676)
- Fixed issue with `ReplicationConnection` incorrectly copying state, doesn't transfer connection context correctly when transitioning between the same read-only states. (Bug #15570)
- No "dos" character set in MySQL > 4.1.0. (Bug #15544)
- `INOUT` parameter does not store `IN` value. (Bug #15464)
- `PreparedStatement.setObject()` serializes `BigInteger` as object, rather than sending as numeric value (and is thus not complementary to `.getObject()` on an `UNSIGNED LONG` type). (Bug #15383)
- Fixed issue where driver was unable to initialize character set mapping tables. Removed reliance on `.properties` files to hold this information, as it turns out to be too problematic to code around class loader hierarchies that change depending on how an application is deployed. Moved information back into the `CharsetMapping` class. (Bug #14938)
- Exception thrown for new decimal type when using updatable result sets. (Bug #14609)
- Driver now aware of fix for `BIT` type metadata that went into MySQL-5.0.21 for server not reporting length consistently . (Bug #13601)

- Added support for Apache Commons logging, use "com.mysql.jdbc.log.CommonsLogger" as the value for the "logger" configuration property. (Bug #13469)
- Fixed driver trying to call methods that don't exist on older and newer versions of Log4j. The fix is not trying to auto-detect presence of log4j, too many different incompatible versions out there in the wild to do this reliably.

  If you relied on autodetection before, you will need to add "logger=com.mysql.jdbc.log.Log4JLogger" to your JDBC URL to enable Log4J usage, or alternatively use the new "CommonsLogger" class to take care of this. (Bug #13469)
- LogFactory now prepends `com.mysql.jdbc.log` to the log class name if it cannot be found as specified. This enables you to use “short names” for the built-in log factories, for example, `logger=CommonsLogger` instead of `logger=com.mysql.jdbc.log.CommonsLogger`. (Bug #13469)
- `ResultSet.getShort()` for `UNSIGNED TINYINT` returned wrong values. (Bug #11874)

D.5.3.4. Changes in MySQL Connector/J 3.1.12 (30 November 2005)

Bugs Fixed

- Process escape tokens in `Connection.prepareStatement(...)`. You can disable this behavior by setting the JDBC URL configuration property `processEscapeCodesForPrepStmts` to `false`. (Bug #15141)
- Usage advisor complains about unreferenced columns, even though they've been referenced. (Bug #15065)
- Driver incorrectly closes streams passed as arguments to `PreparedStatements`. Reverts to legacy behavior by setting the JDBC configuration property `autoClosePStmtStreams` to `true` (also included in the 3-0-Compat configuration “bundle”). (Bug #15024)
- Deadlock while closing server-side prepared statements from multiple threads sharing one connection. (Bug #14972)
- Unable to initialize character set mapping tables (due to J2EE classloader differences). (Bug #14938)
- Escape processor replaces quote character in quoted string with string delimiter. (Bug #14909)
- `DatabaseMetaData.getColumns()` doesn't return `TABLE_NAME` correctly. (Bug #14815)
- `storesMixedCaseIdentifiers()` returns `false` (Bug #14562)
- `storesLowerCaseIdentifiers()` returns `true` (Bug #14562)
- `storesMixedCaseQuotedIdentifiers()` returns `false` (Bug #14562)
- `storesMixedCaseQuotedIdentifiers()` returns `true` (Bug #14562)
- If `lower_case_table_names=0` (on server):
  - `storesLowerCaseIdentifiers()` returns `false`
  - `storesLowerCaseQuotedIdentifiers()` returns `false`
  - `storesMixedCaseIdentifiers()` returns `true`
  - `storesMixedCaseQuotedIdentifiers()` returns `true`
  - `storesUpperCaseIdentifiers()` returns `false`
  - `storesUpperCaseQuotedIdentifiers()` returns `true`

  (Bug #14562)
- `storesUpperCaseIdentifiers()` returns `false` (Bug #14562)
- `storesUpperCaseQuotedIdentifiers()` returns `true` (Bug #14562)
- If `lower_case_table_names=1` (on server):
  - `storesLowerCaseIdentifiers()` returns `true`
  - `storesLowerCaseQuotedIdentifiers()` returns `true`

  - `storesMixedCaseIdentifiers()` returns `false`
  - `storesMixedCaseQuotedIdentifiers()` returns `false`
  - `storesUpperCaseIdentifiers()` returns `false`
  - `storesUpperCaseQuotedIdentifiers()` returns `true`

  (Bug #14562)

- `storesLowerCaseQuotedIdentifiers()` returns `true` (Bug #14562)
- Fixed `DatabaseMetaData.stores*Identifiers()`:
  - If `lower_case_table_names=0` (on server):
    - `storesLowerCaseIdentifiers()` returns `false`
    - `storesLowerCaseQuotedIdentifiers()` returns `false`
    - `storesMixedCaseIdentifiers()` returns `true`
    - `storesMixedCaseQuotedIdentifiers()` returns `true`
    - `storesUpperCaseIdentifiers()` returns `false`
    - `storesUpperCaseQuotedIdentifiers()` returns `true`
  - If `lower_case_table_names=1` (on server):
    - `storesLowerCaseIdentifiers()` returns `true`
    - `storesLowerCaseQuotedIdentifiers()` returns `true`
    - `storesMixedCaseIdentifiers()` returns `false`
    - `storesMixedCaseQuotedIdentifiers()` returns `false`
    - `storesUpperCaseIdentifiers()` returns `false`
    - `storesUpperCaseQuotedIdentifiers()` returns `true`

  (Bug #14562)

- `storesMixedCaseIdentifiers()` returns `true` (Bug #14562)
- `storesLowerCaseQuotedIdentifiers()` returns `false` (Bug #14562)
- Java type conversion may be incorrect for `MEDIUMINT`. (Bug #14562)
- `storesLowerCaseIdentifiers()` returns `false` (Bug #14562)
- Added configuration property `useGmtMillisForDatetimes` which when set to `true` causes `ResultSet.getDate()`, `.getTimestamp()` to return correct millis-since GMT when `.getTime()` is called on the return value (currently default is `false` for legacy behavior). (Bug #14562)
- Extraneous sleep on `autoReconnect`. (Bug #13775)
- Reconnect during middle of `executeBatch()` should not occur if `autoReconnect` is enabled. (Bug #13255)
- `maxQuerySizeToLog` is not respected. Added logging of bound values for `execute()` phase of server-side prepared statements when `profileSQL=true` as well. (Bug #13048)
- OpenOffice expects `DBMD.supportsIntegrityEnhancementFacility()` to return `true` if foreign keys are supported by the datasource, even though this method also covers support for check constraints, which MySQL *doesn't* have. Setting the configuration property `overrideSupportsIntegrityEnhancementFacility` to `true` causes the driver to return `true` for this method. (Bug #12975)
- Added `com.mysql.jdbc.testsuite.url.default` system property to set default JDBC url for testsuite (to speed up bug resolution when I'm working in Eclipse). (Bug #12975)

- `logSlowQueries` should give better info. (Bug #12230)
- Don't increase timeout for failover/reconnect. (Bug #6577)
- Fixed client-side prepared statement bug with embedded `?` characters inside quoted identifiers (it was recognized as a placeholder, when it was not).
- Do not permit `executeBatch()` for `CallableStatements` with registered `OUT`/`INOUT` parameters (JDBC compliance).
- Fall back to platform-encoding for `URLDecoder.decode()` when parsing driver URL properties if the platform doesn't have a two-argument version of this method.

D.5.3.5. Changes in MySQL Connector/J 3.1.11 (07 October 2005)

Bugs Fixed

- The configuration property `sessionVariables` now permits you to specify variables that start with the “`@`” sign. (Bug #13453)
- URL configuration parameters do not permit “`&`” or “`=`” in their values. The JDBC driver now parses configuration parameters as if they are encoded using the application/x-www-form-urlencoded format as specified by `java.net.URLDecoder` (http://java.sun.com/j2se/1.5.0/docs/api/java/net/URLDecoder.html).

  If the “`%`” character is present in a configuration property, it must now be represented as `%25`, which is the encoded form of “`%`” when using application/x-www-form-urlencoded encoding. (Bug #13453)
- Workaround for Bug #13374: `ResultSet.getStatement()` on closed result set returns `NULL` (as per JDBC 4.0 spec, but not backward-compatible). Set the connection property `retainStatementAfterResultSetClose` to `true` to be able to retrieve a `ResultSet`'s statement after the `ResultSet` has been closed using `.getStatement()` (the default is `false`, to be JDBC-compliant and to reduce the chance that code using JDBC leaks `Statement` instances). (Bug #13277)
- `ResultSetMetaData` from `Statement.getGeneratedKeys()` caused a `NullPointerException` to be thrown whenever a method that required a connection reference was called. (Bug #13277)
- Backport of `VAR[BINARY|CHAR] [BINARY]` types detection from 5.0 branch. (Bug #13277)
- Fixed `NullPointerException` when converting `catalog` parameter in many `DatabaseMetaDataMethods` to `byte[]`s (for the result set) when the parameter is `null`. (`null` is not technically permitted by the JDBC specification, but we have historically permitted it). (Bug #13277)
- Backport of `Field` class, `ResultSetMetaData.getColumnClassName()`, and `ResultSet.getObject(int)` changes from 5.0 branch to fix behavior surrounding `VARCHAR BINARY`/`VARBINARY` and related types. (Bug #13277)
- Read response in `MysqlIO.sendFileToServer()`, even if the local file can't be opened, otherwise next query issued will fail, because it is reading the response to the empty `LOAD DATA INFILE` packet sent to the server. (Bug #13277)
- When `gatherPerfMetrics` is enabled for servers older than 4.1.0, a `NullPointerException` is thrown from the constructor of `ResultSet` if the query doesn't use any tables. (Bug #13043)
- `java.sql.Types.OTHER` returned for `BINARY` and `VARBINARY` columns when using `DatabaseMetaData.getColumns()`. (Bug #12970)
- `ServerPreparedStatement.getBinding()` now checks if the statement is closed before attempting to reference the list of parameter bindings, to avoid throwing a `NullPointerException`. (Bug #12970)
- Tokenizer for `=` in URL properties was causing `sessionVariables=....` to be parameterized incorrectly. (Bug #12753)
- `cp1251` incorrectly mapped to `win1251` for servers newer than 4.0.x. (Bug #12752)
- `getExportedKeys()` (Bug #12541)
- Specifying a catalog works as stated in the API docs. (Bug #12541)
- Specifying `NULL` means that catalog will not be used to filter the results (thus all databases will be searched), unless you've set `nullCatalogMeansCurrent=true` in your JDBC URL properties. (Bug #12541)
- `getIndexInfo()` (Bug #12541)

- `getProcedures()` (and thus indirectly `getProcedureColumns()`) (Bug #12541)
- `getImportedKeys()` (Bug #12541)
- Specifying `""` means “current” catalog, even though this isn't quite JDBC spec compliant, it is there for legacy users. (Bug #12541)
- `getCrossReference()` (Bug #12541)
- Added `Connection.isMasterConnection()` for clients to be able to determine if a multi-host master/slave connection is connected to the first host in the list. (Bug #12541)
- `getColumns()` (Bug #12541)
- Handling of catalog argument in `DatabaseMetaData.getIndexInfo()`, which also means changes to the following methods in `DatabaseMetaData`:
  - `getBestRowIdentifier()`
  - `getColumns()`
  - `getCrossReference()`
  - `getExportedKeys()`
  - `getImportedKeys()`
  - `getIndexInfo()`
  - `getPrimaryKeys()`
  - `getProcedures()` (and thus indirectly `getProcedureColumns()`)
  - `getTables()`

  The `catalog` argument in all of these methods now behaves in the following way:

  - Specifying `NULL` means that catalog will not be used to filter the results (thus all databases will be searched), unless you've set `nullCatalogMeansCurrent=true` in your JDBC URL properties.
  - Specifying `""` means “current” catalog, even though this isn't quite JDBC spec compliant, it is there for legacy users.
  - Specifying a catalog works as stated in the API docs.
  - Made `Connection.clientPrepare()` available from “wrapped” connections in the `jdbc2.optional` package (connections built by `ConnectionPoolDataSource` instances).

  (Bug #12541)
- `getBestRowIdentifier()` (Bug #12541)
- Made `Connection.clientPrepare()` available from “wrapped” connections in the `jdbc2.optional` package (connections built by `ConnectionPoolDataSource` instances). (Bug #12541)
- `getTables()` (Bug #12541)
- `getPrimaryKeys()` (Bug #12541)
- `Connection.prepareCall()` is database name case-sensitive (on Windows systems). (Bug #12417)
- `explainSlowQueries` hangs with server-side prepared statements. (Bug #12229)
- Properties shared between master and slave with replication connection. (Bug #12218)
- Geometry types not handled with server-side prepared statements. (Bug #12104)
- `maxPerformance.properties` mis-spells “elideSetAutoCommits”. (Bug #11976)
- `ReplicationConnection` won't switch to slave, throws “Catalog can't be null” exception. (Bug #11879)
- `Pstmt.setObject(...., Types.BOOLEAN)` throws exception. (Bug #11798)

- Escape tokenizer doesn't respect stacked single quotation marks for escapes. (Bug #11797)
- `GEOMETRY` type not recognized when using server-side prepared statements. (Bug #11797)
- Foreign key information that is quoted is parsed incorrectly when `DatabaseMetaData` methods use that information. (Bug #11781)
- The `sendBlobChunkSize` property is now clamped to `max_allowed_packet` with consideration of stream buffer size and packet headers to avoid `PacketTooBigExceptions` when `max_allowed_packet` is similar in size to the default `sendBlobChunkSize` which is 1M. (Bug #11781)
- `CallableStatement.clearParameters()` now clears resources associated with `INOUT`/`OUTPUT` parameters as well as `INPUT` parameters. (Bug #11781)
- Fixed regression caused by fix for Bug #11552 that caused driver to return incorrect values for unsigned integers when those integers where within the range of the positive signed type. (Bug #11663)
- Moved source code to Subversion repository. (Bug #11663)
- Incorrect generation of testcase scripts for server-side prepared statements. (Bug #11663)
- Fixed statements generated for testcases missing `;` for “plain” statements. (Bug #11629)
- Spurious `!` on console when character encoding is `utf8`. (Bug #11629)
- `StringUtils.getBytes()` doesn't work when using multi-byte character encodings and a length in *characters* is specified. (Bug #11614)
- `DBMD.storesLower/Mixed/UpperIdentifiers()` reports incorrect values for servers deployed on Windows. (Bug #11575)
- Reworked `Field` class, `*Buffer`, and `MysqlIO` to be aware of field lengths > `Integer.MAX_VALUE`. (Bug #11498)
- Escape processor didn't honor strings demarcated with double quotation marks. (Bug #11498)
- Updated `DBMD.supportsCorrelatedQueries()` to return `true` for versions > 4.1, `supportsGroupByUnrelated()` to return `true` and `getResultSetHoldability()` to return `HOLD_CURSORS_OVER_COMMIT`. (Bug #11498)
- Lifted restriction of changing streaming parameters with server-side prepared statements. As long as `all` streaming parameters were set before execution, `.clearParameters()` does not have to be called. (due to limitation of client/server protocol, prepared statements can not reset *individual* stream data on the server side). (Bug #11498)
- `ResultSet.moveToCurrentRow()` fails to work when preceded by a call to `ResultSet.moveToInsertRow()`. (Bug #11190)
- `VARBINARY` data corrupted when using server-side prepared statements and `.setBytes()`. (Bug #11115)
- `Statement.getWarnings()` fails with NPE if statement has been closed. (Bug #10630)
- Only get `char[]` from SQL in `PreparedStatement.ParseInfo()` when needed. (Bug #10630)

D.5.3.6. Changes in MySQL Connector/J 3.1.10 (23 June 2005)

Bugs Fixed

- Initial implemention of `ParameterMetadata` for `PreparedStatement.getParameterMetadata()`. Only works fully for `CallableStatements`, as current server-side prepared statements return every parameter as a `VARCHAR` type.
- Fixed connecting without a database specified raised an exception in `MysqlIO.changeDatabaseTo()`.

D.5.3.7. Changes in MySQL Connector/J 3.1.9 (22 June 2005)

Bugs Fixed

- Production package doesn't include JBoss integration classes. (Bug #11411)

- Removed nonsensical “costly type conversion” warnings when using usage advisor. (Bug #11411)
- Fixed `PreparedStatement.setClob()` not accepting `null` as a parameter. (Bug #11360)
- Connector/J dumping query into `SQLException` twice. (Bug #11360)
- `autoReconnect` ping causes exception on connection startup. (Bug #11259)
- `Connection.setCatalog()` is now aware of the `useLocalSessionState` configuration property, which when set to `true` will prevent the driver from sending `USE ...` to the server if the requested catalog is the same as the current catalog. (Bug #11115)
- `3-0-Compat`: Compatibility with Connector/J 3.0.x functionality (Bug #11115)
- `maxPerformance`: Maximum performance without being reckless (Bug #11115)
- `solarisMaxPerformance`: Maximum performance for Solaris, avoids syscalls where it can (Bug #11115)
- Added `maintainTimeStats` configuration property (defaults to `true`), which tells the driver whether or not to keep track of the last query time and the last successful packet sent to the server's time. If set to `false`, removes two syscalls per query. (Bug #11115)
- `VARBINARY` data corrupted when using server-side prepared statements and `ResultSet.getBytes()`. (Bug #11115)
- Added the following configuration bundles, use one or many using the `useConfigs` configuration property:

  - `maxPerformance`: Maximum performance without being reckless
  - `solarisMaxPerformance`: Maximum performance for Solaris, avoids syscalls where it can
  - `3-0-Compat`: Compatibility with Connector/J 3.0.x functionality

  (Bug #11115)
- Try to handle `OutOfMemoryErrors` more gracefully. Although not much can be done, they will in most cases close the connection they happened on so that further operations don't run into a connection in some unknown state. When an OOM has happened, any further operations on the connection will fail with a “Connection closed” exception that will also list the OOM exception as the reason for the implicit connection close event. (Bug #10850)
- Setting `cachePrepStmts=true` now causes the `Connection` to also cache the check the driver performs to determine if a prepared statement can be server-side or not, as well as caches server-side prepared statements for the lifetime of a connection. As before, the `prepStmtCacheSize` parameter controls the size of these caches. (Bug #10850)
- Don't send `COM_RESET_STMT` for each execution of a server-side prepared statement if it isn't required. (Bug #10850)
- 0-length streams not sent to server when using server-side prepared statements. (Bug #10850)
- Driver detects if you're running MySQL-5.0.7 or later, and does not scan for `LIMIT ?[,?]` in statements being prepared, as the server supports those types of queries now. (Bug #10850)
- Reorganized directory layout. Sources now are in `src` folder. Don't pollute parent directory when building, now output goes to `./build`, distribution goes to `./dist`. (Bug #10496)
- Added support/bug hunting feature that generates `.sql` test scripts to `STDERR` when `autoGenerateTestcaseScript` is set to `true`. (Bug #10496)
- `SQLException` is thrown when using property `characterSetResults` with `cp932` or `eucjpms`. (Bug #10496)
- The data type returned for `TINYINT(1)` columns when `tinyInt1isBit=true` (the default) can be switched between `Types.BOOLEAN` and `Types.BIT` using the new configuration property `transformedBitIsBoolean`, which defaults to `false`. If set to `false` (the default), `DatabaseMetaData.getColumns()` and `ResultSetMetaData.getColumnType()` will return `Types.BOOLEAN` for `TINYINT(1)` columns. If `true`, `Types.BOOLEAN` will be returned instead. Regardless of this configuration property, if `tinyInt1isBit` is enabled, columns with the type `TINYINT(1)` will be returned as `java.lang.Boolean` instances from `ResultSet.getObject(...)`, and `ResultSetMetaData.getColumnClassName()` will return `java.lang.Boolean`. (Bug #10485)
- `SQLException` thrown when retrieving `YEAR(2)` with `ResultSet.getString()`. The driver will now always treat `YEAR` types as `java.sql.Dates` and return the correct values for `getString()`. Alternatively, the `yearIsDateType` connection property can be set to `false` and the values will be treated as `SHORT`s. (Bug #10485)
- Driver doesn't support `{?=CALL(...)}` for calling stored functions. This involved adding support for function retrieval to

`DatabaseMetaData.getProcedures()` and `getProcedureColumns()` as well. (Bug #10310)

- Unsigned `SMALLINT` treated as signed for `ResultSet.getInt()`, fixed all cases for `UNSIGNED` integer values and server-side prepared statements, as well as `ResultSet.getObject()` for `UNSIGNED TINYINT`. (Bug #10156)
- Made `ServerPreparedStatement.asSql()` work correctly so auto-explain functionality would work with server-side prepared statements. (Bug #10155)
- Double quotation marks not recognized when parsing client-side prepared statements. (Bug #10155)
- Made JDBC2-compliant wrappers public to enable access to vendor extensions. (Bug #10155)
- `DatabaseMetaData.supportsMultipleOpenResults()` now returns `true`. The driver has supported this for some time, DBMD just missed that fact. (Bug #10155)
- Cleaned up logging of profiler events, moved code to dump a profiler event as a string to `com.mysql.jdbc.log.LogUtils` so that third parties can use it. (Bug #10155)
- Made `enableStreamingResults()` visible on `com.mysql.jdbc.jdbc2.optional.StatementWrapper`. (Bug #10155)
- Actually write manifest file to correct place so it ends up in the binary jar file. (Bug #10144)
- Added `createDatabaseIfNotExist` property (default is `false`), which will cause the driver to ask the server to create the database specified in the URL if it doesn't exist. You must have the appropriate privileges for database creation for this to work. (Bug #10144)
- Memory leak in `ServerPreparedStatement` if `serverPrepare()` fails. (Bug #10144)
- `com.mysql.jdbc.PreparedStatement.ParseInfo` does unnecessary call to `toCharArray()`. (Bug #9064)
- Driver now correctly uses CP932 if available on the server for Windows-31J, CP932 and MS932 java encoding names, otherwise it resorts to SJIS, which is only a close approximation. Currently only MySQL-5.0.3 and newer (and MySQL-4.1.12 or .13, depending on when the character set gets backported) can reliably support any variant of CP932.
- Overhaul of character set configuration, everything now lives in a properties file.

D.5.3.8. Changes in MySQL Connector/J 3.1.8 (14 April 2005)

Bugs Fixed

- Should accept `null` for catalog (meaning use current) in DBMD methods, even though it is not JDBC-compliant for legacy's sake. Disable by setting connection property `nullCatalogMeansCurrent` to `false` (which will be the default value in C/J 3.2.x). (Bug #9917)
- Fixed driver not returning `true` for `-1` when `ResultSet.getBoolean()` was called on result sets returned from server-side prepared statements. (Bug #9778)
- Added a `Manifest.MF` file with implementation information to the `.jar` file. (Bug #9778)
- More tests in `Field.isOpaqueBinary()` to distinguish opaque binary (that is, fields with type `CHAR(n)` and `CHARACTER SET BINARY`) from output of various scalar and aggregate functions that return strings. (Bug #9778)
- `DBMD.getTables()` shouldn't return tables if views are asked for, even if the database version doesn't support views. (Bug #9778)
- Should accept `null` for name patterns in DBMD (meaning “`%`”), even though it isn't JDBC compliant, for legacy's sake. Disable by setting connection property `nullNamePatternMatchesAll` to `false` (which will be the default value in C/J 3.2.x). (Bug #9769)
- The performance metrics feature now gathers information about number of tables referenced in a SELECT. (Bug #9704)
- The logging system is now automatically configured. If the value has been set by the user, using the URL property `logger` or the system property `com.mysql.jdbc.logger`, then use that, otherwise, autodetect it using the following steps:

  1. Log4j, if it is available,
  2. Then JDK1.4 logging,

3. Then fallback to our `STDERR` logging.

(Bug #9704)

- `Statement.getMoreResults()` could throw NPE when existing result set was `.close()`d. (Bug #9704)
- Stored procedures with `DECIMAL` parameters with storage specifications that contained “`,`” in them would fail. (Bug #9682)
- `PreparedStatement.setObject(int, Object, int type, int scale)` now uses scale value for `BigDecimal` instances. (Bug #9682)
- Added support for the c3p0 connection pool's (http://c3p0.sf.net/) validation/connection checker interface which uses the lightweight `COM_PING` call to the server if available. To use it, configure your c3p0 connection pool's `connectionTesterClassName` property to use `com.mysql.jdbc.integration.c3p0.MysqlConnectionTester`. (Bug #9320)
- `PreparedStatement.getMetaData()` inserts blank row in database under certain conditions when not using server-side prepared statements. (Bug #9320)
- Better detection of `LIMIT` inside/outside of quoted strings so that the driver can more correctly determine whether a prepared statement can be prepared on the server or not. (Bug #9320)
- `Connection.canHandleAsPreparedStatement()` now makes “best effort” to distinguish `LIMIT` clauses with placeholders in them from ones without to have fewer false positives when generating work-arounds for statements the server cannot currently handle as server-side prepared statements. (Bug #9320)
- Fixed `build.xml` to not compile `log4j` logging if `log4j` not available. (Bug #9320)
- Added finalizers to `ResultSet` and `Statement` implementations to be JDBC spec-compliant, which requires that if not explicitly closed, these resources should be closed upon garbage collection. (Bug #9319)
- Stored procedures with same name in different databases confuse the driver when it tries to determine parameter counts/types. (Bug #9319)
- A continuation of Bug #8868, where functions used in queries that should return nonstring types when resolved by temporary tables suddenly become opaque binary strings (work-around for server limitation). Also fixed fields with type of `CHAR(n) CHARACTER SET BINARY` to return correct/matching classes for `RSMD.getColumnClassName()` and `ResultSet.getObject()`. (Bug #9236)
- Cannot use `UTF-8` for characterSetResults configuration property. (Bug #9206)
- `PreparedStatement.addBatch()` doesn't work with server-side prepared statements and streaming `BINARY` data. (Bug #9040)
- `ServerPreparedStatements` now correctly “stream” `BLOB`/`CLOB` data to the server. You can configure the threshold chunk size using the JDBC URL property `blobSendChunkSize` (the default is 1MB). (Bug #8868)
- `DATE_FORMAT()` queries returned as `BLOB`s from `getObject()`. (Bug #8868)
- Server-side session variables can be preset at connection time by passing them as a comma-delimited list for the connection property `sessionVariables`. (Bug #8868)
- `BlobFromLocator` now uses correct identifier quoting when generating prepared statements. (Bug #8868)
- Fixed regression in `ping()` for users using `autoReconnect=true`. (Bug #8868)
- Check for empty strings (`''`) when converting `CHAR`/`VARCHAR` column data to numbers, throw exception if `emptyStringsConvertToZero` configuration property is set to `false` (for backward-compatibility with 3.0, it is now set to `true` by default, but will most likely default to `false` in 3.2). (Bug #8803)
- `DATA_TYPE` column from `DBMD.getBestRowIdentifier()` causes `ArrayIndexOutOfBoundsException` when accessed (and in fact, didn't return any value). (Bug #8803)
- `DBMD.supportsMixedCase*Identifiers()` returns wrong value on servers running on case-sensitive file systems. (Bug #8800)
- `DBMD.supportsResultSetConcurrency()` not returning `true` for forward-only/read-only result sets (we obviously support this). (Bug #8792)
- Fixed `ResultSet.getTime()` on a `NULL` value for server-side prepared statements throws NPE.

- Made `Connection.ping()` a public method.
- Added support for new precision-math `DECIMAL` type in MySQL 5.0.3 and up.
- Fixed `DatabaseMetaData.getTables()` returning views when they were not asked for as one of the requested table types.

D.5.3.9. Changes in MySQL Connector/J 3.1.7 (18 February 2005)

Bugs Fixed

- `PreparedStatements` not creating streaming result sets. (Bug #8487)
- Don't pass `NULL` to `String.valueOf()` in `ResultSet.getNativeConvertToString()`, as it stringifies it (that is, returns `null`), which is not correct for the method in question. (Bug #8487)
- Fixed NPE in `ResultSet.realClose()` when using usage advisor and result set was already closed. (Bug #8428)
- `ResultSet.getString()` doesn't maintain format stored on server, bug fix only enabled when `noDatetimeStringSync` property is set to `true` (the default is `false`). (Bug #8428)
- Added support for `BIT` type in MySQL-5.0.3. The driver will treat `BIT(1-8)` as the JDBC standard `BIT` type (which maps to `java.lang.Boolean`), as the server does not currently send enough information to determine the size of a bitfield when < 9 bits are declared. `BIT(>9)` will be treated as `VARBINARY`, and will return `byte[]` when `getObject()` is called. (Bug #8424)
- Added `useLocalSessionState` configuration property, when set to `true` the JDBC driver trusts that the application is well-behaved and only sets autocommit and transaction isolation levels using the methods provided on `java.sql.Connection`, and therefore can manipulate these values in many cases without incurring round-trips to the database server. (Bug #8424)
- Added `enableStreamingResults()` to `Statement` for connection pool implementations that check `Statement.setFetchSize()` for specification-compliant values. Call `Statement.setFetchSize(>=0)` to disable the streaming results for that statement. (Bug #8424)
- `ResultSet.getBigDecimal()` throws exception when rounding would need to occur to set scale. The driver now chooses a rounding mode of “half up” if nonrounding `BigDecimal.setScale()` fails. (Bug #8424)
- Fixed synchronization issue with `ServerPreparedStatement.serverPrepare()` that could cause deadlocks/crashes if connection was shared between threads. (Bug #8096)
- Emulated locators corrupt binary data when using server-side prepared statements. (Bug #8096)
- Infinite recursion when “falling back” to master in failover configuration. (Bug #7952)
- Disable multi-statements (if enabled) for MySQL-4.1 versions prior to version 4.1.10 if the query cache is enabled, as the server returns wrong results in this configuration. (Bug #7952)
- Removed `dontUnpackBinaryResults` functionality, the driver now always stores results from server-side prepared statements as is from the server and unpacks them on demand. (Bug #7952)
- Fixed duplicated code in `configureClientCharset()` that prevented `useOldUTF8Behavior=true` from working properly. (Bug #7952)
- Added `holdResultsOpenOverStatementClose` property (default is `false`), that keeps result sets open over statement.close() or new execution on same statement (suggested by Kevin Burton). (Bug #7715)
- Detect new `sql_mode` variable in string form (it used to be integer) and adjust quoting method for strings appropriately. (Bug #7715)
- Timestamps converted incorrectly to strings with server-side prepared statements and updatable result sets. (Bug #7715)
- Timestamp key column data needed `_binary` stripped for `UpdatableResultSet.refreshRow()`. (Bug #7686)
- Choose correct “direction” to apply time adjustments when both client and server are in GMT time zone when using `ResultSet.get(..., cal)` and `PreparedStatement.set(...., cal)`. (Bug #4718)
- Remove `_binary` introducer from parameters used as in/out parameters in `CallableStatement`. (Bug #4718)

- Always return `byte[]`s for output parameters registered as `*BINARY`. (Bug #4718)
- By default, the driver now scans SQL you are preparing using all variants of `Connection.prepareStatement()` to determine if it is a supported type of statement to prepare on the server side, and if it is not supported by the server, it instead prepares it as a client-side emulated prepared statement. You can disable this by passing `emulateUnsupportedPstmts=false` in your JDBC URL. (Bug #4718)
- Added `dontTrackOpenResources` option (default is `false`, to be JDBC compliant), which helps with memory use for nonwell-behaved apps (that is, applications that don't close `Statement` objects when they should). (Bug #4718)
- Send correct value for “boolean” `true` to server for `PreparedStatement.setObject(n, "true", Types.BIT)`. (Bug #4718)
- Fixed bug with Connection not caching statements from `prepareStatement()` when the statement wasn't a server-side prepared statement. (Bug #4718)

D.5.3.10. Changes in MySQL Connector/J 3.1.6 (23 December 2004)

Bugs Fixed

- `DBMD.getProcedures()` doesn't respect catalog parameter. (Bug #7026)
- Fixed hang on `SocketInputStream.read()` with `Statement.setMaxRows()` and multiple result sets when driver has to truncate result set directly, rather than tacking a `LIMIT n` on the end of it.

D.5.3.11. Changes in MySQL Connector/J 3.1.5 (02 December 2004)

Bugs Fixed

- Use 1MB packet for sending file for `LOAD DATA LOCAL INFILE` if that is < `max_allowed_packet` on server. (Bug #6537)
- `SUM()` on `DECIMAL` with server-side prepared statement ignores scale if zero-padding is needed (this ends up being due to conversion to `DOUBLE` by server, which when converted to a string to parse into `BigDecimal`, loses all “padding” zeros). (Bug #6537)
- Use `DatabaseMetaData.getIdentifierQuoteString()` when building DBMD queries. (Bug #6537)
- Use our own implementation of buffered input streams to get around blocking behavior of `java.io.BufferedInputStream`. Disable this with `useReadAheadInput=false`. (Bug #6399)
- Make auto-deserialization of `java.lang.Objects` stored in `BLOB` columns configurable using `autoDeserialize` property (defaults to `false`). (Bug #6399)
- `ResultSetMetaData.getColumnDisplaySize()` returns incorrect values for multi-byte charsets. (Bug #6399)
- Re-work `Field.isOpaqueBinary()` to detect `CHAR(n) CHARACTER SET BINARY` to support fixed-length binary fields for `ResultSet.getObject()`. (Bug #6399)
- Failing to connect to the server when one of the addresses for the given host name is IPV6 (which the server does not yet bind on). The driver now loops through *all* IP addresses for a given host, and stops on the first one that `accepts()` a `socket.connect()`. (Bug #6348)
- Removed unwanted new `Throwable()` in `ResultSet` constructor due to bad merge (caused a new object instance that was never used for every result set created). Found while profiling for Bug #6359. (Bug #6225)
- `ServerSidePreparedStatement` allocating short-lived objects unnecessarily. (Bug #6225)
- Use null-safe-equals for key comparisons in updatable result sets. (Bug #6225)
- Fixed too-early creation of `StringBuffer` in `EscapeProcessor.escapeSQL()`, also return `String` when escaping not needed (to avoid unnecessary object allocations). Found while profiling for Bug #6359. (Bug #6225)
- `UNSIGNED BIGINT` unpacked incorrectly from server-side prepared statement result sets. (Bug #5729)
- Added experimental configuration property `dontUnpackBinaryResults`, which delays unpacking binary result set values until they're asked for, and only creates object instances for nonnumeric values (it is set to `false` by default). For some

usecase/jvm combinations, this is friendlier on the garbage collector. (Bug #5706)

- Don't throw exceptions for `Connection.releaseSavepoint()`. (Bug #5706)
- Inefficient detection of pre-existing string instances in `ResultSet.getNativeString()`. (Bug #5706)
- Use a per-session `Calendar` instance by default when decoding dates from `ServerPreparedStatements` (set to old, less performant behavior by setting property `dynamicCalendars=true`). (Bug #5706)
- Fixed batched updates with server prepared statements weren't looking if the types had changed for a given batched set of parameters compared to the previous set, causing the server to return the error "Wrong arguments to mysql_stmt_execute()". (Bug #5235)
- Handle case when string representation of timestamp contains trailing "`.`" with no numbers following it. (Bug #5235)
- Server-side prepared statements did not honor `zeroDateTimeBehavior` property, and would cause class-cast exceptions when using `ResultSet.getObject()`, as the all-zero string was always returned. (Bug #5235)
- Fix comparisons made between string constants and dynamic strings that are converted with either `toUpperCase()` or `toLowerCase()` to use `Locale.ENGLISH`, as some locales "override" case rules for English. Also use `StringUtils.indexOfIgnoreCase()` instead of `.toUpperCase().indexOf()`, avoids creating a very short-lived transient `String` instance.

D.5.3.12. Changes in MySQL Connector/J 3.1.4 (04 September 2004)

Bugs Fixed

- Fixed `ServerPreparedStatement` to read prepared statement metadata off the wire, even though it is currently a placeholder instead of using `MysqlIO.clearInputStream()` which didn't work at various times because data wasn't available to read from the server yet. This fixes sporadic errors users were having with `ServerPreparedStatements` throwing `ArrayIndexOutOfBoundExceptions`. (Bug #5032)
- Added three ways to deal with all-zero datetimes when reading them from a `ResultSet`: `exception` (the default), which throws an `SQLException` with an SQLState of `S1009`; `convertToNull`, which returns `NULL` instead of the date; and `round`, which rounds the date to the nearest closest value which is `'0001-01-01'`. (Bug #5032)
- The driver is more strict about truncation of numerics on `ResultSet.get*()`, and will throw an `SQLException` when truncation is detected. You can disable this by setting `jdbcCompliantTruncation` to `false` (it is enabled by default, as this functionality is required for JDBC compliance). (Bug #5032)
- You can now use URLs in `LOAD DATA LOCAL INFILE` statements, and the driver will use Java's built-in handlers for retrieving the data and sending it to the server. This feature is not enabled by default, you must set the `allowUrlInLocalInfile` connection property to `true`. (Bug #5032)
- `ResultSet.getObject()` doesn't return type `Boolean` for pseudo-bit types from prepared statements on 4.1.x (shortcut for avoiding extra type conversion when using binary-encoded result sets obscured test in `getObject()` for "pseudo" bit type). (Bug #5032)
- Use `com.mysql.jdbc.Message`'s classloader when loading resource bundle, should fix sporadic issues when the caller's classloader can't locate the resource bundle. (Bug #5032)
- `ServerPreparedStatements` dealing with return of `DECIMAL` type don't work. (Bug #5012)
- Track packet sequence numbers if `enablePacketDebug=true`, and throw an exception if packets received out-of-order. (Bug #4689)
- `ResultSet.wasNull()` does not work for primitives if a previous `null` was returned. (Bug #4689)
- Optimized integer number parsing, enable "old" slower integer parsing using JDK classes using `useFastIntParsing=false` property. (Bug #4642)
- Added `useOnlyServerErrorMessages` property, which causes message text in exceptions generated by the server to only contain the text sent by the server (as opposed to the SQLState's "standard" description, followed by the server's error message). This property is set to `true` by default. (Bug #4642)
- `ServerPreparedStatement.execute*()` sometimes threw `ArrayIndexOutOfBoundsException` when unpacking field metadata. (Bug #4642)
- Connector/J 3.1.3 beta does not handle integers correctly (caused by changes to support unsigned reads in `Buf-`

`fer.readInt()` -> `Buffer.readShort()`). (Bug #4510)

- Added support in `DatabaseMetaData.getTables()` and `getTableTypes()` for views, which are now available in MySQL server 5.0.x. (Bug #4510)
- `ResultSet.getObject()` returns wrong type for strings when using prepared statements. (Bug #4482)
- Calling `MysqlPooledConnection.close()` twice (even though an application error), caused NPE. Fixed. (Bug #4482)

D.5.3.13. Changes in MySQL Connector/J 3.1.3 (07 July 2004)

Bugs Fixed

- Support new time zone variables in MySQL-4.1.3 when `useTimezone=true`. (Bug #4311)
- Error in retrieval of `mediumint` column with prepared statements and binary protocol. (Bug #4311)
- Support for unsigned numerics as return types from prepared statements. This also causes a change in `ResultSet.getObject()` for the `bigint unsigned` type, which used to return `BigDecimal` instances, it now returns instances of `java.lang.BigInteger`. (Bug #4311)
- Externalized more messages (on-going effort). (Bug #4119)
- Null bitmask sent for server-side prepared statements was incorrect. (Bug #4119)
- Added constants for MySQL error numbers (publicly accessible, see `com.mysql.jdbc.MysqlErrorNumbers`), and the ability to generate the mappings of vendor error codes to SQLStates that the driver uses (for documentation purposes). (Bug #4119)
- Added packet debugging code (see the `enablePacketDebug` property documentation). (Bug #4119)
- Use SQL Standard SQL states by default, unless `useSqlStateCodes` property is set to `false`. (Bug #4119)
- Mangle output parameter names for `CallableStatements` so they will not clash with user variable names.
- Added support for `INOUT` parameters in `CallableStatements`.

D.5.3.14. Changes in MySQL Connector/J 3.1.2 (09 June 2004)

Bugs Fixed

- Don't enable server-side prepared statements for server version 5.0.0 or 5.0.1, as they aren't compatible with the '4.1.2+' style that the driver uses (the driver expects information to come back that isn't there, so it hangs). (Bug #3804)
- `getWarnings()` returns `SQLWarning` instead of `DataTruncation`. (Bug #3804)
- `getProcedureColumns()` doesn't work with wildcards for procedure name. (Bug #3540)
- `getProcedures()` does not return any procedures in result set. (Bug #3539)
- Fixed `DatabaseMetaData.getProcedures()` when run on MySQL-5.0.0 (output of `SHOW PROCEDURE STATUS` changed between 5.0.0 and 5.0.1. (Bug #3520)
- Added `connectionCollation` property to cause driver to issue `set collation_connection=...` query on connection init if default collation for given charset is not appropriate. (Bug #3520)
- `DBMD.getSQLStateType()` returns incorrect value. (Bug #3520)
- Correctly map output parameters to position given in `prepareCall()` versus. order implied during `registerOutParameter()`. (Bug #3146)
- Cleaned up detection of server properties. (Bug #3146)
- Correctly detect initial character set for servers >= 4.1.0. (Bug #3146)
- Support placeholder for parameter metadata for server >= 4.1.2. (Bug #3146)

- Added `gatherPerformanceMetrics` property, along with properties to control when/where this info gets logged (see docs for more info).
- Fixed case when no parameters could cause a `NullPointerException` in `CallableStatement.setOutputParameters()`.
- Enabled callable statement caching using `cacheCallableStmts` property.
- Fixed sending of split packets for large queries, enabled nio ability to send large packets as well.
- Added `.toString()` functionality to `ServerPreparedStatement`, which should help if you're trying to debug a query that is a prepared statement (it shows SQL as the server would process).
- Added `logSlowQueries` property, along with `slowQueriesThresholdMillis` property to control when a query should be considered "slow."
- Removed wrapping of exceptions in `MysqlIO.changeUser()`.
- Fixed stored procedure parameter parsing info when size was specified for a parameter (for example, `char()`, `varchar()`).
- `ServerPreparedStatements` weren't actually de-allocating server-side resources when `.close()` was called.
- Fixed case when no output parameters specified for a stored procedure caused a bogus query to be issued to retrieve out parameters, leading to a syntax error from the server.

D.5.3.15. Changes in MySQL Connector/J 3.1.1 (14 February 2004 alpha)

Bugs Fixed

- Use DocBook version of docs for shipped versions of drivers. (Bug #2671)
- `NULL` fields were not being encoded correctly in all cases in server-side prepared statements. (Bug #2671)
- Fixed rare buffer underflow when writing numbers into buffers for sending prepared statement execution requests. (Bug #2671)
- Fixed `ConnectionProperties` that weren't properly exposed through accessors, cleaned up `ConnectionProperties` code. (Bug #2623)
- Class-cast exception when using scrolling result sets and server-side prepared statements. (Bug #2623)
- Merged unbuffered input code from 3.0. (Bug #2623)
- Enabled streaming of result sets from server-side prepared statements. (Bug #2606)
- Server-side prepared statements were not returning data type `YEAR` correctly. (Bug #2606)
- Fixed charset conversion issue in `getTables()`. (Bug #2502)
- Implemented multiple result sets returned from a statement or stored procedure. (Bug #2502)
- Implemented `Connection.prepareCall()`, and `DatabaseMetaData`. `getProcedures()` and `getProcedureColumns()`. (Bug #2359)
- Merged prepared statement caching, and `.getMetaData()` support from 3.0 branch. (Bug #2359)
- Fixed off-by-1900 error in some cases for years in `TimeUtil.fastDate`/`TimeCreate()` when unpacking results from server-side prepared statements. (Bug #2359)
- Reset `long binary` parameters in `ServerPreparedStatement` when `clearParameters()` is called, by sending `COM_RESET_STMT` to the server. (Bug #2359)
- `NULL` values for numeric types in binary encoded result sets causing `NullPointerExceptions`. (Bug #2359)
- Display where/why a connection was implicitly closed (to aid debugging). (Bug #1673)
- `DatabaseMetaData.getColumns()` is not returning correct column ordinal info for non-`'%'` column name patterns. (Bug #1673)
- Fixed `NullPointerException` in `ServerPreparedStatement.setTimestamp()`, as well as year and month dis-

crepencies in `ServerPreparedStatement.setTimestamp()`, `setDate()`. (Bug #1673)

- Added ability to have multiple database/JVM targets for compliance and regression/unit tests in `build.xml`. (Bug #1673)
- Fixed sending of queries larger than 16M. (Bug #1673)
- Merged fix of data type mapping from MySQL type `FLOAT` to `java.sql.Types.REAL` from 3.0 branch. (Bug #1673)
- Fixed NPE and year/month bad conversions when accessing some datetime functionality in `ServerPreparedStatements` and their resultant result sets. (Bug #1673)
- Added named and indexed input/output parameter support to `CallableStatement`. MySQL-5.0.x or newer. (Bug #1673)
- `CommunicationsException` implemented, that tries to determine why communications was lost with a server, and displays possible reasons when `.getMessage()` is called. (Bug #1673)
- Detect collation of column for `RSMD.isCaseSensitive()`. (Bug #1673)
- Optimized `Buffer.readLenByteArray()` to return shared empty byte array when length is 0.
- Fix support for table aliases when checking for all primary keys in `UpdatableResultSet`.
- Unpack “unknown” data types from server prepared statements as `Strings`.
- Implemented `Statement.getWarnings()` for MySQL-4.1 and newer (using `SHOW WARNINGS`).
- Ensure that warnings are cleared before executing queries on prepared statements, as-per JDBC spec (now that we support warnings).
- Correctly initialize datasource properties from JNDI Refs, including explicitly specified URLs.
- Implemented long data (Blobs, Clobs, InputStreams, Readers) for server prepared statements.
- Deal with 0-length tokens in `EscapeProcessor` (caused by callable statement escape syntax).
- `DatabaseMetaData` now reports `supportsStoredProcedures()` for MySQL versions >= 5.0.0
- Support for `mysql_change_user()`. See the `changeUser()` method in `com.mysql.jdbc.Connection`.
- Removed `useFastDates` connection property.
- Support for NIO. Use `useNIO=true` on platforms that support NIO.
- Check for closed connection on delete/update/insert row operations in `UpdatableResultSet`.
- Support for transaction savepoints (MySQL >= 4.0.14 or 4.1.1).
- Support “old” `profileSql` capitalization in `ConnectionProperties`. This property is deprecated, you should use `profileSQL` if possible.
- Fixed character encoding issues when converting bytes to ASCII when MySQL doesn't provide the character set, and the JVM is set to a multi-byte encoding (usually affecting retrieval of numeric values).
- Centralized setting of result set type and concurrency.
- Fixed bug with `UpdatableResultSets` not using client-side prepared statements.
- Default result set type changed to `TYPE_FORWARD_ONLY` (JDBC compliance).
- Fixed `IllegalAccessError` to `Calendar.getTimeInMillis()` in `DateTimeValue` (for JDK < 1.4).
- Allow contents of `PreparedStatement.setBlob()` to be retained between calls to `.execute*()`.
- Fixed stack overflow in `Connection.prepareCall()` (bad merge).
- Refactored how connection properties are set and exposed as `DriverPropertyInfo` as well as `Connection` and `DataSource` properties.
- Reduced number of methods called in average query to be more efficient.
- Prepared `Statements` will be re-prepared on auto-reconnect. Any errors encountered are postponed until first attempt to re-execute the re-prepared statement.

D.5.3.16. Changes in MySQL Connector/J 3.1.0 (18 February 2003 alpha)

Bugs Fixed

- Added `useServerPrepStmts` property (default `false`). The driver will use server-side prepared statements when the server version supports them (4.1 and newer) when this property is set to `true`. It is currently set to `false` by default until all bind/fetch functionality has been implemented. Currently only DML prepared statements are implemented for 4.1 server-side prepared statements.
- Added `requireSSL` property.
- Track open `Statements`, close all when `Connection.close()` is called (JDBC compliance).

D.5.4. Changes in MySQL Connector/J 3.0.x

D.5.4.1. Changes in MySQL Connector/J 3.0.17 (23 June 2005)

Bugs Fixed

- Workaround for server Bug #9098: Default values of `CURRENT_*` for `DATE`, `TIME`, `DATETIME`, and `TIMESTAMP` columns can't be distinguished from `string` values, so `UpdatableResultSet.moveToInsertRow()` generates bad SQL for inserting default values. (Bug #8812)
- `NON_UNIQUE` column from `DBMD.getIndexInfo()` returned inverted value. (Bug #8812)
- `EUCKR` charset is sent as `SET NAMES euc_kr` which MySQL-4.1 and newer doesn't understand. (Bug #8629)
- Added support for the `EUC_JP_Solaris` character encoding, which maps to a MySQL encoding of `eucjpms` (backported from 3.1 branch). This only works on servers that support `eucjpms`, namely 5.0.3 or later. (Bug #8629)
- Use hex escapes for `PreparedStatement.setBytes()` for double-byte charsets including “aliases” `Windows-31J`, `CP934`, `MS932`. (Bug #8629)
- `DatabaseMetaData.supportsSelectForUpdate()` returns correct value based on server version. (Bug #8629)
- Which requires hex escaping of binary data when using multi-byte charsets with prepared statements. (Bug #8064)
- Fixed duplicated code in `configureClientCharset()` that prevented `useOldUTF8Behavior=true` from working properly. (Bug #7952)
- Backported SQLState codes mapping from Connector/J 3.1, enable with `useSqlStateCodes=true` as a connection property, it defaults to `false` in this release, so that we don't break legacy applications (it defaults to `true` starting with Connector/J 3.1). (Bug #7686)
- Timestamp key column data needed `_binary` stripped for `UpdatableResultSet.refreshRow()`. (Bug #7686)
- `MS932`, `SHIFT_JIS`, and `Windows_31J` not recognized as aliases for `sjis`. (Bug #7607)
- Handle streaming result sets with more than 2 billion rows properly by fixing wraparound of row number counter. (Bug #7601)
- `PreparedStatement.fixDecimalExponent()` adding extra `+`, making number unparseable by MySQL server. (Bug #7601)
- Escape sequence {fn convert(..., type)} now supports ODBC-style types that are prepended by `SQL_`. (Bug #7601)
- Statements created from a pooled connection were returning physical connection instead of logical connection when `getConnection()` was called. (Bug #7316)
- Support new protocol type `MYSQL_TYPE_VARCHAR`. (Bug #7081)
- Added `useOldUTF8Behavior`' configuration property, which causes JDBC driver to act like it did with MySQL-4.0.x and earlier when the character encoding is `utf-8` when connected to MySQL-4.1 or newer. (Bug #7081)
- `DatabaseMetaData.getIndexInfo()` ignored `unique` parameter. (Bug #7081)
- `PreparedStatement.fixDecimalExponent()` adding extra `+`, making number unparseable by MySQL server. (Bug #7061)

- `PreparedStatements` don't encode Big5 (and other multi-byte) character sets correctly in static SQL strings. (Bug #7033)
- Connections starting up failed-over (due to down master) never retry master. (Bug #6966)
- Adding `CP943` to aliases for `sjis`. (Bug #6549, Bug #7607)
- `Timestamp`/`Time` conversion goes in the wrong “direction” when `useTimeZone=true` and server time zone differs from client time zone. (Bug #5874)

D.5.4.2. Changes in MySQL Connector/J 3.0.16 (15 November 2004)

Bugs Fixed

- Made `TINYINT(1)` -> `BIT`/`Boolean` conversion configurable using `tinyInt1isBit` property (default `true` to be JDBC compliant out of the box). (Bug #5664)
- Off-by-one bug in `Buffer.readString(string)`. (Bug #5664)
- `ResultSet.updateByte()` when on insert row throws `ArrayOutOfBoundsException`. (Bug #5664)
- Fixed regression where `useUnbufferedInput` was defaulting to `false`. (Bug #5664)
- `ResultSet.getTimestamp()` on a column with `TIME` in it fails. (Bug #5664)
- Fixed `DatabaseMetaData.getTypes()` returning incorrect (this is, nonnegative) scale for the `NUMERIC` type. (Bug #5664)
- Only set `character_set_results` during connection establishment if server version >= 4.1.1. (Bug #5664)
- Fixed `ResultSetMetaData.isReadOnly()` to detect nonwritable columns when connected to MySQL-4.1 or newer, based on existence of “original” table and column names.
- Re-issue character set configuration commands when re-using pooled connections or `Connection.changeUser()` when connected to MySQL-4.1 or newer.

D.5.4.3. Changes in MySQL Connector/J 3.0.15 (04 September 2004)

Bugs Fixed

- `ResultSet.getMetaData()` should not return incorrectly initialized metadata if the result set has been closed, but should instead throw an `SQLException`. Also fixed for `getRow()` and `getWarnings()` and traversal methods by calling `checkClosed()` before operating on instance-level fields that are nullified during `.close()`. (Bug #5069)
- Use `_binary` introducer for `PreparedStatement.setBytes()` and `set*Stream()` when connected to MySQL-4.1.x or newer to avoid misinterpretation during character conversion. (Bug #5069)
- Parse new time zone variables from 4.1.x servers. (Bug #5069)
- `ResultSet` should release `Field[]` instance in `.close()`. (Bug #5022)
- `RSMD.getPrecision()` returning 0 for nonnumeric types (should return max length in chars for nonbinary types, max length in bytes for binary types). This fix also fixes mapping of `RSMD.getColumnType()` and `RSMD.getColumnTypeName()` for the `BLOB` types based on the length sent from the server (the server doesn't distinguish between `TINYBLOB`, `BLOB`, `MEDIUMBLOB` or `LONGBLOB` at the network protocol level). (Bug #4880)
- “Production” is now “GA” (General Availability) in naming scheme of distributions. (Bug #4860, Bug #4138)
- `DBMD.getColumns()` returns incorrect JDBC type for unsigned columns. This affects type mappings for all numeric types in the `RSMD.getColumnType()` and `RSMD.getColumnTypeNames()` methods as well, to ensure that “like” types from `DBMD.getColumns()` match up with what `RSMD.getColumnType()` and `getColumnTypeNames()` return. (Bug #4860, Bug #4138)
- Calling `.close()` twice on a `PooledConnection` causes NPE. (Bug #4808)
- `DOUBLE` mapped twice in `DBMD.getTypeInfo()`. (Bug #4742)
- Added FLOSS license exemption. (Bug #4742)

- Removed redundant calls to `checkRowPos()` in `ResultSet`. (Bug #4334)
- Failover for `autoReconnect` not using port numbers for any hosts, and not retrying all hosts.

  > **Warning**
  >
  > This required a change to the `SocketFactory` `connect()` method signature, which is now `public Socket connect(String host, int portNumber, Properties props)`; therefore, any third-party socket factories will have to be changed to support this signature.

  (Bug #4334)
- Logical connections created by `MysqlConnectionPoolDataSource` will now issue a `rollback()` when they are closed and sent back to the pool. If your application server/connection pool already does this for you, you can set the `rollbackOnPooledClose` property to `false` to avoid the overhead of an extra `rollback()`. (Bug #4334)
- `StringUtils.escapeEasternUnicodeByteStream` was still broken for GBK. (Bug #4010)

D.5.4.4. Changes in MySQL Connector/J 3.0.14 (28 May 2004)

Bugs Fixed

- Fixed URL parsing error.

D.5.4.5. Changes in MySQL Connector/J 3.0.13 (27 May 2004)

Bugs Fixed

- `No Database Selected` when using `MysqlConnectionPoolDataSource`. (Bug #3920)
- `PreparedStatement.getGeneratedKeys()` method returns only 1 result for batched insertions. (Bug #3873)
- Using a `MySQLDatasource` without server name fails. (Bug #3848)

D.5.4.6. Changes in MySQL Connector/J 3.0.12 (18 May 2004)

Bugs Fixed

- Inconsistent reporting of data type. The server still doesn't return all types for *BLOBs *TEXT correctly, so the driver won't return those correctly. (Bug #3570)
- `UpdatableResultSet` not picking up default values for `moveToInsertRow()`. (Bug #3557)
- Not specifying database in URL caused `MalformedURL` exception. (Bug #3554)
- Auto-convert MySQL encoding names to Java encoding names if used for `characterEncoding` property. (Bug #3554)
- Use `junit.textui.TestRunner` for all unit tests (to enable them to be run from the command line outside of Ant or Eclipse). (Bug #3554)
- Added encoding names that are recognized on some JVMs to fix case where they were reverse-mapped to MySQL encoding names incorrectly. (Bug #3554)
- Made `StringRegressionTest` 4.1-unicode aware. (Bug #3520)
- Fixed regression in `PreparedStatement.setString()` and eastern character encodings. (Bug #3520)
- `DBMD.getSQLStateType()` returns incorrect value. (Bug #3520)
- Renamed `StringUtils.escapeSJISByteStream()` to more appropriate `escapeEasternUnicodeByteStream()`. (Bug #3511)
- `StringUtils.escapeSJISByteStream()` not covering all eastern double-byte charsets correctly. (Bug #3511)
- Return creating statement for `ResultSets` created by `getGeneratedKeys()`. (Bug #2957)

- Use `SET character_set_results` during initialization to enable any charset to be returned to the driver for result sets. (Bug #2670)
- Don't truncate `BLOB` or `CLOB` values when using `setBytes()` and `setBinary/CharacterStream()`. (Bug #2670)
- Dynamically configure character set mappings for field-level character sets on MySQL-4.1.0 and newer using `SHOW COLLATION` when connecting. (Bug #2670)
- Map `binary` character set to `US-ASCII` to support `DATETIME` charset recognition for servers >= 4.1.2. (Bug #2670)
- Use `charsetnr` returned during connect to encode queries before issuing `SET NAMES` on MySQL >= 4.1.0. (Bug #2670)
- Add helper methods to `ResultSetMetaData` (`getColumnCharacterEncoding()` and `getColumnCharacterSet()`) to permit end users to see what charset the driver thinks it should be using for the column. (Bug #2670)
- Only set `character_set_results` for MySQL >= 4.1.0. (Bug #2670)
- Allow `url` parameter for `MysqlDataSource` and `MysqlConnectionPool` `DataSource` so that passing of other properties is possible from inside appservers.
- Don't escape SJIS/GBK/BIG5 when using MySQL-4.1 or newer.
- Backport documentation tooling from 3.1 branch.
- Added `failOverReadOnly` property, to enable the user to configure the state of the connection (read-only/writable) when failed over.
- Allow `java.util.Date` to be sent in as parameter to `PreparedStatement.setObject()`, converting it to a `Timestamp` to maintain full precision. . (Bug #103)
- Add unsigned attribute to `DatabaseMetaData.getColumns()` output in the `TYPE_NAME` column.
- Map duplicate key and foreign key errors to SQLState of `23000`.
- Backported “change user” and “reset server state” functionality from 3.1 branch, to enable clients of `MysqlConnectionPoolDataSource` to reset server state on `getConnection()` on a pooled connection.

D.5.4.7. Changes in MySQL Connector/J 3.0.11 (19 February 2004)

Bugs Fixed

- Return `java.lang.Double` for `FLOAT` type from `ResultSetMetaData.getColumnClassName()`. (Bug #2855)
- Return `[B` instead of `java.lang.Object` for `BINARY`, `VARBINARY` and `LONGVARBINARY` types from `ResultSetMetaData.getColumnClassName()` (JDBC compliance). (Bug #2855)
- Issue connection events on all instances created from a `ConnectionPoolDataSource`. (Bug #2855)
- Return `java.lang.Integer` for `TINYINT` and `SMALLINT` types from `ResultSetMetaData.getColumnClassName()`. (Bug #2852)
- Added `useUnbufferedInput` parameter, and now use it by default (due to JVM issue http://developer.java.sun.com/developer/bugParade/bugs/4401235.html) (Bug #2578)
- Fixed failover always going to last host in list. (Bug #2578)
- Detect `on/off` or `1`, `2`, `3` form of `lower_case_table_names` value on server. (Bug #2578)
- `AutoReconnect` time was growing faster than exponentially. (Bug #2447)
- Trigger a `SET NAMES utf8` when encoding is forced to `utf8` *or* `utf-8` using the `characterEncoding` property. Previously, only the Java-style encoding name of `utf-8` would trigger this.

D.5.4.8. Changes in MySQL Connector/J 3.0.10 (13 January 2004)

Bugs Fixed

- Enable caching of the parsing stage of prepared statements using the `cachePrepStmts`, `prepStmtCacheSize`, and `prepStmtCacheSqlLimit` properties (disabled by default). (Bug #2006)
- Fixed security exception when used in Applets (applets can't read the system property `file.encoding` which is needed for `LOAD DATA LOCAL INFILE`). (Bug #2006)
- Speed up parsing of `PreparedStatements`, try to use one-pass whenever possible. (Bug #2006)
- Fixed exception `Unknown character set 'danish'` on connect with JDK-1.4.0 (Bug #2006)
- Fixed mappings in SQLError to report deadlocks with SQLStates of `41000`. (Bug #2006)
- Removed static synchronization bottleneck from instance factory method of `SingleByteCharsetConverter`. (Bug #2006)
- Removed static synchronization bottleneck from `PreparedStatement.setTimestamp()`. (Bug #2006)
- `ResultSet.findColumn()` should use first matching column name when there are duplicate column names in `SELECT` query (JDBC-compliance). (Bug #2006)
- `maxRows` property would affect internal statements, so check it for all statement creation internal to the driver, and set to 0 when it is not. (Bug #2006)
- Use constants for SQLStates. (Bug #2006)
- Map charset `ko18_ru` to `ko18r` when connected to MySQL-4.1.0 or newer. (Bug #2006)
- Ensure that `Buffer.writeString()` saves room for the `\0`. (Bug #2006)
- `ArrayIndexOutOfBounds` when parameter number == number of parameters + 1. (Bug #1958)
- Connection property `maxRows` not honored. (Bug #1933)
- Statements being created too many times in `DBMD.extractForeignKeyFromCreateTable()`. (Bug #1925)
- Support escape sequence {fn convert ... }. (Bug #1914)
- Implement `ResultSet.updateClob()`. (Bug #1913)
- Autoreconnect code didn't set catalog upon reconnect if it had been changed. (Bug #1913)
- `ResultSet.getObject()` on `TINYINT` and `SMALLINT` columns should return Java type `Integer`. (Bug #1913)
- Added more descriptive error message `Server Configuration Denies Access to DataSource`, as well as retrieval of message from server. (Bug #1913)
- `ResultSetMetaData.isCaseSensitive()` returned wrong value for `CHAR`/`VARCHAR` columns. (Bug #1913)
- Added `alwaysClearStream` connection property, which causes the driver to always empty any remaining data on the input stream before each query. (Bug #1913)
- `DatabaseMetaData.getSystemFunction()` returning bad function `VResultsSion`. (Bug #1775)
- Foreign Keys column sequence is not consistent in `DatabaseMetaData.getImported/Exported/CrossReference()`. (Bug #1731)
- Fix for `ArrayIndexOutOfBounds` exception when using `Statement.setMaxRows()`. (Bug #1695)
- Subsequent call to `ResultSet.updateFoo()` causes NPE if result set is not updatable. (Bug #1630)
- Fix for 4.1.1-style authentication with no password. (Bug #1630)
- Cross-database updatable result sets are not checked for updatability correctly. (Bug #1592)
- `DatabaseMetaData.getColumns()` should return `Types.LONGVARCHAR` for MySQL `LONGTEXT` type. (Bug #1592)
- Fixed regression of `Statement.getGeneratedKeys()` and `REPLACE` statements. (Bug #1576)
- Barge blobs and split packets not being read correctly. (Bug #1576)
- Backported fix for aliased tables and `UpdatableResultSets` in `checkUpdatability()` method from 3.1 branch. (Bug #1534)

- “Friendlier” exception message for `PacketTooLargeException`. (Bug #1534)
- Don't count quoted IDs when inside a 'string' in `PreparedStatement` parsing. (Bug #1511)

D.5.4.9. Changes in MySQL Connector/J 3.0.9 (07 October 2003)

Bugs Fixed

- `ResultSet.get/setString` mashing char 127. (Bug #1247)
- Added property to “clobber” streaming results, by setting the `clobberStreamingResults` property to `true` (the default is `false`). This will cause a “streaming” `ResultSet` to be automatically closed, and any outstanding data still streaming from the server to be discarded if another query is executed before all the data has been read from the server. (Bug #1247)
- Added `com.mysql.jdbc.util.BaseBugReport` to help creation of testcases for bug reports. (Bug #1247)
- Backported authentication changes for 4.1.1 and newer from 3.1 branch. (Bug #1247)
- Made `databaseName`, `portNumber`, and `serverName` optional parameters for `MysqlDataSourceFactory`. (Bug #1246)
- Optimized `CLOB.setChracterStream()`. (Bug #1131)
- Fixed `CLOB.truncate()`. (Bug #1130)
- Fixed deadlock issue with `Statement.setMaxRows()`. (Bug #1099)
- `DatabaseMetaData.getColumns()` getting confused about the keyword “set” in character columns. (Bug #1099)
- Clip +/- INF (to smallest and largest representative values for the type in MySQL) and NaN (to 0) for `setDouble`/`setFloat()`, and issue a warning on the statement when the server does not support +/- INF or NaN. (Bug #884)
- Don't fire connection closed events when closing pooled connections, or on `PooledConnection.getConnection()` with already open connections. (Bug #884)
- Double-escaping of `'\'` when charset is SJIS or GBK and `'\'` appears in nonescaped input. (Bug #879)
- When emptying input stream of unused rows for “streaming” result sets, have the current thread `yield()` every 100 rows to not monopolize CPU time. (Bug #879)
- Issue exception on `ResultSet.getXXX()` on empty result set (wasn't caught in some cases). (Bug #848)
- Don't hide messages from exceptions thrown in I/O layers. (Bug #848)
- Fixed regression in large split-packet handling. (Bug #848)
- Better diagnostic error messages in exceptions for “streaming” result sets. (Bug #848)
- Don't change timestamp TZ twice if `useTimezone==true`. (Bug #774)
- Don't wrap `SQLExceptions` in `RowDataDynamic`. (Bug #688)
- Don't try and reset isolation level on reconnect if MySQL doesn't support them. (Bug #688)
- The `insertRow` in an `UpdatableResultSet` is now loaded with the default column values when `moveToInsertRow()` is called. (Bug #688)
- `DatabaseMetaData.getColumns()` wasn't returning `NULL` for default values that are specified as `NULL`. (Bug #688)
- Change default statement type/concurrency to `TYPE_FORWARD_ONLY` and `CONCUR_READ_ONLY` (spec compliance). (Bug #688)
- Fix `UpdatableResultSet` to return values for `getXXX()` when on insert row. (Bug #675)
- Support `InnoDB` constraint names when extracting foreign key information in `DatabaseMetaData` (implementing ideas from Parwinder Sekhon). (Bug #664, Bug #517)
- Backported 4.1 protocol changes from 3.1 branch (server-side SQL states, new field information, larger client capability flags, connect-with-database, and so forth). (Bug #664, Bug #517)

- `refreshRow` didn't work when primary key values contained values that needed to be escaped (they ended up being doubly escaped). (Bug #661)
- Fixed `ResultSet.previous()` behavior to move current position to before result set when on first row of result set. (Bug #496)
- Fixed `Statement` and `PreparedStatement` issuing bogus queries when `setMaxRows()` had been used and a `LIMIT` clause was present in the query. (Bug #496)
- Faster date handling code in `ResultSet` and `PreparedStatement` (no longer uses `Date` methods that synchronize on static calendars).
- Fixed test for end of buffer in `Buffer.readString()`.

D.5.4.10. Changes in MySQL Connector/J 3.0.8 (23 May 2003)

Bugs Fixed

- Fixed SJIS encoding bug, thanks to Naoto Sato. (Bug #378)
- Fix problem detecting server character set in some cases. (Bug #378)
- Allow multiple calls to `Statement.close()`. (Bug #378)
- Return correct number of generated keys when using `REPLACE` statements. (Bug #378)
- Unicode character 0xFFFF in a string would cause the driver to throw an `ArrayOutOfBoundsException`. . (Bug #378)
- Fix row data decoding error when using *very* large packets. (Bug #378)
- Optimized row data decoding. (Bug #378)
- Issue exception when operating on an already closed prepared statement. (Bug #378)
- Optimized usage of `EscapeProcessor`. (Bug #378)
- Use JVM charset with file names and `LOAD DATA [LOCAL] INFILE`.
- Fix infinite loop with `Connection.cleanup()`.
- Changed Ant target `compile-core` to `compile-driver`, and made testsuite compilation a separate target.
- Fixed result set not getting set for `Statement.executeUpdate()`, which affected `getGeneratedKeys()` and `getUpdateCount()` in some cases.
- Return list of generated keys when using multi-value `INSERTS` with `Statement.getGeneratedKeys()`.
- Allow bogus URLs in `Driver.getPropertyInfo()`.

D.5.4.11. Changes in MySQL Connector/J 3.0.7 (08 April 2003)

Bugs Fixed

- Fixed charset issues with database metadata (charset was not getting set correctly).
- You can now toggle profiling on/off using `Connection.setProfileSql(boolean)`.
- 4.1 Column Metadata fixes.
- Fixed `MysqlPooledConnection.close()` calling wrong event type.
- Fixed `StringIndexOutOfBoundsException` in `PreparedStatement.setClob()`.
- `IOExceptions` during a transaction now cause the `Connection` to be closed.
- Remove synchronization from `Driver.connect()` and `Driver.acceptsUrl()`.

- Fixed missing conversion for `YEAR` type in `ResultSetMetaData.getColumnTypeName()`.
- Updatable `ResultSets` can now be created for aliased tables/columns when connected to MySQL-4.1 or newer.
- Fixed `LOAD DATA LOCAL INFILE` bug when file > `max_allowed_packet`.
- Don't pick up indexes that start with `pri` as primary keys for `DBMD.getPrimaryKeys()`.
- Ensure that packet size from `alignPacketSize()` does not exceed `max_allowed_packet` (JVM bug)
- Don't reset `Connection.isReadOnly()` when autoReconnecting.
- Fixed escaping of 0x5c (`'\'`) character for GBK and Big5 charsets.
- Fixed `ResultSet.getTimestamp()` when underlying field is of type `DATE`.
- Throw `SQLExceptions` when trying to do operations on a forcefully closed `Connection` (that is, when a communication link failure occurs).

D.5.4.12. Changes in MySQL Connector/J 3.0.6 (18 February 2003)

Bugs Fixed

- Backported 4.1 charset field info changes from Connector/J 3.1.
- Fixed `Statement.setMaxRows()` to stop sending `LIMIT` type queries when not needed (performance).
- Fixed `DBMD.getTypeInfo()` and `DBMD.getColumns()` returning different value for precision in `TEXT` and `BLOB` types.
- Fixed `SQLExceptions` getting swallowed on initial connect.
- Fixed `ResultSetMetaData` to return `""` when catalog not known. Fixes `NullPointerExceptions` with Sun's `CachedRowSet`.
- Allow ignoring of warning for “non transactional tables” during rollback (compliance/usability) by setting `ignoreNonTxTables` property to `true`.
- Clean up `Statement` query/method mismatch tests (that is, `INSERT` not permitted with `.executeQuery()`).
- Fixed `ResultSetMetaData.isWritable()` to return correct value.
- More checks added in `ResultSet` traversal method to catch when in closed state.
- Implemented `Blob.setBytes()`. You still need to pass the resultant `Blob` back into an updatable `ResultSet` or `PreparedStatement` to persist the changes, because MySQL does not support “locators”.
- Add “window” of different `NULL` sorting behavior to `DBMD.nullsAreSortedAtStart` (4.0.2 to 4.0.10, true; otherwise, no).

D.5.4.13. Changes in MySQL Connector/J 3.0.5 (22 January 2003)

Bugs Fixed

- Fixed `ResultSet.isBeforeFirst()` for empty result sets.
- Added missing `LONGTEXT` type to `DBMD.getColumns()`.
- Implemented an empty `TypeMap` for `Connection.getTypeMap()` so that some third-party apps work with MySQL (IBM WebSphere 5.0 Connection pool).
- Added update options for foreign key metadata.
- Fixed `Buffer.fastSkipLenString()` causing `ArrayIndexOutOfBounds` exceptions with some queries when unpacking fields.
- Quote table names in `DatabaseMetaData.getColumns()`, `getPrimaryKeys()`, `getIndexInfo()`, `getBe-`

`stRowIdentifier()`.

- Retrieve `TX_ISOLATION` from database for `Connection.getTransactionIsolation()` when the MySQL version supports it, instead of an instance variable.

- Greatly reduce memory required for `setBinaryStream()` in `PreparedStatements`.

D.5.4.14. Changes in MySQL Connector/J 3.0.4 (06 January 2003)

Bugs Fixed

- Streamlined character conversion and `byte[]` handling in `PreparedStatements` for `setByte()`.

- Fixed `PreparedStatement.executeBatch()` parameter overwriting.

- Added quoted identifiers to database names for `Connection.setCatalog`.

- Added support for 4.0.8-style large packets.

- Reduce memory footprint of `PreparedStatements` by sharing outbound packet with `MysqlIO`.

- Added `strictUpdates` property to enable control of amount of checking for “correctness” of updatable result sets. Set this to `false` if you want faster updatable result sets and you know that you create them from `SELECT` statements on tables with primary keys and that you have selected all primary keys in your query.

- Added support for quoted identifiers in `PreparedStatement` parser.

D.5.4.15. Changes in MySQL Connector/J 3.0.3 (17 December 2002)

Bugs Fixed

- Allow user to alter behavior of `Statement`/ `PreparedStatement.executeBatch()` using `continueBatchOnError` property (defaults to `true`).

- More robust escape tokenizer: Recognize `--` comments, and permit nested escape sequences (see `testsuite.EscapeProcessingTest`).

- Fixed `Buffer.isLastDataPacket()` for 4.1 and newer servers.

- `NamedPipeSocketFactory` now works (only intended for Windows), see `README` for instructions.

- Changed `charsToByte` in `SingleByteCharConverter` to be nonstatic.

- Use nonaliased table/column names and database names to fully qualify tables and columns in `UpdatableResultSet` (requires MySQL-4.1 or newer).

- `LOAD DATA LOCAL INFILE ...` now works, if your server is configured to permit it. Can be turned off with the `allowLoadLocalInfile` property (see the `README`).

- Implemented `Connection.nativeSQL()`.

- Fixed `ResultSetMetaData.getColumnTypeName()` returning `BLOB` for `TEXT` and `TEXT` for `BLOB` types.

- Fixed charset handling in `Fields.java`.

- Because of above, implemented `ResultSetMetaData.isAutoIncrement()` to use `Field.isAutoIncrement()`.

- Substitute `'?'` for unknown character conversions in single-byte character sets instead of `'\0'`.

- Added `CLIENT_LONG_FLAG` to be able to get more column flags (`isAutoIncrement()` being the most important).

- Honor `lower_case_table_names` when enabled in the server when doing table name comparisons in `DatabaseMetaData` methods.

- `DBMD.getImported/ExportedKeys()` now handles multiple foreign keys per table.

- More robust implementation of updatable result sets. Checks that *all* primary keys of the table have been selected.

- Some MySQL-4.1 protocol support (extended field info from selects).
- Check for connection closed in more `Connection` methods (`createStatement`, `prepareStatement`, `setTransactionIsolation`, `setAutoCommit`).
- Fixed `ResultSetMetaData.getPrecision()` returning incorrect values for some floating-point types.
- Changed `SingleByteCharConverter` to use lazy initialization of each converter.

D.5.4.16. Changes in MySQL Connector/J 3.0.2 (08 November 2002)

Bugs Fixed

- Implemented `Clob.setString()`.
- Added `com.mysql.jdbc.MiniAdmin` class, which enables you to send `shutdown` command to MySQL server. This is intended to be used when “embedding” Java and MySQL server together in an end-user application.
- Added SSL support. See `README` for information on how to use it.
- All `DBMD` result set columns describing schemas now return `NULL` to be more compliant with the behavior of other JDBC drivers for other database systems (MySQL does not support schemas).
- Use `SHOW CREATE TABLE` when possible for determining foreign key information for `DatabaseMetaData`. Also enables cascade options for `DELETE` information to be returned.
- Implemented `Clob.setCharacterStream()`.
- Failover and `autoReconnect` work only when the connection is in an `autoCommit(false)` state, to stay transaction-safe.
- Fixed `DBMD.supportsResultSetConcurrency()` so that it returns `true` for `ResultSet.TYPE_SCROLL_INSENSITIVE` and `ResultSet.CONCUR_READ_ONLY` or `ResultSet.CONCUR_UPDATABLE`.
- Implemented `Clob.setAsciiStream()`.
- Removed duplicate code from `UpdatableResultSet` (it can be inherited from `ResultSet`, the extra code for each method to handle updatability I thought might someday be necessary has not been needed).
- Fixed `UnsupportedEncodingException` thrown when “forcing” a character encoding using properties.
- Fixed incorrect conversion in `ResultSet.getLong()`.
- Implemented `ResultSet.updateBlob()`.
- Removed some not-needed temporary object creation by smarter use of `Strings` in `EscapeProcessor`, `Connection` and `DatabaseMetaData` classes.
- Escape `0x5c` character in strings for the SJIS charset.
- `PreparedStatement` now honors stream lengths in setBinary/Ascii/Character Stream() unless you set the connection property `useStreamLengthsInPrepStmts` to `false`.
- Fixed issue with updatable result sets and `PreparedStatements` not working.
- Fixed start position off-by-1 error in `Clob.getSubString()`.
- Added `connectTimeout` parameter that enables users of JDK-1.4 and newer to specify a maximum time to wait to establish a connection.
- Fixed various non-ASCII character encoding issues.
- Fixed `ResultSet.isLast()` for empty result sets (should return `false`).
- Added driver property `useHostsInPrivileges`. Defaults to `true`. Affects whether or not `@hostname` will be used in `DBMD.getColumn/TablePrivileges`.
- Fixed `ResultSet.setFetchDirection(FETCH_UNKNOWN)`.

- Added `queriesBeforeRetryMaster` property that specifies how many queries to issue when failed over before attempting to reconnect to the master (defaults to 50).
- Fixed issue when calling `Statement.setFetchSize()` when using arbitrary values.
- Properly restore connection properties when autoReconnecting or failing-over, including `autoCommit` state, and isolation level.
- Implemented `Clob.truncate()`.

D.5.4.17. Changes in MySQL Connector/J 3.0.1 (21 September 2002)

Bugs Fixed

- Charsets now automatically detected. Optimized code for single-byte character set conversion.
- Fixed `ResultSetMetaData.isSigned()` for `TINYINT` and `BIGINT`.
- Fixed `RowDataStatic.getAt()` off-by-one bug.
- Fixed `ResultSet.getRow()` off-by-one bug.
- Massive code clean-up to follow Java coding conventions (the time had come).
- Implemented `ResultSet.getCharacterStream()`.
- Added limited `Clob` functionality (`ResultSet.getClob()`, `PreparedStatement.setClob()`, `PreparedStatement.setObject(Clob)`.
- `Connection.isClosed()` no longer “pings” the server.
- `Connection.close()` issues `rollback()` when `getAutoCommit()` is `false`.
- Added `socketTimeout` parameter to URL.
- Added `LOCAL TEMPORARY` to table types in `DatabaseMetaData.getTableTypes()`.
- Added `paranoid` parameter, which sanitizes error messages by removing “sensitive” information from them (such as host names, ports, or user names), as well as clearing “sensitive” data structures when possible.

D.5.4.18. Changes in MySQL Connector/J 3.0.0 (31 July 2002)

Bugs Fixed

- General source-code cleanup.
- The driver now only works with JDK-1.2 or newer.
- Fix and sort primary key names in `DBMetaData` (SF bugs 582086 and 582086).
- `ResultSet.getTimestamp()` now works for `DATE` types (SF bug 559134).
- Float types now reported as `java.sql.Types.FLOAT` (SF bug 579573).
- Support for streaming (row-by-row) result sets (see `README`) Thanks to Doron.
- Testsuite now uses Junit (which you can get from http://www.junit.org.
- JDBC Compliance: Passes all tests besides stored procedure tests.
- `ResultSet.getDate/Time/Timestamp` now recognizes all forms of invalid values that have been set to all zeros by MySQL (SF bug 586058).
- Added multi-host failover support (see `README`).
- Repackaging: New driver name is `com.mysql.jdbc.Driver`, old name still works, though (the driver is now provided by MySQL-AB).

- Support for large packets (new addition to MySQL-4.0 protocol), see `README` for more information.
- Better checking for closed connections in `Statement` and `PreparedStatement`.
- Performance improvements in string handling and field metadata creation (lazily instantiated) contributed by Alex Twisleton-Wykeham-Fiennes.
- JDBC-3.0 functionality including `Statement/PreparedStatement.getGeneratedKeys()` and `ResultSet.getURL()`.
- Overall speed improvements using controlling transient object creation in `MysqlIO` class when reading packets.
- **!!! LICENSE CHANGE !!!** The driver is now GPL. If you need non-GPL licenses, please contact me `<mark@mysql.com>`.
- Performance enhancements: Driver is now 50–100% faster in most situations, and creates fewer temporary objects.

D.5.5. Changes in MySQL Connector/J 2.0.x

D.5.5.1. Changes in MySQL Connector/J 2.0.14 (16 May 2002)

Bugs Fixed

- `ResultSet.getDouble()` now uses code built into JDK to be more precise (but slower).
- Fixed typo for `relaxAutoCommit` parameter.
- `LogicalHandle.isClosed()` calls through to physical connection.
- Added SQL profiling (to `STDERR`). Set `profileSql=true` in your JDBC URL. See `README` for more information.
- `PreparedStatement` now releases resources on `.close()`. (SF bug 553268)
- More code cleanup.
- Quoted identifiers not used if server version does not support them. Also, if server started with `--ansi` or `--sql-mode=ANSI_QUOTES`, “`"`” will be used as an identifier quote character, otherwise “`'`” will be used.

D.5.5.2. Changes in MySQL Connector/J 2.0.13 (24 April 2002)

Bugs Fixed

- Fixed unicode chars being read incorrectly. (SF bug 541088)
- Faster blob escaping for `PrepStmt`.
- Added `setURL()` to `MySQLXADataSource`. (SF bug 546019)
- Added `set/getPortNumber()` to `DataSource(s)`. (SF bug 548167)
- `PreparedStatement.toString()` fixed. (SF bug 534026)
- More code cleanup.
- Rudimentary version of `Statement.getGeneratedKeys()` from JDBC-3.0 now implemented (you need to be using JDK-1.4 for this to work, I believe).
- `DBMetaData.getIndexInfo()` - bad PAGES fixed. (SF BUG 542201)
- `ResultSetMetaData.getColumnClassName()` now implemented.

D.5.5.3. Changes in MySQL Connector/J 2.0.12 (07 April 2002)

Bugs Fixed

- Fixed `testsuite.Traversal` `afterLast()` bug, thanks to Igor Lastric.

- Added new types to `getTypeInfo()`, fixed existing types thanks to Al Davis and Kid Kalanon.
- Fixed time zone off-by-1-hour bug in `PreparedStatement` (538286, 528785).
- Added identifier quoting to all `DatabaseMetaData` methods that need them (should fix 518108).
- Added support for `BIT` types (51870) to `PreparedStatement`.
- `ResultSet.insertRow()` should now detect auto_increment fields in most cases and use that value in the new row. This detection will not work in multi-valued keys, however, due to the fact that the MySQL protocol does not return this information.
- Relaxed synchronization in all classes, should fix 520615 and 520393.
- `DataSources` - fixed `setUrl` bug (511614, 525565), wrong datasource class name (532816, 528767).
- Added support for `YEAR` type (533556).
- Fixes for `ResultSet` updatability in `PreparedStatement`.
- `ResultSet`: Fixed updatability (values being set to `null` if not updated).
- Added `getTable/ColumnPrivileges()` to DBMD (fixes 484502).
- Added `getIdleFor()` method to `Connection` and `MysqlLogicalHandle`.
- `ResultSet.refreshRow()` implemented.
- Fixed `getRow()` bug (527165) in `ResultSet`.
- General code cleanup.

D.5.5.4. Changes in MySQL Connector/J 2.0.11 (27 January 2002)

Bugs Fixed

- Full synchronization of `Statement.java`.
- Fixed missing `DELETE_RULE` value in `DBMD.getImported/ExportedKeys()` and `getCrossReference()`.
- More changes to fix `Unexpected end of input stream` errors when reading `BLOB` values. This should be the last fix.

D.5.5.5. Changes in MySQL Connector/J 2.0.10 (24 January 2002)

Bugs Fixed

- Fixed null-pointer-exceptions when using `MysqlConnectionPoolDataSource` with Websphere 4 (bug 505839).
- Fixed spurious `Unexpected end of input stream` errors in `MysqlIO` (bug 507456).

D.5.5.6. Changes in MySQL Connector/J 2.0.9 (13 January 2002)

Bugs Fixed

- Fixed extra memory allocation in `MysqlIO.readPacket()` (bug 488663).
- Added detection of network connection being closed when reading packets (thanks to Todd Lizambri).
- Fixed casting bug in `PreparedStatement` (bug 488663).
- `DataSource` implementations moved to `org.gjt.mm.mysql.jdbc2.optional` package, and (initial) implementations of `PooledConnectionDataSource` and `XADataSource` are in place (thanks to Todd Wolff for the implementation and testing of `PooledConnectionDataSource` with IBM WebSphere 4).
- Fixed quoting error with escape processor (bug 486265).

- Removed concatenation support from driver (the `||` operator), as older versions of VisualAge seem to be the only thing that use it, and it conflicts with the logical `||` operator. You will need to start `mysqld` with the `--ansi` flag to use the `||` operator as concatenation (bug 491680).
- `Ant` build was corrupting included `jar` files, fixed (bug 487669).
- Report batch update support through `DatabaseMetaData` (bug 495101).
- Implementation of `DatabaseMetaData.getExported/ImportedKeys()` and `getCrossReference()`.
- Fixed off-by-one-hour error in `PreparedStatement.setTimestamp()` (bug 491577).
- Full synchronization on methods modifying instance and class-shared references, driver should be entirely thread-safe now (please let me know if you have problems).

D.5.5.7. Changes in MySQL Connector/J 2.0.8 (25 November 2001)

Bugs Fixed

- `XADataSource`/`ConnectionPoolDataSource` code (experimental)
- `DatabaseMetaData.getPrimaryKeys()` and `getBestRowIdentifier()` are now more robust in identifying primary keys (matches regardless of case or abbreviation/full spelling of `Primary Key` in `Key_type` column).
- Batch updates now supported (thanks to some inspiration from Daniel Rall).
- `PreparedStatement.setAnyNumericType()` now handles positive exponents correctly (adds `+` so MySQL can understand it).

D.5.5.8. Changes in MySQL Connector/J 2.0.7 (24 October 2001)

Bugs Fixed

- Character sets read from database if `useUnicode=true` and `characterEncoding` is not set. (thanks to Dmitry Vereshchagin)
- Initial transaction isolation level read from database (if available). (thanks to Dmitry Vereshchagin)
- Fixed `PreparedStatement` generating SQL that would end up with syntax errors for some queries.
- `PreparedStatement.setCharacterStream()` now implemented
- Capitalize type names when `capitalizeTypeNames=true` is passed in URL or properties (for WebObjects. (thanks to Anjo Krank)
- `ResultSet.getBlob()` now returns `null` if column value was `null`.
- Fixed `ResultSetMetaData.getPrecision()` returning one less than actual on newer versions of MySQL.
- Fixed dangling socket problem when in high availability (`autoReconnect=true`) mode, and finalizer for `Connection` will close any dangling sockets on GC.
- Fixed time zone issue in `PreparedStatement.setTimestamp()`. (thanks to Erik Olofsson)
- PreparedStatement.setDouble() now uses full-precision doubles (reverting a fix made earlier to truncate them).
- Fixed `DatabaseMetaData.supportsTransactions()`, and `supportsTransactionIsolationLevel()` and `getTypeInfo()` `SQL_DATETIME_SUB` and `SQL_DATA_TYPE` fields not being readable.
- Updatable result sets now correctly handle `NULL` values in fields.
- PreparedStatement.setBoolean() will use 1/0 for values if your MySQL version is 3.21.23 or higher.
- Fixed `ResultSet.isAfterLast()` always returning `false`.

D.5.5.9. Changes in MySQL Connector/J 2.0.6 (16 June 2001)

Bugs Fixed

- Fixed `PreparedStatement` parameter checking.
- Fixed case-sensitive column names in `ResultSet.java`.

D.5.5.10. Changes in MySQL Connector/J 2.0.5 (13 June 2001)

Bugs Fixed

- `ResultSet.insertRow()` works now, even if not all columns are set (they will be set to `NULL`).
- Added `Byte` to `PreparedStatement.setObject()`.
- Fixed data parsing of `TIMESTAMP` values with 2-digit years.
- Added `ISOLATION` level support to `Connection.setIsolationLevel()`
- `DataBaseMetaData.getCrossReference()` no longer `ArrayIndexOOB`.
- `ResultSet.getBoolean()` now recognizes `-1` as `true`.
- `ResultSet` has +/-Inf/inf support.
- `getObject()` on `ResultSet` correctly does `TINYINT`->`Byte` and `SMALLINT`->`Short`.
- Fixed `ResultSetMetaData.getColumnTypeName` for `TEXT`/`BLOB`.
- Fixed `ArrayIndexOutOfBounds` when sending large `BLOB` queries. (Max size packet was not being set)
- Fixed NPE on `PreparedStatement.executeUpdate()` when all columns have not been set.
- Fixed `ResultSet.getBlob()` `ArrayIndex` out-of-bounds.

D.5.5.11. Changes in MySQL Connector/J 2.0.3 (03 December 2000)

Bugs Fixed

- Fixed composite key problem with updatable result sets.
- Faster ASCII string operations.
- Fixed off-by-one error in `java.sql.Blob` implementation code.
- Fixed incorrect detection of `MAX_ALLOWED_PACKET`, so sending large blobs should work now.
- Added detection of -/+INF for doubles.
- Added `ultraDevHack` URL parameter, set to `true` to enable (broken) Macromedia UltraDev to use the driver.
- Implemented `getBigDecimal()` without scale component for JDBC2.

D.5.5.12. Changes in MySQL Connector/J 2.0.1 (06 April 2000)

Bugs Fixed

- Columns that are of type `TEXT` now return as `Strings` when you use `getObject()`.
- Cleaned up exception handling when driver connects.
- Fixed `RSMD.isWritable()` returning wrong value. Thanks to Moritz Maass.
- `DatabaseMetaData.getPrimaryKeys()` now works correctly with respect to `key_seq`. Thanks to Brian Slesinsky.

- Fixed many JDBC-2.0 traversal, positioning bugs, especially with respect to empty result sets. Thanks to Ron Smits, Nick Brook, Cessar Garcia and Carlos Martinez.
- No escape processing is done on `PreparedStatements` anymore per JDBC spec.
- Fixed some issues with updatability support in `ResultSet` when using multiple primary keys.

D.5.5.13. Changes in MySQL Connector/J 2.0.0pre5 (21 February 2000)

- Fixed Bad Handshake problem.

D.5.5.14. Changes in MySQL Connector/J 2.0.0pre4 (10 January 2000)

- Fixes to ResultSet for insertRow() - Thanks to Cesar Garcia
- Fix to Driver to recognize JDBC-2.0 by loading a JDBC-2.0 class, instead of relying on JDK version numbers. Thanks to John Baker.
- Fixed ResultSet to return correct row numbers
- Statement.getUpdateCount() now returns rows matched, instead of rows actually updated, which is more SQL-92 like.

10-29-99

- Statement/PreparedStatement.getMoreResults() bug fixed. Thanks to Noel J. Bergman.
- Added Short as a type to PreparedStatement.setObject(). Thanks to Jeff Crowder
- Driver now automagically configures maximum/preferred packet sizes by querying server.
- Autoreconnect code uses fast ping command if server supports it.
- Fixed various bugs with respect to packet sizing when reading from the server and when alloc'ing to write to the server.

D.5.5.15. Changes in MySQL Connector/J 2.0.0pre (17 August 1999)

- Now compiles under JDK-1.2. The driver supports both JDK-1.1 and JDK-1.2 at the same time through a core set of classes. The driver will load the appropriate interface classes at runtime by figuring out which JVM version you are using.
- Fixes for result sets with all nulls in the first row. (Pointed out by Tim Endres)
- Fixes to column numbers in SQLExceptions in ResultSet (Thanks to Blas Rodriguez Somoza)
- The database no longer needs to specified to connect. (Thanks to Christian Motschke)

D.5.6. Changes in MySQL Connector/J 1.2.x and lower

D.5.6.1. Changes in MySQL Connector/J 1.2b (04 July 1999)

- Better Documentation (in progress), in doc/mm.doc/book1.html
- DBMD now permits null for a column name pattern (not in spec), which it changes to '%'.
- DBMD now has correct types/lengths for getXXX().
- ResultSet.getDate(), getTime(), and getTimestamp() fixes. (contributed by Alan Wilken)
- EscapeProcessor now handles \{ \} and { or } inside quotation marks correctly. (thanks to Alik for some ideas on how to fix it)
- Fixes to properties handling in Connection. (contributed by Juho Tikkala)

- ResultSet.getObject() now returns null for NULL columns in the table, rather than bombing out. (thanks to Ben Grosman)
- ResultSet.getObject() now returns Strings for types from MySQL that it doesn't know about. (Suggested by Chris Perdue)
- Removed DataInput/Output streams, not needed, 1/2 number of method calls per IO operation.
- Use default character encoding if one is not specified. This is a work-around for broken JVMs, because according to spec, EVERY JVM must support "ISO8859_1", but they do not.
- Fixed Connection to use the platform character encoding instead of "ISO8859_1" if one isn't explicitly set. This fixes problems people were having loading the character- converter classes that didn't always exist (JVM bug). (thanks to Fritz Elfert for pointing out this problem)
- Changed MysqlIO to re-use packets where possible to reduce memory usage.
- Fixed escape-processor bugs pertaining to {} inside quotation marks.

D.5.6.2. Changes in MySQL Connector/J 1.2a (14 April 1999)

- Fixed character-set support for non-Javasoft JVMs (thanks to many people for pointing it out)
- Fixed ResultSet.getBoolean() to recognize 'y' & 'n' as well as '1' & '0' as boolean flags. (thanks to Tim Pizey)
- Fixed ResultSet.getTimestamp() to give better performance. (thanks to Richard Swift)
- Fixed getByte() for numeric types. (thanks to Ray Bellis)
- Fixed DatabaseMetaData.getTypeInfo() for DATE type. (thanks to Paul Johnston)
- Fixed EscapeProcessor for "fn" calls. (thanks to Piyush Shah at locomotive.org)
- Fixed EscapeProcessor to not do extraneous work if there are no escape codes. (thanks to Ryan Gustafson)
- Fixed Driver to parse URLs of the form "jdbc:mysql://host:port" (thanks to Richard Lobb)

D.5.6.3. Changes in MySQL Connector/J 1.1i (24 March 1999)

- Fixed Timestamps for PreparedStatements
- Fixed null pointer exceptions in RSMD and RS
- Re-compiled with jikes for valid class files (thanks ms!)

D.5.6.4. Changes in MySQL Connector/J 1.1h (08 March 1999)

- Fixed escape processor to deal with unmatched { and } (thanks to Craig Coles)
- Fixed escape processor to create more portable (between DATETIME and TIMESTAMP types) representations so that it will work with BETWEEN clauses. (thanks to Craig Longman)
- MysqlIO.quit() now closes the socket connection. Before, after many failed connections some OS's would run out of file descriptors. (thanks to Michael Brinkman)
- Fixed NullPointerException in Driver.getPropertyInfo. (thanks to Dave Potts)
- Fixes to MysqlDefs to allow all *text fields to be retrieved as Strings. (thanks to Chris at Leverage)
- Fixed setDouble in PreparedStatement for large numbers to avoid sending scientific notation to the database. (thanks to J.S. Ferguson)
- Fixed getScale() and getPrecision() in RSMD. (contrib'd by James Klicman)
- Fixed getObject() when field was DECIMAL or NUMERIC (thanks to Bert Hobbs)
- DBMD.getTables() bombed when passed a null table-name pattern. Fixed. (thanks to Richard Lobb)

- Added check for "client not authorized" errors during connect. (thanks to Hannes Wallnoefer)

D.5.6.5. Changes in MySQL Connector/J 1.1g (19 February 1999)

- Result set rows are now byte arrays. Blobs and Unicode work bidirectonally now. The useUnicode and encoding options are implemented now.
- Fixes to PreparedStatement to send binary set by setXXXStream to be sent untouched to the MySQL server.
- Fixes to getDriverPropertyInfo().

D.5.6.6. Changes in MySQL Connector/J 1.1f (31 December 1998)

- Changed all ResultSet fields to Strings, this should allow Unicode to work, but your JVM must be able to convert between the character sets. This should also make reading data from the server be a bit quicker, because there is now no conversion from StringBuffer to String.
- Changed PreparedStatement.streamToString() to be more efficient (code from Uwe Schaefer).
- URL parsing is more robust (throws SQL exceptions on errors rather than NullPointerExceptions)
- PreparedStatement now can convert Strings to Time/Date values using setObject() (code from Robert Currey).
- IO no longer hangs in Buffer.readInt(), that bug was introduced in 1.1d when changing to all byte-arrays for result sets. (Pointed out by Samo Login)

D.5.6.7. Changes in MySQL Connector/J 1.1b (03 November 1998)

- Fixes to DatabaseMetaData to allow both IBM VA and J-Builder to work. Let me know how it goes. (thanks to Jac Kersing)
- Fix to ResultSet.getBoolean() for NULL strings (thanks to Barry Lagerweij)
- Beginning of code cleanup, and formatting. Getting ready to branch this off to a parallel JDBC-2.0 source tree.
- Added "final" modifier to critical sections in MysqlIO and Buffer to allow compiler to inline methods for speed.

9-29-98

- If object references passed to setXXX() in PreparedStatement are null, setNull() is automatically called for you. (Thanks for the suggestion goes to Erik Ostrom)
- setObject() in PreparedStatement will now attempt to write a serialized representation of the object to the database for objects of Types.OTHER and objects of unknown type.
- Util now has a static method readObject() which given a ResultSet and a column index will re-instantiate an object serialized in the above manner.

D.5.6.8. Changes in MySQL Connector/J 1.1 (02 September 1998)

- Got rid of "ugly hack" in MysqlIO.nextRow(). Rather than catch an exception, Buffer.isLastDataPacket() was fixed.
- Connection.getCatalog() and Connection.setCatalog() should work now.
- Statement.setMaxRows() works, as well as setting by property maxRows. Statement.setMaxRows() overrides maxRows set using properties or url parameters.
- Automatic re-connection is available. Because it has to "ping" the database before each query, it is turned off by default. To use it, pass in "autoReconnect=true" in the connection URL. You may also change the number of reconnect tries, and the initial timeout value using "maxReconnects=n" (default 3) and "initialTimeout=n" (seconds, default 2) parameters. The timeout is an exponential backoff type of timeout; for example, if you have initial timeout of 2 seconds, and maxReconnects of 3, then the driver will timeout 2 seconds, 4 seconds, then 16 seconds between each re-connection attempt.

D.5.6.9. Changes in MySQL Connector/J 1.0 (24 August 1998)

- Fixed handling of blob data in Buffer.java
- Fixed bug with authentication packet being sized too small.
- The JDBC Driver is now under the LGPL

8-14-98

- Fixed Buffer.readLenString() to correctly read data for BLOBS.
- Fixed PreparedStatement.stringToStream to correctly read data for BLOBS.
- Fixed PreparedStatement.setDate() to not add a day. (above fixes thanks to Vincent Partington)
- Added URL parameter parsing (?user=... and so forth).

D.5.6.10. Changes in MySQL Connector/J 0.9d (04 August 1998)

- Big news! New package name. Tim Endres from ICE Engineering is starting a new source tree for GNU GPL'd Java software. He's graciously given me the org.gjt.mm package directory to use, so now the driver is in the org.gjt.mm.mysql package scheme. I'm "legal" now. Look for more information on Tim's project soon.
- Now using dynamically sized packets to reduce memory usage when sending commands to the DB.
- Small fixes to getTypeInfo() for parameters, and so forth.
- DatabaseMetaData is now fully implemented. Let me know if these drivers work with the various IDEs out there. I've heard that they're working with JBuilder right now.
- Added JavaDoc documentation to the package.
- Package now available in .zip or .tar.gz.

D.5.6.11. Changes in MySQL Connector/J 0.9 (28 July 1998)

- Implemented getTypeInfo(). Connection.rollback() now throws an SQLException per the JDBC spec.
- Added PreparedStatement that supports all JDBC API methods for PreparedStatement including InputStreams. Please check this out and let me know if anything is broken.
- Fixed a bug in ResultSet that would break some queries that only returned 1 row.
- Fixed bugs in DatabaseMetaData.getTables(), DatabaseMetaData.getColumns() and DatabaseMetaData.getCatalogs().
- Added functionality to Statement that enables executeUpdate() to store values for IDs that are automatically generated for AUTO_INCREMENT fields. Basically, after an executeUpdate(), look at the SQLWarnings for warnings like "LAST_INSERTED_ID = 'some number', COMMAND = 'your SQL query'". If you are using AUTO_INCREMENT fields in your tables and are executing a lot of executeUpdate()s on one Statement, be sure to clearWarnings() every so often to save memory.

D.5.6.12. Changes in MySQL Connector/J 0.8 (06 July 1998)

- Split MysqlIO and Buffer to separate classes. Some ClassLoaders gave an IllegalAccess error for some fields in those two classes. Now mm.mysql works in applets and all classloaders. Thanks to Joe Ennis <jce@mail.boone.com> for pointing out the problem and working on a fix with me.

D.5.6.13. Changes in MySQL Connector/J 0.7 (01 July 1998)

- Fixed DatabaseMetadata problems in getColumns() and bug in switch statement in the Field constructor. Thanks to Costin Manolache <costin@tdiinc.com> for pointing these out.

D.5.6.14. Changes in MySQL Connector/J 0.6 (21 May 1998)

- Incorporated efficiency changes from Richard Swift <Richard.Swift@kanatek.ca> in `MysqlIO.java` and `ResultSet.java`:
- We're now 15% faster than gwe's driver.
- Started working on `DatabaseMetaData`.
- The following methods are implemented:
  - `getTables()`
  - `getTableTypes()`
  - `getColumns()`
  - `getCatalogs()`

D.6. MySQL Connector/MXJ Change History

D.6.1. Changes in MySQL Connector/MXJ 5.0.12 (07 July 2011)

Functionality Added or Changed

- **Incompatible Change**: Connector/MXJ now contains MySQL 5.5.9, not MySQL 5.1.
- These platform mappings were added:
  - Windows_Vista-amd64=Win-x86
  - Windows_2003-amd64=Win-x86
  - Windows_2000-amd64=Win-x86
  - FreeBSD-i386=FreeBSD-x86

D.6.2. Changes in MySQL Connector/MXJ 5.0.11 (24 November 2009)

Functionality Added or Changed

- The embedded MySQL binaries have been updated to MySQL 5.1.40 for GPL releases and MySQL 5.1.40 for Commercial releases.
- The contents of the directory used for bootstrapping the MySQL databases is now configurable by using the `windows-share-dir-jar` property. You should supply the name of a jar containing the files you want to use.
- The embedded Aspect/J class has been removed.
- The default timeout for the kill delay within the embedded test suite has been increased from 10 to 30 seconds.

Bugs Fixed

- On startup Connector/MXJ generated an exception on Windows 7:

```
Exception in thread “Thread-3” java.util.MissingResourceException?: Resource
‘5-0-51a/Windows_7-x86/mysqld-nt.exe’ not found
at com.mysql.management.util.Streams.getResourceAsStream(Streams.java:133)
at com.mysql.management.util.Streams.getResourceAsStream(Streams.java:107)
at com.mysql.management.util.Streams$1.inner(Streams.java:149) at
com.mysql.management.util.Exceptions$VoidBlock?.exec(Exceptions.java:128)
```

```
at com.mysql.management.util.Streams.createFileFromResource(Streams.java:162)
at com.mysql.management.MysqldResource?.makeMysqld(MysqldResource?.java:533)
at com.mysql.management.MysqldResource?.deployFiles(MysqldResource?.java:518)
at com.mysql.management.MysqldResource?.exec(MysqldResource?.java:495)
at com.mysql.management.MysqldResource?.start(MysqldResource?.java:216)
at com.mysql.management.MysqldResource?.start(MysqldResource?.java:166)
```

The default `platform-map.properties` file, which maps platforms to the supplied binary bundles, has been updated with additional platforms, including Windows 7, Windows Server 2008, `amd64` and `sparcv9` for Solaris, and Mac OS X 64-bit. (Bug #48298)

D.6.3. Changes in MySQL Connector/MXJ 5.0.10 (Not released)

This was an internal only release.

Functionality Added or Changed

- The embedded MySQL has been updated to the MySQL 5.1 series. The embedded MySQL binaries have been updated to MySQL 5.1.33 for GPL releases and MySQL 5.1.34 for Commercial releases.
- The MySQL binary for Windows targets has been updated to be configurable through the `windows-mysqld-command` property. This is to handle the move in MySQL 5.1.33 from `mysqld-nt.exe` to `mysqld.exe`. The default value is `mysqld.exe`.

D.6.4. Changes in MySQL Connector/MXJ 5.0.9 (19 August 2008)

Functionality Added or Changed

- The port used in the `ConnectorMXJUrlTestExample` and `ConnectorMXJObjectTestExample` port is no longer hard coded. Instead, the code uses the `x-mxj_test_port` property a default value of `3336`
- The utility used to kill MySQL on Windows (`kill.exe`) has been configured to be loaded from the `kill.exe` property, instead of being hard-coded. The corresponding timeout, `KILL_DELAY` has also been moved to the properties file and defaults to 5 minutes.
- The embedded MySQL binaries have been updated to MySQL 5.0.51a for GPL releases and MySQL 5.0.54 for Commercial releases.
- The timeout for kill operations in the embedded test suite has been set to a default of 10 seconds.

D.6.5. Changes in MySQL Connector/MXJ 5.0.8 (06 August 2007)

Functionality Added or Changed

- The embedded documentation has been updated so that it now points to the main MySQL documentation pages in the MySQL reference manual.
- The embedded MySQL binaries have been updated to MySQL 5.0.45 for GPL releases and MySQL 5.0.46 for Commercial releases.

D.6.6. Changes in MySQL Connector/MXJ 5.0.7 (27 May 2007)

Functionality Added or Changed

- Updated the jar file name to be consistent with the Connector/J jar file name. Files are now formatted as `mysql-connector-mxj-`*`mxj-version`*.
- The `ConnectorMXJUrlTestExample` and `ConnectorMXJObjectTestExammple` have been updated to include an example of initializing the user/password and creating an initial database. The `InitializePasswordExample` example class has now been removed.

- The `PatchedStandardSocketFactory` class has been removed, because it fixed an issue in Connector/J that was corrected in Connector/J 5.0.6.
- The embedded MySQL binaries have been updated to MySQL 5.0.41 for GPL releases and MySQL 5.0.42 for Commercial releases.

Bugs Fixed

- Added a null-check to deal with class loaders where `getClassLoader()` returns null.

D.6.7. Changes in MySQL Connector/MXJ 5.0.6 (04 May 2007)

Functionality Added or Changed

- Updated internal jar file names to include version information and be more consistent with Connector/J jar naming. For example, `connector-mxj.jar` is now `mysql-connector-mxj-${mxj-version}.jar`.
- Updated commercial license files.
- Added copyright notices to some classes which were missing them.
- Added `InitializeUser` and `QueryUtil` classes to support new feature.
- Added new tests for initial-user & expanded some existing tests.
- `ConnectorMXJUrlTestExample` and `ConnectorMXJObjectTestExample` now demonstrate the initialization of user/password and creating the initial database (rather than using "test").
- Added new connection property `initialize-user` which, if set to `true` will remove the default, un-passworded anonymous and root users, and create the user/password from the connection url.
- Removed obsolete field `SimpleMysqldDynamicMBean.lastInvocation`.
- Clarified code in `DefaultsMap.entrySet()`.
- Removed obsolete `PatchedStandardSocketFactory` java file.
- Added `main(String[])` to `com/mysql/management/AllTestsSuite.java`.
- Errors reading `portFile` are now reported using `stacktrace(err)`, previously `System.err` was used.
- `portFile` now contains a new-line to be consistent with `pidFile`.
- Fixed where `versionString.trim()` was ignored.
- Removed references to `File.deleteOnExit`, a warning is printed instead.

Bugs Fixed

- Changed tests to shutdown mysqld prior to deleting files.
- Fixed port file to always be written to datadir.
- Added os.name-os.arch to resource directory mapping properties file.
- Swapped out commercial binaries for v5.0.40.
- Delete `portFile` on shutdown.
- Moved `platform-map.properties` into `db-files.jar`.
- Clarified the startup max wait numbers.
- Updated `build.xml` in preperation for next beta build.
- Removed `use-default-architecture` property replaced.

- Added null-check to deal with C/MXJ being loaded by the bootstrap classloaders with JVMs for which `getClassLoader()` returns null.
- Added robustness around reading portfile.
- Removed `PatchedStandardSocketFactory` (fixed in Connector/J 5.0.6).
- Refactored duplication from tests and examples to `QueryUtil`.
- Removed obsolete `InitializePasswordExample`

D.6.8. Changes in MySQL Connector/MXJ 5.0.5 (14 March 2007)

Bugs Fixed

- Moved `MysqldFactory` to main package.
- Reformatting: Added newlines some files which did not end in them.
- Swapped out commercial binaries for v5.0.36.
- Found and removed dynamic linking in mysql_kill; updated solution.
- Changed protected constructor of `SimpleMysqldDynamicMBean` from taking a `MysqldResource` to taking a `MysqldFactory`, to lay groundwork for addressing BUG discovered by Andrew Rubinger. See: MySQL Forums (Actual testing with JBoss, and filing a bug, is still required.)
- `build.xml`: `usage` now slightly more verbose; some reformatting.
- Now incorporates Reggie Bernett's `SafeTerminateProcess` and only calls the unsafe TerminateProcess as a final last resort.
- New windows `kill.exe` fixes a bug where mysqld was being force terminated. Issue reported by bruno haleblian and others, see: MySQL Forums.
- Replaced `Boolean.parseBoolean` with JDK 1.4 compliant `valueOf`.
- Changed `connector-mxj.properties` default mysql version to 5.0.37.
- In testing so far mysqld reliably shuts down cleanly much faster.
- Added testcase to `com.mysql.management.jmx.AcceptanceTest` which demonstrates that `dataDir` is a mutable MBean property.
- Updated `build.xml` in prep for next release.
- Changed `SimpleMysqldDynamicMBean` to create `MysqldResource` on demand to enable setting of `datadir`. (Rubinger bug groundwork).
- Clarified the synchronization of `MysqldResource` methods.
- `SIGHUP` is replaced with `MySQLShutdown<PID>` event.
- Clarified the immutability of `baseDir`, `dataDir`, `pidFile`, `portFile`.
- Added 5.1.15 binaries to the repository.
- Removed 5.1.14 binaries from the repository.
- Added `getDataDir()` to interface `MysqldResourceI`.
- Added 5.1.14 binaries to repository.
- Replaced windows `kill.exe` resource with re-written version specific to mysqld.
- Added Patched `StandardSocketFactory` from Connector/J 5-0 HEAD.
- Ensured 5.1.14 compatibility.

- Swapped out gpl binaries for v5.0.37.
- Removed 5.0.22 binaries from the repository.

D.6.9. Changes in MySQL Connector/MXJ 5.0.4 (28 January 2007)

Bugs Fixed

- Allow multiple calls to start server from URL connection on non-3306 port. (Bug #24004)
- Updated `build.xml` to build to handle with different gpl and commercial mysqld version numbers.
- Only populate the options map from the help text if specifically requested or in the MBean case.
- Introduced property for Linux & WinXX to default to 32bit versions.
- Swapped out gpl binaries for v5.0.27.
- Swapped out commercial binaries for v5.0.32.
- Moved mysqld binary resourced into separate jar file NOTICE: `CLASSPATH` will now need to `connector-mxj-db-files.jar`.
- Minor test robustness improvements.
- Moved default version string out of java class into a text editable properties file (`connector-mxj.properties`) in the resources directory.
- Fixed test to be tolerant of `/tmp` being a symlink to `/foo/tmp`.

D.6.10. Changes in MySQL Connector/MXJ 5.0.3 (24 June 2006)

Bugs Fixed

- Removed unused imports, formatted code, made minor edits to tests.
- Removed "TeeOutputStream" - no longer needed.
- Swapped out the mysqld binaries for MySQL v5.0.22.

D.6.11. Changes in MySQL Connector/MXJ 5.0.2 (15 June 2006)

Bugs Fixed

- Replaced string parsing with JDBC connection attempt for determining if a mysqld is "ready for connections" `CLASSPATH` will now need to include Connector/J jar.
- "platform" directories replace spaces with underscores
- extracted array and list printing to ListToString utility class
- Swapped out the mysqld binaries for MySQL v5.0.21
- Added trace level logging with Aspect/J. `CLASSPATH` will now need to include `lib/aspectjrt.jar`
- reformatted code
- altered to be "basedir" rather than "port" oriented.
- help parsing test reflects current help options
- insulated users from problems with "." in basedir
- swapped out the mysqld binaries for MySQL v5.0.18

- Made tests more robust be deleting the /tmp/test-c.mxj directory before running tests.
- ServerLauncherSocketFactory.shutdown API change: now takes File parameter (basedir) instead of port.
- socket is now "mysql.sock" in datadir
- added ability to specify "mysql-version" as an url parameter
- Extended timeout for help string parsing, to avoid cases where the help text was getting prematurely flushed, and thus truncated.
- swapped out the mysqld binaries for MySQL v5.0.19
- MysqldResource now tied to dataDir as well as basedir (API CHANGE)
- moved PID file into datadir
- ServerLauncherSocketFactory.shutdown now works across JVMs.
- extracted splitLines(String) to Str utility class
- ServerLauncherSocketFactory.shutdown(port) no longer throws, only reports to System.err
- ServerLauncherSocketFactory now treats URL parameters in the form of `&server.foo=null` as `serverOptionMap.put("foo", null)`
- ServerLauncherSocketFactory.shutdown API change: now takes 2 File parameters (basedir, datadir)

D.6.12. Changes in MySQL Connector/MXJ 5.0.1 (Not released)

This was an internal only release.

This section has no changelog entries.

D.6.13. Changes in MySQL Connector/MXJ 5.0.0 (09 December 2005)

Bugs Fixed

- Removed HelpOptionsParser's need to reference a MysqldResource.
- Reorganized utils into a single "Utils" collaborator.
- Minor test tweaks
- Altered examples and tests to use new Connector/J 5.0 URL syntax for launching Connector/MXJ ("jdbc:mysql:mxj://")
- Swapped out the mysqld binaries for MySQL v5.0.16.
- Ditched "ClassUtil" (merged with Str).
- Minor refactorings for type casting and exception handling.

D.7. MySQL Connector/C++ Change History

D.7.1. Changes in MySQL Connector/C++ 1.1.x

D.7.1.1. Changes in MySQL Connector/CPP 1.1.0 (13th September 2010 GA)

This fixes bugs since the first GA release 1.0.5 and introduces new features.

Functionality Added or Changed

- **Incompatible Change**: API incompatible change: `ConnectPropertyVal` is no longer a `struct` by a typedef that uses `boost::variant`. Code such as:

  ```
  sql::ConnectPropertyVal tmp;
  ```

```
tmp.str.val=passwd.c_str();
tmp.str.len=passwd.length();
connection_properties["password"] = tmp;
```

Should be changed to:

```
connection_properties["password"] = sql::ConnectPropertyVal(passwd);
```

- Instances of `std::auto_ptr` have been changed to `boost::scoped_ptr`. Scoped array instances now use boost::scoped_array. Further, `boost::shared_ptr` and `boost::weak_ptr` are now used for guarding access around result sets.
- `LDFLAGS`, `CXXFLAGS` and `CPPFLAGS` are now checked from the environment for every binary generated.
- Connection map property `OPT_RECONNECT` was changed to be of type `boolean` from `long long`.
- `get_driver_instance()` is now only available in dynamic library builds - static builds do not have this symbol. This was done to accommodate loading the DLL with `LoadLibrary` or `dlopen`. If you do not use `CMake` for building the source code you will need to define `mysqlcppconn_EXPORTS` if you are loading dynamically and want to use the `get_driver_instance()` entry point.
- `Connection::getClientOption(const sql::SQLString & optionName, void * optionValue)` now accepts the `optionName` values `metadataUseInfoSchema`, `defaultStatementResultType`, `defaultPreparedStatementResultType`, and `characterSetResults`. In the previous version only `metadataUseInfoSchema` was permitted. The same options are available for `Connection::setClientOption()`.

Bugs Fixed

- Certain header files were incorrectly present in the source distribution. The fix excludes dynamically generated and platform specific header files from source packages generated using CPack. (Bug #45846)
- `CMake` generated an error if configuring an out of source build, that is, when `CMake` was not called from the source root directory. (Bug #45843)
- Using Prepared Statements caused corruption of the heap. (Bug #45048)
- Missing includes when using GCC 4.4. Note that GCC 4.4 is not yet in use for any official MySQL Connector/C++ builds. (Bug #44931)
- A bug was fixed in Prepared Statements. The bug occurred when a stored procedure was prepared without any parameters. This led to an exception. (Bug #44931)
- Fixed a Prepared Statements performance issue. Reading large result sets was slow.
- Fixed bug in `ResultSetMetaData` for statements and prepared statements, `getScale` and `getPrecision` returned incorrect results.

D.7.2. Changes in MySQL Connector/C++ 1.0.x

D.7.2.1. Changes in MySQL Connector/CPP 1.0.5 (21 April 2009)

This is the first Generally Available (GA) release.

Functionality Added or Changed

- The interface of `sql::ConnectionMetaData`, `sql::ResultSetMetaData` and `sql::ParameterMetaData` was modified to have a protected destructor. As a result the client code has no need to destruct the metadata objects returned by the connector. MySQL Connector/C++ handles the required destruction. This enables statements such as:

  ```
  connection->getMetaData->getSchema();
  ```

  This avoids potential memory leaks that could occur as a result of losing the pointer returned by `getMetaData()`.
- Improved memory management. Potential memory leak situations are handled more robustly.

- Changed the interface of `sql::Driver` and `sql::Connection` so they accept the options map by alias instead of by value.
- Changed the return type of `sql::SQLException::getSQLState()` from `std::string` to `const char *` to be consistent with `std::exception::what()`.
- Implemented `getResultSetType()` and `setResultSetType()` for `Statement`. Uses `TYPE_FORWARD_ONLY`, which means unbuffered result set and `TYPE_SCROLL_INSENSITIVE`, which means buffered result set.
- Implemented `getResultSetType()` for `PreparedStatement`. The setter is not implemented because currently `PreparedStatement` cannot do refetching. Storing the result means the bind buffers will be correct.
- Added the option `defaultStatementResultType` to `MySQL_Connection::setClientOption()`. Also, the method now returns `sql::Connection *`.
- Added `Result::getType()`. Implemented for the three result set classes.
- Enabled tracing functionality when building with Microsoft Visual C++ 8 and later, which corresponds to Microsoft Visual Studio 2005 and later.
- Added better support for named pipes, on Windows. Use `pipe://` and add the path to the pipe. Shared memory connections are currently not supported.

Bugs Fixed

- A bug was fixed in `MySQL_Connection::setSessionVariable()`, which had been causing exceptions to be thrown.

D.7.2.2. Changes in MySQL Connector/CPP 1.0.4 (31 March 2009 beta)

Functionality Added or Changed

- An installer was added for the Windows operating system.
- Minimum `CMake` version required was changed from 2.4.2 to 2.6.2. The latest version is required for building on Windows.
- `metadataUseInfoSchema` was added to the connection property map, which enables control of the `INFORMATION_SCHEMA` for metadata.
- Implemented `MySQL_ConnectionMetaData::supportsConvert(from, to)`.
- Added support for MySQL Connector/C.
- Introduced `ResultSetMetaData::isZerofill()`, which is not in the JDBC specification.

Bugs Fixed

- A bug was fixed in all implementations of `ResultSet::relative()` which was giving a wrong return value although positioning was working correctly.
- A leak was fixed in `MySQL_PreparedResultSet`, which occurred when the result contained a `BLOB` column.

D.7.2.3. Changes in MySQL Connector/CPP 1.0.3 (02 March 2009 alpha)

Functionality Added or Changed

- Added new tests in `test/unit/classes`. Those tests are mostly about code coverage. Most of the actual functionality of the driver is tested by the tests found in `test/CJUnitPort`.
- New data types added to the list returned by `DatabaseMetaData::getTypeInfo()` are `FLOAT UNSIGNED`, `DECIMAL UNSIGNED`, `DOUBLE UNSIGNED`. Those tests may not be in the JDBC specification. However, due to the change you should be able to look up every type and type name returned by, for example, `ResultSetMetaData::getColumnTypeName()`.

- `MySQL_Driver::getPatchVersion` introduced.
- Major performance improvements due to new buffered `ResultSet` implementation.
- Addition of `test/unit/README` with instructions for writing bug and regression tests.
- Experimental support for STLPort. This feature may be removed again at any time later without prior warning! Type `cmake -L` for configuration instructions.
- Added properties enabled methods for connecting, which add many connect options. This uses a dictionary (map) of key value pairs. Methods added are `Driver::connect(map)`, and `Connection::Connection(map)`.
- New `BLOB` implementation. `sql::Blob` was removed in favor of `std::istream`. C++'s `IOStream` library is very powerful, similar to PHP's streams. It makes no sense to reinvent the wheel. For example, you can pass a `std::istringstream` object to `setBlob()` if the data is in memory, or just open a file `std::fstream` and let it stream to the DB, or write its own stream. This is also true for `getBlob()` where you can just copy data (if a buffered result set), or stream data (if implemented).
- Implemented `ResultSet::getBlob()` which returns `std::stream`.
- Fixed `MySQL_DatabaseMetaData::getTablePrivileges()`. Test cases were added in the first unit testing framework.
- Implemented `MySQL_Connection::setSessionVariable()` for setting variables like `sql_mode`.
- Implemented `MySQL_DatabaseMetaData::getColumnPrivileges()`.
- `cppconn/datatype.h` has changed and is now used again. Reimplemented the type subsystem to be more usable - more types for binary and nonbinary strings.
- Implementation for `MySQL_DatabaseMetaData::getImportedKeys()` for MySQL versions before 5.1.16 using `SHOW`, and above using `INFORMATION_SCHEMA`.
- Implemented `MySQL_ConnectionMetaData::getProcedureColumns()`.
- `make package_source` now packs with bzip2.
- Re-added `getTypeInfo()` with information about all types supported by MySQL and the `sql::DataType`.
- Changed the implementation of `MySQL_ConstructedResultSet` to use the more efficient O(1) access method. This should improve the speed with which the metadata result sets are used. Also, there is less copying during the construction of the result set, which means that all result sets returned from the metadata functions will be faster.
- Introduced, internally, `sql::mysql::MyVal` which has implicit constructors. Used in `mysql_metadata.cpp` to create result sets with native data instead of always string (varchar).
- Renamed `ResultSet::getLong()` to `ResultSet::getInt64()`. `resultset.h` includes typdefs for Windows to be able to use `int64_t`.
- Introduced `ResultSet::getUInt()` and `ResultSet::getUInt64()`.
- Improved the implementation for `ResultSetMetaData::isReadOnly()`. Values generated from views are read only. These generated values don't have `db` in `MYSQL_FIELD` set, while all normal columns do have.
- Implemented `MySQL_DatabaseMetaData::getExportedKeys()`.
- Implemented `MySQL_DatabaseMetaData::getCrossReference()`.

Bugs Fixed

- Bug fixed in `MySQL_PreparedResultSet::getString()`. Returned string that had real data but the length was random. Now, the string is initialized with the correct length and thus is binary safe.
- Corrected handling of unsigned server types. Now returning correct values.
- Fixed handling of numeric columns in `ResultSetMetaData::isCaseSensitive` to return `false`.

D.7.2.4. Changes in MySQL Connector/CPP 1.0.2 (19 December 2008 alpha)

Functionality Added or Changed

- Implemented `getScale()`, `getPrecision()` and `getColumnDisplaySize()` for `MySQL_ResultSetMetaData` and `MySQL_Prepared_ResultSetMetaData`.
- Changed `ResultSetMetaData` methods `getColumnDisplaySize()`, `getPrecision()`, `getScale()` to return `unsigned int` instead of `signed int`.
- `DATE`, `DATETIME` and `TIME` are now being handled when calling the `MySQL_PreparedResultSet` methods `getString()`, `getDouble()`, `getInt()`, `getLong()`, `getBoolean()`.
- Reverted implementation of `MySQL_DatabaseMetaData::getTypeInfo()`. Now unimplemented. In addition, removed `cppconn/datatype.h` for now, until a more robust implementation of the types can be developed.
- Implemented `MySQL_PreparedStatement::setNull()`.
- Implemented `MySQL_PreparedStatement::clearParameters()`.
- Added PHP script `examples/cpp_trace_analyzer.php` to filter the output of the debug trace. Please see the inline comments for documentation. This script is unsupported.
- Implemented `MySQL_ResultSetMetaData::getPrecision()` and `MySQL_Prepared_ResultSetMetaData::getPrecision()`, updating example.
- Added new unit test framework for JDBC compliance and regression testing.
- Added `test/unit` as a basis for general unit tests using the new test framework, see `test/unit/example` for basic usage examples.

Bugs Fixed

- Fixed `MySQL_PreparedStatementResultSet::getDouble()` to return the correct value when the underlying type is `MYSQL_TYPE_FLOAT`.
- Fixed bug in `MySQL_ConnectionMetaData::getIndexInfo()`. The method did not work because the schema name wasn't included in the query sent to the server.
- Fixed a bug in `MySQL_ConnectionMetaData::getColumns()` which was performing a cartesian product of the columns in the table times the columns matching `columnNamePattern`. The example `example/connection_meta_schemaobj.cpp` was extended to cover the function.
- Fixed bugs in `MySQL_DatabaseMetaData`. All `supportsCatalogXXXXX` methods were incorrectly returning `true` and all `supportsSchemaXXXX` methods were incorrectly returning `false`. Now `supportsCatalogXXXXX` returns `false` and `supportsSchemaXXXXX` returns `true`.
- Fixed bugs in the `MySQL_PreparedStatements` methods `setBigInt()` and `setDatetime()`. They decremented the internal column index before forwarding the request. This resulted in a double-decrement and therefore the wrong internal column index. The error message generated was:

  ```
  setString() ... invalid "parameterIndex"
  ```

- Fixed a bug in `getString()`. `getString()` is now binary safe. A new example was also added.
- Fixed bug in `FLOAT` handling.
- Fixed `MySQL_PreparedStatement::setBlob()`. In the tests there is a simple example of a class implementing `sql::Blob`.

D.7.2.5. Changes in MySQL Connector/CPP 1.0.1 (01 December 2008 alpha)

Functionality Added or Changed

- `sql::mysql::MySQL_SQLException` was removed. The distinction between server and client (connector) errors, based on the type of the exception, has been removed. However, the error code can still be checked to evaluate the error type.
- Support for (n)make install was added. You can change the default installation path. Carefully read the messages displayed

after executing cmake. The following are installed:

- Static and the dynamic version of the library, `libmysqlcppconn`.
- Generic interface, `cppconn`.
- Two MySQL specific headers:

  `mysql_driver.h`, use this if you want to get your connections from the driver instead of instantiating a `MySQL_Connection` object. This makes your code portable when using the common interface.

  `mysql_connection.h`, use this if you intend to link directly to the `MySQL_Connection` class and use its specifics not found in `sql::Connection`.

  However, you can make your application fully abstract by using the generic interface rather than these two headers.

- Driver Manager was removed.
- Added `ConnectionMetaData::getSchemas()` and `Connection::setSchema()`.
- `ConnectionMetaData::getCatalogTerm()` returns not applicable, there is no counterpart to catalog in MySQL Connector/C++.
- Added experimental GCov support, `cmake -DMYSQLCPPCONN_GCOV_ENABLE:BOOL=1`
- All examples can be given optional connection parameters on the command line, for example:

  ```
  examples/connect tcp://host:port user pass database
  ```

  or

  ```
  examples/connect unix:///path/to/mysql.sock user pass database
  ```

- Renamed `ConnectionMetaData::getTables: TABLE_COMMENT` to `REMARKS`.
- Renamed `ConnectionMetaData::getProcedures: PROCEDURE_SCHEMA` to `PROCEDURE_SCHEM`.
- Renamed `ConnectionMetaData::getPrimaryKeys(): COLUMN` to `COLUMN_NAME`, `SEQUENCE` to `KEY_SEQ`, and `INDEX_NAME` to `PK_NAME`.
- Renamed `ConnectionMetaData::getImportedKeys(): PKTABLE_CATALOG` to `PKTABLE_CAT`, `PKTABLE_SCHEMA` to `PKTABLE_SCHEM`, `FKTABLE_CATALOG` to `FKTABLE_CAT`, `FKTABLE_SCHEMA` to `FKTABLE_SCHEM`.
- Changed metadata column name `TABLE_CATALOG` to `TABLE_CAT` and `TABLE_SCHEMA` to `TABLE_SCHEM` to ensure JDBC compliance.
- Introduced experimental CPack support, see make help.
- All tests changed to create TAP compliant output.
- Renamed `sql::DbcMethodNotImplemented` to `sql::MethodNotImplementedException`
- Renamed `sql::DbcInvalidArgument` to `sql::InvalidArgumentException`
- Changed `sql::DbcException` to implement the interface of JDBC's `SQLException`. Renamed to `sql::SQLException`.
- Converted Connector/J tests added.
- MySQL Workbench 5.1 changed to use MySQL Connector/C++ for its database connectivity.
- New directory layout.

D.8. MySQL Proxy Change History

D.8.1. Changes in MySQL Proxy 0.8.2 (Not yet released)

Functionality Added or Changed

- The Microsoft Visual C++ runtime libraries are now a requirement for running MySQL Proxy. Users that do not have these libraries must download and install the Microsoft Visual C++ 2008 Service Pack 1 Redistributable Package MFC Security Update. For the current Proxy version, use the following link to obtain the package:

  ```
  http://www.microsoft.com/download/en/details.aspx?displaylang=en&id=26368
  ```

  (Bug #12836100)

D.8.2. Changes in MySQL Proxy 0.8.1 (13 September 2010)

Functionality Added or Changed

- Allow interception of `LOAD DATA INFILE` and `SHOW ERRORS` statements.
- The unused `network_mysqld_com_query_result_track_state()` function has been deprecated.
- `chassis_set_fdlimit()` has been deprecated in favor of `chassis_fdlimit_set()`.
- Shutdown hooks were added to free the global memory of third-party libraries such as `openssl`.
- `con->in_load_data_local` has been removed.

Bugs Fixed

- The admin plugin had an undocumented default value for `--admin-password`. (Bug #53429)
- Use of `LOAD DATA LOCAL INFILE` caused the connection between the client and MySQL Proxy to abort. (Bug #51864)
- If the backend MySQL server went down, and then the clock on the MySQL Proxy host went backward (for example, during daylight saving time adjustments), Proxy stopped forwarding queries to the backend. (Bug #50806)
- `network_address_set_address()->network_address_set_address_ip()` called `gethostbyname()` which was not reentrant. This meant that a MySQL Proxy plugin needed to guard all calls to `network_address_set_address()` with a mutex. `network_address_set_address()` has been modified to be thread safe. (Bug #49099)
- The hard limit was fixed for the case where the fdlimit was set. (Bug #48120)
- MySQL Proxy returned an error message with a nonstandard SQL State when all backends were down:

  ```
  "#07000(proxy) all backends are down"
  ```

  This caused issues for clients with “retry” logic, as they could not handle these “custom” SQL States. (Bug #45417)
- If MySQL Proxy used a UNIX socket, it did not remove the socket file at termination time. (Bug #38415)
- The `--proxy-read-only-backend-addresses` option did not work. (Bug #38341, Bug #11749171)
- When running `configure` to build, the error message relating to the `lua` libraries could be misleading. The wording and build advice have been updated.

D.8.3. Changes in MySQL Proxy 0.8.0 (21 January 2010)

Functionality Added or Changed

- The `--no-daemon` has been renamed to The `--daemon`. By default, MySQL Proxy now starts in foreground mode. Use the `--daemon` option to override this and start in daemon mode.

Bugs Fixed

- A memory leak occurred in MySQL Proxy if clients older than MySQL 4.1 connected to it. (Bug #50993)

- A segmentation fault occurred in MySQL Proxy if clients older than MySQL 4.1 connected to it. (Bug #48641)
- MySQL Proxy would load a configuration file with unsafe permissions, which could permit password information to be exposed through the file. MySQL Proxy now refuses to load a configuration file with unsafe permissions. (Bug #47589)
- Several supplied scripts were updated to account for flag and structure changes:
  - `active-transactions.lua` was updated to use the `resultset_is_needed` flag.
  - `ro-balance.lua` was updated to use the `resultset_is_needed` flag and updated `proxy.connection.dst.name` structure.
  - `rw-splitting.lua` was updated to use the `resultset_is_needed` flag and updated `proxy.connections` structure.

  (Bug #47349, Bug #45408, Bug #47345, Bug #43424, Bug #42841, Bug #46141)
- The line numbers provided in stack traces were off by one. (Bug #47348)
- MySQL Proxy accepted more than one address in the value of the `--proxy-backend-addresses` option. You should specify one `--proxy-backend-addresses` option for each backend address. (Bug #47273)
- MySQL Proxy returned the wrong version string internally from the `proxy.PROXY_VERSION` constant. (Bug #45996)
- MySQL Proxy could stop accepting network packets if it received a large number of packets. The listen queue has been extended to permit a larger backlog. (Bug #45878, Bug #43278)
- Due to a memory leak, memory usage for each new connection to the proxy increased, leading to very high consumption. (Bug #45272)
- MySQL Proxy failed to work with certain versions of MySQL, including MySQL 5.1.15, where a change in the MySQL protocol existed. Now Proxy denies `COM_CHANGE_USER` commands when it is connected to MySQL 5.1.14 to 5.1.17 servers by sending back an error: `COM_CHANGE_USER is broken on 5.1.14-.17, please upgrade the MySQL Server`. (Bug #45167)

  See also Bug #25371.
- Logging to `syslog` with the `--log-use-syslog` option did not work. (Bug #36431)
- MySQL Proxy could incorrectly insert `NULL` values into the returned result set, even though non-`NULL` values were returned in the original query. (Bug #35729)
- MySQL Proxy raised an error when processing query packets larger than 16MB. (Bug #35202)

D.8.4. Changes in MySQL Proxy 0.7.2 (30 June 2009)

Bugs Fixed

- On Windows, MySQL Proxy might not find the required modules during initialization. The core code has been updated to find the components correctly, and the Lua-based C modules are prefixed with `lua-` and Lua plugins with `plugin-`. (Bug #45833)

D.8.5. Changes in MySQL Proxy 0.7.1 (15 May 2009)

Bugs Fixed

- Due to a memory leak, memory usage for each new connection to the proxy increased, leading to very high consumption. (Bug #45272)
- The port number was reported incorrectly in `proxy.connection.client.address`. (Bug #43313)
- Result sets with more than 250 fields could cause MySQL Proxy to crash. (Bug #43078)
- MySQL Proxy was unable to increase its own maximum number of open files according to the limit specified by the `--max-open-files` option, if the limit was less than 8192. When set to debug level, Proxy now reports the open files limit and when the limit has been updated. (Bug #42783)

- MySQL Proxy crashed when connecting to a MySQL 4.0 server. Now it generates an error message instead. (Bug #38601)
- When using the `rw-splitting.lua` script, you could get an error when talking to the backend server:

  ```
  2008-07-28 18:00:30: (critical) (read_query) [string
  "/usr/local/share/mysql-proxy/rw-splitting.l..."]:218: bad argument #1 to 'ipairs' (table
  expected, got userdata)
  ```

  This led to Proxy closing the connection to the configured MySQL backend. (Bug #38419)
- When using MySQL Proxy with multiple backends, failure of one backend caused Proxy to disconnect all backends and stop routing requests. (Bug #34793)

D.8.6. Changes in MySQL Proxy 0.7.0 (Not Released)

Functionality Added or Changed

- Support for using a configuration file, in addition to the command-line options, has been added. To specify such a file, use the `--defaults-file=file_name` command-line option. See Section 14.7.3, “MySQL Proxy Command Options”. (Bug #30206)
- A number of the internal structures developed for use with Lua scripts that work with MySQL Proxy have been updated and harmonized to make their meaning and contents easier to use and consistent across multiple locations.
  - The address information has been updated. Instead of a combined `ip:port` structure that you had to parse to extract the individual information, you can now access that information directly. For example, instead of structures providing a single `.address` item, you now have these items: `name` (the combined `ip:port`), `address` (the IP address), and `port` (port number). In addition, all addresses now supply both the `src` (source) and `dst` (destination) socket information for both ends of connections.

    Some familiar structures have been updated to accommodate this information:

    - `proxy.connection.client.address` is `proxy.connection.client.src.name`
    - `proxy.connection.server.address` is `proxy.connection.server.dst.name`
  - `proxy.backends` is now in `proxy.global.backends` The `.address` field of each backend is an address-object as described earlier. For example, `proxy.backends[1].address` is `proxy.global.backends[1].dst.name`.
  - The `read_auth()` and `read_handshake()` functions no longer receive an `auth` parameter. Instead, all the data is available in the connection tables.

    In `read_handshake()`, you access the information through the global `proxy.connection` table:

0.6	0.7
`auth.thread_id`	`proxy.connection.server.thread_id`
`auth.mysqld_version`	`proxy.connection.server.mysqld_version`
`auth.server_addr`	`proxy.connection.server.dst.name`
`auth.client_addr`	`proxy.connection.client.src.name`
`auth.scramble`	`proxy.connection.server.scramble_buffer`

In `read_auth()`, you can use the following:

0.6	0.7
`auth.username`	`proxy.connection.client.username`
`auth.password`	`proxy.connection.client.scrambled_password`
`auth.default_db`	`proxy.connection.client.default_db`
`auth.server_addr`	`proxy.connection.server.dst.name`
`auth.client_addr`	`proxy.connection.client.src.name`

- In the `proxy.queries:append()` function, a third parameter is an (optional) table with options specific to the this packet. Specifically, if you want to have access to the result set in the `read_query_result()` hook, you must set the `resultset_is_needed` flag:

  ```
  proxy.queries:append( 1, ..., { resultset_is_needed = true } )
  ```

  For more information, see proxy.queries [1349].

- `proxy.backends` is now in `proxy.global.backends`.

Bugs Fixed

- **Security Enhancement**: Accessing MySQL Proxy using a client or backend from earlier than MySQL 4.1 resulted in Proxy aborting with an assertion. This is because Proxy supports only MySQL 4.1 or higher. Proxy now reports a fault. (Bug #31419)
- MySQL Proxy was configured with the `LUA_PATH` and `LUA_CPATH` directory locations according to the build host rather than the execution host. In addition, during installation, certain Lua source files could be installed into the incorrect locations. (Bug #44877, Bug #44497)
- Using MySQL Proxy with very large return data sets from queries could cause a crash, with or without manipulation of the data set within the Lua engine. (Bug #39332)
- MySQL Proxy terminated if a submitted packet was smaller than expected by the protocol. (Bug #36743)
- When using MySQL Proxy in a master-master replication scenario, Proxy failed to identify failure in one of the replication masters and did not redirect connections to the other master. (Bug #35295)

D.8.7. Changes in MySQL Proxy 0.6.1 (06 February 2008)

Functionality Added or Changed

- Fixed assertions on write errors.
- Fixed sending fake server-greetings in `connect_server()`.
- Fixed error handling for socket functions on Windows.
- Added new features to `run-tests.lua`.

D.8.8. Changes in MySQL Proxy 0.6.0 (11 September 2007)

Functionality Added or Changed

- When using read/write splitting and the `rw-splitting.lua` example script, connecting a second user to the proxy returns an error message. (Bug #30867)
- Added support in `read_query_result()` to overwrite the result set.
- By default, MySQL Proxy now starts in daemon mode. Use the new `--no-daemon` option to override this. Added the `--pid-file` option for writing the process ID to a file after becoming a daemon.
- Added hooks for `read_auth()`, `read_handshake()` and `read_auth_result()`.
- Added handling of `proxy.connection.backend_ndx` in `connect_server()` and `read_query()` to support read/write splitting.
- Added support for `proxy.response.packets`.
- Added test cases.
- Added `--no-proxy` to disable the proxy.
- Added support for listening UNIX sockets.

- Added a global Lua-scope `proxy.global.*`.
- Added connection pooling.

Bugs Fixed

- Fixed an assertion on `COM_BINLOG_DUMP`. (Bug #29764)
- Fixed an assertion on result-packets like `[field-len | fields | EOF | ERR]`. (Bug #29732)
- Fixed an assertion that MySQL Proxy raised at login time if a client specified no password and no default database. (Bug #29719)
- Fixed an assertion at `COM_SHUTDOWN`. (Bug #29719)
- Fixed a crash if `proxy.connection` is used in `connect_server()`.
- Fixed the `glib2` check to require at least `glib2` 2.6.0.
- Fixed an assertion at connect time when all backends are down.
- Fixed connection stalling if `read_query_result()` raised an assertion.
- Fixed length encoding on `proxy.resultsets`.
- Fixed compilation on win32.
- Fixed an assertion when connecting to MySQL 6.0.1.
- Fixed decoding of length-encoded ints for 3-byte notation.
- Fixed `inj.resultset.affected_rows` on `SELECT` queries.
- Fixed handling of (SQL) `NULL` in result sets.
- Fixed a memory leak when `proxy.response.*` is used.

D.8.9. Changes in MySQL Proxy 0.5.1 (30 June 2007)

Functionality Added or Changed

- Added `resultset.affected_rows` and `resultset.insert_id`.
- Changed `--proxy.profiling` to `--proxy-skip-profiling`.
- Added missing dependency to `libmysqlclient-dev` to the `INSTALL` file.
- Added `inj.query_time` and `inj.response_time` into the Lua scripts.
- Added support for pre-4.1 passwords in a 4.1 connection.
- Added script examples for rewriting and injection.
- Added `proxy.VERSION`.
- Added support for UNIX sockets.
- Added protection against duplicate result sets from a script.

Bugs Fixed

- Fixed mysql check in `configure` to die when `mysql.h` isn't detected.
- Fixed handling of duplicate ERR on `COM_CHANGE_USER` in MySQL 5.1.18+.
- Fixed a compile error with MySQL 4.1.x on missing `COM_STMT_*`.

- Fixed a crash on fields longer than 250 bytes when the result set is inspected.
- Fixed a warning if `connect_server()` is not provided.
- Fixed an assertion when an error occurs at initial script exec time.
- Fixed an assertion when `read_query_result()` is not provided when `PROXY_SEND_QUERY` is used.

D.8.10. Changes in MySQL Proxy 0.5.0 (19 June 2007)

This is the first beta release.

Bugs Fixed

- Added `automake`/`autoconf` support.
- Added `CMake` support.

Appendix E. Restrictions and Limits

The discussion here describes restrictions that apply to the use of MySQL features such as subqueries or views.

E.1. Restrictions on Stored Routines, Triggers, and Events

These restrictions apply to the features described in Chapter 17, *Stored Programs and Views*.

Some of the restrictions noted here apply to all stored routines; that is, both to stored procedures and stored functions. There are also some restrictions specific to stored functions but not to stored procedures.

The restrictions for stored functions also apply to triggers. There are also some restrictions specific to triggers.

The restrictions for stored procedures also apply to the `DO` clause of Event Scheduler event definitions. There are also some restrictions specific to events.

SQL Statements Not Permitted in Stored Routines

Stored routines cannot contain arbitrary SQL statements. The following statements are not permitted:

- The locking statements `LOCK TABLES` and `UNLOCK TABLES`.
- `ALTER VIEW`.
- `LOAD DATA` and `LOAD TABLE`.
- SQL prepared statements (`PREPARE`, `EXECUTE`, `DEALLOCATE PREPARE`) can be used in stored procedures, but not stored functions or triggers. Thus, stored functions and triggers cannot use dynamic SQL (where you construct statements as strings and then execute them).
- SQL statements that are not permitted within prepared statements are also not permitted in stored routines. See Section 12.6, “SQL Syntax for Prepared Statements”, for a list of statements supported as prepared statements. Only the statements listed there are supported for stored routines, unless noted otherwise in Section 17.2, “Using Stored Routines (Procedures and Functions)”.
- Inserts cannot be delayed. `INSERT DELAYED` syntax is accepted, but the statement is handled as a normal `INSERT`.
- Within all stored programs (stored procedures and functions, triggers, and events), the parser treats `BEGIN [WORK]` as the beginning of a `BEGIN ... END` block. To begin a transaction in this context, use `START TRANSACTION` instead.

Restrictions for Stored Functions

The following additional statements or operations are not permitted within stored functions. They are permitted within stored procedures, except stored procedures that are invoked from within a stored function or trigger. For example, if you use `FLUSH` in a stored procedure, that stored procedure cannot be called from a stored function or trigger.

- Statements that perform explicit or implicit commit or rollback. Support for these statements is not required by the SQL standard, which states that each DBMS vendor may decide whether to permit them.
- Statements that return a result set. This includes `SELECT` statements that do not have an `INTO var_list` clause and other statements such as `SHOW`, `EXPLAIN`, and `CHECK TABLE`. A function can process a result set either with `SELECT ... INTO var_list` or by using a cursor and `FETCH` statements. See Section 12.7.3.3, “`SELECT ... INTO` Statement”.
- `FLUSH` statements.
- Stored functions cannot be used recursively.
- A stored function or trigger cannot modify a table that is already being used (for reading or writing) by the statement that invoked the function or trigger.
- If you refer to a temporary table multiple times in a stored function under different aliases, a `Can't reopen table: 'tbl_name'` error occurs, even if the references occur in different statements within the function.
- `HANDLER ... READ` statements that invoke stored functions can cause replication errors. As of MySQL 5.5.7, such statements are disallowed.

Restrictions for Triggers

For triggers, the following additional restrictions apply:

- Triggers currently are not activated by foreign key actions.
- When using row-based replication, triggers on the slave are not activated by statements originating on the master. The triggers on the slave are activated when using statement-based replication. For more information, see Section 15.4.1.30, “Replication and Triggers”.
- The `RETURN` statement is not permitted in triggers, which cannot return a value. To exit a trigger immediately, use the `LEAVE` statement.
- Triggers are not permitted on tables in the `mysql` database.
- The trigger cache does not detect when metadata of the underlying objects has changed. If a trigger uses a table and the table has changed since the trigger was loaded into the cache, the trigger operates using the outdated metadata.

Name Conflicts within Stored Routines

The same identifier might be used for a routine parameter, a local variable, and a table column. Also, the same local variable name can be used in nested blocks. For example:

```
CREATE PROCEDURE p (i INT)
BEGIN
  DECLARE i INT DEFAULT 0;
  SELECT i FROM t;
  BEGIN
    DECLARE i INT DEFAULT 1;
    SELECT i FROM t;
  END;
END;
```

In such cases, the identifier is ambiguous and the following precedence rules apply:

- A local variable takes precedence over a routine parameter or table column.
- A routine parameter takes precedence over a table column.
- A local variable in an inner block takes precedence over a local variable in an outer block.

The behavior that variables take precedence over table columns is nonstandard.

Replication Considerations

Use of stored routines can cause replication problems. This issue is discussed further in Section 17.7, “Binary Logging of Stored Programs”.

The `--replicate-wild-do-table=`*`db_name.tbl_name`* option applies to tables, views, and triggers. It does not apply to stored procedures and functions, or events. To filter statements operating on the latter objects, use one or more of the `--replicate-*-db` options.

Debugging Considerations

There are no stored routine debugging facilities.

Unsupported Syntax from the SQL:2003 Standard

The MySQL stored routine syntax is based on the SQL:2003 standard. The following items from that standard are not currently supported:

- `UNDO` handlers are not supported.
- `FOR` loops are not supported.

Concurrency Considerations

To prevent problems of interaction between sessions, when a client issues a statement, the server uses a snapshot of routines and triggers available for execution of the statement. That is, the server calculates a list of procedures, functions, and triggers that may be used during execution of the statement, loads them, and then proceeds to execute the statement. While the statement executes, it does not see changes to routines performed by other sessions.

For maximum concurrency, stored functions should minimize their side-effects; in particular, updating a table within a stored function can reduce concurrent operations on that table. A stored function acquires table locks before executing, to avoid inconsistency in the binary log due to mismatch of the order in which statements execute and when they appear in the log. When statement-based binary logging is used, statements that invoke a function are recorded rather than the statements executed within the function. Consequently, stored functions that update the same underlying tables do not execute in parallel. In contrast, stored procedures do not acquire table-level locks. All statements executed within stored procedures are written to the binary log, even for statement-based binary logging. See Section 17.7, “Binary Logging of Stored Programs”.

Event Scheduler Restrictions

The following limitations are specific to the Event Scheduler:

- Event names are handled in case-insensitive fashion. For example, you cannot have two events in the same database with the names `anEvent` and `AnEvent`.
- An event may not be created, altered, or dropped by a stored routine, trigger, or another event. An event also may not create, alter, or drop stored routines or triggers. (Bug #16409, Bug #18896)
- As of MySQL 5.5.8, DDL statements on events are prohibited while a `LOCK TABLES` statement is in effect.
- Event timings using the intervals `YEAR`, `QUARTER`, `MONTH`, and `YEAR_MONTH` are resolved in months; those using any other interval are resolved in seconds. There is no way to cause events scheduled to occur at the same second to execute in a given order. In addition—due to rounding, the nature of threaded applications, and the fact that a nonzero length of time is required to create events and to signal their execution—events may be delayed by as much as 1 or 2 seconds. However, the time shown in the `INFORMATION_SCHEMA.EVENTS` table's `LAST_EXECUTED` column or the `mysql.event` table's `last_executed` column is always accurate to within one second of the actual event execution time. (See also Bug #16522.)
- Each execution of the statements contained in the body of an event takes place in a new connection; thus, these statements has no effect in a given user session on the server's statement counts such as `Com_select` and `Com_insert` that are displayed by `SHOW STATUS`. However, such counts *are* updated in the global scope. (Bug #16422)
- Events do not support times later than the end of the Unix Epoch; this is approximately the beginning of the year 2038. Such dates are specifically not permitted by the Event Scheduler. (Bug #16396)
- References to stored functions, user-defined functions, and tables in the `ON SCHEDULE` clauses of `CREATE EVENT` and `ALTER EVENT` statements are not supported. These sorts of references are not permitted. (See Bug #22830 for more information.)
- Generally speaking, statements that are not permitted in stored routines or in SQL prepared statements are also not permitted in the body of an event. For more information, see Section 12.6, “SQL Syntax for Prepared Statements”.

E.2. Restrictions on Signals

`SIGNAL` and `RESIGNAL` are not permissible as prepared statements. For example, this statement is invalid:

```
PREPARE stmt1 FROM 'SIGNAL SQLSTATE "02000"';
```

`SQLSTATE` values in class `'04'` are not treated specially. They are handled the same as other exceptions.

E.3. Restrictions on Server-Side Cursors

Server-side cursors are implemented in the C API using the `mysql_stmt_attr_set()` function. The same implementation is used for cursors in stored routines. A server-side cursor enables a result set to be generated on the server side, but not transferred to the client except for those rows that the client requests. For example, if a client executes a query but is only interested in the first row, the remaining rows are not transferred.

In MySQL, a server-side cursor is materialized into a temporary table. Initially, this is a `MEMORY` table, but is converted to a `MyISAM` table if its size reaches the value of the `max_heap_table_size` system variable. One limitation of the implementation is that for a large result set, retrieving its rows through a cursor might be slow.

Cursors are read only; you cannot use a cursor to update rows.

`UPDATE WHERE CURRENT OF` and `DELETE WHERE CURRENT OF` are not implemented, because updatable cursors are not supported.

Cursors are nonholdable (not held open after a commit).

Cursors are asensitive.

Cursors are nonscrollable.

Cursors are not named. The statement handler acts as the cursor ID.

You can have open only a single cursor per prepared statement. If you need several cursors, you must prepare several statements.

You cannot use a cursor for a statement that generates a result set if the statement is not supported in prepared mode. This includes statements such as `CHECK TABLE`, `HANDLER READ`, and `SHOW BINLOG EVENTS`.

E.4. Restrictions on Subqueries

- A subquery's outer statement can be any one of: `SELECT`, `INSERT`, `UPDATE`, `DELETE`, `SET`, or `DO`.
- Subquery optimization for `IN` is not as effective as for the `=` operator or for the `IN(value_list)` operator.

  A typical case for poor `IN` subquery performance is when the subquery returns a small number of rows but the outer query returns a large number of rows to be compared to the subquery result.

  The problem is that, for a statement that uses an `IN` subquery, the optimizer rewrites it as a correlated subquery. Consider the following statement that uses an uncorrelated subquery:

  ```
  SELECT ... FROM t1 WHERE t1.a IN (SELECT b FROM t2);
  ```

  The optimizer rewrites the statement to a correlated subquery:

  ```
  SELECT ... FROM t1 WHERE EXISTS (SELECT 1 FROM t2 WHERE t2.b = t1.a);
  ```

  If the inner and outer queries return *M* and *N* rows, respectively, the execution time becomes on the order of O(*M*×*N*), rather than O(*M*+*N*) as it would be for an uncorrelated subquery.

  An implication is that an `IN` subquery can be much slower than a query written using an `IN(value_list)` operator that lists the same values that the subquery would return.

- In general, you cannot modify a table and select from the same table in a subquery. For example, this limitation applies to statements of the following forms:

  ```
  DELETE FROM t WHERE ... (SELECT ... FROM t ...);
  UPDATE t ... WHERE col = (SELECT ... FROM t ...);
  {INSERT|REPLACE} INTO t (SELECT ... FROM t ...);
  ```

  Exception: The preceding prohibition does not apply if you are using a subquery for the modified table in the `FROM` clause. Example:

  ```
  UPDATE t ... WHERE col = (SELECT * FROM (SELECT ... FROM t...) AS _t ...);
  ```

  Here the result from the subquery in the `FROM` clause is stored as a temporary table, so the relevant rows in `t` have already been selected by the time the update to `t` takes place.

- Row comparison operations are only partially supported:

  - For `expr IN (subquery)`, `expr` can be an *n*-tuple (specified using row constructor syntax) and the subquery can return rows of *n*-tuples.
  - For `expr op {ALL|ANY|SOME} (subquery)`, `expr` must be a scalar value and the subquery must be a column subquery; it cannot return multiple-column rows.

  In other words, for a subquery that returns rows of *n*-tuples, this is supported:

  ```
  (val_1, ..., val_n) IN (subquery)
  ```

But this is not supported:

```
(val_1, ..., val_n) op {ALL|ANY|SOME} (subquery)
```

The reason for supporting row comparisons for `IN` but not for the others is that `IN` is implemented by rewriting it as a sequence of `=` comparisons and `AND` operations. This approach cannot be used for `ALL`, `ANY`, or `SOME`.

- Subqueries in the `FROM` clause cannot be correlated subqueries. They are materialized (executed to produce a result set) before evaluating the outer query, so they cannot be evaluated per row of the outer query.

- MySQL does not support `LIMIT` in subqueries for certain subquery operators:

```
mysql> SELECT * FROM t1
    ->   WHERE s1 IN (SELECT s2 FROM t2 ORDER BY s1 LIMIT 1);
ERROR 1235 (42000): This version of MySQL doesn't yet support
 'LIMIT & IN/ALL/ANY/SOME subquery'
```

- The optimizer is more mature for joins than for subqueries, so in many cases a statement that uses a subquery can be executed more efficiently if you rewrite it as a join.

  An exception occurs for the case where an `IN` subquery can be rewritten as a `SELECT DISTINCT` join. Example:

```
SELECT col FROM t1 WHERE id_col IN (SELECT id_col2 FROM t2 WHERE condition);
```

  That statement can be rewritten as follows:

```
SELECT DISTINCT col FROM t1, t2 WHERE t1.id_col = t2.id_col AND condition;
```

  But in this case, the join requires an extra `DISTINCT` operation and is not more efficient than the subquery.

- MySQL permits a subquery to refer to a stored function that has data-modifying side effects such as inserting rows into a table. For example, if `f()` inserts rows, the following query can modify data:

```
SELECT ... WHERE x IN (SELECT f() ...);
```

  This behavior is nonstandard (not permitted by the SQL standard). In MySQL, it can produce indeterminate results because `f()` might be executed a different number of times for different executions of a given query depending on how the optimizer chooses to handle it.

  For statement-based or mixed-format replication, one implication of this indeterminism is that such a query can produce different results on the master and its slaves.

- Possible future optimization: MySQL does not rewrite the join order for subquery evaluation. In some cases, a subquery could be executed more efficiently if MySQL rewrote it as a join. This would give the optimizer a chance to choose between more execution plans. For example, it could decide whether to read one table or the other first.

  Example:

```
SELECT a FROM outer_table AS ot
WHERE a IN (SELECT a FROM inner_table AS it WHERE ot.b = it.b);
```

  For that query, MySQL always scans `outer_table` first and then executes the subquery on `inner_table` for each row. If `outer_table` has a lot of rows and `inner_table` has few rows, the query probably will not be as fast as it could be.

  The preceding query could be rewritten like this:

```
SELECT a FROM outer_table AS ot, inner_table AS it
WHERE ot.a = it.a AND ot.b = it.b;
```

  In this case, we can scan the small table (`inner_table`) and look up rows in `outer_table`, which will be fast if there is an index on `(ot.a,ot.b)`.

- Possible future optimization: A correlated subquery is evaluated for each row of the outer query. A better approach is that if the outer row values do not change from the previous row, do not evaluate the subquery again. Instead, use its previous result.

- Possible future optimization: A subquery in the `FROM` clause is evaluated by materializing the result into a temporary table, and this table does not use indexes. This does not allow the use of indexes in comparison with other tables in the query, although that might be useful.

- Possible future optimization: If a subquery in the `FROM` clause resembles a view to which the merge algorithm can be applied, rewrite the query and apply the merge algorithm so that indexes can be used. The following statement contains such a subquery:

  ```
  SELECT * FROM (SELECT * FROM t1 WHERE t1.t1_col)
           AS _t1, t2 WHERE t2.t2_col;
  ```

  The statement can be rewritten as a join like this:

  ```
  SELECT * FROM t1, t2 WHERE t1.t1_col AND t2.t2_col;
  ```

  This type of rewriting would provide two benefits:

  - It avoids the use of a temporary table for which no indexes can be used. In the rewritten query, the optimizer can use indexes on `t1`.
  - It gives the optimizer more freedom to choose between different execution plans. For example, rewriting the query as a join enables the optimizer to use `t1` or `t2` first.

- Possible future optimization: For `IN`, `= ANY`, `<> ANY`, `= ALL`, and `<> ALL` with uncorrelated subqueries, use an in-memory hash for a result or a temporary table with an index for larger results. Example:

  ```
  SELECT a FROM big_table AS bt
  WHERE non_key_field IN (SELECT non_key_field FROM table WHERE condition)
  ```

  In this case, we could create a temporary table:

  ```
  CREATE TABLE t (key (non_key_field))
  (SELECT non_key_field FROM table WHERE condition)
  ```

  Then, for each row in `big_table`, do a key lookup in `t` based on `bt.non_key_field`.

E.5. Restrictions on Views

View processing is not optimized:

- It is not possible to create an index on a view.
- Indexes can be used for views processed using the merge algorithm. However, a view that is processed with the temptable algorithm is unable to take advantage of indexes on its underlying tables (although indexes can be used during generation of the temporary tables).

Subqueries cannot be used in the `FROM` clause of a view.

There is a general principle that you cannot modify a table and select from the same table in a subquery. See Section E.4, "Restrictions on Subqueries".

The same principle also applies if you select from a view that selects from the table, if the view selects from the table in a subquery and the view is evaluated using the merge algorithm. Example:

```
CREATE VIEW v1 AS
SELECT * FROM t2 WHERE EXISTS (SELECT 1 FROM t1 WHERE t1.a = t2.a);

UPDATE t1, v2 SET t1.a = 1 WHERE t1.b = v2.b;
```

If the view is evaluated using a temporary table, you *can* select from the table in the view subquery and still modify that table in the outer query. In this case the view will be stored in a temporary table and thus you are not really selecting from the table in a subquery and modifying it "at the same time." (This is another reason you might wish to force MySQL to use the temptable algorithm by specifying `ALGORITHM = TEMPTABLE` in the view definition.)

You can use `DROP TABLE` or `ALTER TABLE` to drop or alter a table that is used in a view definition. No warning results from the `DROP` or `ALTER` operation, even though this invalidates the view. Instead, an error occurs later, when the view is used. `CHECK TABLE` can be used to check for views that have been invalidated by `DROP` or `ALTER` operations.

A view definition is "frozen" by certain statements:

- If a statement prepared by `PREPARE` refers to a view, the view definition seen each time the statement is executed later will be the definition of the view at the time it was prepared. This is true even if the view definition is changed after the statement is prepared and before it is executed. Example:

```
CREATE VIEW v AS SELECT RAND();
PREPARE s FROM 'SELECT * FROM v';
ALTER VIEW v AS SELECT NOW();
EXECUTE s;
```

The result returned by the `EXECUTE` statement is a random number, not the current date and time.

With regard to view updatability, the overall goal for views is that if any view is theoretically updatable, it should be updatable in practice. This includes views that have `UNION` in their definition. Currently, not all views that are theoretically updatable can be updated. The initial view implementation was deliberately written this way to get usable, updatable views into MySQL as quickly as possible. Many theoretically updatable views can be updated now, but limitations still exist:

- Updatable views with subqueries anywhere other than in the `WHERE` clause. Some views that have subqueries in the `SELECT` list may be updatable.
- You cannot use `UPDATE` to update more than one underlying table of a view that is defined as a join.
- You cannot use `DELETE` to update a view that is defined as a join.

There exists a shortcoming with the current implementation of views. If a user is granted the basic privileges necessary to create a view (the `CREATE VIEW` and `SELECT` privileges), that user will be unable to call `SHOW CREATE VIEW` on that object unless the user is also granted the `SHOW VIEW` privilege.

That shortcoming can lead to problems backing up a database with `mysqldump`, which may fail due to insufficient privileges. This problem is described in Bug #22062.

The workaround to the problem is for the administrator to manually grant the `SHOW VIEW` privilege to users who are granted `CREATE VIEW`, since MySQL doesn't grant it implicitly when views are created.

Views do not have indexes, so index hints do not apply. Use of index hints when selecting from a view is not permitted.

`SHOW CREATE VIEW` displays view definitions using an `AS` *`alias_name`* clause for each column. If a column is created from an expression, the default alias is the expression text, which can be quite long. Aliases for column names in `CREATE VIEW` statements are checked against the maximum column length of 64 characters (not the maximum alias length of 256 characters). As a result, views created from the output of `SHOW CREATE VIEW` fail if any column alias exceeds 64 characters. This can cause problems in the following circumstances for views with too-long aliases:

- View definitions fail to replicate to newer slaves that enforce the column-length restriction.
- Dump files created with `mysqldump` cannot be loaded into servers that enforce the column-length restriction.

A workaround for either problem is the modify each problematic view definition to use aliases that provide shorter column names. Then the view will replicate properly, and can be dumped and reloaded without causing an error. To modify the definition, drop and create the view again with `DROP VIEW` and `CREATE VIEW`, or replace the definition with `CREATE OR REPLACE VIEW`.

For problems that occur when reloading view definitions in dump files, another workaround is to edit the dump file to modify its `CREATE VIEW` statements. However, this does not change the original view definitions, which may cause problems for subsequent dump operations.

E.6. Restrictions on XA Transactions

XA transaction support is limited to the `InnoDB` storage engine.

For “external XA,” a MySQL server acts as a Resource Manager and client programs act as Transaction Managers. For “Internal XA”, storage engines within a MySQL server act as RMs, and the server itself acts as a TM. Internal XA support is limited by the capabilities of individual storage engines. Internal XA is required for handling XA transactions that involve more than one storage engine. The implementation of internal XA requires that a storage engine support two-phase commit at the table handler level, and currently this is true only for `InnoDB`.

For `XA START`, the `JOIN` and `RESUME` clauses are not supported.

For `XA END`, the `SUSPEND [FOR MIGRATE]` clause is not supported.

The requirement that the `bqual` part of the `xid` value be different for each XA transaction within a global transaction is a limitation of the current MySQL XA implementation. It is not part of the XA specification.

If an XA transaction has reached the `PREPARED` state and the MySQL server is killed (for example, with `kill -9` on Unix) or shuts down abnormally, the transaction can be continued after the server restarts. However, if the client reconnects and commits the transaction, the transaction will be absent from the binary log even though it has been committed. This means the data and the binary log have gone out of synchrony. An implication is that XA cannot be used safely together with replication.

It is possible that the server will roll back a pending XA transaction, even one that has reached the `PREPARED` state. This happens if a client connection terminates and the server continues to run, or if clients are connected and the server shuts down gracefully. (In the latter case, the server marks each connection to be terminated, and then rolls back the `PREPARED` XA transaction associated with it.) It should be possible to commit or roll back a `PREPARED` XA transaction, but this cannot be done without changes to the binary logging mechanism.

E.7. Restrictions on Character Sets

- Identifiers are stored in `mysql` database tables (`user`, `db`, and so forth) using `utf8`, but identifiers can contain only characters in the Basic Multilingual Plane (BMP). Supplementary characters are not permitted in identifiers.
- The `ucs2`, `utf16`, and `utf32` character sets have the following restrictions:
  - They cannot be used as a client character set, which means that they do not work for `SET NAMES` or `SET CHARACTER SET`. (See Section 9.1.4, “Connection Character Sets and Collations”.)
  - It is currently not possible to use `LOAD DATA INFILE` to load data files that use these character sets.
  - `FULLTEXT` indexes cannot be created on a column that uses any of these character sets. However, you can perform `IN BOOLEAN MODE` searches on the column without an index.
  - The use of `ENCRYPT()` with these character sets is not recommended because the underlying system call expects a string terminated by a zero byte.
- The `REGEXP` and `RLIKE` operators work in byte-wise fashion, so they are not multi-byte safe and may produce unexpected results with multi-byte character sets. In addition, these operators compare characters by their byte values and accented characters may not compare as equal even if a given collation treats them as equal.

E.8. Performance Schema Restrictions

The Performance Schema avoids using mutexes to collect or produce data, so there are no guarantees of consistency and results can sometimes be incorrect. Event values in `performance_schema` tables are nondeterministic and nonrepeatable.

If you save event information in another table, you should not assume that the original events will still be available later. For example, if you select events from a `performance_schema` table into a temporary table, intending to join that table with the original table later, there might be no matches.

`mysqldump` and `BACKUP DATABASE` ignore tables in the `performance_schema` database.

Tables in the `performance_schema` database cannot be locked with `LOCK TABLES`, except the `SETUP_xxx` tables.

Tables in the `performance_schema` database cannot be indexed.

Results for queries that refer to tables in the `performance_schema` database are not saved in the query cache.

Tables in the `performance_schema` database are not replicated.

The Performance Schema is not available in `libmysqld`, the embedded server.

The types of timers might vary per platform. The `performance_timers` table shows which event timers are available. If the values in this table for a given timer name are `NULL`, that timer is not supported on your platform.

Instruments that apply to storage engines might not be implemented for all storage engines. Instrumentation of each third-party engine is the responsibility of the engine maintainer.

E.9. Limits in MySQL

This section lists current limits in MySQL 5.5.

E.9.1. Limits of Joins

The maximum number of tables that can be referenced in a single join is 61. This also applies to the number of tables that can be referenced in the definition of a view.

E.9.2. Limits on Number of Databases and Tables

MySQL has no limit on the number of databases. The underlying file system may have a limit on the number of directories.

MySQL has no limit on the number of databases. The underlying file system may have a limit on the number of tables. Individual storage engines may impose engine-specific constraints. `InnoDB` permits up to 4 billion tables.

E.9.3. Limits on Table Size

The effective maximum table size for MySQL databases is usually determined by operating system constraints on file sizes, not by MySQL internal limits. The following table lists some examples of operating system file-size limits. This is only a rough guide and is not intended to be definitive. For the most up-to-date information, be sure to check the documentation specific to your operating system.

Operating System	File-size Limit
Win32 w/ FAT/FAT32	2GB/4GB
Win32 w/ NTFS	2TB (possibly larger)
Linux 2.2-Intel 32-bit	2GB (LFS: 4GB)
Linux 2.4+	(using ext3 file system) 4TB
Solaris 9/10	16TB
MacOS X w/ HFS+	2TB

Windows users, please note that FAT and VFAT (FAT32) are *not* considered suitable for production use with MySQL. Use NTFS instead.

On Linux 2.2, you can get `MyISAM` tables larger than 2GB in size by using the Large File Support (LFS) patch for the ext2 file system. Most current Linux distributions are based on kernel 2.4 or higher and include all the required LFS patches. On Linux 2.4, patches also exist for ReiserFS to get support for big files (up to 2TB). With JFS and XFS, petabyte and larger files are possible on Linux.

For a detailed overview about LFS in Linux, have a look at Andreas Jaeger's *Large File Support in Linux* page at http://www.suse.de/~aj/linux_lfs.html.

If you do encounter a full-table error, there are several reasons why it might have occurred:

- The disk might be full.
- The `InnoDB` storage engine maintains `InnoDB` tables within a tablespace that can be created from several files. This enables a table to exceed the maximum individual file size. The tablespace can include raw disk partitions, which permits extremely large tables. The maximum tablespace size is 64TB.

  If you are using `InnoDB` tables and run out of room in the `InnoDB` tablespace. In this case, the solution is to extend the `InnoDB` tablespace. See Section 13.3.6, “Adding, Removing, or Resizing `InnoDB` Data and Log Files”.
- You are using `MyISAM` tables on an operating system that supports files only up to 2GB in size and you have hit this limit for the data file or index file.
- You are using a `MyISAM` table and the space required for the table exceeds what is permitted by the internal pointer size. `MyISAM` permits data and index files to grow up to 256TB by default, but this limit can be changed up to the maximum permissible size of 65,536TB ($256^7 – 1$ bytes).

  If you need a `MyISAM` table that is larger than the default limit and your operating system supports large files, the `CREATE TABLE` statement supports `AVG_ROW_LENGTH` and `MAX_ROWS` options. See Section 12.1.14, “`CREATE TABLE` Syntax”. The server uses these options to determine how large a table to permit.

  If the pointer size is too small for an existing table, you can change the options with `ALTER TABLE` to increase a table's maximum permissible size. See Section 12.1.6, “`ALTER TABLE` Syntax”.

  ```
  ALTER TABLE tbl_name MAX_ROWS=1000000000 AVG_ROW_LENGTH=nnn;
  ```

You have to specify `AVG_ROW_LENGTH` only for tables with `BLOB` or `TEXT` columns; in this case, MySQL can't optimize the space required based only on the number of rows.

To change the default size limit for `MyISAM` tables, set the `myisam_data_pointer_size`, which sets the number of bytes used for internal row pointers. The value is used to set the pointer size for new tables if you do not specify the `MAX_ROWS` option. The value of `myisam_data_pointer_size` can be from 2 to 7. A value of 4 permits tables up to 4GB; a value of 6 permits tables up to 256TB.

You can check the maximum data and index sizes by using this statement:

```
SHOW TABLE STATUS FROM db_name LIKE 'tbl_name';
```

You also can use `myisamchk -dv /path/to/table-index-file`. See Section 12.4.5, "`SHOW` Syntax", or Section 4.6.3, "`myisamchk` — MyISAM Table-Maintenance Utility".

Other ways to work around file-size limits for `MyISAM` tables are as follows:

- If your large table is read only, you can use `myisampack` to compress it. `myisampack` usually compresses a table by at least 50%, so you can have, in effect, much bigger tables. `myisampack` also can merge multiple tables into a single table. See Section 4.6.5, "`myisampack` — Generate Compressed, Read-Only MyISAM Tables".
- MySQL includes a `MERGE` library that enables you to handle a collection of `MyISAM` tables that have identical structure as a single `MERGE` table. See Section 13.10, "The `MERGE` Storage Engine".

- You are using the `MEMORY` (`HEAP`) storage engine; in this case you need to increase the value of the `max_heap_table_size` system variable. See Section 5.1.3, "Server System Variables".

E.9.4. Table Column-Count and Row-Size Limits

There is a hard limit of 4096 columns per table, but the effective maximum may be less for a given table. The exact limit depends on several interacting factors.

- Every table (regardless of storage engine) has a maximum row size of 65,535 bytes. Storage engines may place additional constraints on this limit, reducing the effective maximum row size.

  The maximum row size constrains the number (and possibly size) of columns because the total length of all columns cannot exceed this size. For example, `utf8` characters require up to three bytes per character, so for a `CHAR(255) CHARACTER SET utf8` column, the server must allocate 255 × 3 = 765 bytes per value. Consequently, a table cannot contain more than 65,535 / 765 = 85 such columns.

  Storage for variable-length columns includes length bytes, which are assessed against the row size. For example, a `VARCHAR(255) CHARACTER SET utf8` column takes two bytes to store the length of the value, so each value can take up to 767 bytes.

  `BLOB` and `TEXT` columns count from one to four plus eight bytes each toward the row-size limit because their contents are stored separately from the rest of the row.

  Declaring columns `NULL` can reduce the maximum number of columns permitted. For `MyISAM` tables, `NULL` columns require additional space in the row to record whether their values are `NULL`. Each `NULL` column takes one bit extra, rounded up to the nearest byte. The maximum row length in bytes can be calculated as follows:

  ```
  row length = 1
               + (sum of column lengths)
               + (number of NULL columns + delete_flag + 7)/8
               + (number of variable-length columns)
  ```

  `delete_flag` is 1 for tables with static row format. Static tables use a bit in the row record for a flag that indicates whether the row has been deleted. *`delete_flag`* is 0 for dynamic tables because the flag is stored in the dynamic row header. For information about `MyISAM` table formats, see Section 13.5.3, "`MyISAM` Table Storage Formats".

  These calculations do not apply for `InnoDB` tables. Storage size is the same for `NULL` and `NOT NULL` columns.

  The following statement to create table `t1` succeeds because the columns require 32,765 + 2 bytes and 32,766 + 2 bytes, which falls within the maximum row size of 65,535 bytes:

  ```
  mysql> CREATE TABLE t1
      -> (c1 VARCHAR(32765) NOT NULL, c2 VARCHAR(32766) NOT NULL)
      -> ENGINE = MyISAM CHARACTER SET latin1;
  Query OK, 0 rows affected (0.02 sec)
  ```

The following statement to create table `t2` fails because the columns are `NULL` and `MyISAM` requires additional space that causes the row size to exceed 65,535 bytes:

```
mysql> CREATE TABLE t2
    -> (c1 VARCHAR(32765) NULL, c2 VARCHAR(32766) NULL)
    -> ENGINE = MyISAM CHARACTER SET latin1;
ERROR 1118 (42000): Row size too large. The maximum row size for the
used table type, not counting BLOBs, is 65535. You have to change some
columns to TEXT or BLOBs
```

The following statement to create table `t3` fails because although the column length is within the maximum length of 65,535 bytes, two additional bytes are required to record the length, which causes the row size to exceed 65,535 bytes:

```
mysql> CREATE TABLE t3
    -> (c1 VARCHAR(65535) NOT NULL)
    -> ENGINE = MyISAM CHARACTER SET latin1;
ERROR 1118 (42000): Row size too large. The maximum row size for the
used table type, not counting BLOBs, is 65535. You have to change some
columns to TEXT or BLOBs
```

Reducing the column length to 65,533 or less permits the statement to succeed.

- Each table has an `.frm` file that contains the table definition. The server uses the following expression to check some of the table information stored in the file against an upper limit of 64KB:

  ```
  if (info_length+(ulong) create_fields.elements*FCOMP+288+
      n_length+int_length+com_length > 65535L || int_count > 255)
  ```

  The portion of the information stored in the `.frm` file that is checked against the expression cannot grow beyond the 64KB limit, so if the table definition reaches this size, no more columns can be added.

  The relevant factors in the expression are:

  - `info_length` is space needed for “screens.” This is related to MySQL's Unireg heritage.
  - `create_fields.elements` is the number of columns.
  - `FCOMP` is 17.
  - `n_length` is the total length of all column names, including one byte per name as a separator.
  - `int_length` is related to the list of values for `ENUM` and `SET` columns.
  - `com_length` is the total length of column and table comments.

  Thus, using long column names can reduce the maximum number of columns, as can the inclusion of `ENUM` or `SET` columns, or use of column, index, or table comments.

- Individual storage engines might impose additional restrictions that limit table column count. Examples:

  - `InnoDB` permits up to 1000 columns.
  - `InnoDB` restricts row size to something less than half a database page (approximately 8000 bytes), not including `VARBINARY`, `VARCHAR`, `BLOB`, or `TEXT` columns.
  - Different `InnoDB` storage formats (`COMPRESSED`, `REDUNDANT`) use different amounts of page header and trailer data, which affects the amount of storage available for rows.

E.9.5. Windows Platform Limitations

The following limitations apply to use of MySQL on the Windows platform:

- **Process memory**

  On Windows 32-bit platforms, it is not possible by default to use more than 2GB of RAM within a single process, including MySQL. This is because the physical address limit on Windows 32-bit is 4GB and the default setting within Windows is to split the virtual address space between kernel (2GB) and user/applications (2GB).

  Some versions of Windows have a boot time setting to enable larger applications by reducing the kernel application. Alternatively, to use more than 2GB, use a 64-bit version of Windows.

- **File system aliases**

  When using `MyISAM` tables, you cannot use aliases within Windows link to the data files on another volume and then link back to the main MySQL `datadir` location.

  This facility is often used to move the data and index files to a RAID or other fast solution, while retaining the main `.frm` files in the default data directory configured with the `datadir` option.

- **Limited number of ports**

  Windows systems have about 4,000 ports available for client connections, and after a connection on a port closes, it takes two to four minutes before the port can be reused. In situations where clients connect to and disconnect from the server at a high rate, it is possible for all available ports to be used up before closed ports become available again. If this happens, the MySQL server appears to be unresponsive even though it is running. Note that ports may be used by other applications running on the machine as well, in which case the number of ports available to MySQL is lower.

  For more information about this problem, see http://support.microsoft.com/default.aspx?scid=kb;en-us;196271.

- **`DATA DIRECTORY` and `INDEX DIRECTORY`**

  The `DATA DIRECTORY` and `INDEX DIRECTORY` options for `CREATE TABLE` are ignored on Windows, because MySQL does not support Windows symbolic links. These options also are ignored on systems that have a nonfunctional `realpath()` call.

- **`DROP DATABASE`**

  You cannot drop a database that is in use by another session.

- **Case-insensitive names**

  File names are not case sensitive on Windows, so MySQL database and table names are also not case sensitive on Windows. The only restriction is that database and table names must be specified using the same case throughout a given statement. See Section 8.2.2, “Identifier Case Sensitivity”.

- **Directory and file names**

  On Windows, MySQL Server supports only directory and file names that are compatible with the current ANSI code pages. For example, the following Japanese directory name will not work in the Western locale (code page 1252):

  ```
  datadir="C:/私たちのプロジェクトのデータ"
  ```

  The same limitation applies to directory and file names referred to in SQL statements, such as the data file path name in `LOAD DATA INFILE`.

- **The “`\`” path name separator character**

  Path name components in Windows are separated by the “`\`” character, which is also the escape character in MySQL. If you are using `LOAD DATA INFILE` or `SELECT ... INTO OUTFILE`, use Unix-style file names with “`/`” characters:

  ```
  mysql> LOAD DATA INFILE 'C:/tmp/skr.txt' INTO TABLE skr;
  mysql> SELECT * INTO OUTFILE 'C:/tmp/skr.txt' FROM skr;
  ```

  Alternatively, you must double the “`\`” character:

  ```
  mysql> LOAD DATA INFILE 'C:\\tmp\\skr.txt' INTO TABLE skr;
  mysql> SELECT * INTO OUTFILE 'C:\\tmp\\skr.txt' FROM skr;
  ```

- **Problems with pipes**

  Pipes do not work reliably from the Windows command-line prompt. If the pipe includes the character `^Z` / `CHAR(24)`, Windows thinks that it has encountered end-of-file and aborts the program.

  This is mainly a problem when you try to apply a binary log as follows:

  ```
  C:\> mysqlbinlog binary_log_file | mysql --user=root
  ```

  If you have a problem applying the log and suspect that it is because of a `^Z` / `CHAR(24)` character, you can use the following workaround:

```
C:\> mysqlbinlog binary_log_file --result-file=/tmp/bin.sql
C:\> mysql --user=root --execute "source /tmp/bin.sql"
```

The latter command also can be used to reliably read in any SQL file that may contain binary data.

ndex

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GET_FORMAT(DATE,'JIS')
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GET_FORMAT(DATETIME,'INTERNAL')
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GET_FORMAT(DATETIME,'ISO')
Section 11.7, “Date and Time Functions”

GET_FORMAT(DATETIME,'JIS')
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GET_FORMAT(DATETIME,'USA')
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GET_FORMAT(TIME,'INTERNAL')
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GET_FORMAT(TIME,'ISO')
Section 11.7, “Date and Time Functions”

GET_FORMAT(TIME,'JIS')
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INET_ATON()
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INET_ATON(expr)
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--log-bin-trust-function-creators[={0|1}]
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--log-bin-trust-routine-creators
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--myisam-recover-options=mode
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`--plugin-load=auth_simple.so`
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`--plugin_dir=path`
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`--plugin_name=0`
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`--plugin_name=1`
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`--plugin_name=FORCE`
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`--plugin_name=OFF`
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`--plugin_name=ON`
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`--protocol=PIPE`
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`--protocol=SOCKET`
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`--relay-log-info-file`
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`--relay-log-info-file=file_name`
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`--relay-log-info-repository`
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`--relay-log-purge={0|1}`
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`--relay-log-recovery`
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`--relay-log-recovery={0|1}`
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`--relay-log-space-limit`
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`--relay-log-space-limit=size`
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--replicate-do-db=db1
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--replicate-do-db=db_name
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--replicate-do-db=dbx
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--replicate-do-db=sales
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--replicate-do-table=db_name.tbl_name
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--replicate-ignore-db
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--replicate-ignore-db=db_name
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--replicate-ignore-db=sales
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--replicate-ignore-table
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--replicate-ignore-table=db_name.tbl_name
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--replicate-rewrite-db
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--replicate-rewrite-db=from_name->to_name
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--replicate-same-server-id
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--replicate-wild-do-table=databaseA.%
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--replicate-wild-do-table=databaseB.%
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--replicate-wild-do-table=databaseC.%
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--replicate-wild-do-table=db%.t1
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--replicate-wild-do-table=db_name.%
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--replicate-wild-do-table=db_name.tbl_name
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--replicate-wild-do-table=foo%.bar%
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--replicate-wild-do-table=my\\_own\\%db
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--replicate-wild-do-table=my_own\%db
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--replicate-wild-ignore-table
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--replicate-wild-ignore-table=db_name.%
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--replicate-wild-ignore-table=foo%.bar%
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--report-password
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--report-password=password
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--report-port
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--report-port=slave_port_num
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--report-user
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--report-user=user_name
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--safe-user-create
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--secure-auth
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--secure-file-priv
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--secure-file-priv=path
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--select_limit
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--set-collation
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--set-collation=name
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`--skip-bdb`
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--skip-host-cache
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--skip-kill-mysqld
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-DCMAKE_BUILD_TYPE=Debug
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-DENABLE_DEBUG_SYNC=0
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DROP DATABASE IF EXISTS
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DROP PROCEDURE
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DROP SERVER
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DROP TABLE
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DROP TABLE t1
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DROP USER 'x'@'localhost'
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DROP VIEW
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Section 21.5.1.6, “Using Server Logs to Find Causes of Errors in mysqld”
Section 11.17.6.2, “Using a Spatial Index”
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EXPLAIN ... SELECT
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EXPLAIN PARTITIONS
Section 12.8.2, “EXPLAIN Syntax”
Section 16.3.4, “Obtaining Information About Partitions”
Section 7.8.1, “Optimizing Queries with EXPLAIN”

EXPLAIN PARTITIONS SELECT
Section 16.3.4, “Obtaining Information About Partitions”

EXPLAIN PARTITIONS SELECT COUNT(*) FROM employees WHERE separated BETWEEN '2000-01-01' AND '2000-12-31' GROUP BY store_id;
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EXPLAIN SELECT
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EXPLAIN SELECT ... ORDER BY
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EXPLAIN tbl_name
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FLUSH
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